JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY

VOLUME VII.

NEW YORK:
PUBLISHED FOR THE SOCIETY,
QUARTERLY.

JOURNAL
OF THE
NEW-YORK MICROSCOPICAL SOCIETY.

VOL. VII. JANUARY, 1891. No. 1.

BIBLIOGRAPHICAL CATALOGUE OF THE DESCRIBED TRANSFORMATIONS OF NORTH AMERICAN COLEOPTERA.

BY WM. BEUTENMÜLLER.

(*Read by title November 21st*, 1890.)

The present catalogue was compiled by me in the spare time that was at my command during the past four years, and was originally intended for my own use and assistance in the study of the earlier stages of North American Coleoptera ; but seeing the imperfect condition of our knowledge, and the vast amount of work that is yet to be done in this neglected branch of entomology, I concluded to publish the results of my labor, to give those who may also be interested in the subject an idea of what work there has been done. It was my intention also to add notes and comments after the references so as to indicate their value, but lack of time prevented me from doing so. Yet I hope the catalogue, which must not be considered as being perfect, will be acceptable, until a better and more complete work can be substituted. I have searched for references in all the entomological publications of this country and Europe that were accessible to me, and I believe I have at least given the main facts that have been recorded on the earlier transformations of North American Coleoptera. In the arrangement and style of the catalogue I have followed Mr. Henry Edward's Bibliographical Catalogue of the described Transformations of N. American Lepidoptera (Bull. U. S. Nat. Mus. No. 35). When the words (quotes Horn, e. g.) occur after the name of the describer, it will be understood that the *text* of the description has been used, and when the words (after Packard, etc.) it signifies that the *figure* has been borrowed from this author. If the word (brief) is used it means that the reference is but a mere *notice* to a short description of the larva or pupa, etc., of the species.

CICINDELIDÆ.

AMBLYCHILA CYLINDRIFORMIS Say.

1845. Larva (brief). Leconte. Ann. Lyc iv. 143 (as *Pasimachus*).
1878. Larva (fig.). Horn. Trans. Am. Ent. Soc. vii. 29. pl. ii.
1877. Larva (brief). Williston. Can. Ent. ix. 163.
1878. Larva (fig.). Riley (Horn, Ms. in advance). 1st Rep. U. S. Ent. Com. 316.
1879. Larva. Schaupp (quotes Horn). Bull. Bk. Ent. Soc. ii. 3.
1883. Larva (fig.). Schaupp. Bull. Bk. Ent. Soc. vi. 74.

OMUS DEJEANI Reiche.

1878. Larva (fig.). Horn. Trans. Am. Ent. Soc. vii. 31. pl. ii.
1879. Larva. Schaupp (quotes Horn). Bull. Bk. Ent. Soc. ii. 3.
1883. Larva (fig.). Schaupp. Bull. Bk. Ent. Soc. vi. 75.

TETRACHA CAROLINA Linn.

1878. Larva. Horn. Trans. Am. Ent. Soc. vii. 34.
1879. Larva (brief). Schaupp (quotes Horn). Bull. Bk. Ent. Soc. ii. 3.
1883. Larva (fig.). Schaupp (quotes Horn). Bull. Bk. Ent. Soc. vi. 79.

CICINDELA REPANDA Dej.

1878. Larva (fig.). Horn. Trans. Am. Ent. Soc. vii. 35. pl. ii. fig. 4.
1879. Larva (brief). Schaupp (quotes Horn). Bull. Bk. Ent. Soc ii. 9.
1882. Pupa (fig.). Schaupp. Bull. Bk. Ent. Soc. v. 18.
1883. Larva (fig.). Schaupp (quotes Horn). Bull. Bk. Ent. Soc. vi. 123.

CICINDELA SPLENDIDA Hentz.

1878. Larva (fig. only). Riley. 1st Rep. U. S. Ent. Com. 314 (1877).
1885. Larva (fig. only). Riley. 4th Rep. U. S. Ent. Com. 95 (1883–85).

CARABIDÆ.

CALOSOMA CALIDUM Fabr.

1861. Larva (fig.). Rathvon. Rep. U. S. Dept. Agri. 59.
1863. Larva (brief, fig.). Fitch. 9th Rep. Trans. N. Y. Agri. Soc. 816.
1868. Larva (fig. only). Glover. Rep. U. S. Dept. Agri 79.
1874. Larva (fig. only). Le Baron. 4th Rep. Nox. & Ben. Ins. Ill. 42.
1875. Larva (fig.). Riley. 8th Rep. Ins. Mo. 52.
1876. Larva (fig. only). Thomas. 6th Rep. Nox. Ins. Ill. 89.
1878. Larva (fig. only). Riley. 1st Rep. U. S. Ent. Com. 314 (1877).
1878. Larva. Williams. Rep. Ent. Soc. Ont. 40.
1879. Larva (brief). Schaupp. Bull. Bk. Ent. Soc. ii. 14.
1879. Larva (fig. only). Comstock. Rep. U. S. Dept. Agri. pl. xi.
1879. Larva (fig. only). Burkhaut. Rep. Bd. Agri. Penn. 35.
1879. Larva (fig. only). Comstock. Cotton Insects. 175.
1880. Larva (fig.). Packard. Guide. 431 (7th Ed.).
1882. Larva, pupa (detailed). Schaupp. Bull. Bk. Ent. Soc. v. 33.
1884. Larva (fig.). Cutting. 8th Rep. Bd. Agri. Vermont. 251.

Calosoma scrutator Fabr.

1855. Larva (detailed). Capuis et Candeze. Mem. Soc. Sc. Liege. viii. 571.
1879. Larva (brief). Schaupp. Bull. Bk. Ent. Soc. ii. 14.

Elaphrus riparius Linn.

1867. Larva (fig.). Schiœdte. Nat. Tidsskr. iv. 452. pl. xiii.

Patrobus longicornis Say.

1881. Larva. Schaupp. Bull. Bk. Ent. Soc. iv. 56. fig. and v. 18.

Anophthalmus sp.

1874. Larva (brief). Packard. Am. Nat. viii. 563.
1876. Larva, pupa (figs.). Packard. Am. Nat. x. 286.
1881. Larva (fig., detailed). Hubbard. Am. Ent. iii. 81.
1889. Larva, pupa (fig.). Packard. Mem. Nat. Acad. Sc. iv. 76.
These are supposed to be either *A. Tellkampfii*, or *Menetriesii*.

Pterostichus mutus Say.

1880. Larva (fig.). Schaupp. Bull. Bk. Ent. Soc. iii. 89.

Pterostichus lucublandus Say.

1880. Larva (fig.). Schaupp. Bull. Bk. Ent. Soc. iii. 88.

Amara obesa Say.

1878. Larva, pupa (figs.). Riley. 1st. Rep. U. S. Ent. Com. 291, 292.

Dicælus dilatatus Say.

1878. Larva (fig.). Schaupp. Bull. Bk. Ent. Soc. i. 1, 44.
1879. Larva (brief, fig.). Schaupp. Bull. Bk. Ent. Soc. ii. 21.
1882. Pupa (fig.). Schaupp. Bull. Bk. Ent. Soc. v. 18.

Dicælus politus Dej.

1878. Larva, pupa (brief). Schaupp. Bull. Bk. Ent. Soc. i. 44, 72, and ii. 21 (1879).

Dicælus elongatus Bon.

1878. Larva, pupa (brief). Schaupp. Bull. Bk. Ent. Soc. i. 43, 44, 72.
1879. Larva (brief). Schaupp. Bull. Bk. Ent. Soc. ii. 21.

Dicælus costatus Lec., or splendidus Say.

1878. Larva. Horn. Trans. Am. Ent. Soc. i. 37. pl. ii. fig. 5.
1879. Larva (brief.) Schaupp (quotes Horn). Bull. Bk. Ent. Soc. ii. 14.

Badister bipustulatus Fabr.

1872. Larva (fig.). Schiœdte. Naturh. Tidsskr. viii. pls. i, iii.

Pristonychus terricola Hbst.

1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Liege. viii. 376.

Platynus extensicollis Say.

1880. Larva (fig.). Schaupp. Bull. Bk. Ent. Soc. iii. 91.

Galerita Lecontei Dej.

1848. Larva, pupa (fig.). Salle. Ann. Soc. Ent. Fr. 298.
1855. Larva. Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 367.
1879. Larva (brief). Schaupp. Bull. Bk. Ent. Soc. ii. 14.
1880. Larva, pupa (figs). Packard. Guide. 433.
1880. Larva (fig.). Anony. Am. Ent. iii. 153.

Galerita janus Fabr.

1871. Larva (fig.). Packard. 1st. Ann. Rep. Inj. & Ben. Ins. Mass. 28–30, also reproduced in Guide. 713.
1875. Larva. Hubbard. Psyche. i. 48.
1879. Larva (brief). Schaupp. Bull. Bk. Ent. Soc. ii. 14.
1882. Pupa (fig.). Schaupp. Bull. Bk. Ent. Soc. v. 18.

Chlænius laticollis Say.

1880. Larva (fig.). Schaupp. Bull. Bk. Ent. Soc. iii. 17.
1882. Pupa (fig.). Schaupp. Bull. Bk. Ent. Soc. v. 18.

Chlænius leucoscelis Chev.

1880. Larva (fig.). Schaupp. Bull. Bk. Ent. Soc. iii. 25, 26.

Harpalus herbivagus Say?

1876. Larva. Riley. 9th Rep. Inj. Ins. Mo. 97.
1878. Larva (fig.). Riley. 1st. Rep. U. S. Ent. Com. 290 (1877).

Harpalus. (?) sp. (?)

1869. Larva (fig. only). Packard (quotes Walsh). Guide. 434.
1874. Larva (fig. only). Le Baron (quotes Walsh). 4th Rep. Nox. & Ben. Ins. Ill. 47.
1876. Larva (fig.). Riley. 9th Rep. Nox. & Ben. Ins. Mo. 97.
1878. Larva (fig. only). Williams. Rep. Ent. Soc. Ont. 42.
1878. Larva (fig. only). Riley. 1st Rep. U. S. Ent. Com. 292.
1883. Larva (fig. only). Saunders. Ins. Inj. Fruit. 185 (as *H. Pennsylvanicus*).
1884. Larva (fig. only). Edge. Rep. Agri. Penn. 102 (as *H. Pennsylvanicus*).

Harpalus caliginosus Fabr. (?)

1879. Larva (fig. only). Comstock. Cotton Ins. 175.
1884. Larva (fig. only). Edge. Rep. Agri. Penn. 102 (as *H. Pennsylvanicus*).

HALIPLIDÆ.

Haliplus ruficollis De G.

1864. Larva (fig.). Schiœdte. Nat. Tidsskr. iii. 161-164.

DYTISCIDÆ.

DYTISCUS MARGINALIS Linn.

1634. Larva. Mouffet. Ins. Min. Animal. Theatr. 320.
1685. Larva (fig.). Swammerdam. Bibl. Nat. pl. xxix.
1749. Larva, pupa (fig.). Rœsel. Insect. Belust. i. 1-8. pl. i.
1758. Larva (fig., brief). Hill. Book of Nat. Hist. Ins. pl. xxix.
1774. Larva. De Geer. Mem. iv. m. 8.
1804. Larva, pupa (fig.). Latreille. Nat. Hist. Ins. & Crust. 70. pl. lxx.
1806. Larva. Clairville. Ent. Helvet. ii. 204.
1806. Larva (fig., brief.) Shaw. General Zoo. 91. pl. xxxiii.
1823. Larva, pupa. Latreille (quotes Rœsel). Regne Anim. 284, 285 (1817).
1826. Larva (fig.). Kirby & Spence (quote Rœsel). Intro. Ent. iii. pl. xiii.
1832. Larva, pupa (figs.). Lyonet. Recherches. 108. pl. xi (1760).
1832. Larva. Erichson. Gen. Dytis. 14.
1834. Larva, pupa (fig.). Sturm (quotes Rœsel). Ins. Deutsch. viii. 11. pl. clxxxvi.
1835. Larva, pupa (figs.). Audouin et Brulle. Nat. Ins. v. 194 pl.
1835. Larva (fig. only). Duncan. Nat. Library. ii. 136.
1836. Larva. Curtis. Trans. Ent. Soc. Lond. i. 86.
1836. Larva (fig.). Heer (quotes Rœsel). Obs. Ent. pl. iii.
1839. Egg, larva, pupa (figs.). Westwood (quotes various authors). Int. Ins. i. 99-101.
1841. Larva, pupa (figs.). Jones. Anim. Kingd. 245.
1842. Larva (fig., brief). Anony. Rudiments of Zoology. 235.
1855. Larva (fig. only). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 383. pl. i.
1864. Larva, pupa (figs.). Schiœdte. Nat. Tidsskr. iii. 182. pl. iii.
1865. Egg, larva, pupa (brief, figs.). Houghton. Intellect. Obs. vi. 422.
1870. Larva. v. Fricken. Nat. and Off. xvi. 474.
1872. Larva, pupa (figs., brief). Figuier. Insect World. 479.
1874. Larva, pupa (figs. only). Le Baron. 4th Rep. Nox. Ins. Ill. 40.

CYBISTER FIMBRIOLATUS Say.

1885. Larva, pupa (figs.). Duges. Ann. Ent. Soc. Belg. xxix. 27. pl. ii.

HYDROPHILIDÆ.

HELOPHORUS GRANULARIS Mots.

1862. Larva, pupa (figs.). Schiœdte. Nat. Tidsskr. iii. 1. 213. pl. vii.

HYDROPHILUS NIMBATUS Say.

1884. Larva, pupa (figs.). Duges (as *H. lateralis*). Ann. Ent. Soc. Belg. xxviii. 7. pl. i.

HYDROPHILUS TRIANGULARIS Say.

1881. Egg, larva (figs.). Garman. Am. Nat. xv. 661.

HYDROCHARIS OBTUSATUS Say.

1884. Egg-case (fig.), young larva. Bowditch. Journ. Bost. Zoo. Soc. iii. 1-6.

SPHÆRIDIUM SCARABÆOIDES Linn.

1862. Larva, pupa (figs.). Schiœdte Nat. Tidsskr. iii. 1. 221. pl. vi.

CERCYON ANALE Payk.

1862. Larva, pupa (figs.). Schiœdte. Nat. Tidsskr. iii. 1. 219. pl. vi.

PLATYPSYLLIDÆ.

PLATYPSYLLA CASTORIS Rit.

1888. Larva (fig.). Horn. Trans. Am. Ent. Soc. xv. 23. pl. iii.
1888. Larva (figs.). Riley. Scient. Am. Supp. June.
1889. Larva (brief). Horn. Pro. Ent. Soc. Wash. i. 144 (1888).
1889 Larva (figs.). Riley. Insect Life. i. 300–307.
1890. Larva (figs.). Riley. Ent. Am. vi. 27–30.
1890. Larva (fig.). Riley. Insect Life. ii. 244–246.
1890. Larva. Horn. Ent. Am. vi. 55.

SILPHIDÆ.

NECROPHORUS TOMENTOSUS Web.

1861. Larva (fig , brief). Rathvon. Rep. U. S. Dept. Agri. 594.
1881. Larva (fig., detailed). Schaupp. Bull. Bk. Ent. Soc. iv. 37, 38.

SILPHA INÆQUALIS Fabr.

Larva, pupa (figs.). Riley.
1874. Larva, pupa (figs., brief). LeBaron (quotes Riley). 4th Rep. Nox. Ins. Ill. 57.

SILPHA AMERICANA Linn.

1861. Larva (fig., brief). Rathvon. Rep. U. S. Dept. Agri. 595.
1882. Larva (fig., detailed). Schaupp. Bull. Bk. Ent. Soc. v. 2. pl. 18.

SILPHA RAMOSA Say.

1880. Egg, larva (figs.). Gissler. Am. Ent. iii. 265.

SILPHA LAPPONICA Hbst.

1869. Larva (figs. only). Packard. Guide. 439 (and other editions).

SILPHA OPACA Linn.

1846. Larva. Guerin. Ann. Ent. Soc. Fr. iv. 2 Ser. Bull. 72.
1852. Larva. Fairmaire. Ann. Soc. Ent. Fr. 2 Ser.

ADELOPS HIRTUS Tellk.

1874. Larva (brief). Packard. Am. Nat. viii. 563.
1876. Larva (fig only) Packard. Am. Nat. x. 286.
1880. Larva, pupa (figs., detailed). Hubbard. Am. Ent. iii. 80.
1889. Larva, pupa (figs.). Packard (quotes Hubbard in part). Mem. Nat. Acad. Sc. iv. 78.

STAPHYLINIDÆ.

QUEDIUS FULGIDUS Fabr.

1834. Larva (fig). Bouche. Nat. Ins. 180, 181. pl. viii.
1858. Larva. Kraatz (quotes Bouche). Nat. Ins. Deutsch. ii. 488.
1864. Larva (fig.). Schiœdte, iii. 205. pl. x.

LISTOTROPHUS CINGULATUS Grav.

1879. Larva (brief). Schaupp. Bull. Bk. Ent. Soc. ii. 30.
1881. Larva (detailed). Schaupp. Bull. Bk. Ent. Soc. iv. 9, 10.

STAPHYLINUS MACULOSUS Grav.

1861. Larva (fig., brief). Rathvon. Rep. U. S. Dept. Agri. 596.
1878. Larva (fig., detailed). Schaupp. Bull. Bk. Ent. Soc. i. 42, 71.
1879. Larva pupa (brief). Schaupp. Bull. Bk. Ent. Soc. ii. 30.

STAPHYLINUS VULPINUS Nordm.

1880. Larva (fig.). Schaupp. Bull. Bk. Ent. Soc. iii. 92.

STAPHYLINUS ERYTHROPTERUS Linn.

1724. Larva, pupa (figs.). Frisch. Beschreib. Ins. v. 50. pl. xxvi.

PHILONTHUS ÆNEUS Rossi.

1834. Larva (fig.). Bouche. Nat. Ins. 199. pl. vii.
1839. Larva (fig.). Westwood. Zoo. Journ. iii. 58, 59.
1858. Larva. Kraatz (quotes Bouche). Nat. Ins. Deutsch. ii 567.
1864. Pupa (fig.). Schiœdte. Nat. Tidsskr. iii. 206. pl. xii.

PHILONTHUS SORDIDUS Grav.

1876. Larva. Mulsant. Hist. Nat. Brevip. 384.

XANTHOLINUS PUNCTULATUS Payk.

1834. Larva (fig.). Bouche. Nat. Ins. 181. pl. viii.
1858. Larva. Kraatz (quotes Bouche). Nat. Ins. Deutsch. ii. 631.

LEPTACINUS BATYCHRUS Gyll.

1876. Larva. Mulsant. Hist. Nat. Brevip. 324.

STENUS BIPUNCTATUS Er.

1873. Larva (fig.). Schiœdte. Nat. Tidsskr. viii. 548. pl. xviii.

TACHYPORUS CHRYSOMELINUS Linn.

1873. Larva (fig.). Schiœdte. Nat. Tidsskr. viii. 557. pl. xix.

OXYTELUS SCULPTUS Grav.

1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 400.
1858. Larva. Kraatz (quotes Chapius et Candeze). Nat. Ins. Deutsch. ii. 849.

ACIDOTA CRENATA Fabr.

1877. Larva, pupa (brief). Beling. Wieg. Archiv. 43. i. 50.

UNKNOWN SPECIES.

1876. Larva (fig). Packard. Am. Nat. x. 286. pl. ii. fig. 9.
1889. Larva (fig.). Packard. Mem. Nat. Ac. Sc. iv. 80.

TRICHOPTERYGIDÆ.

TRICHOPTERYX FASCICULARIS Hbst.

1846. Larva, pupa (figs). Perris. Ann. Soc. Ent. Fr. ii. 4, 465. pl. xi.
1847. Larva, pupa. Allibert (quotes Perris). Revue Zoo. 190.
1855. Larva (fig). Chapuis et Candeze (quote Perris). Mem. Soc. Sc. Liege, viii. 408.

PHALACRIDÆ.

OLIBRUS BICOLOR Gyll.

1857. Larva, pupa (figs.). Heeger. Sitzb. Ak. Wiss. Wien. xxiv. 330–334. pl. vi.
1867. Larva, pupa (brief). Kawall. Stett Ent. Zeit. xxviii. 118.
1874. Larva, pupa (brief). Kaltenbach. Pflanzen feinde. 349, 397.

COCCINELLIDÆ.

MEGILLA MACULATA Deg.

1888. Larva, pupa (figs.). Lintner. 4th Rep. Nox. Ins. N. Y. 83.

HIPPODAMIA AMBIGUA Lec.

1882. Larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 206. pl. xviii.
1883. Larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 416.
1884. Larva, pupa (figs.). Cutting. 8th Rep. Vermont Agri. 257.

HIPPODAMIA 13-PUNCTATA Linn.

1889. Pupa (fig.). Weed. Bull. Ohio Exp. St. i. 13.

HIPPODAMIA PARENTHESIS Say.

1860. Egg, pupa. Fitch. 6th Rep. Nox. Ins. N. Y. 851, 852.

HIPPODAMIA CONVERGENS Guér.

1868. Larva, pupa (figs., brief). Walsh & Riley. Am. Ent. i. 46, 143.
1869. Larva, pupa (figs. only). Packard. Guide. 511 (as *H* 13-*punctata*).
1870. Larva, pupa (figs., brief). Riley. Am. Ent. ii. 309.
1870. Larva, pupa (figs.). Shimer. Am. Nat. iii. 94.
1873. Larva, pupa (figs. only). Riley. 6th Rep. Nox. Ins. Mo. 51.
1874. Larva, pupa (figs. only). Rogers. Can. Ent. vi. 84.
1874. Larva, pupa (figs. only). LeBaron. 4th. Rep. Nox. Ins. Ill. 94.
1876. Larva, pupa (figs. only). Thomas. 1st. Rep. Nox. Ins. Ill. 173.
1877. Larva, pupa (figs. only). Packard. Half Hours Ins. 38.
1877. Larva, pupa (figs. only). Saunders. Rep. Ent. Soc. Ont. 36.
1878. Larva, pupa (figs. only). Thomas. 8th Rep. Nox. Ins. Ill. 173.
1879. Larva, pupa (figs. only). Comstock. Rep. U. S. Dept. Agri. pl. xii.

1879. Larva, pupa (figs. only). Comstock. Cotton Ins. 177.
1880. Larva, pupa (fig. only). Packard. Guide, 511.
1880. Larva, pupa (figs. only). Riley. Bull. No. 3. U. S. Ent. Com. 35.
1883. Larva, pupa (figs. only). Saunders. Ins. Inj. Fruit. 125.
1884. Larva, pupa (figs. only). Cutting. 8th Rep. Vermont Agri. 253.
1885. Larva, pupa (figs. only). Hubbard. Ins. Aff. Orange. 72, 73.
1885. Larva (fig. only). Riley. 4th Rep. U. S. Ent. Com. 96.

Coccinella 9-notata Hbst.

1860. Larva, pupa. Fitch. 6th Rep. Nox. Ins. N. Y. 842–846.
1862. Larva, pupa (fig.). Harris. Inj. Ins. Mass. 246.
1862. Larva, pupa (figs.). Sanborn. 10th Rep. Mass. Bd. Agri. 145.
1869. Pupa (fig. only.). Packard. Guide. 512 (and other editions).
1870. Pupa (fig. only.). Shimer. Am. Nat. iii. 94.
1877. Pupa (fig. only.). Packard. Half Hours. Ins. 209.
1877. Larva (fig. only.). Saunders. Rep. Ent. Soc. Ont. 30.
1878. Larva (fig. only.). Williams. Rep. Ent. Soc. Ont. 43.
1879. Pupa (fig. only.). Comstock. Cotton Ins. 176.
1879. Pupa (fig. only.). Comstock. Rep. U. S. Dept. Agri. pl. xii.

Coccinella sanguinea Linn.

1882. Pupa (fig.). Riley. Rep. U. S. Dept. Agri. 205. pl. xviii. fig. 4.
1883. Pupa (fig., brief.). Saunders. Ins. Inj. Fruit. 415.
1884. Pupa (fig. only). Cutting. 8th Rep. Vermont Agri. 256.
1885. Larva, pupa (figs.). Hubbard. Ins. Aff. Orange. 73.

Coccinella abdominalis Say.

1882. Larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 203. pl. xviii.
1883. Larva, pupa (figs., brief). Saunders. Ins. Inj. Fruit. 431.
1884. Larva, pupa (figs. only). Cutting. 8th Rep. Vermont Agri. 256.
1886. Larva, pupa (figs.). Duges. Ann. Ent. Soc. Belg. xxx. 38. pl. iii.

Adalia bipunctata Linn.

1720. Larva, pupa (figs.). Frisch. Beschreib. Ins. pt. 9. 33. pl. xvi.
1762. Larva. Geoffroy. Hist. Ins. i. 320.
1775. Larva. DeGeer. Mem. v. 427.
1839. Larva (fig.). Westwood. Intro. Ins. i. 396.
1846. Larva. Mulsant. Hist. Nat. Col. Fr. 60.
1858. Larva, pupa (fig.). Letzner. Verw. der Coccinellen. 4.
1869. Egg, larva, pupa (brief.). Packard. Guide. 511, 512.
1874. Larva, pupa. Rogers. Can. Ent. vi. 83.
1878. Egg, larva, pupa. Williams (quotes Packard). Rep. Ent. Soc. Ont. 44.

Vedolia cardinalis.

1889. Egg, larva, pupa (figs.). Coquillett. Insect Life. ii. 70.

Harmonia picta Rand.

1873. Larva, pupa (figs.). Riley. 5th Rep. Nox. Ins. Mo. 101.
1878. Larva (brief). Thomas, 6th Rep. Nox. Ins. Ill. 174.

1883. Larva (brief). Saunders. Rep. Ent. Soc. Ont. 56.
1883. Larva (fig. ,brief). Saunders. Ins. Inj. Fruit. 125.
1885. Larva (fig.). Lintner. 2nd Rep. Inj. Ins. N. Y. 186.

MYSIA 15-PUNCTATA Oliv.

1869. Larva, pupa. Packard. Guide. 512 (and other editions).
1871. Larva, pupa (figs. only). Reed. Can. Ent. iii. 170.
1872. Larva, pupa (figs.). Riley. 4th Rep. Nox. Ins. Mo. 18.
1874. Larva (brief). Rogers. Can. Ent. vi. 85.
1877. Larva, pupa (figs. only). Saunders. Rep. Ent. Soc. Ont. 36.
1878. Larva, pupa (figs. only). Williams. Rep. Ent. Soc. Ont. 43.
1882. Larva, pupa (figs.). Harrington. Rep. Ent. Soc. Ont. 57.
1883. Larva, pupa (figs., brief). Saunders. Ins. Inj. Fruit. 130.
1887. Larva, pupa (figs. only). Fletcher. Rep. Ent. Exp. Farms. 28.

PSYLLOBORA 20—MACULATA Say.

1872. Larva, pupa (fig.). Packard. 3d Rep. Inj. Ins. Mass. 263.
1889. Larva, pupa (figs.). Weed. Bull. Ohio Agri. Exp. St. i. 3, 4. pl. i.

CHILOCORUS BIVULNERUS Muls.

1858. Larva, pupa (brief). Glover. Rep. U. S. Pat. Office (Agri.). 261.
1863. Larva, pupa (brief). Glover. U. S. Pat. Office (Agri.). 579.
1868. Larva (fig. only). Walsh, Riley. Am. Ent. i. 39.
1876. Larva (brief). Thomas. 1st. Rep. Inj. Ins. Ill. 174.
1877. Larva (fig., brief). Smith. 7th Rep. Inj. Ins. Ill. 128.
1877. Larva (fig. only). Saunders. Rep. Ent. Soc. Ont. 36.
1878. Larva (fig. only). Thomas. 8th Rep. Inj. Ins. Ill. 174.
1883. Larva (fig. only). Saunders. Rep. Ent. Soc. Ont. 56.
1883. Larva (fig., brief). Saunders. Ins. Inj. Fruit. 43.
1885. Larva (fig. only). Lintner. 2d Rep. Ins. N. Y. 186.
1885. Larva, pupa (figs.). Hubbard. Ins. Aff. Orange. 71, 72.

CHILOCORUS CACTI Linn.

1839. Larva (fig., brief). Westwood. Intro. Ins. i. 397.
1882. Larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 205. pl. xviii.
1883. Larva, pupa (figs., brief). Saunders. Ins. Inj. Fruit. 415.
1884. Larva, pupa (figs. only). Cutting. 8th Rep. Vermont Agri. 257.

EXOCHOMUS CONTRISTATUS Muls.

1859. Larva, pupa (brief). Glover. U. S. Pat. Office. Rep. (Agri.) 261. (1858). (as *E. Guexi*).
1885. Larva, pupa (figs.). Hubbard. Ins. Aff. Orange. 72.

SCYMNUS CERVICALIS Muls.

1869. Larva (brief). Packard. Guide. 513.

SCYMNUS ARCUATUS Rossi.

1857. Larva, pupa (figs.). Heeger. Sitzb. Ak. Wiss. Wien. xxiv. 326-329. pl. v.

EPILACHNA BOREALIS Fabr.

1862. Larva (brief). O. Sacken. Proc. Ent. Soc. Phil. i. 125.
1867. Larva (fig. only). Walsh. Pract. Ent. ii. 42.
1869 Larva, pupa (brief). Packard (quotes O. Sacken). Guide. 513.
1883. Life History. French. Can. Ent. xv. 189.

EPILACHNA MEXICANA Guér.

1886. Larva, pupa (figs.). Duges. Ann. Ent. Soc. Belg. xxx. 40. pl. iii.

ENDOMYCHIDÆ.

MYCETÆA HIRTA Marsh.

1839. Pupa (fig.). Westwood. Intro. Ins. i. 154.
1849. Larva, pupa (figs.). Blisson. Ann. Soc. Ent. Fr. ii. 7. 315-325. pl.ix.
1863. Larva, pupa. Perris (quotes Blisson). Hist. Pin. Mar. i. 113-116.

APHORISTA VITTATA Fabr.

1886. Larva, pupa (figs.). Smith. Ent. Am. ii. 85.

EROTYLIDÆ.

LANGURIA MOZARDI Lat.

1879. Egg, larva, pupa (figs.). Comstock. Rep. U. S. Dept. Agri. 199, 200. pl. i.
1881. Egg, larva, pupa (figs.). Lintner (quotes Comstock). Trans. N. Y. Agri. Soc. 18 (1880).
1881. Egg, larva, pupa (figs.). Saunders (quotes Comstock). Rep. Ent. Soc. Ont. 44.
1887. Egg, larva, pupa (figs.). Cook (quotes Comstock). Beal's Grasses N. Am. i. 378-380.
1888. Egg, larva, pupa (figs.). Webster (quotes Comstock). Ins. Life. i. 19.

LANGURIA PUNCTICOLLIS Say.

1873. Larva, pupa (figs.). Packard. 3rd Rep. Inj. Ins. Mass. 23, 24.
1873. Larva, pupa (figs.). Packard. Am. Nat. vii. 544.

MEGALODACNE HEROS Fabr.

1873. Larva, pupa (figs., brief). Packard. 3rd Rep. Inj. Ins. Mass. 24.
1873. Larva, pupa (figs.). Packard. Am. Nat. vii. 545.

MEGALODACNE FASCIATA Fabr.

1890. Larva. Beutenmüller. Psyche. v. 318

MEGALODACNE ULKEI Cr.

1878. Larva, pupa (brief). Dury. Can. Ent. x. 210.

ISCHYRUS 4-PUNCTATUS Oliv.

1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 22. pl.

EROTYLUS BOISDUVALI Chev.

1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Inj. Ins. Ill. 180.

COLYDIIDÆ.

BOTHRIDERES GEMINATUS Say.

1878. Cocoon. Dury. Can. Ent. x. 210.

EROTYLATHRIS EXARATUS Melsh.

1878. Cocoon. Dury. Can. Ent. x. 210.

CUCUJIDÆ.

SILVANUS SURINAMENSIS Linn.

1839. Larva (fig.). Westwood. Intro. Ins. i. 154.
1842. Larva. Erichson. Wiegem. Archiv. viii. 378.
1846. Larva, pupa (figs.). Curtis. Journ. Roy. Agri. Soc. Eng. pl. 1. 103.
1848. Larva. Erichson. Nat. Ins. Deutschl. iii. 337.
1849. Larva, pupa (fig.). Blisson. Ann. Soc. Ent. Fr. ii. 7. 163-172.
1849. Larva. Coquerel. Ann. Soc. Ent. Fr. ii. 7. 172.
1854. Larva, pupa (figs.). Emmons. Ins. N. Y. 105.
1869. Larva (brief). Packard. Guide. 446.

SILVANUS CASSIÆ Reiche.

1854. Larva (fig., brief). Glover. Rep. U. S. Pat. Off. (Agri) 66. pl. iv (as *S. quadricollis*).
1868. Larva (fig. only). Glover. Rep. U. S. Dept. Agri. 84 (as *S. quadricollis*).

SILVANUS BIDENTATUS Fabr.

1868. Larva (habits). Glover. Rep. U. S. Dept. Agri. 84.

PROSTOMIS MANDIBULARIS Fabr.

1847. Larva. Erichson. Wiegem. Archiv. xiii. 1. 285.
1854. Larva. Curtis. Trans. Ent. Soc. Lond. 2nd Ser. iii.
1855. Larva. Chapuis et Candeze (quote Erichson). Mem. Soc. Sc. Liege. viii. 425.
1876. Larva. Perris. Ann. Soc. Linn. Lyon. xxii.

CUCUJUS CLAVIPES Fabr.

1874. Larva (figs.). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 65.
1878. Larva (brief). Wilson. Bull. Bk. Ent. Soc. i. 56.
1886. Larva (brief). Hamilton. Can. Ent. xviii. 27.

LÆMOPHLÆUS FERRUGINEUS Steph.

1877. Larva. Carpentier. Bull. Soc. Linn. Nord. Fr. Apr. iii. 239.
1877. Larva. Perris. Larves des Coleopt. 575.

CRYPTOPHAGIDÆ.

ANTHEROPHAGUS OCHRACEUS Melsh.

1869. Larva (fig. only). Packard. Guide. 447.

CRYPTOPHAGUS CELLARIS Scop.

1839. Larva (fig.). Westwood. Intro. Ins. i. 148.
1850. Larva, pupa (figs.). Newport. Trans. Linn. Soc. Lond. xx. 351. pl. xxxiv.

DERMESTIDÆ.

BYTURUS UNICOLOR Say.

1870. Larva. Fitch. 14th Rep. Nox. Ins. N. Y. 357 (Trans. N. Y. State Agri. Soc.).

DERMESTES VULPINUS Fabr.

1885. Egg, larva, pupa (figs.). Riley. Rep U. S. Dept. Agri. 258-264.
1888. Egg, larva, pupa (figs.). Lintner. 4th Rep. Nox Ins. N. Y. 89.
1889. Egg, larva, pupa (figs.). Jones. Ins. Life. ii. 63.

DERMESTES LARDARIUS Linn.

1667. Larva. Gœdart. Metam. Hist. Nat. Insect.
1688. Larva (fig.). Blankaart. Schow-Burg. der Ruspen. etc. 95. pl. xi.
1700. Larva. Gœdart. Met. Hist. Nat. ii. 172. exper. 41.
1720. Larva (fig.). Frisch. Beschreib. all. Ins. pt. 1. 35. pl. x.
1774. Larva, pupa (figs.). De Geer. Mem. iv. Mem. v. 194. pl. vii. figs. 1-9.
1774. Larva. Meineckens. Naturforscher. iii. 55.
1779. Larva. Meineckens. Füssly. Mag. Liebh. Ent. ii. 126.
1792. Larva (brief). Petagne. Instit. Ent. i. 157.
1792. Larva, pupa (figs.). Herbst. Naturg. all. bek. Ins. iv. 118. pl. G.
1804. Larva, pupa. Latreille. Nat. Hist. Ins. & Crust. ix. 238.
1806. Larva (fig. only). Shaw, Gen. Zoo. Ins. 31. pl. vii.
1823. Larva. Latreille. Regne Anim. iii. 362 (1817).
1832. Larva, pupa (figs.). Lyonet. Recherches. 115. pl. xi. figs. 9-13.
1835. Larva. Audouin et Brulle. Hist. Nat. Ins. v. Col. ii. 369.
1837. Larva. Kollar. Nat. Ins. 406.
1839. Larva, pupa (figs.). Westwood. Intro. Ins. i. 158.
1847. Larva (fig.), Sturm. Deutschl. Insect. xix. 65.
1861. Larva, pupa (figs.). Rathvon. Rep. U. S. Dept. Agri. 596.
1867. Larva, pupa (figs.). Mulsant. Hist. Nat. Col. Fr. Scuticollis. pl.
1868. Larva. Healy. Entomologist. vi. 69.
1869. Larva (brief). Walsh & Riley. Am. Nat. ii. 443.
1870. Larva (brief, fig.). Riley. Am. Ent. ii. 308.
1872. Larva, pupa (figs.). Figuier. Ins. World. 475.
1872. Larva. Girard. Ann. Soc. Ent. Fr. v. 2. 302.
1873. Larva (fig., brief). Saunders. Can. Ent. v. 171.
1874. Larva (fig. only). Riley. 6th Rep. Nox. Ins. Ill. 100.
1874 Larva (fig. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 60
1874. Larva (fig.). Williams. Rep. Ent. Soc. Ont. 26.

1876. Larva (fig. only). Thomas. 1st Rep. Nox. Ins. Ill. 92.
1878. Larva (fig. only). Heustes. Rep. Ent. Soc. Ont. 18.
1878. Larva (fig.). Perkins 5th Rep. Vermont Bd. Agri. 266.
1890. Larva (fig.). Lintner. 6th Rep. Inj. Ins. N. Y. 119-123.

ATTAGENUS PELLIO Linn.

1724. Larva (fig.). Frisch. Beschreib. Ins. v. 23, 24. pl. viii. figs. 1-5.
1774. Larva. De Geer. Mem. iv. mem. v. 199.
1779. Larva. Meinecke. Füssly Mag. Liebh. Ent. ii 126.
1784. Larva. Harrer. Beschreib. Ins. i. 37.
1792. Larva (brief). Petagne. Instit. Ent. i. 157.
1823 Larva. Latreille. Regne Anim. iii 362 (1817).
1835. Larva. Audouin et Brulle. Hist Ins. v. 368.
1839. Larva (brief). Westwood. Int. Ins. i. 159.
1847. Larva, pupa (figs.). Sturm. Deutschl. Insect. xix. 78.
1848. Larva. Erichson. Nat. Ins. Deutschl. iii. 438.
1855. Larva (fig. only). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 441. pl. iii.
1867. Pupa (fig.). Mulsant. Hist. Nat. Col. Fr. Scuticollis 10. pl. i.
1869. Larva (brief). Packard. Guide. 397. fig.
1871. Larva (brief). Bethune (quotes De Geer). Can. Ent. iii. 176.
1872. Larva, pupa (figs.). Figuier. Insect World. 475.

ATTAGENUS PICEUS Oliv.

1847. Larva, pupa (figs.). Sturm. Ins. Deutschl. xix. 78. pl. cccliv.
1861. Larva. Löw. Verh. z. b. Ges. Wien. ii. 293.

TROGODERMA TARSALE Melsh.

1882. Larva, pupa. Snow. Psyche. iii. 352.

TROGODERMA ORNATUM Say.

1883. Larva (brief). Hamilton. Can. Ent. xv. 91.
1884. Larva (Biological notes). Hamilton. Can. Ent. xvi. 133.

ANTHRENUS SCROPHULARIÆ Linn.

1774. Larva (brief). De Geer. Mem. iv. M. v. 121.
1792. Larva (brief). Petagne. Instit. Ent. i. 160.
1797. Larva (brief). Herbst. Natur. System. vii. 328.
1846. Larva (brief). Erichson. Nat. Ins. Deutschl. iii. 454.
1867. Larva (fig.). Mulsant. Nat. Hist. Col. Fr. Scuticollis. pl. ii. fig. 4.
1878. Larva, pupa (figs.). Lintner. Am. Nat. xii. 536.
1878. Larva, pupa (figs.). Lintner. Inj. Ins. 7.
1878. Larva, pupa (figs.). Saunders (quotes Lintner). Rep. Ent. Soc. Ont. 33.
1879. Larva, pupa (figs.). Hagen. Rep. Ent. Soc. Ont. 31.
1880. Larva, pupa (figs.). Anony. Am. Ent. iii. 53.
1882. Larva, pupa (figs.). Lintner. 1st Rep. Inj. Ins. N. Y. 10.
1889. Larva, pupa (figs.). Riley. Insect Life. ii. 127-136.

ANTHRENUS MUSÆORUM Linn.

1774. Larva, pupa (figs.). De Geer. Mem. iv. M. v. 305. pl. viii.
1792. Larva (brief). Petagne. Instit. Ent. i. 157.
1809. Larva (brief). Disderi. Mem. Ac. Sc. Turin. xv. 68.
1816. Larva. Latreille. Nouv. Diet. ii. 161.
1817. Larva, pupa (figs.). Sturm. Ins. Deutschl. ii. 125.
1837. Larva (habits). Kollar. Nat. Schädl. Ins. 403.
1839. Larva (fig.). Westwood. Intro. Ins. i. 160.
1846. Larva. Erichson. Nat. Ins. Deutschl. iii. 458.
1854. Larva, pupa. Letzner. Arb. Schles. Ges. Breslau. 82-84.
1867. Larva. Lucas. Ann. Soc. Ent. Fr. iv. 7. Bull. 25.
1869. Larva, pupa (figs. only). Walsh & Riley. Am. Nat. ii. 443.
1883. Larva (fig. only). Calwer. Kaeferbuch. pl. xlix. fig. 7.

ANTHRENUS VARIUS Fabr.

1846. Larva. Erichson. Ins. Deutschl. iii. 455.
1869. Larva, pupa (fig.). Packard. Guide. 449.

HISTERIDÆ.[3]

HISTER MERDARIUS Hoffm.

1811. Larva (fig.). Paykull. Monog. Hister. 22. pl. i. fig. 1.
1835. Larva. Audouin et Brulle (quotes Paykull). Nat. Hist. Ins. iv. Col. II. 416.
1839. Larva (fig.). Westwood (quotes Paykull). Intro. Ins. i. 182.
1854. Larva, pupa (fig.). Marseul. Ann. Soc. Ent. Fr. iii. 2. 132.
1863. Larva, pupa (fig.). Perris. Hist. Pin. Mar. Col. 132 (1854).

NITIDULIDÆ.

1841. Larvæ. Erichson. Ins. Deutschl. iii. 124.
1869. Larvæ (brief). Packard. Guide. 444.

BRACHYPTERUS URTICÆ Fabr.

1876. Larva, pupa. Perris. Gobert. Catal. iii. 103.
1877. Larva, pupa. Perris. Larves des Col. 37.

CARPOPHILUS HEMIPTERUS Linn.

1868. Larva (fig. only). Glover. Rep. U. S. Dept. Agri. fig. 31.
1877. Larva (fig.), pupa. Perris. Larv. des Col. 45–47.

IPS FASCIATUS Oliv.

1869. Larva (fig. only). Packard. Guide. 444.
1874. Larva (fig. only). Le Baron (after Packard). 4th Rep. Nox. Ins. Ill. 60.
1876. Larva (fig. only). Thomas. 1st Rep. Nox. Ins. Ill. 91 (as *I. 4-signatus*).

LATHRIDIIDÆ.

Lathridius minutus Linn.

1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 433. pl. ii. fig. 10.

1869. Larva (fig. only). Packard. Guide. 447.

TROGOSITIDÆ.

Tenebrioides mauritanica Linn.

1787. Larva. Dorethes. Mem. Soc. Agri. Paris.

1797. Larva. Herbst. Natursystem. vii. 274.

1803. Larva. Latreille. Hist. Nat. Crust. & Ins. xi. 234.

1807. Larva. Sturm. Ins. Deutsch. ii. 245.

1832. Larva. Hammerschmidt. De Ins. Agri. damn. pl. ii.

1839. Larva (fig.). Westwood. Intro. Ins. i. 147.

1845. Larva. Erichson. Nat. Ins. Deutsch. iii. 244.

1846. Larva (fig.). Curtis. Journ. Roy. Agri. Soc. Eng. pl. i. 106.

1855. Larva. Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 415.

1863. Larva. Perris. Hist. Pin. Marit i. 86 (1853).

1869. Larva. Glover. Rep. U. S. Dept Agri. 83 (1868).

1877. Larva. Perris. Larv. des Col. 50.

Tenebrioides obscura Horn.

1889. Larva (fig). Popenoe. The Industrialist. xiv. 153.

Tenebrioides corticalis Melsh.

1870. Larva (fig. only). Glover. Rep. U. S. Dept. Agri. 66.

1874. Larva (fig. only). Le Baron (after Riley). 4th Rep. Inj. Ins. Ill. 64.

Thymalus fulgidus Er.

1890. Larva, pupa. Beutenmüller. Ent. Am. vi. 57.

PARNIDÆ.

Psephenus Lecontei Lec.

1844. Larva (fig.). DeKay. Zoo. New York. pt. vi. Crust. 53. pl. x (as *Fluvicola Herricki*).

1850. Larva (brief). Leconte. Proc. Am. Ass. Adv. Sc. 272.

1850. Larva, pupa. Leconte. Agassiz. Lake Supérior. 241.

1852. Larva (brief). Leconte. Pro. Ac. Sc. Phil. vi. 41.

1855. Larva, pupa. Chapuis et Candeze (quote LeConte). Mem. Soc. Sc. Liege. viii. 495.

1869. Larva (fig.). Packard. Guide. 450.

1869. Larva (fig.). Harris. Harr. Corr. 226. pl. iii. fig. 7.

1874. Larva (fig.). Rolph. Wiegem. Archiv. xiv. pt. i. 16–22. pl. i.

1877. Larva (fig. only). Packard. Half Hours Ins. 215.

1880. Larva, pupa (brief). Hubbard. Am. Ent. iii. 73.

1883. Larva (figs.). Kellicott. Can. Ent. xv. 191.

HELICHUS LITHOPHILUS Germ. (?)

1841. Larva. Erichson. Wiegem. Archiv. 107. pt. 1.
1883. Larva (fig. only). Kellicott. Can. Ent. xv. 192.

HELICHUS FASTIGIATUS Say.

1869. Larva (very brief). Leconte. Harr. Corr. 227.

STENELMIS CRENATUS Say.

1869. Larva (very brief). Leconte. Harr. Corr. 227.

DASCILLYDÆ.

PTILODACTYLA SERRICOLLIS Say.

1862. Larva (fig.). O. Sacken. Proc. Ent. Soc. Phil. i. 109. pl. i. fig. 3 (as *P. elaterina*).

PRIONOCYPHON DISCOIDEUS Say.

1862. Larva, pupa. O. Sacken. Proc. Ent. Soc. Ont. i. 115.
1869. Larva, pupa (brief). Packard (quotes O. Sacken). Guide. 464.

CYPHON VARIABILIS Thunb.

1866. Larva, pupa (figs.). Frauenfeld. Verh. z. b. Geo. Wien. xvi. 969.
1867. Larva, pupa. Tournier (quotes Frauenfeld). Assoc. zool. du Leman.
1874. Larva (brief). Rolph. Wiegem. Archiv. 40. pt. 1. 25.

RHIPICERIDÆ.

ZENOA PICEA Beauv.

1862. Larva (fig.). O. Sacken. Proc. Ent. Soc. Phil. i. 107. pl. i. fig. 2.

ELATERIDÆ.

1877. Larvæ. Perris. Larv. des Col. 166–169.

FORNAX ORCHESIDES Newm (?)

1861. Larva (very brief). Horn. Proc. Ent. Soc. Phil. i. 43.
1862. Larva, pupa (fig.). O. Sacken. Proc. Ent. Soc. Phil. i. 112.

FORNAX BADIUS Melsh.

1862. Larva, pupa (figs). O. Sacken.. Proc. Ent. Soc. Phil. i. 113, 114.

ALAUS OCULATUS Linn.

1841. Larva (brief). Harris. Inj. Ins. Mass. 48.
1854. Larva. Emmons. Ins. N. Y. 87.
1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 482. pl. v. fig. 3.
1861. Larva (fig.). Rathvon. Rep. U. S. Dept. Agri. 58.
1865. Larva. Thomas. Trans. Ill. Agri. Soc. v. 417.
1868. Larva (fig. only). Glover. Rep. U. S. Dept. Agri. 93.
1869. Larva (fig. only). Harris. Harr. Corr. 139. pl. iv.
1876. Larva (brief). Thomas. 1st Rep. Inj. Ins. Ill. 116.
1879. Larva. Harrington. Rep. Ent. Soc. Ont. 82.

1881. Larva. Saunders. Can. Ent. xiii. 117.
1881. Larva. Saunders. Rep. Ent. Soc. Ont. 21.
1883. Larva (fig.). Saunders. Ins. Inj. Fruit. 26.

ALAUS MYOPS Fabr.

1862. Larva (very brief). Evett. Proc. Ent. Soc. Phil. i. 227.
1868. Larva (habits). Glover (quotes Evett). Rep. U. S. Dept. Agri. 93.
1870. Larva (fig.). Schiœdte. Nat. Tidsskr. vi.

ELATER NIGRICOLLIS Hbst.

1883. Larva. Coquillett. Can. Ent. xiii. 101.

LUDIUS ATTENUATUS Say.

1869. Larva (fig. only). Packard. Guide. 422.

MELANOTUS CASTANIPES Payk.

1870. Larva, pupa (figs.). Schiœdte. Nat. Tidsskr. vi. pl. vii.

AGRIOTES MANCUS Say.

1872. Larva, pupa (figs.). Pettit. Can. Ent. iv. 3.
1877. Larva, pupa (figs. only). Packard. Half Hours Ins. 26.
1879. Larva, pupa (figs. only). Harrington. Rep. Ent. Soc. Ont. 84.

ATHOUS CUCULLATUS Say.

1883. Larva. Coquillett. Can. Ent. xv. 101.

MELANACTES PICEUS De G. (?)

1874. Larva (fig. only). Le Baron (after Riley). 4th Rep. Inj. Ins. Ill. 45.

UNKNOWN SPECIES.

1868. Luminous Larvæ. Bethune & Morris. Can. Ent. i. 2, 38 (*Melanactes ? ?*).
1875. Luminous Larvæ. Mann. Psyche. i. 89.
1877. Larva (figs.). Packard. Half Hours Ins. 27.
1878. Larva (fig.). Riley. 1st Rep. U. S. Ent. Com. 304.
1880. Larva (fig.). Clark. Am. Ent. iii. fig. 108 (as *Melanactes ?*).

BUPRESTIDÆ.

1890. Food-Habits. Blanchard. Ent. Am. v. 29–32.

CHALCOPHORA VIRGINIENSIS Dr.

1858. Larva (brief). Fitch. Rep. Nox. Ins. N. Y. 697–700 (Trans. N. Y. Agri. Soc. 1857).
1882. Larva (fig.). Packard. 3rd Rep. U. S. Ent. Com. 252. pl. vi.

DICERCA DIVARICATA Say.

1829. Larva. Harris. New Eng. Farm. viii. 2.
1869. Larva. Harris. Harr. Corr. 357.
1881. Larva. Packard. Ins. Inj. For. & Sh. Tr. 108.
1882. Larva (fig.). Packard. 3rd Rep. U. S. Ent. Com. 255. pl. vi. fig. 2.
1883. Larva (brief). Saunders. Ins. Inj. Fruit. 200.

DICERCA OBSCURA Fabr. (?)

1829. Larva. Harris. New Eng. Farm. viii. 2.
1869. Larva. Harris. Harr. Corr. 357.
1881. Larva. Packard (quotes Harris). Ins. Inj. For & Sh. Tr. 72 (as *D. lurida*).

MELANOPHILA Sp.

1883. Larva (fig.). Packard. 3rd Rep. U. S. Ent. Com. 253. pls. vi. fig. 4. xii. fig. 1.

CHRYSOBOTHRIS FEMORATA Fabr.

1854. Larva (fig.). Fitch. 1st Rep. Trans. N. Y. Agri. Soc. 731.
1861. Larva. (fig., brief). Rathvon. Rep. U. S. Dept. Agri. 607.
1865. Larva Thomas (quotes Fitch). Trans. Ill. Agri. Soc. v. 420.
1866. Larva (brief). Walsh. Pract. Ent. i. 26.
1869. Larva (fig. only). Packard. Guide. 457.
1874. Egg, Larva, pupa (figs.). Riley. 7th Rep. Nox. Ins. Mo. 72.
1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins Ill. 94.
1874. Larva (brief, figs.). Reed. Rep. Ent. Soc. Ont. 13.
1875. Larva (fig. only). Cook. 12th Rep. Mich. Bd. Agri. 126 (1873).
1876. Larva (fig.). Perkins. 2nd Bi. Rep. Vermont Bd. Agri. 601.
1876. Egg, larva, pupa (figs.). Thomas (quotes Riley). 1st Rep. Nox. Ins. Ill. 110.
1877. Larva (fig.). Packard. Half Hours Ins. 165.
1877. Larva (brief). Bethune. Can. Ent. ix. 224.
1877. Larva, pupa (figs.). Bethune. Rep. Ent. Soc. Ont. 25.
1878. Larva, pupa (figs.). Fletcher. Rep. Ent. Soc. Ont. 49.
1881. Larva, pupa (figs.). Packard. Ins. Inj. For. & Sh. Tr. 18.
1883. Larva, pupa. Packard. 3d Rep. U. S. Ent. Com. 251, 252.
1883. Larva (fig. only). Harrington. Rep. Ent. Soc. Ont. 44.
1887. Larva, pupa (figs.). Harrington. Rep. Ent. Soc. Ont. 31.
1887. Larva, pupa (figs.). Bethune. Rep. Ent. Soc. Ont. 57.

CHRYSOBOTHRIS CHRYSOELA Ill.

1885. Larva. Hubbard. Ins. Aff. Orange. 172.

AGRILUS RUFICOLLIS Fabr.

1870. Larva (fig. only). Glover. Rep. U. S. Dept. Agri. 67.
1870. Larva (fig.). Riley. Am. Ent. ii. 103, 128.
1873. Larva (fig.). Saunders. Rep. Ent. Soc. Ont. 8.
1876. Larva (brief). Thomas. 1st Rep. Nox. Ins. Ill. 114.
1878. Larva (fig. only). Fletcher. Rep. Ent. Soc. Ont. 54.
1880. Larva (fig. only). Fuller. Am. Ent. iii. 91.
1883. Larva (fig.). Saunders. Ins. Inj. Fruit 307.
1890. Habits (fig. of Gall). Lintner. 6th Rep. Inj. Ins. N. Y. 123–125.

Brachys æruginosa Gory.

1873. Larva (fig.). Packard. 3d Rep Inj. Ins. Mass. 22.
1873. Larva (fig.). Packard. Am Nat. vii. 543.
1881. Larva (fig.). Packard. Ins. Inj. For. & Sh. Tr. 130.

Pachyscelus lævigatus Say.

1873. Larva (fig.). Packard. 3d Rep. Inj. Ins. Mass. 23.
1873. Larva (fig.). Packard. Am. Nat vii. 544.

Unknown species.

1883. Larva Packard. 3d Rep. U. S. Ent. Com. 255. pl. v. fig. 5.
1883. Larva. Packard. 3d Rep. U. S. Ent. Com. 254 (as *Melanophila?*).

LAMPYRIDÆ.

Eros thoracicus Rand.

1876. Larva. Moody. Psyche. i. 185.

Cænia dimidiata Fabr.

1869. Larva (brief). Packard. Guide. 433.
1886. Larva, pupa (brief). Lugger. Proc. Ent. Soc. Wash. i. 30.

Photinus pyralis Linn.

1868. Larva, pupa (figs.). Walsh & Riley. Am Ent. i. 19.
1869. Larva, pupa (figs.). Packard. Guide. 466.
18—. Larva, pupa (figs.). Riley.
1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Inj. Ins. Ill. 106.

Lamprohiza splendidula Linn.

1823. Larva. Latreille. Regne Anim. iii. 328 (1817).
1833. Larva (fig.). Villaret. Ann Soc. Ent. Fr. 354. pl. xva.

Calopteron reticulatum Fabr.

1883. Larva, pupa. Coquillett. Can. Ent. xv. 97.

Photuris pennsylvanica De G.

1869. Larva (brief, fig.). Packard. Guide. 466.
1880. Larva (fig. only). Riley. Am. Ent. iii. 254.

Zarhipis Riversi Horn.

1886. Larva (brief). Rivers. Bull. Cal. Acad. Sc. ii. 5. 71.
1886. Larva (brief). Rivers. Am. Nat. 648.

Chauliognathus pennsylvanicus De G.

1868. Larva (fig.). Walsh. Am. Ent. i. 35.
1872. Larva (fig.). Riley. 4th Rep. Nox. Ins. Mo. 28.
1874. Larva (fig. only). Le Baron. 4th Rep. Inj. Ins. Ill. 108.
1879. Larva (brief, fig.). Comstock. Cotton Insects. 175.

1879. Larva (fig. only). Comstock. Rep. U. S. Dept. Agri. pl. xii. fig. 4.
1880. Larva (fig. only). Riley. Bull. U. S. Ent. Com. No. 3. 35.
1880. Larva (fig.). Hubbard. Am. Ent. iii. 249.
1883. Larva (fig.). Saunders. Ins. Inj. Fruit. 185 (as *C. americanus*).
1884. Larva (fig. only). Cutting. 8th Rep. Vermont Bd. Agri. 252.
1884. Larva (fig. only). Edge. Agri. Penn. 102 (as *C. americanus*).
1885. Egg, young larva (brief), mature larva (fig.). Hubbard. 4th Rep. U. S. Ent. Com. 96.
1888. Larva (fig. only). Lintner. 4th Rep. Inj. Ins. N. Y. 86.

PHENGODES LATICOLLIS Lec.

1887. Egg (brief). Atkinson. Am. Nat. xx. 855.

TELEPHORUS BILINEATUS Say.

1871. Larva (fig. only). Packard. Am. Nat. v. 427.
1872. Larva (fig.). Riley. 4th Rep. Nox. Ins. Mo. 29.
1878. Larva (fig.). Riley. 1st Rep. U. S. Ent. Com. 303.

CLERIDÆ.

ELASMOCERUS TERMINATUS Say.

1886. Pupa. Hamilton. Can. Ent. xviii. 28.

TARSOSTENUS UNIVITTATUS Rossi.

1856. Larva, pupa (figs.). Perris. Mem. Soc. Sc. Liege. x. 238. pl. v.

CLERUS ICHNEUMONEUS Fabr.

1861. Larva, pupa (brief, figs.). Rathvon. Rep. U. S. Dept. Agri. 597.

OPILUS DOMESTICUS Kl.

1837. Larva. Sturm. Nat. Ins. Deutschl. ii. 16.
1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 506. pl. vi.
1857. Pupa. Letzner. Arb. Schles. Ges. Breslau. 122.
1862. Larva. Dœbner. Berlin. Ent. Zeit. vi. 67.

NECROBIA RUFICOLLIS Fabr.

1839. Larva, pupa (figs). Westwood. Intro. Ins. i. 266.
1848. Larva, pupa (fig.). Heeger. Isis. 974. pl. viii.
1863. Larva, pupa. Mulsant (quotes Heeger). Hist. Nat. Col. Fr. Angusticollis. 119.
1877. Larva, pupa (figs.). Perris. Larves des Col. 208–213.

NECROBIA RUFIPES Fabr.

1874. Egg, larva, pupa, cocoon (figs.). Riley. 6th Rep. Nox. Ins. Mo. 96.
1878. Larva, pupa, cocoon. Perkins (quotes Riley). 5th Rep. Vermont Bd. Agri. 267.

PTINIDÆ.

PTINUS FUR Linn.

1700. Larva. Gœdart. Metam. Nat. ii. 172. exp. 41.

1774. Larva. Meinecke. Naturf. iii. 53.
1748. Larva, pupa (very brief). Linne. Syst. Nat. 1607 (6th Ed.).
1774. Larva, pupa (figs.). De Geer. Mem. iv. M. v. 234. pl. ix.
1776. Larva. Gœze. Naturforsch. viii. 62. pl. ii.
1779. Larva. Meinecke. Füssly Mag. Lieb. Ent. ii. 126.
1792. Larva, pupa (brief). Petagne. Instit. Ent. i. 163.
1803. Larva. Latreille. Hist. Nat. Crust. & Ins. ix. 164.
1823. Larva. Latreille. Regne Anim. iii. 336 (1817).
1836. Larva. Audouin & Brulle. Ann. Soc. Ent. Fr. Bull. v. pl. lxii.
1869. Larva (fig.). Packard. Guide. 470.
1869. Larva (fig. only). Riley. Am. Nat. ii. 443.
1876. Larva. Thomas. 1st Rep. Nox. Ins. Ill. 121.
1883. Larva (fig.). Calwer. Kaferb. 375. pl. xlix.

PTINUS BRUNNEUS Duft.

1870. Larva (brief). Shimer. Am. Ent. ii. 323.

ERNOBIUS MOLLIS Linn.

1792. Larva (brief). Petagne. Instit. Ent. i. 162.
1837. Larva (brief). Ratzburg. Forstius. i. 42.
1863. Larva, pupa (figs.). Perris. Hist. Pin. Mar. i. 228–233 (1854).
1869. Larva (fig. only). Packard. Guide. 471.
1877. Larva (brief). Kiesenwetter. Nat. Ins. Deutschl. v. 124.

XESTOBIUM AFFINE Lec.

1881. Larva. Packard. Ins. Inj. For. & Sh. Tr. 109.
1882. Larva (fig.). Packard. 3d Rep. U. S. Ent. Com. pl. xiii. fig. 3.

SITODREPA PANICEA Linn.

1721. Larva, pupa (figs.). Frisch. Beschreib. Ins. (as *Anobium*).
1837. Larva (brief). Kollar. Nat. Ins. 396 (as *Anobium*).
1839. Larva (brief). Westwood. Intro. Ins. i. 270 (as *Anobium*).
1854. Larva, pupa (figs.). Glover. Rep. U. S. Pat. Off. (Agri.). 72. pl. v (as *Anobium*).
1861. Larva (notes). Horn. Proc. Ent. Soc. Phil. i. 28 (as *Anobium*).
1863. Larva (brief). Stierlin. Mitth. Schw. Ent. Ges. 119 (as *Anobium*).
1868. Larva, pupa (figs.). Glover. Rep. U. S. Dept. Agri. 98.
1869. Larva. Perris. Ann. Soc. Ent. Fr. iv. 9. 467 (as *Anobium*).
1869. Larva (brief), pupa (fig.). Packard. Guide. 470.
1870. Larva. Dunning. Proc. Ent. Soc. Lond. 33 (as *Anobium*).
1870. Egg, larva (brief). Shimer. Am. Ent. ii. 322.
1876. Larva (brief). Thomas. 1st Rep. Nox. Ins. Ill. 122.

EUCRADA HUMERALIS Melsh.

1882. Cocoon. Bowditch. J. Bost. Zoo. Soc. i. 27.

'SINOXYLON BASILARE Say.

1872. Larva, pupa (figs.). Riley. 4th Rep. Nox. Ins. Mo. 53.

1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 103.
1876. Larva, pupa (figs.). Thomas (quotes Riley). 1st Rep. Nox. Ins. Ill. 124.
1878. Larva, pupa (figs.). Perkins (quotes Riley).
1883. Larva, pupa (figs.). Saunders (quotes Riley). Ins. Inj. Fruit. 243.
1885. Larva, pupa (figs.). Lintner. 2d Rep. Nox. Ins. N. Y. 130.

AMPHICERUS BICAUDATUS Say.

1872. Larva (habits). Riley. 4th Rep. Nox. Ins. Mo. 51.
1885. Larva (brief). Lintner. 2d Rep. Nox. Ins. N. Y. 127.
1888 Larva, pupa (brief). Popenoe. The Industrialist. xiii. 181.

DINAPATES WRIGHTII Horn.

1886. Larva (fig.). Horn. Trans. Am. Ent. Soc.

DINODERUS SUBSTRIATUS Payk.

1856. Larva, pupa. Fuss. Verhandl. Siebeub. Ver. Nat. vii. 35–37.
1863. Larva, pupa (figs.). Perris. Hist. Pin. Mar. i. 493-497.

LYCTUS OPACULUS Lec.

1869. Larva, pupa (figs., brief). Packard. Guide. 472.
1885. Larva, pupa (figs. only). Lintner. 2d Rep. Nox. Ins. N Y. 130.

LUCANIDÆ.

LUCANUS DAMA Thunb.

1861. Larva, pupa (figs. brief). Rathvon. Rep. U. S. Agri. 599.
1869. Larva, cocoon. Packard. Guide. 451.
1874. Larva, cocoon (figs. only). Le Baron (after Packard). 4th Rep. Nox. Ins. Ill. 77.
1879. Egg, larva (brief). Fletcher. Rep. Ent. Soc. Ont. 66.
1881. Larva, pupa (brief). Saunders. Rep. Ent. Soc. Ont. 22.
1881. Larva (brief). Saunders. Can. Ent. xiii. 118.
1882. Larva (fig.). Fuchs. Bull. Bk. Ent. Soc. v. 50.
1883. Larva, cocoon (figs.). Saunders. Ins. Inj. Fruit. 24.

DORCUS PARALLELUS Say.

1881. Pupa. Schaupp. Bull. Bk. Ent. Soc. iv. 35.
1882. Pupa (fig.). Schaupp. Bull. Bk. Ent. Soc. v. 18. pl. fig. 7.
1882. Pupa (fig.). Fuchs. Bull. Bk. Ent. Soc. v. 52.

CERUCHUS PICEUS Web.

1882. Larva (fig.), pupa (brief). Fuchs. Bull. Bk. Ent. Soc. v. 59.

PASSALUS CORNUTUS Fabr.

1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 467. pl. xi.
1861. Larva (fig. only). Rathvon. Rep. U. S. Dept. Agri. 599.
1872. Larva, pupa (figs.). Riley. 4th Rep. Nox. Ins. Mo. 139.

1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 78.

1874. Larva, pupa (figs.). Schiœdte. Nat. Tidsskr. ix. 356. pls. xviii, xix.

1882. Larva (brief), pupa (fig.). Fuchs. Bull. Bk. Ent. Soc. v. 60.

SCARABIDÆ.

Copris carolina Linn.

1862. Larva (fig.). O. Sacken. Proc. Ent. Soc. Phil. i. 105. pl. i. fig. 1.

1874. Larva, pupa, cocoon (figs.). Le Baron (quotes Riley). 4th Rep. Nox. Ins. Ill. 80.

Onthophagus nuchicornis Linn.

1877. Larva (fig.). Perris. Larves des Col. 109.

Aphodius fossor Linn.

1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 464. pl. iv.

1869. Larva (fig. only). Packard. Guide. 453.

1874. Larva. Schiœdte. Nat. Tidsskr. iii. 9. 328.

1877. Larva (fig.). Perris. Larves des Col. 109.

Aphodius fimetarius Linn.

1720. Larva, pupa (figs.). Frisch. Beschreib. all. Ins. 35. pl. xix. (Supposed by De Haan Mem. s. l. Met. 23 to be a Staphylinid.)

1842. Larva. Mulsant. Hist. Nat. Col. Fr. Lamell. 159.

1848. Larva. Erichson. Nat. Ins. Deutschl. 806.

Aphodius granarius Linn.

1874. Larva. Schiœdte. Nat. Tidsskr. iii. 9. 327.

Aphodius lividus Oliv.

1834. Larva, pupa (figs.). Bouche. Nat. der Ins. 190. No. 16.

1848. Larva, pupa. Erichson (quotes Bouche). Nat. Ins. Deutsch. iii. 838.

Aphodius inquinatus Hbst.

1842. Larva (fig.). Mulsant. Hist. Nat. Col. Fr. Lamell. pl. i. fig. 89.

Pleocoma sp.

1866. Larva (fig.). O. Sacken. Tran. Am. Ent. Soc. v. 84.

Trox monachus Hbst.

1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 82 (as *T. pustulatus*).

Trox scabrosus Beauv.

1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 466. pl. iv. fig. 4 (as *T. carolinus*).

1869. Larva (fig. only). Packard. Guide. 454.

MACRODACTYLUS SUBSPINOSUS Fabr.

1841. Egg, larva, pupa (brief). Harris. Inj. Ins. Mass. 33.
1855. Larva, pupa (brief). Fitch. 2d Rep. Nox. Ins. (Tran. N. Y. Agri. Soc. 483).
1861. Larva (fig. only). Rathvon. Rep. U. S. Dept. Agri. 602.
1869. Egg, larva, pupa (brief). Packard. Guide. 454.
1873. Egg, larva, pupa. Riley. 5th Rep. Nox. Ins. Mo. 108.
1876. Egg, larva. Thomas (quotes Harris). 1st. Rep. Nox. Ins. Ill. 103.
1878. Egg, larva (brief). Perkins. 5th Rep. Verm. Bd. Agri. 284.
1883. Egg, larva, pupa. Saunders (quotes Harris). Ins. Inj. Fruit. 281.
1890. Egg, larva, pupa (figs.). Riley. Insect Life. ii. 295.

LACHNOSTERNA FUSCA Fröhl.

1841. Larva (brief). Harris. Inj. Ins. Mass. 28 (as *Phyllophaga quercina*).
1861. Larva (fig. only.). Rathvon. Rep. U. S. Dept. Agri. 601.
1866. Larva (brief). Walsh. Pract. Ent. i. 60 (as *L. quercina*).
1869. Larva (fig. only). Packard. Guide. 455.
1869. Pupa (fig. only). Riley. Am. Nat. ii. 192.
1872. Larva, pupa (figs. only). Packard. 3d Rep. Inj. & Ben. Ins. Mass.
1873. Larva, pupa (figs. only). Packard. Am. Nat. vii. 530.
1874. Larva, pupa (figs., brief). Geddes. Can. Ent. vi. 68 (as *L. quercina*).
1874. Larva, pupa (figs. only). Le Baron. 4th Rep. Nox. Ins. Ill. 85.
1875. Larva, pupa (figs.). Cook. 12th Rep. Bd. Agri. Mich. 112.
1876. Larva, pupa (figs.). Thomas. 1st Rep. Nox. Ins. Ill 97.
1877. Larva, pupa (fig. only). Gott. Rep. Ent. Soc. Ont. 43 (as *P. quercina*).
1877. Larva, pupa (figs. only). Thomas. 7th Rep. Nox. Ins. Ill. 33.
1877. Larva, pupa (figs. only). Packard. Half Hours Ins. 89.
1879. Larva, pupa (figs. only). Fletcher. Rep. Ent. Soc. Ont. 69.
1879. Larva (brief). Howard. Rep. Ent. Soc. Ont. 35.
1880. Larva, pupa (figs. only). Packard. Zoology. 372 (2d Ed.).
1883. Larva, pupa (figs. only). Forbes. Tr. Wis. Hort. Soc. xiii. 37.
1883. Larva (fig.), pupa (brief). Saunders. Ins. Inj. Fruit. 213.
1883. Larva, pupa (figs. only). Harrington. Rep. Ent. Soc. Ont. 42.
1884. Larva, pupa (figs. only). Forbes. 2nd Rep. Nox. Ins. Ill. 144 (1883).
1884. Larva, pupa (figs. only). Edge. Agri. Penn. 37.
1885. Larva, pupa (figs. only). Fletcher. Rep. Ent. Soc. Ont. 49.
1888. Egg, larva, pupa (figs.). Lintner. Bull. No. 5. N. Y. State Mus. Nat. Hist. 5.
1890. Larva, pupa (figs.). Weed. Bull. Ohio Exp. St. i. 133.

POLYPHYLLA IO-LINEATA Say.

1888. Larva (fig.). Horn. Trans. Am. Ent. Soc. xv. 21. pl. iii. fig.

PELIDNOTA PUNCTATA Linn.

1855. Larva (fig.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 460. pl. iv.

1870. Larva, pupa (figs.). Riley. Am. Ent. ii. 295.
1871. Larva, pupa (figs.). Riley. 3rd Rep. Nox. Ins. Mo. 77-79.
1874. Larva, pupa (figs. only). Le Baron (quotes Riley). 4th Rep. Nox. Ins. Ill. 88.
1874. Larva, pupa (figs.). Saunders. (quotes Riley). Can. Ent. vi. 141.
1876. Larva, pupa (figs.). Thomas. 1st Rep. Nox. Ins. Ill. 106.
1877. Larva, pupa (figs. only). Gott. Rep. Ent. Soc. Ont. 45.
1878. Larva, pupa (figs.). Perkins. 5th Rep. Verm. Bd. Agri. 283.
1879. Larva, pupa (figs.). Fletcher. Rep. Ent. Soc. Ont. 69.
1883. Larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 277.

COTALPA LANIGERA Linn.

1869. Egg, young larva (brief), mature larva (fig.). Lockwood. Am. Nat. ii. 186.
1869. Egg, larva, pupa (fig., brief). Packard (quotes Lockwood). Guide. 455.
1872. Larva (fig.). Packard. 3rd Rep. Nox. Ins. Mass. 244.
1873. Egg, larva (fig.). Packard. Am. Nat. vii. 531.
1877. Larva (fig.). Packard Half Hours Ins. 32.
1879. Larva (brief). Fletcher. Rep. Ent. Soc. Ont. 70.
1879. Egg, larva (fig.). Saunders. Can. Ent. xi. 22.
1883. Larva (fig.). Forbes. Trans. Wisc. Hort. Soc. xiii. 39.
1883. Egg, larva (figs.). Saunders. Ins. Inj. Fruit. 155.
1884. Egg, larva (fig.). Forbes. 2nd Rep. Nox. & Ben. Ins. Ill. 146.

CHALEPUS TRACHYPYGUS Burm.

1882. Larva (fig.). Riley. Rep. U. S. Dept. Agri. 129. pl. vi. fig. 5.

LIGYRUS RELICTUS Say.

1880. Larva (brief). Lintner. Bull. 5th N. Y. St. Mus. Nat. Hist. 6.

LIGYRUS RUGICEPS Lec.

1888. Young larva (brief). Howard. Ins. Life. i. 11.

XYLORYCTES SATYRUS Fabr.

1863. Larva (brief). Walsh. Proc. Bost. Soc. Nat. Hist. ix. 287.
1868. Larva (brief). Anony. Am. Nat. i. 60.
1873. Larva (brief). Glover. Rep. U. S. Dept. Agri. 152.

STRATEGUS JULIANUS Burm.

1886. Larva, pupa (figs.). Duges. Ann. Ent. Soc. Belg. xxx. 27. pl. i.

ALLORHINA NITIDA Linn.

1861. Larva (fig.). Rathvon. Rep. U. S. Dept. Agri. 602.
1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 89.
1876. Larva, pupa (figs. only). Thomas. 1st Rep. Nox. Ins. Ill. 107.
1884. Larva, pupa (figs. only). Forbes. 2nd Rep. Nox. Ins. Ill. 149. pl. vii.
1884. Larva, pupa (figs.). Forbes (after Riley). Miss. Vall. Hort. Soc. ii. 245.

OSMODERMA SCABRA Beauv.

1841. Larva (brief). Harris. Inj. Ins. Mass. 39.
1861. Larva, cocoon (brief). Harris. Ins. Mass. 42.
1869. Larva, cocoon. Packard (quotes Harris). Guide. 457.
1879. Cocoon. Schaupp. Bull. Bk. Ent. Soc. ii. 98.
1883. Larva (brief). Harrington. Rep. Ent. Soc. Ont. 44.
1883. Larva, cocoon (brief). Saunders. Ins. Inj. Fruit. 26.
1889. Larva. Beutenmüller. Psyche. v. p.

VALGUS SQUAMIGER Beauv.

1858. Larva (Biol. notes). Fitch. 4th Rep. Nox. Ins. N. Y. 695 (Trans. N. Y. Agri. Soc. 1857, as *V. Seticollis* Beauv.).

SPONDYLIDÆ.

1862. Larva (fig.). O. Sacken. Pro. Ent. Soc. Phil. i. 118. pl. i. fig. 6.
1869. Larva (fig.). Packard. Guide. 494.

CERAMBYCIDÆ.

1880. Food-Habits. Riley. Am. Ent. iii. 237-239, 270, 271.

CRIOCEPHALUS AGRESTIS Kby.

1882. Pupa (fig.). Packard. 3rd Rep. U. S. Ent. Com. pl. vii. fig. 3.

ORTHOSOMA BRUNNEUM Forst.

1861. Larva (fig. only). Rathvon. Rep. U. S. Dept. Agri. 611 (as *P. cylindricus*).
1869. Larva (fig. only). Packard. Guide. 495 (as *O. unicolor*).
1877. Larva (brief). Bethune. Can. Ent. ix. 221.
1877. Larva (figs. only). Packard. Half Hours Ins. 236.
1881. Larva, pupa. Packard. Ins. Inj. For. & Sh. Tr. 161.
1882. Larva (fig.). Packard. 3d Rep. U. S. Ent. Com. 260. pl. x. fig. 1.
1883. Larva (brief). Saunders. Rep. Ent. Soc. Ont. 54.

PRIONUS LATICOLLIS Dr.

1861. Larva (fig. only). Rathvon. Rep. U. S. Dept. Agri. 612.
1869. Larva, pupa (figs.). Walsh & Riley. Am. Ent. i. 231.
1870. Larva, pupa (figs.). Riley. 2nd Rep. Nox. Ins. Mo. 87.
1873. Larva (fig.). Smith. 6th Rep. Conn. Bd. Agri. 346 (as *P. brevicornis*).
1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th. Rep. Nox. Ins. Ill. 151.
1875. Larva (fig. only). Saunders. Can. Ent. vi. 29.
1875. Larva (fig. only). Saunders. Rep. Ent. Soc. Ont. 39.
1876. Larva (brief). Thomas. 1st Rep. Nox. Ins. Ill. 147.
1877. Larva (fig. only). Bethune. Rep. Ent. Soc. Ont. 23.
1877. Larva (fig. only). Packard. Half Hours Ins. 237.
1877. Larva (fig. only). Cook. 16th Rep. Mich. Bd. Agri.
1878. Larva (fig.). Perkins. 5th Rep. Verm. Bd. Agri. 271.

1881. Larva (fig.). Goldsmith (quotes Riley). Ky. Bureau Agri. 254.
1881. Larva, pupa (figs. only). Packard. Ins. Inj. For. & Sh. Tr. 119.
1883. Larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 232.

ASEMUM MŒSTUM Hald.

1869. Larva, pupa (figs.). Packard. Guide. 496.
1881. Larva, pupa (figs.). Packard. Ins. Inj. For. & Sh. Tr. 158.
1882. Larva, pupa (figs.). Packard. 3rd. Rep. U. S. Ent. Com. 256. pl. ix.

HYLOTRUPES BAJULUS Linn.

1848. Larva (biological notes). Nordlinger. ix. 256.
1857. Larva, pupa (figs.). Heeger. Sitzb. Wien. Acad. Wiss. xxiv. 323.
1863. Larva, pupa (figs.). Perris. Hist. Pin. Mar. i. 368-373.
1875. Larva, pupa (fig.). Schiœdte. Nat. Tidsskr. x. 417. pl. xv.

PHYMATODES AMŒNUS Say.

1871. Larva (fig.). Packard. 1st. Rep. Inj. Ins. Mass. 17 (as *callidium*).
1871. Larva (fig.). Packard. Am. Nat. v. 423 (as *callidium*).
1876. Larva (brief) Thomas. 1st Rep. Nox. Ins. Ill. 149. (as *callidium*).
1881. Larva, pupa (fig.). Packard. Ins. Inj. For. & Sh. Tr. 25.

CALLIDIUM ANTENNATUM Newm.

1861. Larva (fig.). Rathvon. Rep. U. S. Pat. Off. (Agri.). 616 (as *C. violæ*).

CHION CINCTUS Dr.

1888. Egg, larva, pupa (figs.). Osborn. Gard. & Forest. i. 148.

ELAPHIDION VILLOSUM Fabr.

1819 Larva. Harris. Agri. Reposit. v. 307 (as *Stenocerus putator*).
1826. Larva. Peck. Zoo. Journ. ii. 489 (as *Stenocerus putator*).
1854. Larva (brief). Emmons. Ins. N. York. 124
1858. Larva, pupa. Fitch. 5th Rep. Nox. Ins. 801 (Tr. N. Y. Agri. Soc.).
1862. Larva, pupa (brief). Harris. Inj. Ins. Mass. 98.
1869. Larva, pupa (figs. only). Packard. Guide. 496 (as *S. putator*).
1872. Larva (fig.). Glover. Rep. U. S. Dept. Agri. 72 (1871).
1877. Larva, pupa (fig.). Packard (quotes Fitch) Half Hours Ins. 241 (as *S. putator*).
1878. Larva, pupa (figs.). Buckhaut. Agricul. Penn. 258.
1881. Larva, pupa (fig.). Packard. Ins. Inj. For. & Sh. Tr. 33.
1883. Larva, pupa (fig.). Saunders. Ins. Inj. Fruit. 32.
1884. Larva, pupa (figs.). Edge. Agricul. Penn. 107.

ELAPHIDION PARALLELUM Newm.

1874. Larva, pupa (figs.). Le Baron (after Reilly). 4th Rep. Nox. Ins. Ill. 152.

1875. Larva, pupa (figs. only). Cook. 12th Rep. Mich. Bd. Agri. 128 (1873–74).
1876. Larva, pupa (figs. only). Thomas. 1st Rep. Nox. Ins. Ill.
1882. Larva (fig.). Packard. 3rd Rep. U. S. Ent. Com. 257. pl. vii. fig. 1.
1883. Larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 33.
1885. Larva, pupa (figs.). Hubbard. Ins. Aff. Orange. 126, 171.

ELAPHIDION INERME Newm.

1885. Larva. Hubbard. Ins. Aff. Fruit. 171.

TRAGIDION FULVIPENNE Say.

1889. Egg. Popenoe. Insect Life. ii. 197.

CYLLENE PICTUS Dr.

1862. Larva, pupa (fig.). O. Sacken. Pro. Ent. Soc. Phil. i. 121. pl. i. (might be *C. robiniæ*).
1869. Larva, pupa (figs.). Packard. Guide. 497.
1881. Larva, pupa (figs). Packard. Ins. Inj. For. & Sh. Tr. 70.

CYLLENE ROBINIÆ Forst.

1861. Larva, pupa (figs.). Rathvon. Rep. U. S. Pat. Off. (Agri.) 616.
1877. Larva (brief). Bethune. Can. Ent. ix. 223.
1881. Larva, pupa. Packard. Ins. Inj. For. & Sh. Tr. 97.

CYLLENE ERYTHROPTERUS Chev.

1885. Larva, pupa (figs.). Duges. Ann. Ent. Soc. Belg. xxix. 40. pl. iii.

GLYCOBIUS SPECIOSUS Say.

1884. Young larva (brief). Packard. Am. Nat. xviii. 1151.

XYLOTRECHUS COLONUS Fabr.

1881. Larva, pupa. Packard. Ins. Inj. For. & Sh. Tr. 27.
1882. Larva, pupa (fig.). Packard. 3rd Rep. U. S. Ent. Com. 258. pl. xii.
1888. Larvá (fig. only). Lintner (after Packard). 4th Rep. Inj. Ins. N. Y. 94.

XYLOTRECHUS ANNOSUS Say.

1883. Larva (biol. notes). Coquillett. Can. Ent. xv. 31.

RHAGIUM LINEATUM Oliv.

1861. Larva (fig.). Rathvon. Rep. U. S. Pat. Off. (Agri.) 620.
1881. Larva. Packard. Ins. Inj. For. & Sh. Tr. 163.
1882. Larva (fig.). Packard. 3rd. Rep. U. S. Ent. Com. 259. pl. xi.

MONOHAMMUS TITILLATOR Fabr.

1858. Larva (brief). Fitch. 4th. Rep. Nox. Ins. 707 (Trans. N. Y. Agri. Soc. 1858, as *M. notatus* Dr.).

1861. Larva, pupa (figs.). Rathvon. Rep. U. S. Pat. Off. (Agri.) 614.

MONOHAMMUS CONFUSOR Kby.

1877. Larva (brief). Bethune. Can. Ent. ix. 225.

1881. Larva, pupa (figs.). Packard. Ins. Inj. For. & Sh. Tr. 154.

1883. Larva (brief). Saunders. Rep. Ent. Soc. Ont. 53.

1884. Egg, young larva (brief). Packard. Am. Nat. xviii. 1150.

MONOHAMMUS SCUTELLATUS Say.

1877. Larva, pupa (brief). Bethune. Rep. Ent. Soc. Ont. 23.

1883. Larva (brief). Saunders. Rep. Ent. Soc. Ont. 53.

GOES TIGRINA De G.

1855. Larva, pupa (fig.). Fitch. Trans. N. Y. Agri. Soc. 853 (1854). (as *Monohanus tigrinus*).

PSENOCERUS SUPERNOTATUS Say.

1862. Larva. O. Sacken. Proc. Ent. Soc. Phil. i. 122.

1869. Larva (fig.). Packard. Guide. 499–500.

1877. Larva (fig.). Packard. Half Hours Ins. 166.

1880. Larva (brief). Saunders. Can. Ent. xii. 6.

1883. Larva (brief). Saunders. Ins. Inj. Fruit. 338.

LEPTOSTYLUS BIUSTUS Lec.

1885. Larva (brief). Ins. Inj. Orange. 174.

LIOPUS FASCICULARIS Harr.

1869. Larva (brief). Packard. Guide. 497.

1871. Larva, pupa (fig.). Packard. 1st Rep. Inj. Ins. Mass. 15–17 (as *L. xanthoxyli*).

1871. Larva, pupa (fig. only). Packard. Am. Nat. v. 424.

1877. Larva (fig. only). Packard. Half Hours Ins. 169, (as *L. xanthoxyli*).

1881. Larva (fig.), pupa. Packard. Ins. Inj. For. & Sh. Tr. 252.

UROGRAPHIS FASCIATUS De G.

1858. Larva. Fitch. 5th. Rep. Trans. N. Y. Agri. Soc. 795.

1881. Larva. Packard. Ins. Inj. For. & Sh. Tr. 22.

ONCIDERES CINGULATA Say.

1880. Larva, pupa (figs.). Riley. Am. Ent. iii. 297.

1885. Egg, larva, pupa (figs., brief). Hubbard. Ins. Inj. Orange. 128.

SAPERDA CALCARATA Say.

1841. Larva (brief). Harris. Inj. Ins. Mass. 88.
1854. Larva (brief). Emmons. Ins. N. Y. 121.
1877. Larva (fig. only). Packard. Half Hours Ins. 251.
1881. Larva (fig.). Packard. Ins. Inj. For. & Sh. Tr. 118.
1889. Larva (fig.). Lugger (after Packard). Bull. No. 9. Minn. Exp. St. 55, 56.

SAPERDA MŒSTA Lec.

1874. Larva, pupa. Saunders. Can. Ent. vi. 60–63.
1881. Larva, pupa. Packard (quotes Saunders). Ins. Inj. For. & Sh. Tr. 118.

SAPERDA CANDIDA Fabr.

1841. Larva (brief). Harris. Inj. Ins. Mass. 89 (as *S. bivittata*).
1855. Larva (fig.). Fitch. Trans. N. Y. St. Agri. Soc. 721 (1854).
1860. Larva. Uhler. Rep. U. S. Pat. Off. (Agri.). 317.
1861. Larva (fig. only). Rathvon. Rep. U. S. Pat. Off. (Agri.) 617. (as *S. bivittata*).
1862. Larva (fig.). Couper. Can. Nat. and Geo. vii. 280.
1862. Larva. Packard. 2nd Rep. Nat. Hist. Soc. Me. 192. (7th Rep. Agri. Me.).
1862. Larva (fig.). Harris. Inj. Ins. Mass. 108. pl. ii. fig. 17.
1869. Larva (fig.). Packard. Guide. 500.
1872. Larva (fig. only). Tenney. Nat. Hist. Anim. 166.
1873. Larva (fig. only). Smith. 6th Rep. Conn. Bd. Agri. 348 (1872–73).
1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 157.
1875. Larva, pupa (figs.). Cook (after Riley). 12th Rep. Mich. Bd. Agri. 124 (1873).
1876. Larva, pupa (figs. only). Thomas (after Riley). 1st. Rep. Nox. Ins. Ill. 153.
1876. Larva, pupa (figs.). Perkins (after Riley). 2d Bi-Rep. Vermont Bd. Agri. 599.
1877. Larva, pupa (figs. only). Half Hours Ins. 164.
1877. Larva (brief). Bethune. Can. Ent. ix. 223.
1877. Larva, pupa (figs.). Bethune. Rep. Ent. Soc. Ont. 27.
1883. Larva, pupa (figs. only). Harrington. Rep. Ent. Soc. Ont. 45.
1883. Egg, larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 17, 18.
1887. Larva, pupa (figs.). Bethune. Rep. Ent. Soc. Ont. 58.

SAPERDA VESTITA Say.

1861. Larva (fig. only). Rathvon. Rep. U. S. Pat. Off. (Agri.). 618.
1877. Larva (fig. only). Packard. Half Hours Ins. 250.
1881. Larva (fig. only). Packard. Ins. Inj. For. & Sh. Tr. 124.

SAPERDA TRIDENTATA Oliv.

1858. Larva. Fitch. 5th Rep. Trans. N. Y. Agri. Soc. 840.
1869. Larva (fig.). Packard. Guide. 499.

1876. Larva (brief). Thomas. 1st Rep. Nox. Ins. Ill. 156.
1877. Larva (fig. only). Packard. Half Hours Ins. 249.
1881. Larva. Packard. Ins. Inj. For. & Sh. Tr. 58.
1882 Larva. Packard. 3d Rep. U. S. Ent. Com. pl. viii. fig. 2.
1885. Larva. Forbes. 3d Rep. Nox. Ins. Ill. 112–114 (1884).
1887. Larva (brief). Harrington. Rep. Ent. Soc. Ont. 31.

Saperda Fayi Bland.

1878. Biological Notes. Zimmerman. Can. Ent. x. 220.
1888. Larva, pupa (biological notes). Hamilton. Can. Ent. xx. 6.
1888. Larva, pupa (biological notes). Hamilton. Rep. Ent. Soc. Ont. 41 (1887).

Saperda concolor Lec.

1888. Larva (biolog. notes). Hamilton. Can. Ent. xx. 8.
1888. Larva (biolog. notes). Hamilton. Rep. Ent. Soc Ont. 42 (1887).
1889. Larva (fig., gall-like swelling). Lugger. Bull. No. 9. Minn. Exp. St. 56, 57.

Saperda sp.

1882. Larva (fig.). Packard. 3d Rep. U. S. Ent. Com. 256. pl. xii. fig. 4.

Oberea tripunctata Swed.

1841. Larva (brief). Harris. Inj. Ins. Mass. 91.
1854. Larva (brief). Emmons. Ins. N. York. 122.
1861. Larva (fig.). Rathvon. Rep. U. S. Pat. Off. (Agri.). 619.
1873. Egg, larva (brief). Saunders. Rep. Ent. Soc. Ont. 9.
1877. Egg, larva (brief). Bethune. Can. Ent. ix. 226.

Unknown species.

1882. Larvæ and pupa. Packard. 3d Rep. U. S. Ent. Com. 15 unidentified species are described and figured in this work.

CHRYSOMELIDÆ.

1890. Food-Habits. Beutenmüller. Ent. Am. vi. 175–178.

Lema collaris Say.

1883. Larva. Coquillett. Can. Ent. xv. 22.

Lema trilineata Oliv.

1841. Egg, larva (brief). Harris. Inj. Ins. Mass. 96.
1862. Egg, larva, pupa (brief). Harris. Inj. Ins. Mass. 119.
1865. Larva. Thomas. Trans. Ill. Agri. Soc. v. 431.
1866. Egg, larva (brief). Walsh. Pract. Ent. ii. 26.
1868. Egg, larva (fig.), pupa (brief). Walsh & Riley. Am. Ent. i. 26.
1869. Egg, larva, pupa (figs., brief). Packard. Guide. 503.
1870. Egg, larva, pupa (figs.). Compton. Prize Ess. of the Cult. of the Potato. 22.
1871. Egg, larva, pupa (figs.). Riley. Am. Ent. ii. 327.

1871. Egg, larva, pupa (figs.). Saunders. Can. Ent. iii. 43.
1871. Egg, larva, pupa (figs.). Glover. Rep. U. S. Dept. Agri. 74.
1874. Egg, larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 164.
1876. Egg, larva, pupa (figs.). Perkins. 3d Bi-Rep. Verm. Bd. Agri. 573.
1876. Egg, larva, pupa. Thomas. 1st Rep. Nox. Ins. Ill. 159.
1879. Egg, larva, pupa (figs.). Comstock. Rep. U. S. Dept. Agri. 214. pl. iii.
1882. Larva, pupa (figs.). Harrington. Rep. Ent. Soc. Ont. 55.
1885. Egg, larva, pupa (figs.). Lintner. 2d Rep. Nox. Ins. N. Y. 133, 134.

CRIOCERIS ASPARAGI Linn.

1720. Larva, pupa (figs.). Frisch. Beschreib. Ins. i. 27–30. pl. vi. figs. 1–3.
1749. Larva, pupa (figs.). Rösel. Ins. Belust. ii. 11, 12. pl. vi.
1834. Larva (figs.). Bouche. Nat. Ins. 204. pl. x. figs. 38–42.
1839. Egg, larva, pupa (figs.). Westwood. Intro. Ins. i. 374.
1841. Egg, larva. Harris. Inj. Ins. Mass. 96.
1862. Egg, larva, pupa (figs.) Fitch. 8th Rep. Nox. Ins. Trans. N. Y. Agri. Soc. 664–667.
1857. Larva, pupa (detailed). Letzner. Arb. Schles. Geschell. 119.
1873. Egg (brief). Smith. 6th Rep. Conn. Bd. Agri. 349 (1872–73).
1879. Egg, larva (figs.). Comstock. Rep. U. S. Dept. Agri. 216. pl. iii.
1880. Egg, larva (figs. only). Bethune. Rep. Ent. Soc. Ont. 47.
1880. Egg, larva (fig. only). Fuller. Am. Ent. iii. 3.
1880. Egg, larva (figs.). Omerod. Inj. Ins. p.
1881. Egg, larva (figs. only). Bethune. Can. Ent. xiii. 253.
1881. Egg, larva (figs. only). Bethune. Rep. Ent. Soc. Ont. 36.
1882. Egg, larva (figs.). Harrington. Rep. Ent. Soc. Ont. 55.
1882. Egg, larva (figs.). Lintner. 1st. Rep. Nox. Ins. N. Y. 241, 242.
1884. Larva (fig.). Edge. Agri. Penn. 101.

CRIOCERIS 12-PUNCTATUS Linn.

1738. Larva (fig.). Frisch. Beschreib. Ins. xiii. 29, 30. pl. xxviii.

COSCINOPTERA DOMINICANA Fabr.

1869. Larval case. Harris. Harr. Corr. 76.
1874. Egg, larva, case (figs.). Riley. 6th Rep. Nox. Ins. Mo. 127 (1873).
1874. Egg, larva, case (figs.). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 169.
1880. Egg, larva (fig. only). W. S. B. Am. Ent. iii. 227.
1882. Egg, larva (figs. only). Harrington (after Riley). Rep. Ent. Soc. Ont. 55.

CHLAMYS PLICATA Fabr.

1869. Larva, case (figs). Packard. Guide. 507.
1874. Larva, case (figs.). Riley (after Packard). 6th Rep. Nox. Ins. Mo. 128.
1877. Larva, case (fig. only). Packard. Half Hours Ins. 211 (as *Chlamys* sp.).
1882. Larva, case (figs. only). Harrington (after Packard). Rep. Ent. Soc. Ont. 56.

1888. Egg, larva, pupa (figs.). Marlatt. The Industrialist. xiv. 53.

ADOXUS VITIS Linn.

1803. Larva. Latreille. Nat. Hist. Crust. & Ins. xi. 331.
1846. Larva (notes). Guerin-Meneville. Ann. Soc. Ent. Fr. ii. 4 Bull. 35.
1873. Larva (fig.). Von Horvath. Verh. z. b. Ges. Wien. xxiii. 37–40. pl. xviii.
1874. Larva (notes). Girard. Ann. Soc. Ent. Fr. v. 4 Bull. 63. 1140.
1875. Larva. Lichtenstein. Ann. Soc. Ent. Fr. v. 5 Bull. 105.
1879. Life-history. Lichtenstein. Etudes sur le Griboure, Montpellier. 12.

METACHROMA PALLIDA Say.

1883. Larva. Coquillett. Can. Ent. xv. 21 (as *Chrysomela pallida*).

PARIA ATERRIMA Oliv.

1880. Larva, pupa. Cook. 19th Rep. Mich. Bd. Agri. 274.
1880. Larva, pupa, cocoon. Riley. Am. Ent. iii. 243.
1883. Larva (fig.). Forbes. Trans. Wis. Hort. Soc. xiii. 41.
1884. Larva (fig.). Forbes. 2d Rep. Nox. Ins. Ill. 159. pl. ix. fig. 5*b*.
1884. Larva, pupa (fig.). Forbes. Miss. Vall. Hort. Soc. ii. 249.
1884. Larva, pupa (figs.). Forbes. Psyche. iv. 126. pl. i.

GRAPHOPS PUBESCENS Melsh.

1884. Larva, pupa (fig.). Forbes. Trans. Wis. Hort. Soc. xiii. 44 (1883).
1884. Life-history (figs.). Forbes. 2nd Rep. Nox. Ins. Ill. 163. pls. vii, xix (1883).
1884. Larva, pupa (fig.). Forbes. Miss. Vall. Hort. Soc. ii. 246.
1885. Larva, pupa (figs.). Forbes. 3rd Rep. Nox. Ins. Ill. pl. xi. figs. 1, 2, 3 (1884).

COLASPIS BRUNNEA Fabr.

1871. Larva (fig.). Riley. 3rd Rep. Nox. Ins. Mo. 81–84 (as *C. flavida*).
1872. Larva (fig.). Riley. 4th Rep. Nox. Ins. Mo. 34 (as *C. flavida*).
1872. Larva (fig.). Riley. Am. Nat. vi. 293 (as *C. flavida*).
1876. Larva. Thomas (quotes Riley). 1st Rep. Nox. Ins. Ill. 164 (as *C. flavida*).
1880. Larva (fig. only). Anony. Am. Ent. iii. 243.
1882. Larva (fig. only). Harrington. Rep. Ent. Soc. Ont. 57 (as *C. flavida*).
1883. Larva (fig.), pupa (brief). Saunders. Ins. Inj. Fruit. 283.
1884. Larva (fig.). Forbes. 2nd Rep. Nox. Ins. Ill. 156. pl. ix.
1884. Larva, pupa (figs.). Forbes. Psyche. iv. 123. pl. i.
1884. Larva, pupa (figs.). Forbes. Miss. Vall. Hort. Soc. ii. 246.

DORYPHORA CLIVICOLLIS Kby.

1841. Larva, pupa (very brief). Harris. Inj. Ins. Mass. 107 (as *Chrysomela trimaculata*).
1861. Larva (brief). Proc. Ent. Soc. Phil. i. 44 (as *D. trimaculata*).
1869. Larva (fig. only). Packard. Guide. 508 (as *Chry. trimaculata*).
1883. Larva. Coquillett. Can. Ent. xv. 21.

1885. Larva, pupa. French. Can. Ent. xvii. 19.

DORYPHORA 11-LINEATA Stäl.

1884. Larva, pupa (figs.). Duges. Ann. Ent. Soc. Belg. xxviii. 1. pl. i. figs. 1–14.

DORYPHORA 10-LINEATA Say.

1863. Egg, larva. Fitch. 9th Rep. Nox. Ins. Trans. N.Y. Agri. Soc. 788.
1864. Larva. Thomas. Tran. Ill. Agri. Soc. v. 437.
1865. Larva (brief). Walsh. Pract. Ent. i. 3.
1866. Egg, larva (figs. only). Walsh. Pract. Ent. ii. 13.
1866. Egg, larva (brief). Shimer. Pract. Ent. i. 84.
1867. Larva (fig. only). Glover. Rep. U. S. Dept. Agri. 63.
1868. Egg, larva, pupa (figs.). Walsh & Riley. Am. Ent. i. 41.
1869. Egg, larva, pupa (figs). Packard. Guide. 506.
1870. Egg, larva, pupa (figs.). Compton. Prize Essay of Cult. Potatoe. 23.
1870. Egg, larva, pupa (figs. only). Shimer. Am. Nat. iii. 92.
1871. Egg, larva, pupa (figs., brief). Saunders & Reed. Can. Ent. iii. 42.
1871. Larva (fig., brief). Glover. Rep. U. S. Dept. Agri. 74 (1870).
1874. Egg, larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 165.
1875. Larva (fig. only). Glover. Rep. U. S. Dept. Agric. 123 (1874).
1875. Egg, larva, pupa (figs.). Cook. 12th Rep. Bd. Agri. Mich. 107 (1873).
1875. Egg, larva, pupa (figs. only). Saunders. Rep. Ent. Soc. Ont. 34.
1876. Larva. Thomas. 1st Rep. Nox. Ins. Ill. 161.
1876. Egg, larva, pupa (figs.). Perkins. 3rd Bi. Rep. Verm. Bd. Agri. 578.
1875. Egg, larva, pupa (figs.). Cutting. 2nd Bi. Rep. Verm. Bd. Agri. 671.
1877. Larva, pupa (figs. only). Packard. Half Hours Ins. 280
1880. Egg, larva, pupa (figs.). Fuller. Am. Ent. iii. 116.
1882 Egg, larva, pupa (figs. only). Harrington. Rep. Ent. Soc. Ont. 58.
1883. Pupa (notes). Coleman Quart. Journ. Bost. Zoo. Soc. ii. 31.
1883. Egg, larva (figs. only). Griffith & Henfrey. Microg. Dict. 270.
1883. Larva. Coquillett. Can. Ent. xv. 21.
1885. Egg, larva, pupa (figs.). Fletcher. Rep. Ent. Ex. Farms. 16.

DORYPHORA JUNCTA Germ.

1868. Egg, larva, pupa (figs.). Walsh & Riley. Am. Ent. i. 43.
1869. Egg, larva (figs.). Packard. Guide. 509.
1870. Larva (fig.). Compton (quotes Walsh). Prize Essay on Cult. of Potatoe. 25.
1871. Larva (fig.). Glover. Rep. U. S. Dept. Agri. 74.
1874. Egg, larva (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 165.
1874. Larva (fig.). Glover. Rep. U. S. Dept. Agric. 123.
1876. Larva. Thomas. 1st Rep. Nox. Ins. Ill. 161.
1877. Egg, larva (figs.). Packard. Half Hours Ins. 208.

1880. Egg, larva (figs.). Fuller. Am. Ent. iii. 117.
1883. Larva. Coquillett. Can. Ent. xv. 22.

CHRYSOMELA MULTIGUTTATA Stål.

1883. Larva. Coquillett. Can. Ent. xv. 22.

CHRYSOMELA SCALARIS Lec.

1841. Larva (brief). Harris. Inj. Ins. Mass. 107.
1881. Egg, larva, pupa. Packard. Ins. Inj. For. & Sh. Tr. 126.

CHRYSOMELA PHILADELPHICA Linn.

1869. Larva (brief, fig.). Packard. Guide. 509.

CHRYSOMELA SIMILIS Rog.

1883. Larva. Coquillett. Can. Ent. xv. 22.

CHRYSOMELA BIGSBYANA Kby.

1883. Larva. Coquillett. Can. Ent. xv. 22.

PRASOCURIS PHELLANDRII Linn.

1850. Larva (biological notes). Boic. Stett. Ent. zeit. ii. 360.
1857. Larva, pupa. Cornelius. Stett. Ent. zeit. xviii. 404.
1857. Larva, pupa. Letzner. Arb. Schles. Geo. Breslau. 127-130.
1866. Larva (biolog. notes). Low. Ver h. z. b. Ges. Wien. xvi. 956.
1874. Larva, pupa. Kaltenbach (quotes Cornelius). Pflanze feinde. 10.

GASTROIDEA POLYGONI Linn.

1854. Larva, pupa (figs.). Heeger. Sitzb. Ak. Wiss. Wien. xi. 927-929.
1855. Larva (brief). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 612.
1856. Larva. Letzner. Arb. Schles. Ges. 104-106.
1857. Larva, pupa (figs.). Curtis. Journ. Roy. Agri. Soc. Eng. 58. pl.
1874. Larva, pupa. Kaltenbach. Pflanze feinde. 511.

LINA TREMULÆ Fabr.

1837. Larva, pupa (figs.). Ratzeburg. Forst. Insect. i. 245. pl. xx.
1843. Egg, larva, pupa (brief). Klingelhofer. Ent. Zeit. Stett. 85.
1880. Larva. Anony. Am. Ent. iii. 161.
1889. Larva, pupa (figs.). Lugger (after Taschenberg). Bull. No. 9. Exp. St. Minn. 55.

LINA LAPPONICA Linn.

1857. Larva. Mærkel. Allg. Nat. Zeit. 174.
1875. Larva (habits). Letzner. Arb. Schles. Ges. Breslau. 170.
1882. Larva (brief). Harrington. Rep. Ent. Soc. Ont. 59.
1889. Larva (brief). Lugger. Bull. No. 9. Exp. St. Minn. 55.

LINA SCRIPTA Fabr.

1855. Larva (brief). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 611.
1880. Larva, pupa (figs.). Riley. Am. Ent. iii. 157-161.
1881. Larva, pupa (figs.). Packard. Ins. Inj. For. & Sh. Tr. 116 (after Riley).

1884. Larva (brief). Riley. Rep. U. S. Dept. Agri. 336–340.
1889. Larva (fig.). Lugger. Bull. No. 9. Exp. St. Minn. 53, 54.

PHYLLODECTA VULGATISSIMA Linn.

1775. Larva, pupa (figs.). De Geer. Mem. v. 401. pl. ix. figs. 27–33.
1857. Larva, pupa. Cornelius. Stett Ent. Zeit. xviii. 392–399.

MONOCESTA CORYLI Say.

1878. Egg, larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 246.
1881. Larva, pupa (figs.). Packard. Ins. Inj. For. & Sh. Tr. 64.

ANGELASTICA HALENSIS Linn.

1874. Biological note. Kaltenbach. Pflanze feinde. 308.

DIABROTICA VITTATA Fabr.

1869. Larva, pupa (figs.). Packard. Guide. 505.
1870. Larva, pupa (figs.). Riley. 2nd Rep. Nox. Ins. Mo. 65
1871. Larva, pupa (brief). Glover. Rep. U. S. Dept. Agri. 74 (1870).
1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 170.
1875. Larva (fig.). Cook. 12th Rep. St. Bd. Agri. Mich. 122 (1873).
1876. Larva (fig. only). Thomas. 1st Rep. Nox. Ins. Ill. 165.
1878. Larva, pupa (figs.). Saunders. Rep. Ent. Soc. Ont. 30.
1882. Larva (brief). Harrington. Rep. Ent. Soc. Ont. 59.
1883. Larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 363.
1884. Larva (fig.). Edge. Agricul. Penn. 65.

DIABROTICA LONGICORNIS Say.

1884. Larva, pupa (figs.). Forbes. 2nd Rep. Nox. Ins. Ill. 55 (1883).

TRIRHABDA TOMENTOSA Linn.

1888. Larva (brief). Lintner. 4th Rep. Inj. Ins. N. Y. 142 (as *T. canadensis*).
1890. Larva. Beutenmüller. Can. Ent. xxii. 36.

GALERUCA XANTHOMELÆNA Schr.

1841. Egg, larva (brief). Harris. Inj. Ins. Mass. 73 (as *G. calmariensis*).
1867. Egg, larva, pupa. Glover. Rep. U. S. Dept. Agri. 62. (as *G. calmariensis*).
1867. Larva, pupa. Cornelius. Stett. Ent. Zeit. xxviii. 213, 214.
1871. Egg, larva. Glover. Rep. U. S. Dept. Agri. 73.
1882. Egg, larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 159–170.
1882. Egg, larva, pupa (figs.). Anony. (quotes Riley). Scient. Am. xvii. 6885.
1883. Egg, larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 160. pl. xii.
1885. Egg, larva, pupa (figs.). Riley. Bull. U. S. Dept. Agri. 6, 7.
1886. Egg, larva, pupa (figs.). Buckhout. Rep. Penn. Bd. Agri. 214. pl. iii.
1888. Egg, larva, pupa (figs.). Lintner. 4th Rep. Nox. Ins. N. Y. 143.
1888. Egg, larva, pupa (figs.). Riley. Bull. No. 10. Div. Ent. 9.
1889. Egg, larva, pupa (figs.). Lintner. 5th Rep. Nox. Ins. N. Y. 235.

Galeruca marginella Kby.

1869. Larva, pupa (figs.). Packard. Guide. 505.

Galeruca sagittariæ Gyll.

1883. Egg, larva, pupa. Schaupp. Bull. Bk. Ent. Soc. vi. 54.

Blepharida rhois Forst.

1874. Egg, larva, pupa (figs). Riley. 6th Rep. Nox. Ins. Mo. 118-122.
1876. Larva. Thomas. 1st Rep. Nox. Ins. Ill. 167.
1889. Egg, larva, pupa (figs.). Fernald (after Riley). Ann. Rep. Exp. St. Mass. 10.

Disonycha collaris Fabr.

Larva, pupa. Murtfeldt. Bull. No. 22. U. S. Div. Ent. 76.

Haltica chalybea Ill.

1854. Larva (brief). Harris. Rep. Ins. & Diseases Inj. Veget. 11 (Am. Pom. Soc.).
1866. Larva. Walsh. Pract. Ent. i. 40 (as *Graptodera chalybea*).
1867. Larva (brief). Walsh. Pract. Ent. ii. 50.
1869. Larva (brief). Packard. Guide. 507 (as *Graptodera chalybea*).
1876. Larva, pupa (figs.). Riley. 3rd Rep. Nox. Ins. Mo. 79–81.
1874. Larva (fig. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 173.
1876. Larva (fig.). Thomas (quotes Riley). 1st Rep. Nox. Ins. Ill. 170.
1877. Egg, larva (fig.). Gott. Rep. Ent. Soc. Ont. 45.
1878. Egg, larva, pupa (figs.). Perkins. 5th Rep. Vermont Bd. Agri. 282.
1880. Larva, pupa (figs.). Anony. Am. Ent. iii. 183.
1882. Larva, pupa (figs.). Harrington. Rep. Ent. Soc. Ont. 60.
1883. Larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 278.
1888. Larva (fig. only). Lintner. 4th Rep. Nox. Ins. N. Y. 96.

Haltica bimarginata. Say.

1888. Larva, pupa. Lintner. 4th Rep. Inj. Ins. N. Y. 98.

Haltica foliacea Lec.

1887. Larva. Riley. Scient. Am. June 16 (as *G. punctipennis*).
1887. Larva. Riley. Gardner's Monthly. xxix. 216.
1888. Egg, young and mature larva. Murtfeldt. Insect Life. i. 74–76.

Phyllotreta vittata Fabr.

1869. Larva, pupa (figs.). Shimer. Am. Nat. ii. 150 (as *H. striolata*).
1869. Larva, pupa figs.). Packard (quotes Shimer). Guide. 507.
1869. Larva, pupa (figs.). Shimer. Am. Ent. i. 158 (as *H. striolata*).

1876. Larva. Thomas. 1st Rep. Nox. Ins. Ill. 169.
1882. Larva, pupa (figs.). Harrington. Rep. Ent. Soc. Ont. 60.
1883. Larva, pupa (figs.). Edge. Agri. Penn. 69.
1883. Larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 330.
1884. Egg, larva, pupa. Riley. Rep. U. S. Dept. Agri. 301-304.

PHYLLOTRETA ZIMMERMANII Cr.

1884. Larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 304–308. pl. iv.

DIBOLIA ÆREA Mels.

1879. Larva. Comstock. Rep. U. S. Dept. Agri. 248.

MICRORHOPALA VITTATA Fabr.

1837. Larva (figs.). Harris. Journ. Bost. Nat. Hist. Soc. i. 147.

ODONTOTA RUBRA Web.

1837. Larva, pupa (fig.). Harris. Journ. Bost. Nat. Hist. Soc. i. 143 (as *H. rosea*).
1869. Larva, pupa. Packard (quotes Harris). Guide. 503.
1883. Larva. Saunders. Ins. Inj. Fruit. 121.

ODONTOTA DORSALIS Thunb.

1837. Pupa (fig.). Harris. Journ. Bost. Nat. Hist. i. 146.
1839. Pupa (fig.). Westwood. Intro. Ins. i. 379 (as *H. suturalis*).
1868. Larva (brief). Walsh & Riley. Am. Ent. i. 58 (as *H. suturalis*).
1880. Larva (brief). Chambers. Am. Ent. iii. 60 (as *H. suturalis*).
1881. Larva (brief). Packard. Ins. Inj. For. & Sh. Tr. 100 (as *H. suturalis*).

PHYSONOTA UNIPUNCTATA Say.

1869. Larva. Walsh & Riley. Am. Ent. ii. 4 (as *P. 5-punctata*).
1870. Larva (fig.) Riley. 2nd Rep. Nox. Ins. Mo. 59.
1885. Larva (brief). Canfield. Can. Ent. xvi. 227.
1885. Larva (brief). Hamilton. Can. Ent. xvi. 134.

CASSIDA BIVITTATA Say.

1865. Larva. Thomas. Trans. Ill. Agri. Soc. v. 433.
1868. Larva. Riley. Prairie Farmer. Annual. 53.
1869. Larva, pupa (figs.) Walsh & Riley. Am. Ent. i. 235.
1870. Larva (fig.). Riley. 2nd Rep. Nox. Ins. Ill. 61.
1874. Larva, pupa (figs. only) Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 175.
1876. Larva, pupa (figs. only). Thomas. 1st Rep. Nox. Ins. Ill. 172.

CASSIDA NIGRIPES Oliv.

1869. Larva, pupa (figs.). Walsh & Riley. Am. Ent. i. 238.
1870. Larva, pupa (figs.). Riley. 2nd Rep. Nox. Ins. Mo 63.

COPTOCYCLA AURICHALCEA Fabr.

1841. Larva (brief). Harris. Inj. Ins. Mass. 98.
1865. Larva (brief). Thomas. Trans. Ill. Agri. Soc. v. 433.

1869. Egg, larva, pupa (figs.). Walsh & Riley. Am. Ent. i. 237.
1869. Larva (brief). Packard. Guide. 504.
1870. Larva, pupa (figs.). Riley. 2nd Rep. Nox. Ins. Mo. 62.
1882. Larva (brief). Harrington. Rep. Ent. Soc. Ont. 62.
1890. Larva (brief). Lintner. 6th Rep. Inj. Ins. N. Y. 125, 126.

COPTOCYCLA GUTTATA Oliv.

1869. Egg, larva, pupa (figs.). Walsh & Riley. Am. Ent. i. 237.
1870. Larva, pupa (figs.). Riley. 2nd Rep. Nox. Ins. Mo. 63.

CHELYMORPHA ARGUS Licht.

1869. Larva (fig.). Walsh & Riley. Am. Ent. ii. 4 (as *Ch. cribraria*).
1869. Larva (brief), pupa (fig.). Packard. Guide. 504.
1870. Pupa (fig.). Riley. 2nd Rep. Nox. Ins. Mo. 58.
1877. Pupa (fig. only). Packard. Half Hours Ins.
1882. Larva, pupa (brief). Harrington. Rep. Ent. Soc. Ont. 61.
1883. Pupa (fig.). Saunders. Ins. Inj. Fruit. 315.

BRUCHIDÆ.

CARYOBORUS ARTHRITICUS Fabr.

1869. Larva (habits). Glover. Rep. U. S. Dept. Agri. 71 (1868).
1881. Larva (habits). Dury. Can. Ent. xiii. 21.

BRUCHUS PISI Linn.

1761. Larva (notes). Kalm. Voy. to America. ii. 294.
1775. Larva (notes). De Geer (quotes Kalm). Mem. v. 380.
1815. Larva (notes). Kirby & Spence (quote Kalm). Intro. Ent. i. p.
1839. Larva (notes). Westwood (quotes Kalm). Intro. Ins. i. 330.
1841. Larva (habits). Harris. Inj. Ins. Mass. 56.
1854. Larva (biological notes). Kollar. Vert. z. b. Ges. Wien. iv. 27–30.
1854. Larva, pupa (des). Letzner. Arb. Schles. Ges. Breslau. 79–82.
1858. Larva (biological notes). Kollar. Vert. z. b. Ges. Wien. viii.421-425.
1862. Egg, larva, pupa (brief). Harris. Inj. Ins. Mass. 62.
1863. Larva (fig.). Ogerien. Hist. Nat. Journ. iii. 403.
1868. Larva (habits). Glover. Rep. U. S. Agri. Dept. 72.
1870. Larva (fig.). Glover. Rep. U. S. Dept. Agri. 92.
1871. Egg, larva, pupa (figs.). Riley. 3rd Rep. Nox. Ins. Mo. 44–50.
1874. Larva (habits). Stefanelli. Bull. Ent. Ital. vi. p.
1874. Egg, larva (brief). Thomas. 1st Rep. Nox. Ins. Ill. 28.
1878. Egg, larva, pupa (figs.). Perkins. 5th Rep. Vermont Bd. Agri. 269.
1879. Egg, larva (fig.). Saunders. Rep. Ent. Soc. Ont. 64.
1880. Larva (fig. only). Bethune. Rep. Ent. Soc. Ont. 50.
1883. Larva (fig.). Edge. Agri. Penn. 69.
1887. Egg, larva. Fernald. Rep. Bd. Agri. Mass. 90.

BRUCHUS OBSOLETUS Say.

1871. Larva (habits). Riley. 3rd Rep. Nox. Ins. Mo. 52.
1873. Larva (fig.). Packard. 3rd Rep. Inj. Ins. Mass. 15 (1872. as *Bruchus fabæ*).
1873. Larva (fig.). Packard. Am. Nat. vii. 537 (as *Bruchus fabæ*).

TENEBRIONIDÆ.

ELEODES DENTIPES Esch.

1878. Larva (fig.). Gissler. Bull. Bk. Ent. Soc. i. 19, 87.

ELEODES GIGANTEA Mann.

1878. Egg, larva (fig.). Gissler. Bull. Bk. Ent. Soc. i. 18, 87.

BLAPS MORTISAGA Linn.

1838. Larva. Patterson. Trans. Ent. Soc. Lond. ii. 99.
1839. Larva (fig. only). Westwood. Intro. Ins. i. 321.
1878. Larva (brief). Gissler. Bull. Bk. Ent. Soc. i. 87.
(This species is, perhaps, erroneously placed in our Catalogue.)

SCOTOBATES CALCARATUS Fabr.

1883. Larva (brief). Coquillett. Can. Ent. xv. 102.
1890. Larva, pupa. Beutenmüller. Psyche. vi.

XYLOPINUS SAPERDIOIDES Oliv.

1878. Larva (brief). Gissler. Bull. Bk. Ent. Soc. i. 87.

TENEBRIO MOLITOR Linn.

1720. Larva, pupa (figs.). Frisch. Beschreib. All. Ins. pt. 3. pl. i.
1775. Larva (fig.). De Geer. Mem. v. M. i. 35. pl. ii. figs. 6-11.
1795. Larva. Oliver. Entomol. iv. No. 57.
1796. Larva. Gœze. Belehr 35–67.
1802. Larva. Latreille. Hist. Nat. Crust. & Ins. x. 289.
1804. Larva (anatomy). Posselt. Beitr. Anatom. Ins. 25. pl. iii.
1807. Larva, pupa (figs.). Sturm. Deutschl. Ins. ii. 220–223.
1833. Larva, pupa (figs.). Hammerschmidt. Beitr. Ent. pl. vi.
1839. Larva. Westwood. Intro. Ins. i. 317.
1854. Larva. Mulsant. Nat. Hist. Col. Fr. Latig. 281.
1853. Larva. Hagen. Stett. Ent. Zeit. xiv. 56.
1868. Larva, pupa (brief). Glover. Rep. U. S. Pat. Off. (Agri.) 100.
1869. Larva (brief). Packard. Guide. 474.
1872. Larva (fig.). Figuier. Ins. World. 499.
1878. Larva, pupa (figs.). Schiœdte. Naturh. Tidsskr. xi. pl. i.
1874. Larva (brief). Le Baron. 4th Rep. Nox. Ins. Ill. 121.
1883. Larva (fig. only). Calwer. Käferbuch. 585. pl. xlix. fig. 14.

TENEBRIO OBSCURUS Fabr.

1839. Larva (brief). Westwood. Intro. Ins. i. 318.

1854. Larva (Developments). Mulsant. Nat. Hist. Col. Fr. Latig. 186.
1874. Larva, pupa (fig.). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 123.
1878. Larva (brief). Gissler. Bull. Bk. Ent. Soc. i. 87.

Tribolium ferrugineum Fabr.

1839. Larva (fig.). Westwood. Intro. Ins. i. 319.
1854. Larva. Luccas. Ann. Soc. Ent. Fr. iii. 2. Bull. 51.
1855. Larva, pupa (figs.). Luccas. Ann. Soc. Ent. Fr. iii. 3. 249–259. pl. xiii. No. 3.
1878. Larva. Schiœdte. Nat. Tidsskr. xi. p.
1885. Larva (fig.). Lintner. 2nd Rep. Inj. Ins. N. Y. 137.

Gnathocerus cornutus Fabr.

1845. Larva, pupa (figs.). Motschulsky. Bull. Soc. Nat. Moscow. i. 80.
1854. Larva. Motschulsky. Etudes. Ent. iii. 67.
1870. Larva, pupa (figs.). Gernet. Horæ Soc. Ent. Ross. vi. 11. pl. ii.
1874. Larva, pupa (figs.). Letzner. Arb. Schles. Ges. Breslau. 166–168.
1878 Larva (brief). Gissler. Bull. Bk. Ent. Soc. i. 87.

Diaperis hydni Fabr.

1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox Ins. Ill. 125.
1880. Larva (brief). Harrington. Can. Ent. xii. 261.

Platydema excavatum Say.

1878. Larva (brief). Gissler. Bull. Bk. Ent. Soc. i. 87.

Boletotherus bifurcus Fabr.

1869. Larva, pupa (figs.). Packard. Guide. 474.
1878. Larva (brief). Gissler. Bull. Bk. Ent. Soc. i. 87.
1882. Larva, pupa. Hayward. Journ. Bost. Zoo. Soc. i. 35, 36.

ÆGIALITIDÆ.

Ægialites debilis Mann.

1888. Larva (fig.). Horn. Trans. Am. Ent. Soc. xv. pl. iii.

CISTELIDÆ.

Androchirus fuscipes Mels.

1883. Larva. Coquillett. Can. Ent. xv. 101.

OTHNIIDÆ.

Othnius lugubris Horn.

1888. Larva (fig.). Horn. Trans. Am. Ent. Soc. xv. pl. iii.

MELANDRYIDÆ.

Xylita lævigata Hellw.

1842. Larva. Erichson. Wiegm. Archiv. viii. pl. 1. 368.

1855. Larva, pupa (figs.). Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 248.

ŒDEMERIDÆ.

NACERDES MELANURA Linn.

1861. Larva, pupa (figs.). Herklotz. Tidsskr. Ent. iv. 164–166. pl. xi.
1863. Larva, pupa (figs.). Perris. Hist. Pin. Mar. i. 452
1877. Larva. Perris. Larves des Col. 350.
1880. Egg, larva. Moody. Psyche. iii. 68.
1880. Larva (figs.). Schiœdte. Naturh. Tidsskr. xii. pl. xvii.

MORDELLIDÆ.

MORDELLA 8-PUNCTATA Fabr.

1874. Larva, pupa (figs.). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 114.

MORDELLA ? Sp.

1881. Larva (note). Chambers. Can. Ent. xiii. 173.

ANTHICIDÆ.

ANTHICUS FLORALIS Linn.

1883. Larva. Rey. Ann. Soc. Linn. Lyon. new ser. xxix. 141, 142.

PYROCHROIDÆ.

PYROCHROA FLABELLATA Fabr.

1880. Larva. Moody. Psyche. iii. 76.

SCHIZOTUS CERVICALIS Newm.

1880. Larva (brief). Moody. Psyche. iii. 76.

DENDROIDES CANADENSIS Lat.

1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 117.
1880. Larva. Moody. Psyche. iii. 76.

DENDROIDES CONCOLOR Newm.

1880. Larva. Moody. Psyche. iii. 76.

MELOIDÆ.

MELOE sp. (probably *M. angusticollis*).

1862. Larva. Packard. 2nd Rep. Nat. Hist. & Geo. Surv. Maine. 190.
1869. Larva (fig.). Packard. Guide. 478.
1869. Larva (fig.). Packard. Am. Nat. ii. 199. pl. iv.
1874. Larva (fig. only). Le Baron (after Packard). 4th Rep. Nox. Ins. Ill. 114.
1876. Larva (fig.). Saunders. Rep. Ent. Soc. Ont. 27.
1878. Larva (fig.). Riley. Am. Nat. xii. 216.
1878. Larva (fig.). Riley. 1st Rep. U. S. Ent. Com. 259.

1880. Larva, pupa. Packard. Zoology. 373 (2nd Ed.).
1883. Larva, pupa (figs.). Packard. Am. Nat. xvii. 941

HORIA MACULATA Swed.

1825. Larva (fig.). Guilding. Trans. Linn. Soc. Lond. xiv. 316. pl. viii.

EPICAUTA CINEREA Forst.

1841. Larva (brief). Harris. Inj. Ins. Mass. 112.
1878. Pupa (fig.). Riley. Am. Nat. xii. pl. i. fig. 9.

EPICAUTA VITTATA Fabr.

1876. Egg, larva. Saunders (quotes Riley). Rep. Ent. Soc. Ont. 29.
1878. Egg, larva, pupa (figs.). Riley. Am. Nat. xii. 285. pl. i.
1878. Egg, larva, pupa (figs.). Riley. 1st Rep. U. S. Ent. Com. 298–300 pl. iv.
1890. Larval habits. Lintner. 6th Rep. Inj. Ins. N. Y. 132–134.

HORNIA MINUTIPENNIS Riley.

1878. Larva (fig.). Riley. Am. Nat. xii. 218. pl. i. figs. 3*a*, 13*c*.
1878. Egg, larva (fig.). Riley. 1st Rep. U. S. Ent. Com. 296. pl. iv.

STYLOPIDÆ.

STYLOPS CHILDRENI Gray.

1869. Larva (fig.). Packard. Guide. 482.
1869. Larva (fig.). Packard. Am. Nat. ii. 201. pl. v. fig. 6.

ATTELABIDÆ.

ATTELABUS BIPUSTULATUS Fabr.

1881. Larva, pupa. Packard (quotes Murtfeldt). Ins. Inj. For. & Sh. Tr. 51.

OTIORHYNCHIDÆ.

OTIORYHNCHUS SULCATUS Fabr.

1834. Larva (fig.). Bouche. Nat. Ins. 201. pl. x. figs. 15–20.
1837. Larva, pupa (figs). Westwood. Gard. Mag. xiii. 157.
1839. Larva, pupa (figs.). Westwood. Intro. Ins. i. 344.
1849. Larva (brief). Preston. Gardner's Chron. 744.
1869. Larva (brief). Lucas. Ann. Soc. Ent. Fr. iv. 9. 50.
1876. Larva. Snellen. Tijdsskr. Ent. xix. 210.
1879. Larva, pupa (figs.). Ormerod. Inj. Ins. 6.
1884. Larva (brief). Forbes. 2d Rep. Nox. Ins. Ill. 177.

OTIORHYNCHUS OVATUS Linn.

1853. Larva (notes). Laboulbene. Ann. Soc. Ent. Fr. iii. 1. Bull. 48.

ARAMIGUS FULLERI Horn.

1878. Egg, larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 256, 257. pl. vii.
1885. Egg, larva, pupa (figs.). Lintner. 2d Ann. Rep. Inj. Ins. 143.

CURCULIONIDÆ.

1890. Food-Habits. Beutenmüller. Can. Ent. xxii. p.

Sitones hispidulus Germ.

1876. Larva, pupa. Brischke. Ent. Monatblatt. 42.

Ithycerus noveboracensis Forst.

1868. Larva (fig.). Walsh & Riley. Am. Ent. i. 221.
1869. Larva, pupa (figs.). Walsh & Riley. Am. Ent. ii. 26.
1871. Larva. Riley. 3d Rep. Nox. Ins. Mo. 57.
1874. Larva (fig. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 136.
1876. Larva (fig.). Thomas. 1st Rep. Nox. Ins. Ill.
1883. Larva (fig.). Saunders. Ins. Inj. Fruit. 196.

Podapion gallicola Riley.

1883. Larva (brief). Riley. Bull. Bk. Ent. Soc. iv. 62.
1887. Larva (brief). Fletcher. Rep. Ent. Exp. Farms. 39.

Listronotus latiusculus Boh.

1890. Larva, pupa (figs.). Weed. Bull. Ohio Exp. St. i. 10, 11. pl. ii. fig. 1.

Phytonomus punctatus Fabr.

1881. Egg, larva. Riley. Am. Nat. xv. 12.
1882. Egg, larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 171–179. pl. x.
1882. Egg, larva, pupa (figs.). Lintner. 1st Rep. Inj. Ins. N. Y. 250.
1884. Egg, larva, pupa (figs.). Cutting. 8th Rep. Vermont Bd. Agri. 271, 272.
1884. Larva, pupa (figs.). Buckhaut. Agricul. Penn. 216.
1887. Egg, larva, pupa (figs.). Cook (quotes Riley). Beal's Grasses N. Am. i. 380–383.

Pissodes strobi Peck.

1817. Larva. Peck. Mass. Agricul. Reposit. iv. 205–211. pl. i.
1825. Larva. Peck. Zoo. Journ. ii. 490–492.
1841. Larva (brief). Harris. Inj. Ins. Mass. 64.
1858. Larva. Fitch. 4th Rep. Nox. Ins. (Trans. N. Y. Agri. Soc.) 732-736 (1857).
1869. Larva (brief). Glover. Rep. U. S. Dept. Agri. 71 (1868).
1869. Larva, pupa (figs). Riley. Am. Ent. ii. 164.
1869. Larva, pupa (figs). Packard. Guide. 486.
1874. Larva, pupa (figs.). Le Baron (after Packard). 4th Rep. Nox. Ins. Ill. 139.
1876. Larva, pupa (figs.). Thomas. 1st Rep. Nox. Ins. Ill. 133.
1877. Larva, pupa (figs. only). Packard. Half Hours Ins. 299.
1877. Larva, pupa (figs.). Cook. 16th Rep. Mich. Bd. Agricul. 251.
1880. Larva, pupa (figs.). Fuller. Am. Ent. iii. 5.
1880. Larva, pupa (figs. only). Packard. Zoology. 372. 2nd Ed.
1881. Larva, pupa (figs.). Packard. Ins. Inj. For. & Sh. Tr. 187.

1882. Larva, pupa (figs.). Packard. 3rd Rep. U. S. Ent. Com. pl. xiii.
1883. Larva (brief). Saunders. Rep. Ent. Soc. Ont. 55.
1885. Larva, pupa (figs.). Packard. Rep. U. S. Dept. Agri. 322-325.
1886. Larva, pupa (figs.). Buckhaut. Agricul. Penn. 214. pl. iii.
1888. Larva, pupa (figs.). Lintner. 4th Rep. Inj. Ins. N. Y. 24.
1889. Larva, pupa (figs.). Smith. Garden & Forest. ii. p.

HYLOBIUS PALES Hbst.

1841. Larva (brief). Harris. Inj. Ins. Mass. 62.
1883. Larva (brief). Saunders. Rep. Ent. Soc. Ont. 55.

LIXUS CONCAVUS Say.

1889. Egg, larva, pupa. Webster. Ent. Am. v. 13-16.
1890. Egg, larva, pupa (figs.). Weed. Bull. Ohio Ex. St. iii. No. 8. 2nd Ser. 232.
1890. Larva, pupa (figs.). Weed. Journ. Col. Hort. Soc. v. 73.

LIXUS MACER Lec.

1883. Egg, larva (brief). Coquillett. Can. Ent. xv. 113.
1889. Egg, larva, pupa (Biolog. notes). Webster. Ent. Am. v. 11.

LIXUS PARCUS Lec.

1881. Biological Notes. Riley. Proc. Ent. Soc. Wash. i. 33.

LISSORHOPTRUS SIMPLEX Say.

1882. Larva (fig.). Riley. Rep. U. S. Dept. Agri. 132. pl. vi. fig. 4.

MAGDALIS OLYRA Hbst.

1869. Larva, pupa (figs.). Packard. Guide. 488.
1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th. Rep. Nox. Ins. Ill. 139.
1876. Larva, pupa (fig. only). Thomas. 1st Rep. Nox. Ins. Ill. 132.
1877. Larva, pupa (figs. only). Packard. Half Hours Ins. 241.
1881. Larva, pupa (figs.). Packard. Ins. Inj. For. & Sh. Tr. 28.
1884. Larva (brief). Bowditch. Journ. Bost. Zoo. Soc. iii. 6.

MAGDALIS ARMICOLLIS Say.

1875. Larva, pupa (brief). Hubbard. Psyche. i. 6 (1875).

ANTHONOMUS 4-GIBBUS Say.

1871. Egg, larva, pupa (figs.). Riley. 3rd Rep. Nox. Ins. Mo. 29-35.
1874. Larva, pupa (figs.). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 141.
1876. Egg, larva. Thomas. 1st Rep. Nox. Ins. Ill. 135.
1883. Larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 134.

ANTHONOMUS SUTURALIS Lec.

1869. Larva. Packard. Guide. 488.
1883. Larva (fig.). Saunders. Ins. Inj. Fruit. 375.

COCCOTORUS SCUTELLARIS Lec.

1871. Larva (brief). Riley. 3rd Rep. Nox. Ins. Mo. 39.
1876. Larva (brief). Thomas. 1st Rep. Nox. Ins. Ill. 136 (as *Anthonomus prunicida*).
1883. Larva (brief). Saunders. Ins. Inj. Fruit. 188.
1888. Egg, larva (brief). Bruner. Insect Life. i. p.

CIONUS SCROPHULARIÆ Linn.

1775. Larva (fig.). De Geer. Mem. v. p.
1779. Larva (fig.). Schaeffer. Abhandl. Ins. iii. pl. ix.
1790. Larva (habits). Rossi. Fauna Etrusca. 121.
1795. Larva (brief). Herbst. Nat. Syot. vi. 184.
1803. Larva, pupa (brief). Latreille. Nat. Hist. Crust. & Ins. xi. 72.
1843. Larva. Huber. Mem. Soc. Sc. Phys. & Nat. Hist. Geneve. x. 15–34.
1849. Larva. Westwood. Gardner's Chronicle. 228.
1850. Larva. Perris. Ann. Soc. Linn. Lyon. ii. 291.
1853. Larva. Letzner. Arb. Schles. Ges. Breslau. 177.
1879. Larva. Osborne. Ent. Month. Mag. xvi. 18.

GYMNETRON TETER Fabr.

1859. Larva, pupa (figs.). Heeger. Sitzb. Ak. Wiss. Wien. 218–221. pl. iii.
1874. Larva, pupa. Kaltenbach (quotes Heeger). Pflanzen feinde. 465.

CONOTRACHELUS NENUPHAR Hbst.

1841. Larva (brief). Harris. Inj. Ins. Mass. 66.
1854. Larva (fig.). Glover. Rep. U. S. Pat. Off. (Agri.) 81. pl. vii.
1861. Larva (fig.). Rathvon. Rep. U. S. Pat. Off. (Agri.) 605.
1862. Larva (brief). Harris. Inj. Ins. 76.
1865. Larva, pupa (figs.). Trimble. Ins. Enemies Fruit. 33. pl. vi.
1869. Larva, pupa (figs.). Packard. Guide. 489.
1870. Larva, pupa (figs.). Saunders. Can. Ent. ii. 137.
1870. Larva, pupa (figs.). Riley. Am. Ent. ii. 130.
1871. Larva, pupa (figs.). Saunders. Can. Ent. iii. 26.
1871. Eggs, larva, pupa (figs.). Riley. 3rd Rep. Nox. Ins. Mo. 11.
1873. Larva, pupa (figs.). Cook. 12th Rep. Mich. Bd. Agri. 132.
1874. Larva, pupa (figs.). Le Baron. 4th Rep. Nox. Ins. Ill. 142.
1876. Egg, larva, pupa (figs.). Thomas. 1st Rep. Nox. Ins. Ill. 138.
1877. Larva, pupa (figs.). Gott. Rep. Ent. Soc. Ont. 46.
1877. Larva, pupa (figs). Packard. Half Hours Ins. 273.
1879. Larva, pupa (figs.). Gott. Rep. Ent. Soc. Ont. 84.
1880. Larva, pupa (figs.). Harrington. Rep. Ent. Soc. Ont. 53.
1881. Larva, pupa (figs.). Chase. Trans. Wis. Agri. Soc. xix. 452.
1883. Egg, larva, pupa (figs.). Saunders. Ins. Inj. Fruit. 181.
1885. Larva, pupa (figs.). Fletcher. Rep. Ent. Exp. Farms. 25.

Conotrachelus cratægi Walsh.

1871. Larva, pupa (figs.). Riley. 3d Rep. Nox. Ins. Mo. 35-39.
1876 Larva (brief). Thomas. 1st Rep. Nox. Ins. Ill. 141.
1883. Larva (brief). Saunders. Ins. Inj. Fruit. 226.

Rhyssematus lineaticollis Say.

1889. Larva (brief). Webster. Insect Life. ii. 112.

Tyloderma foveolatum Say.

1889. Egg, larva (brief). Webster. Insect Life. ii 111.

Tyloderma fragariæ Riley.

1871. Larva (fig.). Riley. 3rd Rep. Nox. Ins. Mo. 42.
1872. Larva (fig. only). Anony. (after Riley). Am. Nat. vi. 293.
1874. Larva (fig. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill 143.
1880. Larva (fig.). Harrington. Rep. Ent. Soc. Ont. 54.
1880. Larva (fig. only). Fuller. Am. Ent. iii. 110.
1883. Larva, pupa (figs.). Forbes. Trans. Wis. Hort. Soc. xiii.
1883. Larva, pupa (figs.). Forbes. 1st Rep. Nox. Ins. Ill. 64.
1883. Larva (fig.). Saunders. Ins. Inj. Fruit. 323.
1884. Larva (fig.). Forbes. 2nd Rep. Nox. Ins. Ill. 142. pl. ix.
1889. Egg. Webster. Ins. Life. ii. 110.

Cryptorhynchus parochus Hbst.

1881. Larva, pupa (brief). Schaupp. Bull. Bk. Ent. Soc. iv. 35.

Cryptorhynchus lapathi Linn.

1791. Larva, pupa (figs.). Curtis. Trans. Linn. Soc. Lond. i. 86–89. pl. v.
1793. Larva, pupa (figs.). Reiche (quotes Curtis). Mag. Thier. i. 11–14. pl. i.
1854. Larva, pupa (figs.). Loudon. Arbor. Britan. 1479 (2d Ed.).
1863. Larva, pupa (biolog. notes). Westwood. Trans. Ent. Soc. Lond. Pro. 65.
1864. Larva, pupa (figs.). Westwood. Gardner's Chron. Jan. 16th.
1867. Larva (biolog. notes). Goureau. Ann. Soc. Ent. Fr. iv. 7. Bull. 85.
1868. Larva, pupa (figs.). Ratzeburg. Die Waldverderbuiss. ii. 247. pl. xlix.
1873. Larva. Erne. Mitth. Schweiz. Ent. Ges. iv. 138.

Craponius inæqualis Say.

1869. Larva, pupa (brief). Glover. Rep. U. S. Agri. 76 (1868).
1869. Larva (fig.). Packard. Guide. 490.

Ceutorhynchus cyanipennis Grm.

1845. Biolog. Notes. Guerin Meneville. Ann. Soc. Ent. Fr. ii. 3. Bull. 33.
1855. Biolog. Notes. Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 562.
1855. Larva. Haimhoffer. Verh. z. b. Ges. Wien. v. 525–529.
1865. Larva (fig.). Taschenberg. Schädl. Insect. 57–59. pl. ii. fig. 11.
1866. Larva, pupa (figs.). Kessler. Lebengeshichte. 3–25.

1874. Larva. Kaltenbach. Pflanzen feinde. 31.
1874. Larva. Nowicki. Verh. z. b. Ges. Wien. xxiv. 364.

BARIDIUS TRINOTATUS.

1841. Larva (brief). Harris. Inj. Ins. Mass.
1862. Larva (brief). Harris. Inj. Ins. Mass. 81.
1868. Larva, pupa (figs.). Walsh & Riley. Am. Ent. i. 22.
1869. Larva, pupa (figs.). Packard. Guide. 491.
1870. Larva (brief). Compton. Prize Ess. Cult. Potato. 20.
1876. Larva (brief). Thomas. 1st Rep. Nox. Ins. Ill. 142.
1880. Larva, pupa (figs.). Harrington. Rep. Ent. Soc. Ont. 56.

BALANINUS NASICUS Say.

1861. Larva (fig.). Rathvon. Rep. U. S. Pat. Off. 605 (as *B. Sayi*).

BALANINUS CARYATRYPES Boh.

1872. Larva (fig.). Packard. 2d Ann. Rep. Inj. Ins. Mass. 17.
1877. Larva (fig.). Packard. Half Hours Ins. 247 (as Chestnut weevil).
1881. Larva (fig.). Packard. Ins. Inj. For. & Sh. Tr. 93.

BRENTHIDÆ.

CYLAS FORMICARIUS Fabr.

1879. Egg, larva, pupa. Comstock. Rep. U. S. Dept. Agri. 250.

EUPSALIS MINUTA Dr.

1841. Larva, pupa (brief). Harris. Inj. Ins. Mass. 60 (as *B. septrionalis*).
1855. Larva (brief). Chapuis et Candeze (quotes Harris). Mem. Soc. Sc. Liege. viii. 546.
1862. Larva, pupa. Harris. Inj. Ins. Mass. 63–69 (as *B. septrionalis*).
1874. Larva, pupa (figs.). Riley. 6th Rep. Nox. Ins. Mo. 113–118.
1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 130.
1881. Larva, pupa (figs.). Packard (quotes Riley). Ins. Inj. For. & Sh. Tr. 22.
1887. Larva, pupa (figs.). Harrington. Rep. Ent. Soc. Ont. 32.

CALANDRIDÆ.

RHYNCHOPHORUS CRUENTATUS Fabr.

1873. Larva, pupa, cocoon. Summers. Can. Ent. v. 123 (as *R. Zimmermanii*).
1878. Larva (brief). Horn. Trans. Am. Ent. Soc. vii. 39.

RHYNCHOPHORUS PALMARUM Linn.

1705. Larva (fig.). Marian. Insects Surinam. 48. pl. xlviii.
1796. Larva (fig.). Stedman. Exped. South Am. ii. 22. pl. (as Palmetto weevil).
1803. Larva (brief) Latreille. Hist. Nat. Crust. & Ins. xi. 54.
1806. Larva, pupa (fig.). Shaw. Gen. Zoology Ins. pt. i. 62. pl. xx (as *Curculio palmarum*).

1832. Larva, pupa, cocoon (figs. only). J. D. Mag. Nat. Hist. v. 466 (as *Calandra palmarum*).

1845. Larva, pupa (figs.). Blanchard. Hist. des Insects. pl. x.

SPHENOPHORUS PARVULUS Gyll.

1886. Larva. Forbes. Misc. Essays. 22 (Trans. Agri. Soc. Ill. 1885).
Larva (brief). Brunner. Bull. No. 22. U. S. Div. Ent. 99.

1890. Larva. Forbes. 16th Rep. Nox. & Ben. Ins. Ill. 67 (1887–88).

SPHENOPHORUS ROBUSTUS Horn.

1882. Larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 141-142. pl. viii.

SPHENOPHORUS OCHREUS Lec.

1889. Larva (fig.). Webster. Ins. Life. ii. 132-134.

1890. Larva (fig.). Webster. Bull. No. 22. Div. Ent. 53.

1890. Larva. Forbes. 16th Rep. Nox. & Ben. Ins. Ill. 66 (1887–88).

CALANDRA GRANARIA Linn.

1778. Larva. DeGeer. Mem. v. 360.

1795. Larva. Herbst. Natur. System. vi. 15.

1798. Larva (habits). Geoffroy. Hist. Abr. Ins. i. 285.

1803. Larva, pupa. Latreille. Hist. Nat. Crust. & Ins. xi. 54.

1834. Larva, pupa (figs.). Kerstenstein. Silberm. Rev. Ent. ii. 115-120.

1841. Larva (Biolog. notes). Harris. Inj. Ins. Mass. 70.

1842. Larva, pupa. Kollar. Verh. Landw. Ges. Wien. N. F. i. 139-145.

1846. Larva, pupa. Curtis. Journ. Roy. Agri. Soc. Eng. pt. 1. 97.

1854. Larva, pupa (figs.). Emmons. Ins. N. Y. 102. pl. ii.

1855. Larva, pupa (figs.). Nordlinger. Kl. Feinde. 153-163.

1869. Larva, pupa (figs.). Packard. Guide. 490.

1870. Larva. Westwood. Trans. Ent. Soc. Lond. Proc. 16.

1879. Larva. Fitch. The Entomologist. 41.

1879. Larva. Ormerod. The Entomologist. 51-54.

CALANDRA ORYZÆ Linn.

1841. Larva, (brief). Harris. Inj. Ins. Mass. 70.

1846. Pupa, (fig.). Curtis. Journ. Roy. Agri. Soc. pt. 1, 95.

1848. Larva, pupa. Kollar. Sitzb. Wien. Acad. v. 3.

1854. Larva, pupa (figs.). Glover. Rep. U. S. Pat. Off. 75.

1855. Biological Notes. Rogers. Stett. Ent. Zeit. xvi. 307.

1879. Larva. Fitch. The Entomologist. Feb.

PHLŒOPHAGUS SPADIX Hbst.

1888. Larva (brief). Jülich. Ent. Am. iv. 35.

SCOLYTIDÆ.

PITYOPHTHORUS CONSIMILIS Lec.

Habits. Schwarz. Proc. Ent. Soc. Wash. i. 164.

PITYOPHTHORUS CONCENTRALIS Eich.

Biological Notes. Schwarz. Proc. Ent. Soc. Wash. i. 163.

Pityophthorus annectens Lec.

Biological Notes. Schwarz. Proc. Ent. Soc. Wash. i. 164.
1877. Larvæ. Perris. Larves des Coleopt. 412.

Hypothenemus eruditus Westw.

1885. Egg, larva, pupa. Hubbard. Ins. Aff. Orange. 173.

Xyloterus bivittatus Kby.

1882. Larva, pupa (figs. only). Packard. 3d Rep. U. S. Ent. Com. pl. xiv figs. 1, 1 *a*.

Xyleborus cælatus Eich.

1882. Larva, pupa (figs. only). Packard. 3d Rep. U. S. Ent. Com. pl. xiv. figs. 2, 3.

Xyleborus xylographus Say.

1857. Egg, larva, pupa. Fitch. 4th. Rep. Nox. Ins. 720 (Trans. N. Y. Agri. Soc.).
1881. Egg, larva, pupa. Packard. Ins. Inj. For. & Sh. Tr. 165.

Xyleborus pyri Peck.

1819. Larva (biol. notes). Peck. Mass. Agri. Rep. v. 307–313.
1826. Larva (biol.). Peck. Zoo. Journ. 387–402.
1841. Larvæ (notes). Harris. Inj. Ins. Mass. 75.
1889. Biological notes. Schwarz. Proc. Ent. Soc. Wash. i. 138.

Dryocœtes affaber Mann.

1881. Larva, pupa (figs.). Packard. Ins. Inj. For. & Sh. Tr. 243.

Tomicus pini Say.

1858. Fig. of Galleries. Fitch. 4th Rep. Nox. Ins. 722 (Trans. N. Y. Agri. Soc. 1857).
1881. Pupa (fig.). Packard. Ins. Inj. For. & Sh. Tr. 169.

Tomicus calligraphus Germ.

1858. Burrows. Fitch. 4th Rep. Nox. Ins. 721 (Trans. N. Y. Agri. Soc. 1857).

Scolytus 4-spinosus Say.

1873. Larva, pupa (figs.). Riley. 5th Rep. Nox. Ins. Mo. 103-108.
1874. Larva, pupa (figs. only). Le Baron (after Riley). 4th Rep. Nox. Ins. Ill. 146.
1876. Larva, pupa (figs. only). Thomas (after Riley). 1st Rep. Nox. Ins. Ill. 145.
1881. Larva, pupa (figs.). Packard (after Riley). Ins. Inj. For. & Sh. Tr. 73.

Scolytus unispinosus Lec.

1886. Larva (borings). Smith. Ent. Am. ii. 125.

Scolytus rugulosus Ratz.

1837. Larva (biol. notes). Ratzeburg. Forst. Insect. i. 185.
1884. Larva (habits). Hagen. Can. Ent. xvi. 161.
1855. Larva (biol. notes). Nördlinger. Kleine Feinde. 187.
1867. Larva (biol. notes). Gourean. Ins. Nuis. aux Forets. 97.
1886. Larva (habits, etc.). Scudder. Can. Ent. xviii. 195.
1888. Larva (biolog. notes). Lintner. 4th Rep. Inj. Ins. N. York. 103–107.

Hylesinus trifolii Müll.

1807. Larva (biol. notes). Müller. Avis sur. une spece de Bostriche. 64.
1844. Larva. Schmitt. Ent. Zeit. Stett. v. 389–397.
1879. Larva, pupa (figs.). Riley. Rep. U. S. Dept. Agri. 248. pl. v. (1878).
1880. Egg, larva, pupa (figs.). Anony. Am. Ent. iii. 180.
1881. Larva, pupa (figs.). Lintner. Rep. N. Y. Agri. Soc. 16 (1880).
1881. Larva, pupa (figs.). Saunders. Rep. Ent. Soc. Ont. 43.
1881. Egg, larva, pupa (figs.). Chase. Trans. Wis. Agri. Soc. xix. 465 (1880–81).
1884. Larva, pupa (figs.). Buckhaut. Agricul. Penn. 215.
1887. Larva, pupa (figs.). Cook. Beal's Grasses N. Am. i. 375–378.

Dendroctonous terebrans Oliv.

1841. Larva (brief). Harris. Inj. Ins. Mass. 72.
1857. Larva (brief). Fitch. Rep. Nox. Ins. N. Y. 728 (Trans. N. Y. Agri. Soc. 1858).
1876. Larva (brief). Thomas. 1st Rep. Nox. Ins. Ill. 146.
1881. Larva (brief). Packard. Ins. Inj. For. & Sh. Tr. 175.

Crypturgus atomus Lec.

1882. Larva, pupa (figs. only). Packard. 3rd Rep. U. S. Ent. Com. pl. xiv. figs. 4, 5.

Hylurgops pinifex Fitch.

1882. Larva (fig.) Packard. 3rd Rep. U. S. Ent. Com. pl. xiii. fig. 4

Phlœosinus dentatus Say.

1858. Borings. Fitch. 4th Rep. Nox. Ins. 750 (Trans. N. Y. Agri. Soc. 1857).

ANTHRIBIDÆ.

Cratoparis lunatus Fabr.

1855. Larva. Chapuis et Candeze. Mem. Soc. Sc. Liege. viii. 540.

PROCEEDINGS.

Meeting of October 3d, 1890.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Seven persons present.

OBJECTS EXHIBITED.

1. Bermuda Grass, *Cynodon dactylon*, inflorescence : by P. H. Dudley.

2. A sub-stage condenser : by J. D. Hyatt.

President Dudley furnished a description of his exhibit as follows :

"The specimen of Bermuda Grass exhibited is from the New Orleans and North Eastern Railroad embankment, in Mississippi, and was collected in June, 1890.

"'It is a low creeping perennial grass, with abundant short leaves at the base, sending up slender, nearly leafless culms, which have from three to five slender diverging spikes at the summit. The spikelets are sessile in two rows on one side of the slender spikes ; they each have one flower with a short pediceled naked rudiment of a second flower ; the outer glumes nearly equal, keeled, the flowering glume boat-shaped, broader and prominently keeled.' (Vasey.)

"This beautiful little grass in many parts of the South is of great value in protecting railroad embankments and levees from washing. Once planted it is extremely difficult to eradicate, soon re-grassing the roadbed, when ties have been renewed or other repairs made. In most cases the entire roadbed would be covered, the only portion of the track visible being the two bright surfaces of the line of rails. I did not notice the spikelets rising but one or two inches above the top of the rails, yet in some places so many were crushed on the rails by the drivers that the adhesion of the locomotive was affected.

"Though the Bermuda Grass is a native of tropical countries it rarely seeds in the Southern States, and is propagated by planting small pieces of its sod a few feet apart, the grass quickly growing and filling the entire space. It thrives in the hottest weather, and is little affected by drouth. The tops are killed by the frost, though the roots are hardy. The stability it gives to a railroad embankment, or a levee is astonishing. In this respect it is unequalled by any other grass."

Mr. Hyatt stated that the condenser which he exhibited was constructed by himself on the principle announced some time since by Prof. Alfred M. Mayer ——— three plano-convex lenses, the largest one, of two inch focal distance, with a central stop, placed below, and two smaller lenses, paired, with their convex surfaces opposed to each other, and placed near the under surface of the stage. The combination gives an excellent dark ground illumination.

A discussion was held upon the atmospheric discoloration of the "Abbe glass." Specimens were exhibited, and were commented upon by Mr. Wales.

Meeting of October 17th, 1890.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Twenty persons present.

OBJECTS EXHIBITED.

1. Spider crab, *Libinia canaliculata*, zoea stage : by Ludwig Riederer.
2. Mantis shrimp, *Squilla empusa*, alima stage : by Ludwig Riederer.
3. Fore-tibia of the grasshopper, *Scudderia curvicauda* Serv., with auditory organ : by J. L. Zabriskie.
4. Moult of fore-tibia of *Orchelimum glaberrimum* Burm., with auditory organ : by J. L. Zabriskie.
5. Malachite from Paterson, N. J.: by James Walker.
6. Azurite from Paterson, N. J.: by James Walker.
7. Fungus in solution of cocaine : by Frank D. Skeel.
8. Sections of leaf of Long-leaved Pine of Colorado : by P. H. Dudley.

Dr. Dean remarked upon Mr. Riederer's exhibit of the alima stage of *Mantis* as an especially interesting slide.

A discussion upon the tenacity of life and the reproduction of lost parts among the crustaceæ was participated in by Messrs. Leggett, Dean, Lockwood and Helm.

Mr. Zabriskie said that the green grasshoppers in general are furnished with curious structures situated on either side of the vertically flattened and enlarged proximal portions of the fore-tibiæ, which structures are said to be auditory organs. The tibia of *Scudderia* exhibited shows two elliptical structures, exactly opposed to each other, on the inner and outer surfaces of the leg, furnished with prominent rounded rims, and plainly seen by the unaided eye. When magnified, these elliptical enclosures are seen to be crossed by many fine transverse striæ. Exhibit No. 4 is from a specimen of *Orchelimum* which moulted in captivity. It is mounted so that a view is obtained from directly in front. A longitudinal slit can be observed in each elliptical enclosure, through which slits a view can be had into the interior of the moult, probably indicating that here, in the act of moulting, some delicate structures are torn away, which formerly maintained communication with the interior.

Dr. Skeel said his preparation was from an eight per cent. solution of cocaine, which three months ago was clear, but which now presented these forms of fungus.

Mr. Stephen Helm announced that he had been successful in finding at Greenwood Lake, amongst a good many other beautiful forms, the fresh water Zoophytes, *Lophopus crystallinus* and *Alcyonella fungosa*. The latter were in the ordinary orthodox cœnœcia. But in the lakes in Prospect Park, Brooklyn, by dredging, he had found *A. fungosa* in the most extraordinary abundance, and in colonies varying from the size of a bantam's egg to that of a man's head ; one in particular, of a pointed elliptical form, he found by actual measurement, was fourteen inches in the long, and eight inches in the short, or central diameter. On the estimate of 250 to the square inch, for the lophophores are quite close together, this particular colony must have contained the enormous number of nearly 100,000 individuals.

They were found encrusting the stems of water plants at Greenwood, and submerged twigs and branches of trees at Prospect Park, and were solid throughout the entire mass. The branch which held the large specimen also held six or eight others nearly as large. The whole would have filled three or four pails.

His object in bringing these finds before the Society was two-fold :—to notify the members as to the localities of these forms, and to place on record the enormous size the cœnœcia sometimes attain under favorable circumstances. Prof. E. Ray Lankester, *Encyc. Brit.* 9th ed. xix. 437, says, "*Alcyonella* forms massive cœnœcia of many hundred polypides, as large as a man's fist." And again, "All the genera known are British."

Mr. Walter H. Meade announced the death, on June 28th last, of Mr. William R. Mitchell, a member of the Society. The following committee was appointed by the chair to formulate suitable action in this matter: Walter H. Meade, J. L. Zabriskie and A. Woodward.

The Recording Secretary, Dr. Dean, gave notice of his intended absence for three months, and Mr. George E. Ashby was elected Recording Secretary *pro tem.*

Meeting of November 7th, 1890.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Sixteen persons present.

A communication from the New York Camera Club was read by the Secretary, inviting the Society to an exhibit of reproductions by various photographic processes.

On motion the invitation was accepted, and the Secretary was instructed to transmit the thanks of the Society for the same to the Camera Club.

OBJECTS EXHIBITED.

1. A *Pycnogonum*: by Ludwig Riederer.
2. *Obelia commissuralis* McCready: by Ludwig Riederer.
3. Pollen of Cotton Plant: by P. H. Dudley.
5. Pseudo-scorpion: by J. L. Zabriskie.
6. Nest of Pseudo-scorpion: by J. L. Zabriskie.
7. Section of Cinnabar in chalcedonic quartz: by J. D. Hyatt.
8. Foraminifera, with dark field illumination: by J. D. Hyatt.

FROM THE CABINET OF THE SOCIETY.

9. Section of Chlorite Schist from France.
10. Section of Argillyte from Wales.
11. Section of Sherzolyte from France.

Mr. Riederer described his exhibits as follows: "*Pycnogonidæ* or *Pygnogonidæ* were placed formerly by Milne-Edwards among the Crustaceæ. At present they are placed between the mites and spiders among the Arachnida, although they possess a greater number of appendages than either, inasmuch as the males have an accessory pair of legs, used in carrying the eggs. They are small animals with a conical suctorial proboscis, and rudimentary abdomen reduced to a tubercle. They live in the sea, and crawl slowly about amongst the seaweeds. They have four pairs of very long many jointed legs, which contain tubular diverticula of the stomach and the sexual organs. They have no tracheæ, but have a well-developed heart with an aorta and several lateral ostia. Above the brain lie four small simple eyes. They have a considerably extended ventral chain, composed of several glanglia. The eggs are carried on the accessory pair of legs on the thorax of the male, until the larvæ are hatched.

"*Obelia commissuralis* is a Hydromedusa, belonging to the Polynomedusæ, or Hydrozoa. The individual polyps are joined in a colony. The chitinous tubes widen out around the head to form a cup-like hydrotheca. The head, the oral cone and the tentacles can be retracted into the hydrotheca. The generative buds arise on the walls of the proliferous individuals, which have neither mouth nor tentacles. The buds form, in *Obelia*, flat, disk-shaped Medusæ, with numerous marginal tentacles, but with eight inter-radial vesicles. The urn-shaped reproductive capsules discharge the small Medusæ, and these swim freely for some time, until they fasten to suitable places and form new colonies. The Hydromedusæ feed entirely upon animal substances, and are most common in warm seas. The free moving Medusæ are phosphorescent. *Obelia* occurs at low water mark and in tide-pools, attached to stones and seaweeds. It is very delicate and much branched, and sometimes grows five or six inches high, though usually smaller."

Mr. Zabriskie said of his exhibits : "The Pseudo-scorpions are distinguished from the true scorpions by the absence of a tail and by a difference in the mode of respiration. They are related to the spiders, spin a web for protection during moulting and hybernating, and are classified with the Arachnida. They have two pairs of pincers : a large pair, the palpi, extending on either side, and a small pair, the falces, lying close together in front of the head.

"The nest here exhibited was found in February, 1884, with the occupant dead therein, it having died in the act of moulting. This nest is composed of an oval cocoon-like web, flat and very delicate on the under side, convex and firmer on the upper side, and strengthened all around the margin by glued fragments of sawdust.

"In August, 1884, two house-flies were observed alighting at a dish of fly-poison, each fly having a living pseudo-scorpion clinging to a middle leg with a firm grip of the palpus. The flies made exertion to brush off their antagonists, but when the flies rested the scorpions would take a fresh and firmer hold."

Mr. Hyatt stated that it was unusual to find cinnabar in quartz. In his section, here exhibited, there was an appearance as of free quicksilver. Mr. Hyatt also further described the construction and operation of his substage condenser as noted at the last meeting, and with which he secured the dark field illumination for his exhibit of Foraminifera.

This led to a discussion on condensers, which was participated in by Mr. C. S. Shultz and others.

Mr. F. W. Leggett announced that he had kept for two weeks fiddler crabs in fresh water, where the crabs had been accidentally introduced, and that the creatures appeared to be thriving. This opened a discussion, participated in by Dr. Hoffmann and Messrs. L. Riederer and A. Woodward.

Meeting of November 21st, 1890.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Twenty-four persons present.

The chair appointed the following committee on Nomination of Officers: Messrs. F. W. Devoe, William G. De Witt and Walter H. Mead.

Mr. William Beutenmüller read by title a paper, entitled "Bibliographical Catalogue of the described tranformations of North American Coleoptera." This Paper is published in the present number of the Journal, p. 1.

OBJECTS EXHIBITED.

1. *Amœba proteus*: by George C. F. Haas.
2. *Euglena viridis*: by J. D. Hyatt.
3. *Epistylis* sp., from *Belostoma*: by J. L. Zabriskie.

4. *Clathrulina elegans :* by STEPHEN HELM.

5. *Actinosphærium Eichhornii :* by STEPHEN HELM.

Mr. Stephen Helm, of 417 Putnam Avenue, Brooklyn, N. Y., addressed the Society on "The Protozoa." This address opened with an exhibit and explanation of the collecting apparatus employed by Mr. Helm, and was illustrated by numerous enlarged and beautiful diagrams, and by reference to the objects exhibited under the microscopes.

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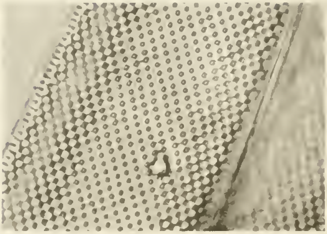
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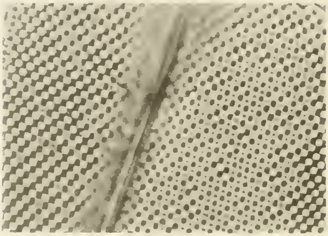
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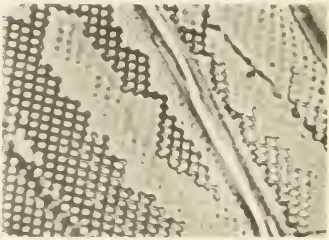
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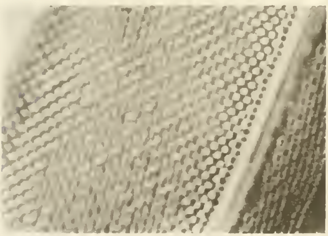
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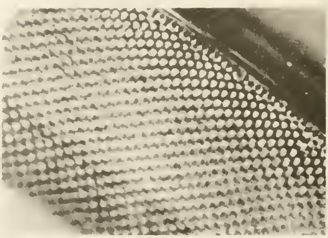
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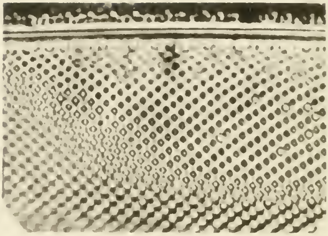
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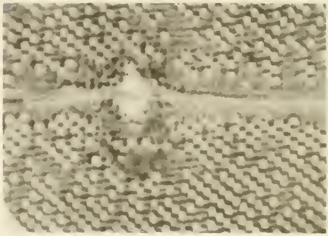
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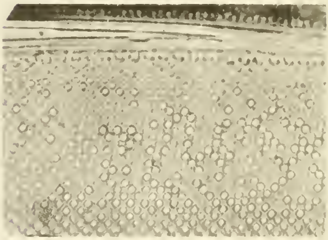
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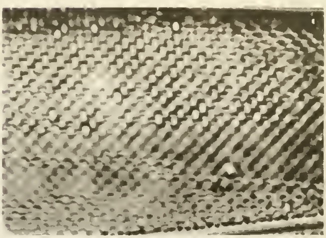
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T. F. SMITH ON THE STRUCTURE
OF THE
PLEUROSIGMA VALVE.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. VII. APRIL, 1891. No. 2.

ON THE STRUCTURE OF THE PLEUROSIGMA VALVE.

BY T. F. SMITH, F.R.M.S.

(*Read January 2d*, 1891.)

On September the 28th, 1888, I had the honor of reading before the Quekett Club a paper bearing the above title, in which I attempted to prove that the supposed single plate of silex forming the pleurosigma valve was, in reality, built up of two or three layers of structure.

That this idea of mine was not a new one I subsequently discovered and admitted in a paper on the same subject, read by me before the Royal Microscopical Society, in which I quoted the remarks of Herr Grunow and Mr. Kitton on the subject. I also have taken the opportunity in this paper of bearing testimony to the labors of Dr. Jacob D. Cox in working out the structure of the diatom-shell; who, although he makes no positive statement on the pleurosigma valve, says that certain appearances are "not inconsistent with a double structure."

Incidentally I may say that after arriving at a certain stage of my work I searched through the collections of photographs of diatom-structure belonging to the Royal Microscopical Society, and found Dr. Cox's prints of *P. angulatum* to be the only ones giving a correct rendering of one of the layers—the one shown in my slides Nos. 35, 36, and 37 of that diatom.

The reason is very simple: This layer can only be distinguished from the one on the other side of the valve by the use of a large cone of light; and having so distinguished it, I think America can claim in Dr. Cox the first worker in photomicrography under those new, and the only true, conditions.

But, while making no claims now to be the first to originate this idea of a compound structure in the finer forms of diatoms, I think I may claim to have been the first to attempt to photograph the different layers; not from possessing any superior powers of observation, but because the work was only possible after the advent of the new apochromatic lenses from Germany.

When we consider the difference between the actinic and the visual foci in the best lenses of the ordinary achromatic correction when used photographically, and also the infinitesimal distances which must separate the different layers in the valves of the minute forms of diatoms, it will be seen at once how utterly impossible it would be to make any allowance fine enough to bring the particular layer aimed at sharp in focus on the negative. The reduction, however, of the secondary spectrum in the apochromatics entirely obliterates this difference, and what is seen sharp on the focussing screen may be depended upon to be sharp in the negative, given correct exposure and development.

This capacity of standing more light was pointed out from the first by Mr. E. M. Nelson, but has not received the attention it deserves; and the neglect of this point has stultified the efforts of many microscopists, both here and on the Continent, to get more out of the new glasses than the old objectives. Unfortunately, the most flagrant examples of "how not to do it" come from the very workshop which produces the glasses, and Dr. Roderick Zeiss' celebrated print of *P. angulatum* shows how an oil-immersion apo: of 1.3 N. A. may be made to perform no better than a good dry $\frac{1}{4}$-inch.

The conclusion arrived at in my first paper is that the valve of *P. formosum*—as being the one most easily studied from its coarse structure—consists of three layers, figured as Nos. 1, 2, and 5 in the plate belonging to that paper.

The figures may still be taken as correct representations of the layers, but I am afraid this is the only part not rendered obsolete by subsequent observations by myself, and most of the theories proposed there must be thrust aside as crude deductions from imperfect observations. The figures of *P. formosum* may stand, but that given of the middle layer is not the middle layer at all in the sense of its occupying the centre of the section of the valve. To understand its position it must be remembered that in section the valve is V-shaped (Fig. 1); No. 1 being the inner, No 3 the extreme outer side of the valve, and No. 2 immediately under No. 3, and optically, but not structurally, a part of it. When I say optically a part, I mean that had I not seen them separated I should never have ventured to declare them different layers. Nos. 1 and 2 are comparatively robust in structure, while No. 3 is exceedingly fragile and often seen lying in strips on the face of the valve; and it is from the fact that under these circumstances No. 2 is still found sound I have been able to differentiate the two. This difference of curve between the two sides of the valve is seen to run through all the species of *Pleurosigma*, although in none of them are they so pronounced in character as in *P. formosum.* This difference always corresponds with a difference of

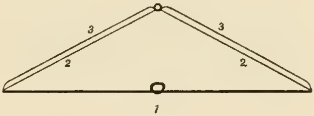


FIG. 1.

appearance, and although I do not believe the variation, structurally, between the two sides of some of them is much, it must be enough to account for the difference.

The first four of the series of lantern slides sent to illustrate this paper are numbered 1, 2, 3, and 4, and represent the three layers of the valve of *P. formosum;* Nos. 1 and 2 being taken from the inner side and showing it to be nearly flat in section. The structure of this layer seems to be a square grating set lengthways on the valve, and its peculiarity is that on the same plane the focal images are formed in the alternate squares of the grating only, giving the usual appearance of the diagonal markings. On the outer focus the alternate holes are red, the interspaces white, as in slide No. 12; but on focussing inward the white interspaces turn into green "beads," and the outer red interspaces become white. This red and green is not merely a negative and positive image of the same structure, but formed in entirely different positions (Fig. 2), the "X" marking the red, and the "o" the green. Taking note of the difference of the colors in the alternate holes of a grating may seem trivial to a biologist marking out, say, the life history of some obscure organism, but in reality it points out a valuable quality belonging to an apochromatic lens only and helping to call attention, in all branches of microscopic research, to points which else might escape attention. I say this advisedly, having tested some of the finest glasses of our English makes, but not apochromatics, on this object; and although the two sets were shown in their proper positions, they were both of the same color, and thus the different positions likely to escape notice. I have not yet been able to discover the cause of the two sets of images in this layer. There is no difficulty about the outer red ones being simply the alternate holes of the grating; but I can find no cause for the inner green

O	X	O	X	O	X	O	X	O	X	O	X
X	O	X	O	X	O	X	O	X	O	X	O
O	X	O	X	O	X	O	X	O	X	O	X
X	O	X	O	X	O	X	O	X	O	X	O

Fig. 2.

"beads," although it may point to a second grating inside on which they are received as on a screen.

The difference of appearance between the two sides of the valve is most characteristic and one not to be mistaken when once seen and noted, and is well shown on slides Nos. 12 and 13—No. 12 being the inner and No 13 the outer side of the valve.

As I have said before, the structure of the outer part of the valve is really divided into two—Nos. 2 and 3 in Fig. 1—but it is with the outer one of the two, as offering numerous examples of torn structure, we have chiefly to deal. I have been able, fortunately, to determine its character with absolute certainty, and also probably to obtain a key from it of the structure of the other two layers of the valve; but the results I propose to lay before you are so little in accordance with any theory of structure hitherto accepted by diatomists, that I can well understand any reluctance there may be to receive them as true. I certainly should have hesitated to accept them myself, had they not been forced upon me by the continual work of nearly three years in a manner which left me no room to come to any other conclusion. My state of mind on beginning to work on a dry slide of *P. formosum* was one of utter bewilderment at the variety of appearances presented by the different valves, and my first impulse was not only to throw up the work, but also the microscope, in disgust, as giving no image of any structure which could be depended upon. After a time, however, I began to classify the appearances by observing that it was different sides of the same diatom presented to me, and, given the same side, the same appearance. After this my work became easy, and all my subsequent work a natural outgrowth from the labors preceding.

In coming before you with a brand-new theory of diatom-structure—as far, at least, as the *Pleurosigma* are concerned—I know the difficulties of the subject; how easy it is to mistake interference phenomena for new structure; how even the assumption by me of different layers would put me out of court on the laws

FIG. 3.

of these phenomena alone, did I attempt to base my theory on these appearances only. But I have made no such attempt, have never assumed the truth of any appearance until I have examined the structure causing it, by seeing it isolated from anything above or below. This I have been fortunate enough to do in numerous instances, and, after you have seen the results on the screen, will leave it with confidence to your judgment to decide whether I have been deceived in my conclusions or not.

The ultimate structure of the outer layer of the outer, or convex, side of *P. formosum* is seen in slide No. 9, and consists of a long fibril subdivided into short bars (Fig. 3), but how joined together I have not been able to discover. These fibrils are placed side by side lengthways on the valve, and run from end to end, and when perfect the appearance is as in Fig. 4, as plainly shown around the nodule in slide No. 11. When the structure is perfect, a white focal "bead" is formed in each of the larger interspaces and the whole run diagonally across the diatom, as in slides Nos. 5 and 13. On focussing inward you lose the bright spots and come upon a grating running diagonally across the valve—as in slides Nos. 3, 6, and 8—and it will be seen that the holes of the diagonal grating lie immediately under the larger interspaces left between the fibrils. I believe these round white patches to be only ghosts, or, in other words, images of the inner layer thrown on the outer as on a screen, in proof of which I submit slides Nos. 7 and 8. In No. 7 the fibrils are distinctly seen running parallel to the median line, but only some of the interspaces are filled up, and on focussing down you discover the cause. In the under layer the holes are irregular in size, and it is only from the larger ones that the images are thrown. The outer layer often appears as if formed of definite squares, but I have no reason to believe there are any actual cross-bars, for directly the torn fibrils begin to diverge from each other, as in parts of slide No. 11 already referred to, cross-lines disappear.

Fig. 4.

There is nothing to say, that I know of, against the idea of a regular grating; but when we get positive evidence to the contrary, a merely reasonable interpretation of appearances must give way to actual fact. It may be easily seen, however, on referring again to Fig. 4, how an appearance of cross-lines may be brought about.

Having done my best to establish the nature of the structure of the different layers of *P. formosum*, it remains to see how far the structure of the valves of the minute forms of this genus are identical with it. Similarity of form in itself should almost be enough to establish a unity of structure, and it satisfied myself a long time before I had obtained positive evidence to support it. But proof to one's self does not mean proof to others, and it was necessary to complete the evidence by offering sufficient examples of torn structure from each typical species to prove the identity. But before going on to this I would mention a few salient points common to all the *Pleurosigma*, and which hitherto seem to have escaped attention. There is first the difference of curve between the two sides of the valve—flat on the inner and convex on the outer—common to all, and with it the different appearance presented optically; secondly, all the valves of this species characterized by diagonal "markings" have a row of coarser perforations running parallel to the margin of the valve, and also a row of similar ones on each side of the median line, making altogether four rows on the face of each valve ; and, lastly, the nodule shows a characteristic difference on the two sides of the valve. On the one side it seems simply a cavity with the larger perforations running around, while on the other side it seems to be formed as a ring connecting the two halves of the median line. The four parallel rows, however, of larger perforations present the most characteristic features in common, and many of the specimens thrown on the screen from *P. formosum* downward will show them distinctly.

The finer specimens will mostly explain themselves, coming after *P formosum ;* for convenience of comparison with which I have taken some of the latter at half the number of diameters, that the detail may appear of about the same minuteness as the finer forms. Except that of *P. angulatum*, all my negatives have been taken from two slides of *P. formosum*, and for a long time I was unable to get any positive evidence of the finer structure of *P. angulatum* much different from the usual appearance, although there was no doubt about its resemblance in the general features to the coarser forms. But latterly I have been more fortunate, and am able to present a series of slides of that diatom which establishes beyond a doubt the identity of its structure with the other forms of the genus to which it belongs. Altogether, then, we have examples of four different species, differing vastly in size and shape, but in the finer structure all present the same features. I admit that examples of torn structure in the last three typical forms, although numerous enough to prove my point, do not offer the same extent of torn surface to study from as *P. formosum ;* but, under certain circumstances, this would be scarcely possible. *P. formosum* has the structure twice as coarse as the other forms, and the mechanical pressure exerted on them in mounting being the same in both cases, what would be sufficient force to separate the fibrils only, and still leave them sound in the one, would simply, in the others, smash them into bits so small as to be useless for purposes of investigation.

This is so generally ; but in places enough of the structure is left intact to establish its identity, and I need not say that, having once found out what a chain is, there is no difficulty afterwards in proving that a link is a part of a chain, even if we can find no more than that link. In *P. formosum*, as we have seen, we find whole chains ; in the finer forms only occasional links, but unmistakably belonging to the same sort of chain.

The first slides of *P. angulatum*, Nos. 35, 36, 37, and 38, are taken (three of them across the nodule) to show the different curves of the two sides of the valve ; Nos. 35. 36, and 37 being from the inner side, and No. 38 from the outer. It will be seen that on the inner side the surface starts straight from each side and curves down towards the median line, while the outer starts straight from the median line and curves down towards each margin. The outer, or convex side, like the corresponding side of *P. formosum*, is the one from which all my torn examples are taken, and is absolutely identical in character ; but beyond *P. decorum* I have been unable to discover any diagonal layer immediately underneath. The non-discovery of this may be due to two reasons : it may not exist at all, or the two may be so close together that even the little depth of focus of a wide aperture may be too much to allow them to be separated, in which case they would be microscopically non-existent. I have made experiments to this purpose on *P. formosum* with a dry apochromatic ¼-inch of .95 N. A , and found that the torn structure could not be seen with it when lying at the usual distance above the valve, but when the valve had sunk down—increasing the normal distance between the two layers—they could be seen readily enough ; indeed, when floated off the valve altogether they could be seen with a one-inch of very moderate angle. I can offer no evidence, therefore, of the existence of a double layer on the outer side of the finer forms, although analogy may tell us there should be one, and must leave it at present as not proven.

The first two slides of the inner side, Nos. 35 and 36, taken on the same spot, will give you both squares and hexagons, and you must take your choice between them ; for, having no examples of torn structure from that side of the valve, beyond a notched edge, I do not care to speak absolutely. Other examples, however, from the outer side, will show you how hexagons can be made, and you can form your conclusions accordingly.

Slides Nos. 40, 41, and 42 are taken at different focal planes on the same valve, which shows the surface abraded and two isolated fibrils running lengthways on the valve. The difference of appearance on the sound parts is considerable and varies from long rectangles on the upper focus to decided hexagons on the lower, while the only difference it makes on the fibrils themselves is just to thicken them a little. The same thing happens also on slides Nos. 47 and 48, taken with a little difference of focus, where we have squares on the upper and hexagons on the lower, while the free ends of the torn fibrils suffer but little change.

All my remarks up to now apply to the species having diagonal "markings" only ; but the last slide of the list is taken from *P. balticum*, as an attempt to give a general idea of the difference of the structure between the two. Here we have still fibrils, but apparently of one continuous strand with swellings at regular intervals, which, lying side by side of the others, with the knobs nearly touching, give the appearance of squares.

In conclusion it may be necessary for me to say something about my methods of investigation, that no outstanding doubts may be left as to the correctness of my conclusions. This is all the more binding on me, as Dr. Cox has kindly told me that "I had need to tell the details of my examination so fu ly as to repel the possibility of doubt that the matter is in no sense illusory." I accept the invitation most cordially, as every practical microscopist will know that the method of investigation is everything.

First, as to illumination : I use a strictly central cone of light, collected first from the edge of the lamp flame by a bull's-eye condenser before being further condensed by the achromatic condenser. In this way I get a more intense illumination. Indeed, I found it impossible to differentiate some of the structure without it. My achromatic condenser is a dry one, and with the bull's-eye will give me all the light the lens will stand. In theory, of course, the whole of the aperture can only be utilized by the aid of an oil-immersion condenser. Granted the back lens of the combination can be only filled that way ; but the objective which can be so used without breaking up the image has yet to be made, in Europe at least.

The slides from which I have taken my examples are two slides of *P. formosum* and one of *P. angulatum*, mounted dry by Möller; but I have verified my observations on a type-slide of *Pleurosigma* mounted by Thum, also on dry mounts by the same mounter and on a slide of *P. formosum* mounted in phosphorus by Mr. Stephenson, F.R.M.S., to prove there is nothing abnormal about the structure.

All my specimens have been tight on the cover, that the full available aperture of the lens might be used on them; and in some instances, when there has been a doubt raised by others whether some of the appearances might not be due to some of the objects being off the cover, they have been tested by the vertical illuminator.

I have never taken a single photograph of any structure without thoroughly working it out visually first, that every point might be known to me before attaching the microscope to the camera; and each hour's work there means six hours at least of previous investigation.

The question is sometimes asked, "What is a true focus?" and I admit that without certain landmarks the question is a puzzling one, as the image will keep repeating itself both in and out of focus. But to me those landmarks always exist, and in the structure I have been working at will be found in the leading features, such as the median line and the rows of larger perforations I have before mentioned. Thus, in comparing slides Nos. 35 and 38, the former gives what Mr. E. M Nelson calls the black dot, and the latter the white dot; but a little higher focus on each will reverse them. The question then comes in, Which is right? and the answer is found in the median line with its two rows of perforations in one case and the margins in the other. In both cases you can reverse the image by raising the focus, but at the same time you lose the salient points of the valve. But, quite apart from this, there is a crispness and brightness about the image when at the true focus which cannot be mistaken by an expert.

The image of diatom-structure with an apochromatic is absolutely colorless, making the slides exhibited a true rendering of the appearances in the microscope—that is, with all the upper layers; but where I have taken an under layer on the same valve, air comes between and the image has suffered—will, in fact, be recognized by you at once by its dull tone, and I wish you to draw no other inference from it but to see that there is another structure underneath.

On the slide No. 34 will be found in the centre a single layer of a fine species allied to *P. angulatum*, and at the side a part, I believe, of the same valve with the both layers intact ; and a study of the changes which take place in both on focussing up and down enables me to draw certain deductions, for my own guidance at least.

In the single layer there are no changes whatever beyond a change from a positive to a negative image up and down, and then the object vanishes altogether ; but on the other fragment there are six changes at least, proving the structure to be more complicated.

It will then, I think, be safe to argue that when the object under investigation changes from more than a positive to a negative image ; when, after losing, or almost losing it, you come upon another distinct image, either higher or lower, it proves this, at least : that the structure you are examining is a compound one, although I need not argue from it that the appearance you get is necessarily the true one.

The inference I would draw, then, from certain appearances on the surface, would be a limited one, but within those limits to be trusted. Thus, where you see squares or hexagons, it is not necessary that there should be squares or hexagons in the structure ; but it may be safely inferred that the recurring distances of the image represent the true distances of the actual structure. There is, in fact, with any legitimate use of the objective, no doubling and trebling of the lines as represented in influential quarters, but a correct rendering of distances if within the resolving power of the aperture, as shown by me in my " Note on the Abbe Diffraction Plate," published in the July number of the *Quekett Journal* for 1889.

Knowing my Abbe Diffraction Plate well, then, I have come to no conclusions on appearances only, and have formed no definite opinions on any structure until I have seen it isolated ; and can leave the results with all the more confidence in your hands.

LIST OF LANTERN SLIDES REFERRED TO IN THE PAPER "ON THE STRUCTURE OF THE PLEUROSIGMA VALVE."

BY T. F. SMITH, F.R.M.S.

1. *P. formosum.* Inner side of valve seeming to consist of a square grating. in which, when perfect, a focal image is formed in the alternate squares. × 1750.

2. The same. Same side, but another valve—one of the sides, from the margin inward, shows appearance when perfect. × 1750.

3. The same. Layer immediately under No. 4 on the outer side of valve, and seems to consist of a robust diagonal grating. × 1750.

4. The same. Layer immediately over No. 3, above the median line. The under structure has sunk down, leaving the long triangular bit adhering to the cover. × 1750.

5. The same. Layer on the outer side of the valve, sound. × 1750.

6. The same. The diagonal grating immediately under, sound. × 1750.

7. The same. Same layer as No. 5. but images showing in patches.

8. The same. Grating immediately under showing cause of patchiness. The holes in under grating are either some of them stopped up, or all the parts of the grating are not on the same level.

9. The same. Ultimate structure of layer No. 4, consisting of short bars of silex arranged as an irregular fibril. × 1750.

10. The same. Ultimate structure arranged on the valve, but stripped off in places. The diagonal lines represent the No. 3 grating underneath, out of focus. Note how the bright focal spots are caught between the fibrils. × 1750.

11. The same. Same structure arranged to form squares around the nodule. It will be seen that in some places the appearance is that of a square grating with well-defined cross-bars, but when the fibrils diverge from each other the cross-bars are lost. I am inclined to think the cross-bars an optical illusion. × 1750.

12. The same. Inner side of valve, same as No. 1, magnified 875 times only, that the detail may appear of the same size as the smaller species, such as *P. angulatum.* This valve is perfect and does not show the grating except at one edge. On focussing inward all the white interspaces form into green "beads." × 875.

13. The same. Outer layer, same as No. 4, perfect. Median line appears at the edge, but on focussing down that part of the valve is seen shelving down, showing the outer side of the valve to be V-shaped in section. × 875.

14. The same. Torn structure from same side, some of which has floated off from the valve altogether. Note the diagonal lines underneath. × 875.

15. *P. angulatum* (?). Same side, but another valve. Note fibril where marked with a cross, to compare with same structures on finer specimens. × 875.

16. *P. decorum.* Outer side. Underneath is the same diagonal grating, which I have not figured. × 1750.

17. *Pleurosigma* sp. Small species shown where marked with a ×. This is the species from which the next nine slides are taken.

18. The same. Under layer, with a hole clean through in one part. × 1750.

19. The same. Same valve, outer layer, with fibrils projecting over part of hole. × 1750.

20. The same. With torn fibrils, outer layer. × 1750.

21. The same. Under layer of same valve, showing long strip and hole torn out, which the fibrils shown on No. 20 have bridged over. × 1750.

22. The same. With bit chipped off the edge and fibrils lying loose. × 1750.

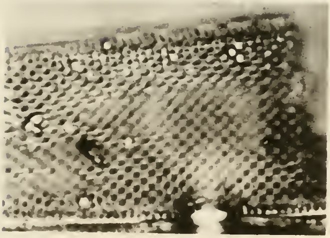
23. The same. With fibrils unravelling. × 1750.

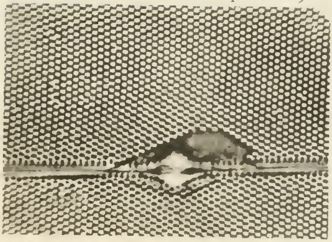
24. The same. Another part of same valve. × 1750.

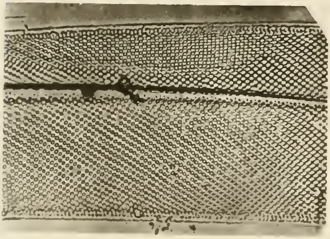
25. The same. Surface abraded, and showing fibrils on parts of valve. × 1750.

26. The same. Inner side of valve, corresponding to No. 1 layer of *P. formosum.* × 1750.

27. *Pleurosigma* sp Specimen marked with a ×, and the same species from which the next six slides are taken.

11 

 38

12 

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T. F. SMITH ON THE STRUCTURE
OF THE
PLEUROSIGMA VALVE.

28. The same. Outer side with torn structure. × 1750.

29. The same. Layer immediately underneath. × 1750.

30. The same. Showing the two layers at one view. × 1750.

31. The same. Layer underneath. × 1750.

32. The same. Outer layer, showing fibrils, perfect but only occasional focal images. × 1750.

33. The same. Layer underneath. × 1750.

34. *Pleurosigma* sp. Single under layer of a fine species of a *Pleurosigma* detached from the outer. At the side will be seen a part of the same valve, I believe, with the both layers complete.

35. *P. angulatum.* Inner side, showing curve straight from each margin and sloping down towards the nodule and median line. This plane shows square. × 1750.

36. The same. Same part taken at a little lower level to show hexagons and intercostals. × 1750.

37. The same. Same side, but another valve. × 1750.

38. The same. Outer side, showing curve straight from nodule and median line, and slopes down towards the margins. N. B.—Structure on this side corresponds to No. 4 slide of *P. formosum.* × 1750.

39. The same. Same side, showing longitudinal crack with fibril bridged across it in one place. × 1750.

40. The same. Surface abraded and two fibrils left isolated. × 1750.

41 and 42. The same. Same spot, but at a little lower focus to show changes in appearance on sound parts of valve. The changes on the surface are considerable, while the fibrils themselves change but little, except to thicken. The last is the lowest of the three and the appearance hexagonal. × 1750.

43. The same. Same side, showing—where marked with a ×—two fibrils joining together to form the regular structure. × 1750.

44. The same. Same side—end of valve—shows isolated fibrils in places. × 1750.

45. The same. Same side, torn structure. × 1750.

46. The same. Slide of *P. angulatum.* The specimen marked with a × is the one from which the next three slides are taken.

47. The same. Torn structure, showing free ends of fibrils.

48. The same. Same bit taken at a little lower level to show hexagons on sound parts. Note that but little change has taken place in the torn part, on account of there being no interference from structure below. × 1750.

49. The same. Same valve, showing under layer. The part immediately under the torn structure has been torn off and pushed down, leaving a considerable distance in that place between the two layers. × 1750.

50. *P. balticum.* The fibrils here seem to be in long strips and thickened out at regular intervals, giving the appearance, where they approach each other, of a square grating. Indications also are given on the slide of the lower layer. × 1750.

DIATOM-STRUCTURE—THE INTERPRETATION OF MICROSCOPICAL IMAGES.

BY JACOB D. COX, LL.D., F.R.M.S.

(*Read January 2d,* 1891.)

Mr. Smith's paper and his photographs are a valuable and interesting contribution to the discussion not only of diatom-structure, but incidentally of the interpretation and value of microscopical images.

The discussion of the structure of the diatom-valve turned, for a long time, on the question whether the dotted markings were caused by solid spherules or hemi-spherules of silex or by areolæ or alveoli in the shells. Elaborate rules were formulated by which it was supposed the examination should be so conducted as to decide indisputably when a dotted appearance was caused by the one or the other structure. The study of the fractured edges of broken shells, aided and illustrated by photography, may be said to have settled this question in favor of the alveolar structure some years ago. This done, we were prepared for the next question, which was whether these alveoli are capped by a very thin silicified film on one or on both sides of the shell. Are they or are they not cellules in the shell, completely enclosed by a silicified membrane? Without asserting that this is definitively settled, it may fairly be said that the prevalent opinion now is that the alveoli are thus completely enclosed, but that the extremely thin membranous caps are not so solidly silicified but that endosmose acts through them and the plant is nourished in this way.

The next step in the discussion is the inquiry whether the alveoli are interior cavities in a single homogeneous membrane, or is the shell formed of two or more membranes. In the more robust kinds it was demonstrated that there were at least two plates or membranes in the shell. The larger *Coscinodisci* were often found with the inner film, containing the so-called "eye-spots," separated from the outer part of the shell; this inner film being much thinner than the outer, and nearly flat, the shallow depressions at the eye-spots being surrounded by a hexagonal tracing which marked the place where the walls of the comparatively deep cellules had been attached. The outer film or plate consists, apparently, of stout hexagonal structure capped on the outer side. In several species this outer side has a secondary marking of finer dots within the larger hexagons. In *Triceratium favus* the *inner* film is that which has the secondary marking, consisting of very fine dotted lines radiating from a common centre and continuous over the whole shell. There can be little doubt that these finer, secondary dots are analogous to the larger ones and are indications of a pitted surface. In these coarser forms it is quite conceivable that the structure should consist of three plates, viz., an outer and an inner plate, each nearly flat, and an intermediate one consisting of a hexagonal grating or a plate perforated with holes. The three in apposition would constitute the shell with its alveoli. As a matter of fact, I do not know that more than two such plates have yet been discriminated as components of the diatom-shell, and my present belief is that there are but two, unless Mr. Smith's investigations shall establish a third. As I understand his observations, they are consistent with the foregoing general theory of the shell-structure, and are the basis for a theory of a fibrous film exterior to those above described and superposed upon them. To this I shall presently return.

That the structure of the diatom-shell is the same in very thin and finely marked species as in the more robust, has always seemed probable to investigators, and the argument from analogy has been used with confidence. This, however, has not been allowed to discourage the study of the finer forms, and the improvement of our glasses has been utilized by bringing finer and finer details under direct observation. The separability of the shell into two plates has been noted not only in small and finely marked *Coscinodisci*, like *C. subtilis*, but in the *Actinocycli*. In *Pleurosigma* (*P. formosum*, *P. angulatum*, and *P. balticum*) the broken margin showing what Mr. Smith calls the "postage stamp" fracture has been seen and photographed, and in a number of photomicrographs of my "broken-shell series" (June, 1884) I showed this and what I regarded as separated upper and lower films of the valve of *P. angulatum* in the same specimen.*

Such being the state of our knowledge and theory on the

* In a summary at the end of a series of articles on "Structure of the Diatom-Shell" in the *Am. M. M. J.* (March to June, 1884) I said, p. 109:

"1. The diatom-shell is usually formed of two laminæ, one or both of which may be areolated, and may be strengthened by ribs, which have been described both as costæ and as canaliculi.

"2. The normal form of the areolæ is a circle, and these when crowded together take a hexagonal and sub-hexagonal form.

"3. The areolæ are properly pits or depressions in the inner surface of one of the laminæ, so that when two laminæ are applied together the exterior surfaces of the shell thus formed are approximately smooth and the cavities are within.

"4. The apparent thickening on the exterior of the lines bounding the areolæ in some species, as *Eupodiscus argus*, etc., is not in contravention of, but in addition to, the formation above described.

"5. However fine the marking of diatom-valves may be, the evidence from the color of the spaces between the dots and of the dots themselves supports the conclusion that they follow the analogy of the coarser forms, in which both fracture and color are found to prove that the dots are areolæ and the weaker places in the shell."

subject, Mr. Smith determined to try what could be learned by the systematic and careful use of the Zeiss apochromatic lenses under such conditions as to sub-stage illumination, by means of a wide-angled condenser, as should give the new objective the fullest scope for its power and quality. His conclusions from this examination he has kindly laid before us, so fully illustrated by beautiful lantern slides and prints that we can have little doubt as to the *appearances* on which the conclusions are based, except as to color.

In such a case the real question is one of interpretation of appearances seen under the microscope, and what I have to say will bear chiefly on this point, with direct application to the study of diatoms.

All microscopists are acquainted with the position of Prof. Abbe in regard to images formed by diffraction. As commonly stated it amounts to a declaration that all microscopical images of structure with details smaller than .0005 of an inch are diffraction images from which the true structure may be argued, but which cannot be taken as in themselves true representations of the structure. "The resulting image produced by means of a broad illuminating beam," says Prof. Abbe (*R. M. S. Journal*, December. 1889), "is always a mixture of a multitude of partial images, which are more or less different (and dissimilar to the object itself)."

This theory has been very vigorously assailed by Mr. E. M. Nelson, of London, from the practical and experimental side. In a paper read before the Quekett Club in May last, entitled "The Sub-stage Condenser: Its History, Construction, and Management; and its Effect Theoretically Considered," Mr. Nelson asserts that the cone of light from a sub-stage condenser "should be of such a size as to fill $\frac{3}{4}$ of the back of the objective with light; thus N. A. 1.0 is a suitable illuminating cone for an objective of 1.4 N. A." He says that "this opinion is in direct opposition to that of Prof. Abbe," and to maintain it he denies the truth of the diffraction theory as applied to microscopical images. He says of it: "The diffraction theory rests on no mathematical proof—in the main it accepts the physical law of diffraction; but on experiment it utterly breaks down, all criticism is stopped, and everything connected with it has to be treated in a diplomatic kind of way" (*Quekett Club Journal*, July, 1890, pp. 124, 125). I state Mr. Nelson's position without any purpose of discussing it, and only to point out that it is this to which Mr. Smith refers in his paper when he says: "This capacity of standing more light was pointed out from the first by Mr. E. M. Nelson, but has not received the attention it deserves, and the neglect of this point has stultified the efforts of many microscopists, both here (in England) and on the Continent, to get more out of the new glasses than the old objectives."

Mr. Smith's investigation of diatom-structure is thus closely connected with Mr. Nelson's views and experiments upon the diffraction theory Both will challenge the attention of practical microscopists as well as physicists. I have not gone far enough in my own investigations to warrant me in expressing a judgment on the questions involved ; but I would urge every microscopist to make his ordinary work the occasion for accumulating evidence which may help settle the very important debate. My suggestions are only such as are based upon the well-known history of diatom-study and my own experience. They are offered by way of clearing the field by pointing out the limits of the discussion and the known facts which ought to be kept firmly in mind in all such investigations.

It is no reproach to the microscope as an instrument of investigation that there are limits to its powers and capabilities. Such limitations are common to all methods of investigation. If, trusting to my natural eyesight, I am trying to make out the meaning of appearances on a distant hillside, I find at once that all perception by the sense of sight is an interpretation of visual phenomena which are not in themselves decisive. They may lack clearness by reason of the mist in the air. They may be obscured by something intervening, like foliage, or may be partly hidden by inequalities of surface. A thousand things may prevent clear and easy interpretation of what I see. I may have to change my point of view before I can reach a conclusion, or even have to go to the object itself. If I cannot do this I may be left in abiding doubt as to what I have seen.

Microscopical examination is precisely analogous to this. If I am examining a mounted object, I am tied to one point of view. I cannot approach nearer, and cannot do more than note the visual appearances and make theories to account for them in accordance with facts already learned. We try to vary the conditions as much as we can ; we change our objectives ; we try central light and oblique light ; we examine one specimen dry and another in a dense medium ; one by transmitted and another by reflected light ; but when we approach the limit of minuteness of object or detail which our instruments will define, we are in the same situation as when using our natural eyes across a chasm, neither better nor worse ; we have to account for what we see by a reasonable hypothesis which will make it take an intelligible place amongst natural objects.

Our skill as microscopists, apart from the technical dexterity in the use of our tools, consists largely in devising varied experiments and changes of condition, so as to enlarge the body of evidence from which we draw our inductive conclusions. To assist ourselves in this, we also catalogue such facts and methods, and such cautions and warnings, as our experience (or that of others) has taught us. Let us look for a moment at some examples.

We know very well that we are liable to illusions of sight, so natural and so powerful that even the intellectual certainty that they are illusions will not destroy them. If we are looking through the Abbe binocular eyepiece, using the caps with semicircular openings, we see a hemispherical object as if it were a hollow bowl, and, visually, it refuses to be anything else. But this is not peculiar to microscopical vision, for we do an analogous thing with the stereoscope, and by wrongly placing the pictures may make an equally startling pseudo-perspective.

We find that what we call transparent bodies are full of lines as dark as if made with opaque paint, and throw far-reaching shadows. But I see similar ones in the cubical glass paperweight on the table before me, and know that by the laws of refraction the surface of a transparent body is always dark when its angle to the eye is such as to cause total reflection of the light in the opposite direction. By the same law we know that if the angle of total reflection in the same transparent cube were differently placed with regard to the eye, the now dark surface would become a mirror, reflecting the sky and distant objects as brilliantly as if silvered. Our diatom-shells give us constant experience in these phenomena. A prismatically fractured edge will scintillate so as to defy all efforts to define its outline. Reflected images look like actual details of structure in the object. Dealing, as we constantly are, with objects made of glass, we have constant use for our reasoning faculties to determine the meaning of all these refractions and reflections, which sometimes are almost as confusing as the broken images seen through the glass pendants of a chandelier.

In addition to these familiar effects of refraction and reflection, we have the class of phenomena which we call diffraction effects. These may be wave-like fringes of light and shadow following the outline of the transparent object and reduplicating this outline; or they may be analogous fringes thrown off the sub ivided parts of the object, as from the cup-like outline of alveoli, or from some projecting rib or groove like those along the diatom's median line.

We know by constant experience that when we throw light obliquely through a transparent reticulated object like a diatom-shell, the diffraction fringes from the separate alveoli run together across the shell in dark striæ oblique or at right angles to the direction of the light. In the *Pleurosigma*, in which the rows of alveoli are oblique to the midrib, we very easily get the oblique striation by the use of oblique light; getting both series of lines at once, one only, or one strong and the other faint, as we please and with very little trouble. We get, with a little more pains, a transverse striation, at right angles to the midrib, which is fainter because it proceeds from alveoli not so closely connected in rows. It may be called a secondary striation. With still more effort we may get a much finer and fainter striation, parallel to the midrib, by throwing light at right angles to it or nearly so. By lamplight, and with objectives not apochromatic and not exceeding the aperture of 1.0 N. A., these lines are usually in patches, upon spots here and there, longer (in the length of the shell) than they are wide. But with sunlight this tertiary diffraction striation may be made to cover the whole surface of *Pleurosigma angulatum* by an exquisitely fine longitudinal grating over its whole surface, as was demonstrated by Dr. Woodward in one of the most striking of his photomicrographs in what is called "the Abbe experiment."* As the improvement in our lenses, both by increasing

* See R. M. S. Journal, vol. ii. (1879), p. 675; see also M. M. J. xvii., p. 82.

their angle and by the apochromatic system, tends to make visible by lamplight what before could only be seen by sun, we should expect that something like the fibrillæ shown in Mr. Smith's photographs would be visible. Finding it would not prove that it is purely the result of known laws of diffraction ; but it justifies a cautious and scientific scepticism in receiving a new explanation until we have repeated the experiment often enough and under such varying conditions as to exclude doubt.

As we increase or reduce the obliquity of the light in examining *Pleurosigma formosum*, we know that the alveoli are distorted (or may be) in varying ways and directions. Some of these are figured in "Carpenter on the Microscope," but they are only a few of a numerous series. Whoever will experiment a little may satisfy himself that the permutations and transmutations of the diatom markings may be made little short of kaleidoscopic. Hexagonal markings may become square and may have short lines running off from one angle. These lines may be lengthened and the square or hexagon reduced to a dot, so that the appearance of the surface may be that of oblique series of parallel dashes. The direction of these lines depends on the direction of the light, making a series of gratings, of which the prevalent character may be oblique in either of two directions, transverse or longitudinal. The so-called intercostal points may be enlarged and brightened until they become the most prominent marking, and the alveoli proper may be diminished to insignificance. These appearances are so like many of those in Mr. Smith's series that we, who can only see the print and cannot get our fingers upon the fine adjustment of the microscope and note for ourselves the effect of a change of focus, are necessarily made cautious in accepting his interpretations; but there should be caution in rejecting as well as in accepting, and he fairly challenges us to repeat his investigations under similar circumstances and with similar objectives.

An examination of his print No. 12 with a hand lens will illustrate what I am saying. When looked at with the naked eye, this print shows a long patch of longitudinal striation on the lower side of the valve. Immediately below the midrib we see the coarse, oblique dotting peculiar to *Pleurosigma formosum;* but if we use the lens we see at once that, in the patch referred to, the dots are twice as numerous as the alveoli of the shell. The interpolated ones (proceeding from above downward) are at first very small, then larger but rectangular and twice as long as wide, making the pattern one of alternate dots and rectangles; as we pass to the right the rectangles run into each other obliquely, making a wavy white line, the dots of the alveoli proper being in the bends of the line, very much as in the longitudinal fibrils of print No. 11. This change, distortion, and multiplication of the dots is so entirely within our common experience in diatom-study that I have no hesitation in explaining the longitudinal striated appearance in this patch as the result of the reduplicating of the dots by the intercalation of the rectangular ones, making in fact broken lines which on so small a scale are sufficiently even to make continuous ones to the naked eye. On the other side of the midrib in the same print (No. 12) the rectangles and round dots are of nearly equal size, but they still make a faint longitudinal striation, diverging a little from the midrib as we pass from left to right.

We thus have an ocular demonstration how a striated appearance may be made out of a tessellated one, when there is no question of continuous fibrils. Yet even this does not prove that the fibrils are not there. Of course all visual appearances under the microscope have their cause in the structure of the object, considered in relation to the laws of transmitted and reflected light. The puzzle often is to tell what to attribute to each factor. I do not think it difficult to account for the tesselated appearance of dots and squares with alternate blue and red color. To do so may require us to refer to some elementary matters in diatom-marking.

Dr. Brebisson, at a very early day, divided the regular dotted markings of diatoms into three classes: 1, *Quadrille rectangle droit* (in squares parallel to midrib, e.g., *Pleurosigma balticum*); 2, *Quadrille rectangle oblique* (in squares oblique to midrib, e.g , *P. formosum*); 3, *Quinconce* (quincunx or lozenge of 60° smaller angle, e.g., *P. angulatum*). This classification has been a good deal neglected, but has good claims to remembrance, and will assist me in explaining the phenomena before us.

In Mr. Smith's print No. 6 is well shown what I regard as the normal scheme of areolation of *P. formosum*. It will be seen to be a reticulation with meshes as nearly square as nature gives us in growing things. If the corners of these meshes be filled up, the included circles will still keep to each other the relative position of Brebisson's oblique quadrille. The diminution of the round alveoli would not need to proceed far before the approximately rectangular mass of silex between the circles would be about as large in diameter as the circles themselves. Under the laws of optics, which we have already seen illustrated in print No. 12, the tendency of approximately rectangular details is to become more strictly so in the microscopical image. In Figure 1 I have illustrated this by a geometric diagram of which one half shows the square reticulation, and the other the resulting tessellation of solid squares and round alveoli when the walls are thickened and the corners filled up. It will be noticed that when the

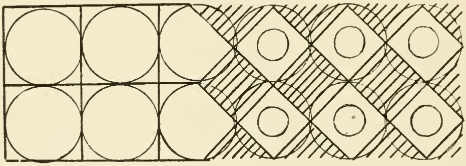

Fig. 1.

corners are so filled as to make the alveoli circular, the interspaces are approximately square, and, being solid, will be red or pink by transmitted light when the alveoli are bluish-white. On the inner side of the shell the thin circles, or "eye-spots," are usually smaller than on the outer side; the diffraction effect by transmission of light will straighten the edges of the tessellated outline; the squares will each have half the area of, and will be diagonal to, the original squares; and with their alternate colors we shall have exactly the appearance which Mr. Smith describes, and which is very well shown in prints Nos. 1 and 2, compared with No. 6.

The peculiarity of the quincuncial arrangement of alveoli is that when the circles crowd upon each other so as to become polygons bounded by straight lines, they form hexagons instead of squares, and even when they are circles in a continuous plate of silex the hexagonal outline is a persistent ocular illusion. We should expect, therefore, that the tessellated appearance with equal squares of red and blue would be a mark of *P. formosum* as distinguished from *P. angulatum*, under proper conditions of illumination and examination.

We are justified in concluding, therefore, that the phenomena of color and form thus examined are not only consistent with, but strongly confirm, the generally received theory of diatom-structure, and cannot be said to indicate anything new in that direction.

Mr. Smith also expresses the opinion that only by means of a wide-angled objective, and illumination by a wide cone of light from the sub-stage condenser, can the upper and lower films of a shell like *P. angulatum* be discriminated. As he recognizes some photographs made by me, and deposited with the Royal Microscopical Society in 1884, as showing this discrimination, it is due to scientific accuracy to say that they were made with a Wales $\frac{1}{15}$ water-immersion objective of about 1.0 N. A. aperture, and with a *narrow* cone of light coming from a Webster condenser under the stage having a diaphragm with a $\frac{1}{4}$-inch opening behind it. Mr. Smith's own objects photographed could not be illuminated with a very wide cone of light, as they were mounted dry and he tells us he used his condenser dry. There was therefore a stratum of air both above and below the slide on which the object was mounted, and the illumination could not exceed the "critical angle," 82°, in passing through the cover glass, and must in fact have been considerably less.*

In my own experience I have found a broad cone of illumination unsatisfactory, for the same reason that I have found oblique light in one direction unsatisfactory. It is almost impossible to centre the sub-stage condenser so accurately that a wide cone can be trusted to be central. If you centre it by examination with a low power, it is almost certain that it will not be centred for a high power, for two objectives are rarely centred alike. The field, under a magnification of 1,750 which Mr. Smith has commonly used, is so small that the least decentring will illumi-

* In my note book, June 3d, 1884, I find that I entered my observation of one of the broken shells which I photographed, as follows: "A remarkably interesting fragment of *P. angulatum*, showing partial removal of one film, and fracture through dots over a large space." In preparing this paper I have repeated the examination with the objective named, and find the distance between upper and lower film easily appreciable in focussing.

nate it only by the oblique rays from one side of the cone, and we then immediately get diffraction effects. I am bound in candor to say that in most of Mr. Smith's prints I recognize similar effects to those which, in my own work, I attribute to oblique light. It may be that, with improved contrivances to secure exact centring of objective and condenser, we shall find advantages in the use of the wide cone. I speak now only of my own experience under existing methods. The slightest turn of the mirror on its axis will change light from central to oblique; and I suppose we are all in the habit of doing this, so as purposely to throw light through one side or segment of the condenser for the purpose of studying the effect on an object of the changing direction of illumination. So unstable a source of light prevents our knowing very exactly when the light is strictly central, and makes it hard to return to any exact condition from which we have departed even a little. These considerations have kept me (perhaps mistakenly) in the practice of using the narrow cone of light for photography, reserving my oblique light for special resolutions of striation and for the professed study of changing effects.

Similar reasons have made me distrustful of dry mounts when high powers are to be used upon any but the thinnest objects. Refraction, and attendant diffraction, are so increased with increase of index, or rather increased difference of index, that it has grown to be a maxim with me to have the mounting medium and the object as near alike in index as is consistent with the discrimination of structure. The pale images of transparent objects are those I find most truthful, for paleness is consistent with good definition and resolution, whilst the brilliant pictures are apt to be glittering deceptions. I fully admit, however, that it may well be that with improved glasses we may add to the extent of details visible upon a surface, like that of a diatom-shell, and that it is possible that mounting in most media would obliterate the finest of these details. To a certain extent we are all familiar with this. A rather coarse dry shell like *P. balticum* will have its details instantly obliterated if water from the immersion of our objective penetrates beneath the cover glass Mr. Smith's print No. 50 might pass as an excellent reproduction of this effect, the fluid passing along the structural lines, obliterating part and leaving part.

But when full weight has been given to all these things, and we have put aside those of Mr. Smith's long and beautiful series of photographs which are liable to our criticism, there still remain several which cannot be thus disposed of.

Prints Nos. 14 and 15, taken with half the magnification of most of the others (× 875), show strips of surface marking which strongly support Mr. Smith's interpretation, viz., that the outer surface of *P. formosum* is covered by a longitudinal series of fibrils separating so as to pass round the alveoli and uniting over the solid corner interspaces. The definition in these cases is not only reasonably clear and free from the ordinary marks of diffraction effects, but, most conclusive of all, there is in No. 15 a bit of this film floated off the shell and lying detached by its side. The fibrillar structure of this bit leaves little room for scepticism, and it so exactly accords with the appearance of the similar fibrils remaining on the surface of the shell that I cannot refuse to accept it as evidence of structure. Going back from these to print Nos. 10 and 11, we now find reason to accept these also as evidences of the same structure, though distorted by obliquity of light, so that they would not have been satisfactory taken by themselves. On No. 5 also we may recognize some of the same fibrils. The single detached fibril in No. 9 is not so directly connected with any other specimen, either in the photograph or in Mr. Smith's description, as to present the evidence on which it is shown to be part of the same structure; but the measurement of its flexures so corresponds with the areolæ of the shell that its probable connection with a similar valve may be assumed.

The interpretation of this structure which seems to me most satisfactory is to regard these fibrils as superposed upon the general surface of the shell as a protection to the thin capping of the alveoli against abrasion. It would, in that case, come under the description of those appearances which I have referred to in paragraph 4 of my general summary (see foot-note, p. 75 ante), viz., a "thickening on the exterior of the lines bounding the areolæ . . . which is not in contravention of, but is in addition to," the usual formation of the shell by means of two principal plates or films. All the species of *Pleurosigma* which have the alveoli arranged in Brebisson's *quadrille* seem to have strengthened ribs between the rows of "dots"—*P. balticum*, *P. attenuatum*, etc., have them longitudinal and straight. Mr. Smith's observations seem to prove that *P. formosum* and its congeners have them longitudinal but wavy, which is a positive addition to our knowledge, since we should naturally have expected them to be oblique. The appearance of the finer square tessellation in either of the principal films of an obliquely marked *Pleurosigma* would seem to prove it to belong to the "quadrille" marked class, and I think the smaller forms which Mr. Smith has left unnamed may be identified as *P. obscurum* W. Smith, which is probably only a small form of *P. formosum* or *P. decorum*.

I do not find in the prints any conclusive evidence that the quincuncial marked species, as *P. angulatum*, have the same series of fibrils. No one doubts that all have a vegetable membrane in which the silex is deposited, and, under favorable circumstances, a fracture through a row of dots would leave the thicker connecting membrane looking approximately like a fibril. The argument from analogy is not as strong here as in the case of the "quadrille" marked kinds. The structure *may* be found in all, but the evidence does not yet seem complete. There is here a good field for further investigation.

This leads me to say that the size of the fibrils shown by Mr. Smith does not seem to me so minute that any good $\frac{1}{10}$ or $\frac{1}{15}$ objective should not define them. We must remember that the condition of an object may count for much in the resolution of its structure. A thickly silicified shell may not show what an imperfectly silicified one will demonstrate. The former will break into small angular bits with a mineral fracture; the latter may separate into threads or membranes. The floating off of the fibrils in print No. 15 seems to show that the shell was in a peculiar condition; a sort of dissection of an uncommon kind having taken place naturally or artificially. It would be an interesting experiment to subject various species of *Pleurosigma* to the action of hydrofluoric acid for varying periods, and then mount them for examination. To extend Prof. Bailey's old experiments in this direction would be very useful; but the danger of injury to the objective is such that it would hardly be advisable to watch the action of the acid under the microscope.

If I seem to have reduced the new matter in Mr. Smith's observations to a minimum, I should not do justice to my sense of the real value of his work unless I add that enough remains to make it, in my judgment, a very important and interesting step in the investigation of diatom-structure. It is also full of promise that still further results may be attained by pursuing the investigation on the same line. I am confident, therefore, that the Society will join with me in expressing a sincere sense of obligation to him for communicating the results of his observations, and especially for the valuable aid in understanding them which is given by his beautiful series of lantern slides and prints.

THE WORK OF THE MICROSCOPE.

ANNUAL ADDRESS OF THE PRESIDENT, P. H. DUDLEY, C E.

(*Read January 16th*, 1891.)

At no period in the history of the microscope have the results of its researches received as much attention as at the present time. The importance of the investigations in recent years, by its means, of many of the causes affecting the health and comfort of mankind, is just being recognized by the efficacy of the remedies which have been suggested from a knowledge of the causes. The indications of a new remedy are daily flashed from continent to continent by that unseen agency, electricity, its messages multiplied by the press in all languages and distributed through the land by steam's swiftest trains. These three great inventions of communication and diffusion of knowledge of to-day have carried the tidings to the peoples of all nations, and there is a common interest and thought upon the subject. History does not record a grander spectacle than that of the entire civilized world, brought into sympathy and interest by the investigations of the microscope, in search of relief for thousands of its sufferers from some of the occult conditions incident to life.

Animal or plant life, either of the highest or lowest orders, is surrounded by conditions, some favorable to growth, others unfavorable; and whether an animal or plant will survive or perish, aside from the inherent vitality, depends upon the preponderance of the favorable or the unfavorable conditions of environment.

This law is coeval with the existence of life. To ascertain and understand the conditions favorable to the human race has and will always occupy the attention of a large portion of the more intelligent of mankind.

Some of the conditions are at once apparent; others, equally important, are unseen, obscure, and only discovered by tracing back from the effect to the cause. We experience effects and not causes, and to analyze the former, assigning each to its proper cause, is by no means an easy matter. The first step is to observe the facts, study their relations, and trace the laws controlling them. It is only in this way that any progress has been made, and then oftentimes the real nature of the cause remains undiscovered.

Jenner's important discovery of vaccination for small-pox, a century since, was not the result of accident, as often stated, but close observation of a series of facts and studying their relations. That small-pox was due to a germ in the system, invisible to the keenest vision, is of recent demonstration by the microscope.

How early minute forms of life were suspected of causing bodily ailments or decomposition in fluids is uncertain. The Egyptians, 3,500 years since, knew how to practically prevent decomposition in bodies and wooden utensils, so that they have been preserved to the present time. More recently Robert Boyle, 200 years ago, expressed the opinion that ferments had something to do with fevers. Leuwenhoek, 1632 to 1723, made small lenses, and described the ferment of yeast as ovoid or spherical bodies, and discovered bacteria in the mouth and in fluids undergoing decomposition. The powers and use of the early simple microscopes were too limited to definitely establish the functions of the minute forms or their relations to the higher orders The belief, however, was becoming more and more general that the minute forms had something to do with bodily ailments and fermentations, but without microscopical aid it could not be clearly demonstrated. As must be expected, some extravagant views were adopted, while others were close approximations to the truth. Boerhaave, in 1693, distinguished three kinds of fermentations, viz , alcoholic, acetous, and putrefactive. Linnæus stated that a certain number of diseases resulted from animated invisible particles dispersed through the air. Spallanzani, in 1769, started his series of experiments upon spontaneous generation and sterilization, resulting in the present method of preserving foods. Opinions were very conflicting, and the truth, which may now be expressed by a line, required years of labor to ascertain, and really follows the improvement in the microscope. In 1837 Cagniard-Latour described yeast as a collection of globules which multiplied by budding. In 1838 Turpin described the yeast plant in beer, and named it *Torula cerevisiæ*. Many chemists were unwilling to admit the important part played by yeast in fermentations, and ascribed it to "catalysis," or action by presence. In 1843 the celebrated French chemist Dumas, from microscopical and chemical examinations, clearly explained the physiological function of the living ferment, yeast. The truth was now proven, but it made little progress until Louis Pasteur, some ten years later, took up the work of studying under the microscope the ferments of yeast, vinegar, and wine, demonstrating conclusively that a germ must be present to start fermentation or decomposition in fluids, that the definite knowledge he learned of the functions of the minute forms of life attracted attention.

Pasteur, by his systematic work with his microscope, tracing the life history of many ferments from the spore, ascertained the laws of growth, so he could induce fermentation or check it as desired. The ability to keep liquids for years when freed from germs, which under ordinary circumstances would ferment or decompose in a few hours, enabled Pasteur to confirm and clearly set forth the general principles of the germ theory of minute forms of life, in place of the theory of spontaneous generation. The theory so completed, revolutionizing current ideas, met with vigorous opposition, but the microscopical demonstration was so complete it has proven invulnerable, and upon it has been formed the important branch of science, bacteriology. We are too near to estimate the value of the demonstration. It will require time to show its full value, for its application is but really commenced.

Pasteur's work has been pre-eminently practical, and the results of his investigations at once applied to the French industries, in which interests they were undertaken. He saved the French silk industry from threatened destruction by investigating the parasitic diseases of the silkworm, and suggested a remedy. His investigations led to the antiseptic treatment in surgical operations which is now considered indispensable. His extensive experiments to obtain vaccines, or attenuated virus for protective inoculations, have been very successful, especially when the difficulties of producing an attenuated virus are considered.

The process for obtaining the protective virus for rabies may be mentioned. He inoculates a morsel of the brain of a mad dog into the brain of a rabbit, which attenuates the virus sufficiently to act as a protective inoculation for dogs, or men bitten by dogs, suffering from rabies. At first the attenuated virus from the rabbit was also passed through the organism of the monkey before using. This feature has been discontinued. This was the first successful step towards checking rabies. Pasteur has a large institute in Paris for the treatment of rabies, and there is now in this city a branch institute under the charge of Dr. Paul Gibier, where about 160 persons have been successfully treated the past year.

Considering for a moment the higher orders of plant life, the microscope has shown conclusively that the functions of the fungi which we see upon them is to undo the structure which has been built up by the higher plants, returning the elements composing them to the air and soil. This is of itself a work of great economic value, and must be more generally understood to save our building timber and forests from the natural process of decay.

The rapid advancement of bacteriology in the last decade is largely due to the arduous labors of Koch, who, by extensive microscopical investigations, discovered the specific bacillus of several diseases, particularly of Asiatic cholera and tuberculosis. He originated a method of staining a specific bacillus so as to differentiate it from all others in enclosed tissue or other media, and found them when others not using as skilful methods failed. He originated a system of solid nutritive media for cultivating and isolating a specific bacillus, producing pure cultures. This has proven of the greatest value, for much has been learned as to the manner of growth and products secreted of each bacillus studied. With the pure cultures he carried out extensive inoculations on animals, and carefully noted the effects. The latter have been analyzed, resulting in his extensive experiments with his so-called lymph to check the bacillus of tuberculosis in the human system. It is this feature of Koch's great work which has made his name a household word to-day in all civilized countries.

Yesterday he gave to the world the formula for his great discovery, which, briefly stated, is a glycerin extract of a certain dilution from the ptomaïnes or the products of the bacillus itself.

The consensus of opinion from the tests is that it is a remedy of great value. Besides its direct benefits the indirect ones will be even greater, for the publicity given by the press to this and kindred discoveries is rapidly educating the people to the important rôle played by microbes in contagious diseases, and the necessity of efficient sanitary measures for our cities as a preventive. Check the causes instead of dealing with the dangerous effects, and have clean streets, wholesome water, and efficient sewerage. Any one or all of these, when not in proper condition, are efficient media for the growth of microbes detrimental to health, particularly in cities of warm climates. But few of our cities in warm climates have as wholesome water as is needed for domestic purposes, being so filled with germs as to be unsafe for many persons to drink without sterilization. The indifference of the people to these important matters is largely due to the fact that their nature and bearing are not understood. The reasons why the streets should be clean, the water wholesome, and that there should be efficient sewerage in our cities, are evident to health boards, but it needs enlightened public opinion to more thoroughly carry out the demonstrations of the microscope.

PROCEEDINGS.

Meeting of December 5th, 1890.

In the absence of the President and Vice-President, Mr. William Wales was elected chairman.

Twelve persons present.

The Corresponding Secretary exhibited the first and second numbers of the new publication, *Le Diatomiste*, edited by M. J. Tempère, Paris, and gave notice of the character of the publication.

OBJECTS EXHIBITED.

1. Longitudinal and transverse sections of an Actinia, *Metridium marginatum* Milne-Edwards, showing tentacles, mouth, œsophageal tube, and mesenteric folds: by L. Riederer.

2. Pipe-fish, *Syngnathus acus* L. Entire fish, young, stained: by L. RIEDERER.

3. Sagittal sections of the head of the same: by L. RIEDERER.

4. Type-slide of 50 recent and fossil Foraminifera, prepared by Edmund Wheeler: by H. W. CALEF.

The following all by ANTHONY WOODWARD:

5. Type-slide of 100 species of Foraminifera, from H M. S. "Challenger" Expedition, Torres Straits, 155 fathoms, prepared by Joseph Wright, Belfast, Ireland.

6. Section of *Eozoon Canadense*.

7. Section of fusulina limestone from Nevada. Also many specimens, such as *Planorbulina larvata*, *Calcarina Spengleri*, *Assilina*, *Numulites*, *Orbitoides Mantelli*, *Fusulina cylindrica*, Foraminifera of the U. S. coast, of Bermuda, of Singapore, and of the Vienna Basin, and others embracing forms extending from the carboniferous age to the present time.

A discussion on building-stone was participated in by Messrs. A. Woodward and M. M. Le Brun.

Mr. Riederer gave the following description of his exhibits: "The Actiniæ belong to the Cœlenterata, or zoophytes. They are cylindrical and radially symmetrical. The oral opening is used not only for the reception of the food, but also for the rejection of excreta. This opening is surrounded by tentacles—contractile tubes—bearing, especially near the ends, large numbers of 'nettle-cells'—cnidoblasts.

"The cavity of the body is divided by numerous vertical partitions—mesenteric folds—into a system of vertical pouches, which communicate with one another at the bottom of this gastric cavity. At the upper extremity the pouches are continuous with the canals leading into the hollow tentacles, since the edges of the mesenteries bounding them unite with the wall of the oral tube, which hangs from the mouth. The generative organs rise on the mesenteries as band-shaped or folded thickenings.

"The body of Actinia has no hard structure. By means of contractile muscles, causing inflow and outflow of water, large differences in size and shape are produced. The contractile foot allows departure from the place of attachment. Many Actiniæ reach a relatively large size and possess beautiful colors.

"The Pipe-fish, *Syngnathus acus*, belongs to the Teleostei, or bony fishes. It is the most common and widely propagated fish of its family. The body is cylindrical, laterally compressed, and covered with a mailed skin. The elongated, tubular snout has no teeth, and opens in front at the top. There are four tufts of gills on each side, and the gill-openings are narrow. The males have brood-pouches on the abdomen. The dorsal fin shows forty rays, but the pectoral and anal fins are small. The tail appears like a fan on a long handle at the end of the long body. Thus the propulsion of the fish is done mostly by the undulating movements of the dorsal fin. The Pipe-fish is found between sea-weeds at the bottom of shallow waters, and feeds on small crustaceæ and worms."

Meeting of December 19th, 1890.

The President, Mr. P. H. Dudley, in the chair.

Eighteen persons present.

The following Committee on Annual Reception was appointed by the chair: Messrs. Charles S. Shultz, George E. Ashby, and Anthony Woodward.

OBJECTS EXHIBITED.

1. A Fish-louse: by F. W. Leggett.
2. *Gomphonema herculeanum* from Dutchess County, N. Y.: by J. D. Hyatt.
3. The Polycistin, *Haliomma Humboldtii:* by Stephen Helm.
4. Polycistina from Barbadoes: by James Walker.
5. Foraminifera from Isle of Jersey, England: by James Walker.
6. Section of *Nummulina lævigata* from Bartom, England: by James Walker.
7. Foraminifera from Bermuda: by William G. De Witt.
8. *Orbiculina* from Bermuda: by William G. De Witt.

Mr. Stephen Helm, of 417 Putnam Avenue, Brooklyn, addressed the Society on "The Foraminifera." This address was illustrated by numerous beautiful and enlarged diagrams, especially prepared by Mr. Helm for the occasion.

On motion the thanks of the Society were tendered Mr. Helm for this address.

Dr. H. Hensoldt remarked upon the subject of the Foraminifera, reviewing the interesting geological side of the subject.

Mr. Hyatt said of his exhibit that it was collected on the 23d of November last, from a brook in Dutchess County, N. Y., where it suddenly appeared, and increased so rapidly as to cover the stones, etc., on the bed of the stream to the thickness of more than one-quarter of an inch. And, further, that the only published locality for this rare diatom is Lake Erie.

Meeting of January 2d, 1891.

The President, Mr. P. H. Dudley, in the chair.

Thirty-five persons present.

The Committee on Nominations of Officers, appointed at the meeting of November 21st, 1890, reported their nominations of the persons who were unanimously elected, as is stated below.

The President appointed as tellers of the election of officers the Rev. George C. F. Haas and Mr. Horace W. Calef.

Mr. Charles F. Cox read the following papers, as announced on the programme of the evening:

1. "On the Structure of the Pleurosigma Valve"; by T. F. Smith, Esq., F.R.M.S., of London, England. This paper, published in the present number of the Journal, p. 61, was illustrated by lantern projections of fifty excellent lantern slides, from original photomicrographs, and by numerous other mounted photomicrographs, by Mr. Smith.

2. "Diatom-Structure—The Interpretation of Microscopical Images"; by Jacob D. Cox, LL.D., F.R.M.S., of Cincinnati, Ohio

This second paper, published in the present number of the Journal, p. 73, was illustrated by one hundred photomicrographs, twelve of which were by the late Col. J. G. Woodward.

Mr. Charles F. Cox announced the donation to the Society by Mr. T. F. Smith of the fifty lantern slides just exhibited.

On motion it was resolved that the thanks of the Society be hereby tendered Mr. T. F. Smith for his interesting and valuable paper, "On the Structure of the Pleurosigma Valve," and for his valuable donation of fifty photomicrographic lantern slides illustrating the same.

On motion it was also resolved that the thanks of the Society be hereby tendered Gen. Jacob D. Cox for his admirable paper on "Diatom-Structure—The Interpretation of Microscopical Images."

The President announced the closing of the polls, and declared the result of balloting to be the election of the following persons as officers of the Society for the present year:

President, P. H. DUDLEY.
Vice-President, J. D. HYATT.
Recording Secretary, BASHFORD DEAN.
Corresponding Secretary, J. L. ZABRISKIE.
Treasurer, CHARLES S. SHULTZ.
Librarian, LUDWIG RIEDERER.
Curator, WILLIAM BEUTENMÜLLER.
Auditors, { WILLIAM E. DAMON, F. W. LEGGETT, H. W. CALEF.

MEETING OF JANUARY 16TH, 1891.

The President, Mr. P. H. Dudley, in the chair.

Twenty-five persons present.

The Treasurer, Mr. Charles S. Shultz, presented his annual report, which was accepted and adopted, and the summary of which is as follows:

Receipts, - - - - -	$530 08
Disbursements, - - - -	421 47
Balance, - - - -	$108 61

The Committee on Publications presented their annual report, which was accepted and adopted.

The Curator, Mr. William Beutenmüller, presented his annual report, stating that he was now cataloguing the slides in the cabinet of the Society, and also that the six revolving tables now in the Society's Rooms had been lately there deposited by some unknown parties.

On motion the thanks of the Society were tendered the donors of these elegant and useful tables.

The President made the following appointments:

Committee on Admissions: F. W. Devoe, Anthony Woodward, William E. Damon, George F. Kunz, and William Wales.

Committee on Publications: J. L. Zabriskie, William G. De Witt, Walter H. Mead, John L. Wall, and Charles F. Cox.

The President delivered his annual address, entitled "The Work of the Microscope," and published in this number of the JOURNAL, p. 87.

Mr. Stephen Helm, of 417 Putnam Avenue, Brooklyn, delivered the third of his series of addresses, entitled "The Rotifera." This address was illustrated by beautiful enlarged diagrams, and by living objects under microscopes.

OBJECTS EXHIBITED.

1. *Stephanoceros Eichhornii:* by STEPHEN HELM.

2. *Floscularia ornata:* by STEPHEN HELM.

3. Longitudinal section of head of embryo of Garter Snake, *Eutania sirtalis* L.: by L RIEDERER.

4. Transverse section through nose of the same: by L. RIEDERER.

5. Transverse section through eye of the same: by L. RIEDERER.

In discussion of the address, Mr. C. Van Brunt stated, as the result of his observations on the desiccation of Rotifera, that when they are dried on the surface of clean glass they are dead and incapable of resuscitation; but if dried among fragments of dirt or vegetable matter they may be revived. He had some pond mud, which had been kept dry, wrapped in paper, for the space of five years. When portions of this were moistened with water the contained Rotifera would revive in two hours' time.

Mr. Riederer remarked on his exhibits: "This harmless snake, *Eutania sirtalis*, belongs to the family Colubridæ. It has a moderately broad and distinct head, covered with scutes. The dentition is complete. It shows a remarkable variability, which has given opportunity to the formation of quite a number of sub-species.

"In the following remarks I refer only to such points as can be seen in the transverse or the sagittal sections of the head of the embryo here exhibited. Commencing with the lower jaw, we see the cartilaginous structure of the bones, as yet unossified, bundles of muscles, and blood vessels. The forked, horny tongue is enclosed in a sheath, from which it can be protruded through an indentation of the mouth, even when the mouth is closed. Above the tongue is the larynx. This is placed extraordinarily far forward, and can be projected into the mouth during the long and difficult act of swallowing. The adjoining trachea shows cartilaginous rings. While all reptiles breathe only by lungs, the embryonic stage of the object still shows the presence of gills. The gullet has a thin, extensible wall. The nasal apertures are placed near the apex of the snout. The olfactory organ has a second groove, with a large surface of mucous membrane, supported by cartilaginous whorls. The olfactory nerve rises at the end of the olfactory lobe, and is spread out like a cup around a cartilaginous papilla. The eyes are without lids, but are protected by a transparent capsule, formed by the skin, filled with lachrymal fluid, and transparent in front of the pupil and cornea. The eyes show all the constituents of a highly developed vertebrate: cornea, crystalline lens, anterior and posterior chamber, iris with pupil, retina with its different layers, choroid with pigment, and optic nerve. The brain, enclosed in the cartilaginous capsula, shows differentiation in layers and structure."

PUBLICATIONS RECEIVED.

The Microscope: Vol. X., No. 11--Vol. XI., No. 1 (November, 1890—January, 1891).

Bulletin of the Torrey Botanical Club: Vol. XVII., No. 12—Vol. XVIII., No. 2 (December, 1890—February, 1891).

Natural Science Association of Staten Island: Proceedings; Meetings of December, 1890, and January, 1891.

Journal of Mycology: Vol. VI., No. 3 (January, 1891).

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PESTALOZZIA INSIDENS.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. VII. JULY, 1891. No. 3.

THE FUNGUS, PESTALOZZIA INSIDENS.

BY J. L. ZABRISKIE.

(*Read March 6th*, 1891.)

This fungus I collected at New Baltimore, near Albany, N. Y., in 1872. I presented specimens to our State Botanist, Prof. Charles H. Peck, and he reported it in his Twenty-eighth Report, but the description has never been published. I take the opportunity to give that description now.

PESTALOZZIA INSIDENS, n. sp. On bark of living trunks of *Ulmus Americana* L. New Baltimore, N. Y., April, 1872. Acervuli scattered, erumpent, discoid, 300–500 μ in diameter; conidia 32 μ long exclusive of the bristles, and 12 μ in diameter, broadly elliptical, slightly curved, 5-septate, the four inner cells very dark brown and slightly constricted at the septa, terminal cells hyaline, the upper terminal cell nearly hemispherical, the lower terminal cell conical and distinctly truncated at the union with the basidium, each terminal cell obliquely prolonged in a stout, curved, sometimes flexuous, gradually tapering, abruptly terminated bristle; bristles 17 μ long; basidia slender, sometimes branching below, and sometimes 214 μ long.

Description of Plate 28.

The figures are all magnified 600 diameters. The central figure shows a mature spore attached to its basidium, the latter being frequently found of this length. Near the base of the basidium is seen a portion of a broken branch. The basidia are occasionally found thrice branched. On the left is shown a mature detached spore, and on the right an immature spore.

tallization of the mica? With nothing to contradict this, we might assume that the Tourmaline was formed first. I had no sooner commenced to believe this, than I found crystals crossing a fault in the mass of mica (probably caused by compression during some of the earth throes which the rocks had endured), which, upon one side, were *above* the continuous sheet, and, upon the other side, *below* the same sheet. One piece of mica, which was, I think, the richest in crystals which I have had, was nearly valueless from the difficulty of getting a crystal out because of this trouble. No matter what care I took, I shattered them.

Some idea of the variety of forms found can be got from the slides Dr. Bolles will show you. I have never seen two that could be said to resemble each other except in a general way. You might say of one group that they were fan-shaped, of another that they were palm-like, of another that they were plumose. The variety is infinite. I have mounted nearly one hundred slides, and I have examined under the glass probably three hundred, but the variety is so great that I have felt unable to attempt a classification by form. I hope you may appreciate my difficulty. I know you would if I could have the pleasure of showing you the collection.

I should like to remark upon another of my questions. By what I have learned of the laws of crystallization, I have been taught to expect that the association of given elements, in given proportions, will give a crystal having certain invariable features, constant in its angles, manner of modification by twinning, etc. The typical crystal of Tourmaline is a three-sided prism, having a three-sided pyramidal termination, striated longitudinally, never tapering in a detached crystal within my observation. I have never but once seen a detached crystal curved. But the slides show tapers, curves, etc., till they are bewildering. In the largest of the enclosed crystals I have been unable to discover longitudinal striation, and the form of the crystals has changed to a flat, blade-like form, in some cases represented by a blade of grass. Also, in most of my specimens the crystals are curved; the straight are the exceptions. In the slide marked No. 3 is an exceptional appearance, which I can only account for upon the theory of alteration. You may agree with me by observing that the crystal polarizes only in the thicker parts.

One thing I have omitted to mention which is of interest. Microscopic crystals are seldom found in clear, straight, laminated mica. They are much more likely to occur in mica which I should describe as crinkled. The piece of mica enclosed in the paper, marked "A," will explain my meaning. I think there are seven separate and distinct crystals in this piece. At one place three fan-shaped crystals can be brought within the field of my one-inch objective, although when the three are seen they will all be well toward the outer limit of the field.

A brief description of my method of getting my specimens ready to mount may be of interest. Having discovered a crystal by examining the piece of mica in a strong light, and by the aid of a hand-glass of two to three inches focus, I endeavor to remove the mica, layer by layer, until I have lifted off the last continuous covering layer, then to do nearly the same thing from the other side until I have removed all but the last layer. This can be done quite easily by cutting out, with the scissors, a square with the crystal about in the centre. Mounting upon a slide is quite simple when the specimen is thus made ready. I have had better success with Canada balsam than with glycerin jelly, but there may be better media with which I am not acquainted. My methods are the methods of twenty-five years ago, as I have hardly looked through a microscope till I found the microscopic Tourmalines, and, being a busy man, I have had no time to give to it, excepting in the evening, generally after nine o'clock.

Hoping I may have been enabled to bring to your notice something before unknown, and which may give you pleasure, and asking your kind indulgence for my slides, which I am aware are faulty in preparation,

I am, very truly,

Your obedient servant,

EDWIN S. DRAKE.

PORTLAND, Maine, January 13th, 1891.

PROCEEDINGS.

Meeting of February 6th, 1891.

The President, Mr. P. H. Dudley, in the chair.

Fourteen persons present.

Mr. Anthony Woodward announced the death at Bournemouth, England, on January 10th, 1891, of Mr. Henry Bowman Brady, F.R.S., LL.D., the writer on Foraminifera in connection with the "Challenger" Expedition.

Rev. E. C. Bolles, D.D, presented a paper by Mr. E. S. Drake, of Portland, Maine, entitled "The Discovery of Microscopic Tourmalines in the Micas of Maine." This paper was illustrated by twenty microscopical slides prepared by Mr. Drake, and it is published in this number of the Journal, page 102.

In the discussion of this paper Dr. Bolles said that this mica is found in pieces of about the size of the human hand. A beautiful, plate-like form of quartz is sometimes found in mica, but not in the locality here mentioned. And, further, that Mr. Drake deserves great credit for isolating these crystals, which are exceedingly fragile.

Mr. J. D. Hyatt said that he had found crystals which resembled these in the mica of Manhattan Island, New York.

OBJECTS EXHIBITED.

1. Twenty microscopical slides, prepared by Mr. E. S. Drake, illustrating the paper of the evening: by E. C. Bolles.

2. Balancer of the House-fly, *Musca domestica* L., with so-called auditory organs: by J. L. Zabriskie.

Mr. Zabriskie said that the balancers of the diptera are doubtless rudimentary posterior wings. They are of dumb-bell form, situated upon, and directed outward and backward from the posterior sides of the thorax. The hou e-fly has two curious structures on the opposed surfaces of the enlarged base of each balancer, which structures are considered by some authors to be auditory organs. These structures occupy elliptical enclosures, which are crossed transversely by ten or eleven prominent ridges of beads, the ridges being separated by flattened depressions, and the depressions being furnished at regular intervals with stout hairs curving backward over the ridges.

Mr. George F. Kunz donated to the Library of the Society Special Report No. 8 of the U. S. Department of Agriculture, entitled "Cotton in the Empire of Brazil (1885): by John C. Branner, Ph.D."

Meeting of February 20th, 1891.

The President, Mr. P. H. Dudley, in the chair.

Twenty-seven persons present.

Mr. H. W. Calef was elected Recording Secretary *pro tem.*

The Corresponding Secretary presented a communication from the New York Academy of Sciences requesting the appointment of "two commissioners to meet with the same number from each of the other scientific societies located in New York City, with a view to holding a conference at which can be discussed plans for mutual benefit."

The Chair appointed as such commissioners Rev. J. L. Zabriskie and Mr. J. D. Hyatt.

Dr. Charles E. Pellew addressed the Society on "The Bacillus of Tuberculosis"

In a most able and interesting manner Dr. Pellew explained the character and operation of tuberculosis, the nature, operation, and culture of various bacilli, and gave a biographical sketch of Dr. Koch, with especial reference to his experimentation connected with the discovery of the properties of "the lymph," and the method of the employment of the latter in combating the disease.

The address was illustrated by an admirable projection of numerous lantern slides, by large colored diagrams, growth of bacilli in culture tubes, a large preparation on glass of human tuberculous mesentery, a bottle of the "Koch lymph" just received from Germany, and the following objects under microscopes, exhibited under the supervision of Dr. Pellew's assistants, Messrs. H. S. Stokes, H. C. A. Amory, and A. S. Vosburgh:

OBJECTS EXHIBITED.

1. Tubercle bacilli in sputum.
2. Giant cell in tubercle of finger.
3. *Bacillus megaterium.*

4. Comma bacilli of *Cholera Asiatica.*
5. Spirilli of *Cholera nostras.*
6. Pneumonia micrococcus.
7. Anthrax bacillus.
8. Anthrax bacillus in blood of mouse.

Meeting of March 6th, 1891.

The President, Mr. P. H. Dudley, in the chair.

Eighteen persons present.

Mr. T. F. Smith, F.R.M.S., of London, England, was elected a Corresponding Member of the Society.

OBJECTS EXHIBITED.

1. Shell of Common Shrimp, *Crangon vulgaris* Fab., showing pigment cells in under layer: by L. Riederer.

2 Pollen in honey of the Hive-bee, *Apis mellifica* L.: by L. Riederer.

3. The fungus, *Pestalozzia insidens*, n. sp., on *Ulmus Americana* L.: by J. L. Zabriskie.

4. The fungus, *Pestalozzia tremelloides*, E. & E, on *Vitis* sp., by J. L. Zabriskie.

5. Ash block from Colon, S. A., containing living specimens of *Calotermes flavicollis* F., sent by Mr. J. Beaumont: by P. H. Dudley.

6 A ruling on glass by the late Charles Fasoldt, with bands from 5,000 per inch to those said to be 200,000 per inch: by P. H. Dudley.

7 Ore from Chihuahua, Mexico, containing iron, silver, copper, lead, and zinc: by H. W. Calef.

Mr. Anthony Woodward, chairman of the Committee on Annual Reception, reported progress, explaining the extended work of the Committee in their endeavor to make provision for a creditable reception.

Mr. Riederer explained his exhibits as follows:

1. Shell of the Common Shrimp, *Crangon vulgaris* Fab. Some crustaceans, like some amphibians, fishes, and cephalopods, have cromatophores, or pigment-cells. I have found only brief notes concerning such pigment-cells in crustaceans, and therefore make this statement respecting amphibians and cephalopods.

Claus remarks on pigment-cells in cephalopods, as *Sepia* and *Loligo* : "The walls of the pigment-cells are formed of a cellular membrane, to which numerous radiating muscular fibres are attached. When these contract the cells are pulled into a star-shape, and the pigment is distributed. When contraction ceases the cell returns, by the elasticity of the wall, to its original spherical shape, and the pigment is concentrated into a small space, thus the animal changes color. As far as color is concerned, there are usually two kinds of chromatophores, placed near and one above the other. They are connected with a special centre on the stalk of the optic ganglion, and they cause a rapid interchange of blue, red, yellow, and dark color."

In amphibians the various colorings of the skin are principally due to branched pigment-cells of the cutis. The change of color in frogs is caused by changes in the form of these cells.

2. Pollen in honey of the Hive-bee. When bees gather nectar from the flowers, they also gather ripe pollen, which is brushed off by the hairs which cover the body Bees, like flies, frequently clean their bodies. This act of cleansing is chiefly accomplished by the fore legs, on which they have a comb-like attachment—exhibited before this Society on several occasions. And the collected pollen, often carried home in large loads, they fasten on the broadened part of the hind legs, the "pollen baskets." *

Even honey taken from the hive invariably contains more or less of pollen ; and the scum, forming on honey after standing for some time, consists almost exclusively of pollen grains and a few other impurities, such as hairs of bees and butterflies. The presence of these impurities is a good test of the quality of honey. Large quantities of glucose, made from maize, are sold under the name of honey. Such honey, as might be expected, contains no pollen.

Mr. Zabriskie explained his exhibits as stated on page 101.

Mr. Dudley explained his exhibits of Termites in blocks of White Ash prepared by Mr. Beaumont. Each block has a shal-

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* The Hive-bee certainly uses also the mandibles and the legs in collecting pollen, especially when the latter is abundant in the particular flowers which it is at the time frequenting. And in such times of abundance the loads in the corbiculæ, or "pollen baskets," may be seen to be increased by a rapid and very peculiar combined motion of all the legs, passing backward the pollen mixed with adhesive nectar, while the bee rises from and is still hovering over the flower.—Ed.

low cavity hollowed in the upper surface, large enough to freely contain the living Termites, which are held captive by a glass slip fastened over the cavity. The block under the microscope is tenanted by two auxiliary queens, one soldier, and three workers of the species mentioned.

Mr. Dudley also stated that he had seen the rulings of the late Mr. Fasoldt, exhibited under the preparer's own manipulations of illumination and magnification, and that he was able to distinguish the bands said to be 190,000 to the inch.

Meeting of March 20th, 1891.

The President, Mr. P. H. Dudley, in the chair.

Eighteen persons present.

Mr. J. D Hyatt, of the Commissioners appointed by the Society to the Conference of the Scientific Societies of New York City, reported the action of said conference. The report was accepted and adopted, and on motion it was resolved: That the present Commissioners be continued in their office for the ensuing year.

Mr. Anthony Woodward, chairman of the Committee on Annual Reception, reported the action of his Committee in arranging for a reception to be held at the American Museum of Natural History in Central Park, on the evening of April 17th next, and stated that the use of the first floor and lecture room of the Museum was offered gratuitously by the authorities to the Society for such purpose.

On motion it was resolved: That the Corresponding Secretary be directed to convey to President Morris K. Jesup and the Trustees of the Museum the hearty thanks of the Society for this kind offer.

Dr. Edward G. Love exhibited one hundred projections of lantern slides of his photomicrographs, and Mr. Charles F. Cox also exhibited projections of a large series of lantern slides made from Dr. Woodward's celebrated prints of diatoms.

[We heartily recommend the new work, "Appleton's School Physics," published by the American Book Company. One desiring assistance in comprehending the foundation principles and operations of optical instruments will find clear, accurate, and valuable instruction in the chapter on "Light," comprising seventy-eight pages, treating of reflection, refraction, lenses, the spectroscope, photography, vision, polarization, etc., abundantly and beautifully illustrated.—ED.]

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Corrections to be made in the number of the JOURNAL for April, 1891:

Fig. 12, plate No. 27 should be reversed in order to agree with General Cox's references to it on page 80.

Page 81, eleventh line from bottom, for Dr. Brebisson read De Brebison.

Page 85, fourteenth line from top, for No. 15 read No. 14.

Page 86, ninth line from bottom, for No. 15 read No. 14.

Journal

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

Vol. VII. OCTOBER, 1891. No. 4.

STRUCTURE IN STEEL.

BY P. H. DUDLEY.

(*Read June 19th*, 1891.)

The subject is so vast and important that I shall confine my remarks principally to rail steel. Besides the iron forming the basis of ordinary steel rails, they have a large range in chemical composition, as shown by the following table :

	Parts of 1 per cent.
Carbon	.25 to .50
Manganese	.30 to 1.50
Silicon	.04 to .30
Phosphorus	.03 to .15
Sulphur	.04 to .10
Copper	.10 to .80

Traces of other minerals are present.

This alloy, being formed by fusion and cast, is of course crystalline in structure. The texture will be fine or coarse, according to composition, size of ingot, rapidity of solidification, amount of mechanical work given to the metal in reducing to the section of the rail, shape and size of the latter, and the temperature at which the rail is finished. In a section of rail of which the ingot or bloom was maintained at too high temperature, the crystallization becomes coarse and often sharply defined, the matrix enclosing or joining the crystals weak and breaks upon the surface, instead of pulling out the portions which penetrated the large pseudo-crystals. The delicate matrix enclosing the pseudo-crystals is shown in specimen No. 1 with low powers, but few traces of lines from the matrix are seen to penetrate to the interior of the polygons. This specimen is from the tire of a steel wheel, is very hard, and contains 6 per cent of manganese. Wheels of such steel have given a very large mileage. Specimen No. 2 is from a rejected heat of rails, and contains .90 of carbon. The ingot was maintained at too high a heat in the reheating furnace, coarse crystals resulting in the head of the rail, and, as will be seen, they are quite well defined. In the fracture the crystals have separated from each other through the matrix without breaking the individual crystals. This shows first the overheating of the steel, which, in a large head of a rail, does not receive sufficient work to break up this coarse crystallization. The distance across the axis of the crystals measures $\frac{150}{1000}$ to $\frac{175}{1000}$ of an inch, which, for a good wearing rail, I consider coarse, though the majority of rails in the track are much coarser. Specimen No. 3 is from the same rail, taken near the top of the head, and shows that the mechanical treatment of rolling has broken up the coarse crystallization, rendering it practically amorphous, very fine in texture—in fact, much finer than can be expected in rails until higher carbons are reached than has been until recently considered advisable to put in the tracks. As we increase the carbon in rails we increase the hardness, raise the elastic limit and tensile strength, but, on the other hand, decrease the elongation, and, without great care, render the steel brittle under shock instead of retaining sufficient toughness in the rails to render them safe in the track during winter in this latitude. The element phosphorus tends to render rails brittle, or cold-short, and as the carbon is increased the phosphorus must be decreased, at least with ordinary sections having deep heads and thin bases. Phosphorus exists in the pig iron, or the ores from which the pig iron is made, and to such an extent in many ores that they are unsuitable for Bessemer metal, and it requires some care to select ores which will run from .08 to .10 of 1 per cent of phosphorus, about the limit to be combined with .35 to .40 of 1 per cent of carbon. While rails, many years since, containing .35 to .40 in carbon were suitable for the traffic at that time, they wear too rapidly under the present traffic. To increase the carbon for better wearing qualities, it is first necessary to introduce a section for heavy rails which would cool more uniformly, reducing the coarseness of the texture, and at the same time keep the phosphorus down to avoid brittleness.

In 1883 I designed an 80-pound section, which makes the structure of the metal in the head much finer than usual. The section was put into service in 1884, the manufacture of which became the type of modern sections. Over 200,000 tons of this section have been put into service, some of the rails having .50 in carbon. Even with so much carbon the elastic limits of the steel are below what is necessary for modern traffic, and I am now making rails with .60 carbon, the phosphorus being down to or under .06. Specimen No. 4 shows a piece of steel from such a composition which is very fine-grained for a large rail, tough, and has a tensile strength of 120,000 to 130,000 in the head, the elastic limits ranging from 60,000 to 65,000 pounds. Such rails can be produced commercially, the cost only being increased about one-tenth above the cost of ordinary rails.

Without microscopic examination it is difficult to see why it is so important to make the rails of fine texture and high elastic limits. If a rail simply had to perform the functions of a girder, we could increase its dimensions so that it would have ample strength, even though the elastic limits of the metal were low. But the upper surface of the rail must also act as the infinitesimal rack by which the drivers secure their adhesion for locomotion. Tracing these matters out more fully, we find the metal, in the head of the rail under a driver, in *compression* to the vertical axis of the section, while the metal under the neutral axis would be in *extension*, which would reach to each tie, beyond which, as far as affected by the weight of that driver, the base would be in compression and the head in extension. These strains would be reversed as the driver or wheel reached the next tie space. The metal in the head directly under the wheel must not only bear the weight upon the driver, but also all the traction the driver is exerting to draw the train. From the small areas in contact, the ratio of pressure is from 60,000 to 80,000 pounds per square inch, while the traction often amounts to one-half as much for the surfaces in contact as longitudinal strain upon a thin layer of surface metal in the rail head. Examining the rails in the track with the microscope, we find not only small portions of the metal torn out, but a series of minute cracks, showing that the metal has been strained upon the surface beyond its elastic limits, and surface wear of metal rapidly occurs. To check this wear we need high elastic limits of the metal for the surfaces in contact. The metal in the tires of wheels abrades on the surface and also drops out in patches, as may be seen in specimens Nos. 3 and 4.

It will be readily understood that, while it is desirable to have sufficiently high elastic limits in the steel to keep the section from taking permanent set under the loads or trains, it is necessary to have high elastic limits in the metal to resist wear. Steel of .35 to .40 carbon has elastic limits in the head varying from 38,000 to 45,000 pounds per square inch, and even then, in the thin-flanged rails, is liable to be brittle. In steel like that shown in specimen No. 4 the elastic limits range from 60,000 to 65,00c pounds in the head, and it is tough in the sections in which it is used. In the 75-pound section, into which several thousand tons have been rolled, the rails are exceptionally tough, exceeding, so far as any records have been published, any tests which have been made. In the 95-pound rails, into which many thousand tons of high carbon metal have been rolled, they are much tougher than was supposed possible to make such large sections. The tendency of improvement in quality of steel is now the production of a fine texture having high elastic limits and considerable percentage of elongation before the full limit of tensile strength is reached. Specimen No. 5 shows the end of a tensile specimen of 53,470 pounds elastic limit and 23 per cent of elongation, the fracture fine and silky, showing at once that it was a tough piece of metal. No evidence of coarse crystallization on the interior of the specimen is to be seen, portions of the matrix penetrating and pulling out from the interior of all the crystals. This steel has been worked to make a fine texture. Specimen No. 6 is from the side of specimen No. 5, and shows on the exterior a tendency to separation on the outside surface of the original large crystals as soon as the steel has passed the elastic limits. On the interior, each crystal being surrounded, greater flow or distortion takes place before separation. This specimen will also serve to better illustrate my remarks about the necessity of high elastic limits in surface of the rails to resist wear.

PROCEEDINGS.

Meeting of April 3d, 1891.

The President, Mr. P. H. Dudley, in the chair.

Twenty-one persons present.

Mr. A. Woodward, chairman of the Committee on Annual Reception, reported the action of the Committee, and the favorable response of the members of the Society, indicating the prospects of a successful Reception.

On motion it was resolved: That the Committee on Annual Reception invite dealers to exhibit instruments and apparatus at said Reception.

Mr. Stephen Helm, F.R.M.S., delivered the fourth and last of his series of addresses on the lower forms of animal life, entitled "Polyzoa and Hydrozoa." This address was illustrated by an extended succession of beautiful, enlarged diagrams, prepared by Mr. Helm, and also by objects exhibited under microscopes as stated below.

OBJECTS EXHIBITED.

1. *Hydra viridis:* by Stephen Helm.
2. Statoblasts of *Pectinatella magnifica:* by Stephen Helm.
3. *Plumatella repens:* by Stephen Helm.
4. *Bugula avicularia* with "bird's-head processes": by Edw. G. Love.
5. *Bicellaria tuba:* by Edw. G. Love.

On motion the thanks of the Society were tendered Mr. Helm for his series of interesting addresses.

Annual Reception.

The Annual Reception of the Society was held at the American Museum of Natural History, Central Park, New York City, on the evening of April 17th, 1891.

The exhibits were displayed in the large Hall of the first floor of the Museum.

In the large new Lecture Room, adjoining, three successive exhibitions were given as follows: At 8 p.m., Exhibition of Lantern Slides of Diatoms, by Charles F. Cox; at 9 p.m., Exhibition of Lantern Slides of Photomicrographs, by Edw. G. Love; at 10 p.m., Exhibition of a series of Wood Sections, by P. H. Dudley.

The projections of these exhibitions were made on two screens by two stereopticons alternately, one illuminated by the electric arc light, under the care of L. H. Laudy, and the other illuminated by the lime light, under the care of L. C. Laudy.

The intervals between the exhibitions were enlivened by excellent band music.

The microscopical objects in the large Hall and their exhibitors are herewith enumerated as follows:

OBJECTS EXHIBITED.

1. (In alcove.) Old Microscopes and Objectives: by Wm. Wales, J. L. Zabriskie, C. F. Cox, D. S. Martin, and F. D. Skeel.

2. Prints of Old Microscopes: by E. G. Love.

3. (In alcove.) Photomicrographic Apparatus: by L. H. Laudy.

4. (In alcove.) Section Cutting, illustrated by Apparatus and a selection of Serial Sections, prepared by the Paraffin Process: by L. Riederer.

5. (In alcove.) Bacteriology, illustrated by growing cultures and slides: by C. E. Pellew.

Photomicrography: by E. G. Love—

6. (In alcove.) Apparatus and the method of its use.

7. Prints of various forms of Photomicrographic Apparatus.

8. Photomicrographs, and the same with Negatives.

9. (In alcove.) Case, showing specimens of Termites, their destructive work, and portions of their nests: by P. H. Dudley.

10. (In alcove.) Case, showing specimens of Fungi and Decayed Wood: by P. H. Dudley.

11. (In alcove.) A Series of Drawings of the lower forms of Animal Life: by Stephen Helm.

12. (In alcove.) Microphotography, illustrated by Apparatus and Slides: by S. N. Ayres.

13. Attachment to the Turn-Table, with mechanism for driving the same: by F. D. Skeel.

Instantaneous Photomicrographs: by J. M. STEDMAN—

14. Colony of Vorticellidæ, from life.

15. Group of Nais in rapid motion.

Foraminifera: by A. WOODWARD—

16. *Haliphysema Tumanowiczii*, Cornwall, Eng.

17. *Faujasinao carinata*, Cornwall, Eng.

18. Specimens from Chalk, Island of Rügen.

19. Specimens from all parts of the world, and a selection from the collection of the American Museum of Natural History.

20–21. Two Slides, mounted by J. W. Bailey about 1845.

22. Human Flea, *Pulex irritans:* by WM. BEUTENMÜLLER.

23. Eye of House Fly, *Musca domestica:* by WM. BEUTENMÜLLER.

24. Sting of Honey-Bee, *Apis mellifica:* by WM. BEUTENMÜLLER.

25. Scales of various Species of Butterflies, with a collection of Butterflies and Moths from the American Museum of Natural History: by WM. BEUTENMÜLLER.

26. Alloy of Gold, Silver, and Copper: by L. P. GRATACAP.

27. Section of Tulip-Tree, *Liriodendron tulipifera:* by L. P. GRATACAP.

28. Crystals of Sulphate of Copper: by ALFRED BEUTENMÜLLER.

29. Crystals of Bichromate of Potassium: by ALFRED BEUTENMÜLLER.

30. Crystals of Chlorate of Potassium: by ALFRED BEUTENMÜLLER.

31. Vinegar Eels, living: by ALFRED BEUTENMÜLLER.

32. Agatized Wood, enclosing Fungus, Arizona: by THOS. B. BRIGGS.

33. Basalt with Olivine: by THOS. B. BRIGGS.

34. Oligoclase, New York City: by THOS. B. BRIGGS.

35. Hornblende, New York City: by THOS. B. BRIGGS.

36. Foot of Fly: by THOS. B. BRIGGS.

37. Section of Pebble from Chagres River, Panama: by THOS. B. BRIGGS.

38. Sections of Epidosyte, Fibrous Hornblende, Tourmaline, Oligoclase, Mica-schist, and Mica, shown with automatic revolving stage: by JAMES WALKER.

39. Sections of Garter-Snake, embryo, *Eutania sirtalis:* by L. RIEDERER.

40. Sections of California Salmon, embryo, *Oncorhynchus chouicha:* by L. RIEDERER.

41. Marine Crustaceans: by L. RIEDERER.

42. Sections of the Eyes on the Mantle of the Common Scallop, *Pecten irradians:* by L. RIEDERER.

43. Sections of the Eye of the Hermit Crab, *Eupagurus Bernhardus:* by L. RIEDERER.

44. Larval English Oysters, polarized light: by SAMUEL LOCKWOOD.

45. Metal Chips cut from Cover of Box by Mexican Beetle: by F. W. DEVOE.

46. Spider's Silk Compared with 120 Spool-Cotton Thread: by F. W. DEVOE.

47. Section of a Rat's Toe: by CHAS. S. SHULTZ.

48. Platino-cyanide of Magnesium, polarized light: by CHAS. S. SHULTZ.

49. Vase and Bouquet of Diatoms and Butterfly Scales: by MISS M. A. BOOTH.

50. Section of Leaf of Scotch Pine, *Pinus sylvestris:* by GEO. E. ASHBY.

51. Fibre from Fruit-stalk of Banana, polarized light: by E. G. LOVE.

52. Anchors and Plates of Synapta, dark-ground illumination: by E. G. LOVE.

53. Crystallized Tin: by E. G. LOVE.

54. Spiracle of Larva of Dytiscus: by E. G. LOVE.

55. Itch Insect, *Sarcoptes scabiei:* by E. G. LOVE.

56. Gizzard of Cricket: by E. G. LOVE.

57. Arrowhairs of Dermestes: by E. G. LOVE.

58. Luxulyanite, polarized light: by J. W. FRECKELTON.

59. Native Copper, crystallized, Lake Superior: by FREDERICK KATO.

60. Crystals of Black Snake Fat, polarized light: by EDGAR J. WRIGHT.

61. Bacillaria paradoxa, living: by A. G. ROBINSON.

62. Hydra viridis: by T. CRAIG.

63. Section of Echinus Spine and Echinus with Spines removed: by A. H. Ehrman.

64. The Parasitic Wasp, *Leucospis affinis* Say: by J. L. Zabriskie.

65. Fragment of "The Pen" of the Squid, *Loligo Pealei* Lesueur, polarized light: by J. L. Zabriskie.

66. Tangential Section of Bamboo: by F. D. Skeel.

67. Section of Gneiss, Long Island, polarized light: by F. D. Skeel.

68. Compound Eye of Insect, with multiple images: by J. D. Hyatt.

Termites, or so-called "White Ants," from Panama: by P. H. Dudley—

69. Eutermes Soldier—entire.

70. Head of Termes—Soldier.

71. Head of Calotermes—Soldier.

72. Worker of Termes minimus Beaumont.

73. Head and Wing of Termes minimus Beaumont.

74. Ovaries, portion, of Eutermes Queen.

75. Circulation of Chlorophyll in Nitella, a fresh-water plant: by Stephen Helm.

76. Pond Life: by Stephen Helm.

77. Diatom, *Arachnoidiscus Ehrenbergii:* by F. Collingwood.

78. Cyclosis in Cells of Anacharis Canadensis: by C. F. Cox.

79. Section of Serjania (stem), polarized light: by C. F. Cox.

80. Section of Skin from Negro, showing pigment cells: by W. H. Mead.

81. Pond Life: by M. M. Le Brun.

82. Circulation of Blood in the Foot of the Frog: by Jno. L. Wall.

83. Gold Crystals, Fern-leaf form: by G. S. Woolman.

84. Section of Wood: by G. S. Woolman.

85. Head of Mosquito: by G. S. Woolman.

86. Silver Crystals in process of deposition from Nitrate of Silver: by Geo. C. F. Haas.

87. Human Blood on Holman's Slide: by F. W. Leggett.

88. Pollen of Lavatera, in situ: by H. W. Calef.

Microphotographs: by S. N. Ayres—

89. Sherman's March to the Sea.

90. Foes or Friends.

91. Portrait of Lady.

92. Portrait of Child.

93. Butterfly Scales (1173) arranged to represent a Vase of Flowers: by C. W. McAllister.

94. Scales of forty varieties of South American Lepidoptera: by J. D. Mallonee.

95. Human Scalp, vertical section showing hair bulbs and sebaceous glands: by H. F. Crosby.

96. Foot of Emerald Spider, *Micromata smaragdula*, by H. Hensoldt.

97. Feathers of Brazilian Humming-bird: by H. Hensoldt.

98. Section of Human Brain: by S. A. Briggs.

99. Daphnia pulex: by O. S. Wilson.

100. Chelifer, Pseudo-scorpion: by Wm. Huckel.

101. Tongue of Honey-bee: by C. W. Brown.

102. Leg and Foot of Honey-bee, showing pollen brushes and pollen in situ: by H. C. Bennett.

103. Human Optic Nerve: by L. Schöney.

104. Phylloxera of Grape Vine: by L. Schöney.

105. Yeast Plant: by A. S. Hunter.

An extended series of Microscopes and Microscopical Apparatus was also exhibited by Meyrowitz Brothers, George S. Woolman, Bausch & Lomb, and Eimer & Amend.

It was estimated that between two and three thousand persons were present during the evening.

Meeting of May 1st, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Fourteen persons present.

Mr. Sereno N. Ayres was elected a Resident Member.

The Corresponding Secretary announced the donation to the Cabinet of the Society by Miss M. A. Booth of 13 slides of her own preparation—1. Flea of Mouse; 2. Parasite of Barred Owl; 3. Jigger Flea from Florida; 4. Parasite of Snipe; 5. Parasite of Snowy Owl; 6. Flea of Cat; 7. Parasite of Pig; 8. Hairs of larva of *Trogoderma ornata;* 9. Parasite, eggs of parasite, and hairs of Monkey; 10. Wing of Mosquito, *Anopheles quadrimaculata;* 11. Spicules of Sponge, *Meyenia fluviatilis;* 12. Statoblasts of *Plumatella;* 13. Epidermal organs of *Mentzelia floridanum.*

In addition to the above Miss Booth also donated three photomicrographs, taken by herself—1. Statoblasts of *Plumatella;* 2. Hairs of *Trogoderma ornata;* 3. Hairs of *Anthrenus scrophulariæ.*

On motion the thanks of the Society were tendered Miss Booth for these donations.

The Recording Secretary, Mr. Geo. E. Ashby, announced the receipt, from the Department of Microscopy of the Brooklyn Institute, of tickets of admission and the invitation of the members of this Society to attend the Annual Reception of said Department of Microscopy, to be held in Brooklyn on the evening of the 13th instant.

On motion the thanks of the Society were tendered the Department of Microscopy for this invitation.

Mr. E. A. Schultze announced the intended visit to this country in the approaching fall of Mr. J. D. Möller, of Holstein. During this visit Mr. Möller will exhibit large collections of his celebrated preparations of diatoms. Mr. Schultze referred at length to the famed work of the eminent preparer, and distributed among the members of the Society Mr. Möller's circulars, giving the history and description of his famous type and test-slides.

On motion of Mr. Schultze it was resolved: That the Board of Managers be requested to extend an invitation to Mr. Möller to meet this Society during his proposed visit to this country, at some time agreeable to his own convenience.

On motion it was resolved: That the thanks of the Society be tendered Mr. Morris K. Jesup, President, and the members of the Board of Trustees of the American Museum of Natural History, for the generous manner in which the Halls of the Museum and all accompanying facilities were accorded the Society on the occasion of the late Annual Reception.

On motion it was resolved: That the thanks of the Society be tendered Dr. L. H. Laudy and Mr. L. C. Laudy for their invaluable assistance in the provision and the management of the stereopticon projections; and to Mr. William Wallace, Superintendent of the Museum, for the courteous manner in which he had assisted the Committee on this same occasion of the Annual Reception.

On motion it was resolved: That the Curator be requested to furnish the Recording Secretary, at intervals, with a list of suitable objects in the Cabinet of the Society, from which selections of exhibits for the regular meetings of the Society may be made when it may be desirable.

The Chairman, Mr. J. D. Hyatt, announced the approaching meeting of the American Society of Microscopists, to be held in the city of Washington on the 11th of August.

OBJECTS EXHIBITED.

1. Jigger Flea from Florida—Donation to the Cabinet and preparation of Miss M. A. Booth: by J. L. Zabriskie.
2. Statoblasts of *Plumatella:* by J. D. Hyatt.
3. Conjugation of *Spirogyra nitida:* by E. G. Love.
4. Photomicrograph of the same: by E. G. Love.
5. Wing of Mosquito from Panama: by T. B. Briggs.
6. Section of Hornblende: by T. B. Briggs.
7. Epidermal organs of *Mentzelia floridanum:* by G. E. Ashby.
8. The cœlenterate, *Obelia commissuralis:* by L. Riederer.
9. *Bugula* sp. with diatoms in situ: by L. Riederer.

Meeting of May 15th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Thirteen persons present.

The Corresponding Secretary announced a communication from Mr. K. M. Cunningham, of Montgomery, Alabama, accompanying a donation to the Society of a packet of infusorial earth, an extended deposit of which earth Mr. Cunningham had lately discovered in the neighborhood of Montgomery. The main portion of the communication consisted of the following article, relating to this subject, published by Mr. Cunningham in a late issue of the Montgomery *Advertiser:*

"*Discovery of a New Infusorial Earth at Montgomery.*

Editor Advertiser:

"As a matter of scientific interest to your readers, I would like to make known the discovery of a deposit of infusorial earth, made on yesterday evening while strolling along the river bluffs, observing the character of the various exposed strata. While in the vicinity of the soap factory I noticed an outcrop of argillaceous earth, which, upon an ocular examination with a small lens, suggested the possibility of its being a fossil earth. On giving it the requisite treatment, I was surprised to find that it proved to be a pure diatomaceous earth, and as it happens to be the first of its kind and character recorded as occurring in the Southern States, I hasten to announce the fact. To convey a popular idea of what the substance is in an economic way, it has the following uses in the industrial arts : under the common name of tripoli it is used in polishing optical lenses of all kinds; next, as the basis of the well-known dentifrice Sozodont; then as an adjunct to nitroglycerin in making the powerful explosive called dynamite; as a silverware-polishing substance known in the trade as electro-silicon; and, finally, as of universal interest as material for microscopic study and research, its value as a microscopic novelty being about one dollar a pound. Incidental to the above points of interest, I would mention that its occurrence adds another component rock to the geological strata of Alabama, hitherto not noticed or mentioned in any work treating of the geology of Alabama. I have barely examined the extent of the thickness of the stratum, but it may have a greater thickness than four feet, and may likewise underlie a very wide area in the vicinity of the hill where its outcrop occurs. A substance similar in its nature and composition occurs in Northern Europe, and is known as 'mountain meal,' and in times of scarcity of food is mixed with wheat or rye and eaten as food. The mineralogical characteristics of the substance are in its being a white clay-like substance, fissile, lamellar; when moistened gives off a clay-like odor and adheres to the tongue; dissolves readily in the mouth, and is pleasant and agreeable to the taste; its mineral composition is practically pure silica; in its microscopic appearance it is a flour composed of millions of minute and very elaborately sculptured silicious, glassy, or transparent shells, associated also with numerous fresh-water sponge spicules, and the absence of all other extraneous vegetable and mineral débris, such as sand grains, etc. The numerous included species are similar to forms already named from localities in the New England States, but an entirely new source of the material must in the future make Montgomery widely known, as diatomists in all parts of the world will want samples of it for their collections when its fame is spread abroad.

"Dr. Wilkerson, of this city, is the first person who has been able to verify this discovery, as it was first viewed through the microscope in his office. K. M. CUNNINGHAM."

OBJECTS EXHIBITED.

1. Eggs of Bot-fly on horse-hair: by H. W. CALEF.

2. A curious unknown, aquatic, hemipterous larva: by J. L. ZABRISKIE.

3. A bar of Flexible Sandstone from South Carolina: by WILLIAM G. DE WITT.

From the Society's Cabinet:

4. Parasite of Barred Owl.

5. Hairs of larva of *Trogoderma ornata.*

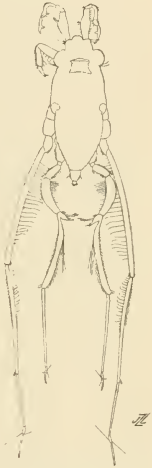
6. Wing of Mosquito, *Anopheles quadrimaculata.*

7. Spicules of Sponge, *Myenia fluviatilis.*

8. Parasite, eggs of parasite, and hairs of Monkey.

Mr. De Witt donated his exhibit of Flexible Sandstone to the Cabinet of the Society.

Mr. Zabriskie said of his exhibit that it was captured on July 11th, 1890, in the stream of the Water Works, Flatbush, Long Island. It was at first supposed to be a young larval form of *Gerris;* but it is much more strange in general contour and in curious additions to the appendages than any observed form of *Gerris.* The color is a uniform black, excepting five whitish spots, visible from above—one on the prothorax, two on the outer posterior margins of the metathorax, and two including the posterior coxæ. It has large, four-jointed palpi, the first proximal joint and the fourth joint bearing prongs, giving the appearance of stag horns. When a palpus is deflected the prong of the first joint apparently enters a cavity near the distal end of the third joint, probably forming a prehensile organ. The beak is short, stout, and reclined upon the sternum. The eyes are large and globular. The anterior legs are short and robust. The middle legs are much the longest, being equal to about two and one-half times the entire length of the body from the vertex to the anus. The femur of each middle leg is furnished throughout nearly its entire length with a row of straight, prominent hairs, about twenty-four in number, averaging in length about twice the diameter of the femur, projecting backward at right angles with the axis of the femur, each hair being slightly hooked at its distal extremity. The tibia of each middle leg is furnished with a row of about sixteen hairs, somewhat resembling those of the femur, excepting that they are shorter, more curved, more prominently hooked, and in that they extend only about one-half the length of the tibia, beginning at the proximal end. The femora of the posterior legs are so curved inwardly that, when opposed to each other, they form a nearly completed circle, and are each furnished with a tuft of stout hairs on their inner opposed surfaces. The tibiæ of the posterior legs are each furnished at the proximal end with a stout projection, turned at an angle inwardly, like the barb of a fish-hook, and each barb is surmounted by a stout, flexuous spine. These tibiæ have also each a slender pencil of long hairs about midway on their inner surfaces, and projecting backward at an acute angle with these surfaces. The last joint but one of the tarsi of the middle legs is furnished with two, and the corresponding joint of the posterior legs is furnished with three, long, diverging bristles. The entire length of the larva, from the curve of the deflexed palpi to the extremities of the long middle legs, when these latter are projected backward, is about three-eighths of an inch, and the length of the body from vertex to anus is a little less than one-eighth of an inch.



Unknown aquatic larva.
Magnified 10 diameters.

Meeting of June 5th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Eighteen persons present.

The Corresponding Secretary announced the death of Mr. Charles W. Brown, a Resident Member of the Society.

On motion it was resolved: That this Society has received with sorrow the intelligence of the death of one of its members, Mr. Charles W. Brown, of this city, whose demise occurred on May 19th last, and hereby records this expression of its loss sustained under this unexpected removal of an interested, sympathetic, and faithful attendant at its sessions.

The Corresponding Secretary announced a communication from Mr. K. M. Cunningham, of Mobile, Alabama, dated May 27th, 1891, and accompanying a donation to the Society of a hand-moulded brick of diatom-bearing clay weighing five pounds, which Mr. Cunningham had secured at Apalachicola, Florida, while on a Government survey of the bay, at a point on the bay shore about two miles south from the steamboat wharf at Apalachicola. Mr. Cunningham stated that "the material, on proper treatment, will yield a very interesting showing of 'Gulf Marine Diatoms.'" This "brick" was exceedingly hard, and only after severe labor with a cold-chisel and a heavy hammer were fragments secured, which were distributed among the members of the Society.

The Corresponding Secretary also read a second communication from Mr. Cunningham, dated May 29th, 1891, describing additional donations from him, as follows:

"1. A packet of Foraminifera from rotten limestone, Selma, Alabama. This rock underlies a wide area in the Black Belt, and outcrops at Selma as a bluff fifty feet high and of indefinite length on the river side. If a specimen of this substance be abraded with a tooth-brush, millions of the crystalline microscopic shells are secured.

"2. A piece of the rotten limestone having two sides prepared and polished so as to show the transparent nature of the microscopic shells.

"3. A packet of diatoms from a great spring near Birmingham, Alabama. The diatoms are related to *Epithemia* and *Eunotia*, and are so coarse that they move as freely in the packet as dry sand. They occur *in situ* or parasitic upon a sphagnum moss which grows on the rocky sides of the spring, from the surface down to fifty feet in depth, and are found in long ribbon-like masses, which, under acid treatment, break up into singles, doubles, etc. When the moss is dry a little shaking causes them to fall off, when they can be secured, if desired, by the pint.

"4. A packet of sand from the chert quarries near Birmingham, mainly composed of fragments of silicious, spicular bodies, and curious as a polariscope object.

"5. A packet of microscopic coral from a ledge on the Chattahoochee River at Fort Gaines, Georgia. The ledge is of enormous thickness and extent. The specimens were obtained by sifting the chalky material through gauze.

"6. A packet of fossil granules from a stratum of iron ore, excavated from the tunnel through the Red Mountain. The specimen suggests waste coffee grounds. It is not pretty, but contains a few microscopic snail-like shells.

"7. Fulgorite from a white sand bank at Apalachicola Bay Beach, Florida. If thin fragments of the cylinders are examined, the interior will be seen to be vitrified and polished, and, being full of gaseous bubbles (air?), will show tension colors as a polariscope mount.

"8. My attention having been drawn to certain blister-like blemishes in the oyster shells at Apalachicola, Florida, a brief examination showed that invariably under each blister a small quantity of mud was sealed. Where the inside of the blister did not touch the mud a great array of oyster-shell pearl particles were strewn. Only one side of the blister presents the phenomenon, and it forms an interesting object for the binocular.

"9. Two smoothed fragments of a colossal vertebral joint from the cretaceous formation of Alabama. These specimens, probably from the vertebra of *Zeuglodon*, are curious as being fossil bone. Two of these joints superposed are as large as a month-old baby."

OBJECTS EXHIBITED.

1. Arranged slide of 275 Diatoms from the Sendai deposit, Japan, prepared by Rev. Albert Mann, Jr.: by E. A. SCHULTZE.
2. Section of wood of Hemlock, *Tsuga canadensis* Carr., polarized: by E. G. LOVE.
3. Photomicrograph of *Pleurosigma angulatum*, taken by Dr. Clifford Mercer with a dry $\frac{1}{8}$, air angle 1.40, to show progress made in the manufacture of lenses: by WILLIAM WALES.
4. Larvæ of *Gerris*, of different ages: by J. L. ZABRISKIE.
5. Unknown larva of a Cecidomiid Fly, mining the leaves of the Red Cedar, *Juniperus virginiana* L.: by J. L. ZABRISKIE.

6. Section of eye of King Crab: by JAMES WALKER.

Mr. Zabriskie said of his exhibits that these larvæ of *Gerris* are of different sizes and doubtless of different ages, some of them being much smaller and all of them much plainer creatures than the remarkable aquatic larva exhibited at the last meeting.

The larva of the fly mining the leaves of the Red Cedar was taken at Cypress Hills, Long Island, on April 25th last, and was found only on this one occasion. The larva mines the base of the leaf—usually the tenth or twelfth leaf from the tip of the twig—causing an orange-colored, gall-like swelling. The mines are usually scattered and solitary. Only in two instances were larvæ found at the bases of adjoining leaves. The larva is of a bright orange color, about one-sixteenth of an inch long, stout, head very small, and with the junctions of the abdominal rings much constricted. Twenty-two specimens were found upon one small branch of the tree. The larva was submitted to Dr. Charles V. Riley, Entomologist-in-Chief, Washington, and he reported it as "new to the National Collection."

MEETING OF JUNE 19TH, 1891.

In the absence of the President and the Vice-President, Mr. Anthony Woodward was elected chairman.

Sixteen persons present.

Mr. Ernest Du Vivier was elected a Resident Member.

Mr. George E. Ashby was elected Recording Secretary in place of Dr. Bashford Dean, who was compelled to resign the office on account of the pressure of other duties.

The Recording Secretary read a paper by the President, Mr. P. H. Dudley, entitled "Structure in Steel." This paper was illustrated by six exhibits, as noted below, and is published in this number of the JOURNAL, p. 115.

OBJECTS EXHIBITED.

Six specimens of Rail Steel: by P. H. DUDLEY.

1. From the tire of a steel wheel; very hard; containing 6% of manganese, and showing the delicate matrix enclosing the pseudo-crystals. Wheels of such steel have given a very large mileage.

2. From a rejected heat of rails. The ingot was maintained at too high a heat in the reheating furnace. Coarse crystals resulted in the head of the rail. In the fracture the crystals have separated from each other without breaking the individual crystals.

3. From the same rail as No. 2, taken near the top of the head. The specimen shows the effect of the mechanical treatment of rolling, which has broken the coarser crystallization, rendering it of very fine texture—practically amorphous.

4. From a fine-grained large rail having a tensile strength of 120,000 to 130,000 in the head, the elastic limits ranging from 60,000 to 65,000 pounds. The specimen contains 60% of carbon, the phosphorus being down to or under .06.

5. The end of a tensile specimen of 53,470 pounds elastic limit and 23% of elongation. The fracture is fine and silky, showing that it was a tough piece of metal. This steel has been worked to a fine texture.

6. From the side of No. 5, showing on the exterior a tendency to separation on the surface of the original large crystals as soon as the steel has passed the elastic limits.

7. Section of ovary of Poppy: by CHARLES S. SHULTZ.

8. Section of English Mistletoe, double stained: by CHARLES S. SHULTZ.

9. Section of scalariform ducts in Tree-fern: by CHARLES S. SHULTZ.

10. Native gold crystals from Catawba Co., North Carolina: by GEORGE E. ASHBY.

11. Malachite from Arizona: by GEORGE E. ASHBY.

12. Section of Luxullianite from Cornwall, England: by JAMES WALKER.

13. Head and mouth parts of *Neris*: by L. RIEDERER.

14. Down feather of Canary Bird: by L. RIEDERER.

15. Transverse section of bud of Lily, of the thickness of one cell of the structure, double stained, having all parts *in situ*, and showing nuclei in all the cells: by ALBERT MANN, JR.

16. Transverse section of the ovipositor of the "Long-Sting Wasp," *Thalessa atrata* Fab.: by J. L. ZABRISKIE.

17. A specimen of *T. atrata*, captured in the act of ovipositing, and having the ovipositing membrane still distended five-eighths of an inch in diameter by the internal coils of the bases of both

the ovipositor proper and the guiding sheaths: by J. L. ZABRISKIE.

Referring to his exhibits, Mr. Zabriskie said that the ovipositor proper of *Thalessa* corresponds with that of *Cryptus* and all its near relatives (see Mr. Riederer's drawings, this JOURNAL, vol. vi., Plate 25), being composed of three main pieces firmly interlocked, but sliding upon each other throughout their entire length. The dorsal piece is the largest. It is solid at the back, nearly cleft in twain from beneath, allowing elastic expansion as of a spring hinge, and having a "tongue" at the middle of either side of the base. The two ventral pieces are counterparts of each other, each being provided with a groove for interlocking with and sliding upon the respective tongues of the ventral piece.

The best published account extant of the oviposition by *Thalessa* is that by Dr. Charles V. Riley in *Insect Life*, i., 172. He shows that the operation is somewhat as follows: The insect stands high upon its feet. The abdomen is raised in the air at right angles with the thorax. The ovipositor, five inches long, more or less, is managed by some of the feet, and its point is brought to bear upon the wood of the tree. The halves of the sheath do not enter the wood with the ovipositor proper, but are used as props and stays for the boring tool during the operation. By a movement from side to side and by bearing upon the ovipositor, the insect gradually forces back the base of the ovipositor proper through the tip of the abdomen into a membrane which issues between the sixth and seventh joints dorsally. There is a wonderful muscular power in the anal joints, and the ovipositor is forced back until it forms a perfect coil, so that, when the abdomen is stretched in a straight line to its utmost, the ovipositor within the membrane makes a circle almost as large as a quarter of a dollar, the anal joint having made a three-fourths turn within the membrane. During this operation the halves of the sheath, which have not followed the ovipositor within the membrane, have been obliged to make a more or less irregular coil opposite to and in front of the membrane on the ventral side. As the ovipositor enters the wood the abdomen descends, the distended membrane gradually subsides, and the halves of the sheath make larger and larger loops above the abdomen. In withdrawing the ovipositor the reverse action takes place, and the loops of the sheath gradually become smaller and smaller, the ovipositor proper is again forced back into the tough bladder-like membrane between the sixth and seventh joints dorsally, and there is a repetition of the appearance already described.

The specimen exhibited was captured with some others at Flatbush, Long Island, on the 8th of June instant, ovipositing in the languishing portion of a Red Maple tree extending about four feet above the surface of the ground. The ovipositor was nearly withdrawn from the wood, and the membrane was distended in a thin translucent disc fully three-fourths of an inch in diameter. The insect died in the cyanide bottle before the membrane was entirely retracted, and the disc remained as now seen, about five-eighths of an inch in diameter. The specimen shows the curious fact, contrary to the published descriptions, that in this case at least the bases of the halves of the sheath, together with the base of the ovipositor proper, are forced back into the distended membrane, and that the specimen died and has remained with all these parts in this position.

On the 2d of June a German laborer named Schoeffer, a robust, healthy man, part of whose duties consisted in the care of the grounds where the Maple tree is situated, was passing the place, when he was surprised to see one of these "Long-Stings" suddenly descend and strike him upon the bare arm about three inches above the wrist. The blow felt like the prick of a pin. The insect was brushed off and arose among the foliage. Presently the affected spot itched severely and was scratched with the finger nail, when a small blister appeared, which in turn was opened with a pocket knife. Nothing more was thought of the occurrence, but that night Schoeffer walked the floor, being unable to sleep on account of violent pains shooting up the affected arm. The attendance of a physician was sought, and for four or five days intense pain, great swelling involving the entire arm, the axilla, and a portion of the side of the body, gave symptoms of a severe case of erysipelas. On the 8th of June he was seen at the office of his physician, having the arm dressed. The swelling was much reduced, and the affected spot was an open sore in the summit of a protuberance measuring about one and one-half by three inches, and discharging copiously. No theories or arguments, however able or subtle, concerning contaminated finger nails and knife blades will ever avail to weaken the conviction of Schoeffer that the sting of the curious insect alone was the occasion of a very close call for the loss of his arm and perhaps for the loss of his life.

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INDEX TO VOLUME VII.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY

VOLUME VIII.

NEW YORK:
PUBLISHED FOR THE SOCIETY,
QUARTERLY.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. VIII. JANUARY, 1892. No. 1.

WHAT IS A DIATOM?

A LECTURE

BY CHARLES F. COX.

(Delivered December 18th, 1891.)

A few years ago, one of the newspapers of this city poured forth most biting sarcasm upon the presumably impractical and altogether useless system of education pursued at the College of the City of New York, because upon its annual examination papers there had appeared the question which I have adopted as the title of this lecture.

Although it is not at all likely that my words will ever reach the editor who put forth this ignorant plea for a shallow utilitarianism, I have felt, ever since I read his peppery article, that I should like to harp upon the theme for which he expressed his bitter disdain. Not because the summit of wisdom is attained when one knows what a diatom is, but because I believe that even yet some good may be done by insisting upon the value there is in pure science. The editor with whom I thus take issue, if he ever was a college student, probably acquired his "education" in the days when there was no place in the curriculum for any science that went below the glittering surface of knowledge. But there has been a great change in recent years. Not only is science more *taught*, but *more science* is taught; and, along with the improvement that has taken place in educational methods, has come an increased appreciation of the unconvertible products of learning,—those intellectual residua which no one expects to turn into bread and butter. The world is finding out that truth, like virtue, is its own reward. But, since knowledge is spreading with tremendous rapidity, and no man can hope to cultivate the whole length and breadth of even one department, he who would be truly learned must dig deep at a single point. It is an old saying, I believe : "Not he who knows many things, but he who knows much, is the wise man."

Now, I fully appreciate the fact that a knowledge of the habits, structure, and systematic position of the diatoms is not a *necessary* part of any man's intellectual equipment. Even scientific specialists, whose field of work includes this class of objects, manage to get along very well with hardly more than superficial information as to their appearances and characteristics, while men who pursue the study of these minute wonders with more than ordinary persistency and enthusiasm have come to be known by the half-contemptuous title, *diatomaniacs*. I am not particularly anxious to inoculate new victims with their mania, but I shall be glad if, under cover of a presentation of a few of the questions which engage their attention, I am able to promote interest in the general subject of microscopical research. I believe it will be found that a study of this one family of very lowly beings will bring before us most of the leading problems of biology, and perhaps some of those of physics, besides; and I shall be disappointed if, around the nucleus which my subject supplies, I fail to gather a body of fact and speculation the contemplation of which will prove both entertaining and stimulating.

I think there is no material attribute of which science justly takes as little account as it does of mere size. All immeasurable things seem great, whether they are immeasurably large or immeasurably small ; and in the same way all inscrutable phenomena are awe-inspiring and overpowering. Whether we look upwards and outwards, through the telescope, at the numberless revolving orbs of the universe, or downwards and inwards, through the microscope, at the myriad active plastides of an organized creature, the same or similar questions ultimately present themselves for solution, without regard to the prodigious size and almost infinite sweep of the one class of objects, and the infinitesimal dimensions and limited range of the other. Of what significance are such magnitudes and distances as we can apply our rules to, when neither the telescope nor the microscope has penetrated to a final boundary? The fact is, we are overwhelmed by the futility of our effort to follow out in imagination an endless series, whether we look in one direction or turn about and look in the other.

The familiar identification of "the law which moulds a tear" and that which "guides the planets in their course," may be paralleled in very various similitudes throughout nature, and the fact that an object of investigation is minute in size, or comparatively simple in structure, does not necessarily render the primal causes of its being and actions any more easily discernible than they are in the case of that which is grand and complicated. On the contrary, complexity and multiplicity of parts have a tendency to appear self-explanatory. Thus our own highly developed body, with its numerous correlated and co-ordinated organs, is regarded as less mysterious than is the apparently undifferentiated and organless rhizopod, a seeming amorphous sample of the so-called basal "life-stuff." So, too, the giant steam engine, which impresses us mostly by its nearly irresistible power, never appears as wholly inexplicable in its operation as does the simple living current of protoplasm circling in a microscopic cell of Chara or Anacharis. In reality, the vaster and more complex a mechanism is, the more points it presents at which we are able to see the immediate connection of cause and effect, and in following back from one of these points to another we fancy we are explaining the whole *modus operandi*. We realize the essential mysteriousness of the matter only when we reach an effect without an obvious cause, as we are sure to do if we pursue the subject persistently and deeply enough.

Thus all thorough study and research end, as they begin, with a question. The interrogation-mark is, after all, the symbol of the highest and latest human wisdom. My lecture, therefore, if it pushes deep enough, is likely to close, as it opens, with the inquiry: *What is a Diatom?*

Meanwhile, however, we may perhaps move our knowledge a link or two along the chain of queries which constitutes the science of the subject, even if we are unable to solve our problem in its entirety. By way of accomplishing what we can in this direction, it is necessary to begin by procuring specimens of the things we propose to investigate. Fortunately they are not difficult to obtain. In fact, they are amongst the most plentiful of all objects, though not ordinarily within the range of our unaided sight. To him who has access to running brooks, quiet ponds, or the greater lakes, a range of several hundred species or varieties is open. To the explorer of brackish estuaries and the deep salt sea, other hundreds offer themselves. To the one who can dig into the extensive deposits of their fossil remains, still other hundreds present their interesting forms. But even to us who dwell within the barren walls of a great city an unstinted supply of certain kinds is always close at hand, for the simplest of filters applied to a Croton-water faucet will, in a few minutes, furnish at least a half a dozen species; and this will be our most convenient source of supply.

If we take the product of our rude filter and place dippings from it under the microscope, we shall at first experience some embarrassment because of the multiplicity of objects presented to our view. There will be an abundance of sand and other amorphous and inorganic substances, and amongst these are likely to be scattered fragments of leaves and stems of exogenous plants, bits of linen, cotton or woollen threads, and various other articles of extraneous origin. Prominent, however, because of their bright color and considerable size, will appear the long jointed tubes of a few of the thread-like aquatic weeds, while deep down through the film of water we shall discern two similar and yet somewhat different sorts of diminutive bodies, which are sure to fasten our attention by their very pretty and symmetrical forms. The one kind is of a deep green color, the other of a thin reddish or brownish-olive hue ; and both will exhibit some differencing of their internal substance into denser and more attenuated parts, with here and there open, oily-looking spots. The dark green bodies appear as single capsules, narrowed, if not pointed, at each end, and floating free or else as loose aggregations of similar flattened cells, forming either rosettes or lace-like mats of various patterns. The brownish bodies will be found either as narrow rods, laid side by side in long bands, or joined to one another by their corners so as to form zigzag lines, or else as disconnected individuals with a very striking resemblance in shape to miniature skiffs or boats. If we make use of some other source of supply than our Croton-water faucet, we may obtain a much greater variety of forms in both the classes of objects referred to, though we shall not fail to notice a certain parallelism in the morphology of the two families, which may easily cause us to think them but one. They are, however, quite distinct, as we shall see. Those forms which I have spoken of in this particular case as decidedly green in color (although this is not a decisive characteristic throughout the family) are known as *Desmids*. Those which I have described as being of a brownish hue are *Diatoms*.

But now, if we look more closely at our desmids and diatoms, we shall discover that the latter have a very rigid, hard, and almost indestructible carapace or shell, while that of the former is hardly more than a stiffened membrane which is with difficulty discerned at all. In the diatoms the enclosing case will prove to be a solid deposit of nearly pure silica; but in the desmids it will be found to be a semi-flexible film slightly infiltrated with carbonate of lime. This is an important distinction, which forms the basis for a sharp separation of the two groups of forms. As regards the particular specimens we are supposed to have under immediate inspection, however, we shall by this time have observed a difference which to most minds will constitute a clearer demarcation than could be established by any other criterion; and that is that our desmids are apparently quite passive, while the little boat-shaped diatoms actively glide about with a seemingly well-defined purpose.

You will need to abstain from generalizing too far and too fast in this connection, for all diatoms do not possess this power of locomotion, since not only are some of them united to one another, as we have seen, but many sorts are attached to plants and other fixed objects, although the theory hás been advanced that all diatoms are, at one time or another, free and migratory. On the other hand, while desmids are never permanently anchored, locomotion is not a prominent characteristic of even the solitary forms, because, while it is pretty general throughout the group, it is too slow to attract attention, and, when observed, has not that appearance of voluntariness which is exceedingly striking in the movements of the free, boat-shaped diatoms. When you have a specimen of the latter under your microscopically-aided eye, you will see it slide over the bottom of your artificial pond without discernible machinery but with very appreciable force and considerable speed. If it meets an obstruction which is not too large, it pushes it aside, but, if too heavy, it halts a few seconds and then reverses its invisible engine and changes its course.

Upon seeing this operation for the first time, one inevitably jumps to the conclusion that he is witnessing the exercise of what, in the highest orders of creatures, we call volition. But again we need to restrain ourselves. Already this microscopic vessel,—perhaps not more than the two-hundredth of an inch long,—has brought us a freight of problems as big as the world! What *is* this diatom? Is it really a living thing? What is the criterion of vitality,—what is life? If the diatom is an organism, to which kingdom of animate beings does it belong? And is there a fundamental and absolute difference between animals and vegetables, and, if so, what is it? When we have disposed of these weighty questions it will be time enough to approach that other great mystery,—the physical basis of mind,—as Alfred Binet has attempted to do in his essay on "The Psychic Life of Micro-Organisms."

Of all the struggles through which scientific progress has been accomplished, none is more interesting than the never-ending conflict of opinion which has raged around the definition of life. There is nothing about which ignorant and thoughtless people are more certain than about their ability to distinguish between that which is alive and that which is dead. On the other hand, amongst the learned and the wise this is one of the unsettled matters which as yet hold out no promise of being set at rest. To the uninformed self-motion is the conclusive evidence of vitality;—that is to say, motion not having an evident cause external to the body moved. "It moves of itself, therefore it is alive," is the offhand expression of the popular judgment.

But if visible motion ever furnishes a trustworthy test, it is under very strict conditions and in a very limited domain. That it supplies no line of demarcation between the organic and the inorganic worlds was made known in 1826 by Robert Brown's discovery of the ceaseless activity, under favorable circumstances, of probably all small particles having a diameter of less than the one-five-thousandth of an inch. This phenomenon, which has come to be known as "the Brownian movement," but the cause of which has never been determined, might easily deceive the inexperienced observer into thinking he had under the microscope a lively colony of animalcules when, in fact, he might be looking at almost any finely-divided insoluble substance,—even, perhaps, at iron filings. In 1874 I rubbed up in water a little gamboge, which I confined in a hermetically-sealed cell, and which, for more than fourteen years (as long as the cell remained intact), was brought out periodically to illustrate the fact that "things are not what they seem." Numerous other illustrations of this uncertainty of appearances might be drawn from things in sight and above sight, as well as beneath sight ; and it is well to remember in this connection that, broadly considered, motion is an attribute of every form and condition of matter, great or small, simple or combined, inorganic or organized.

All forces are now regarded as modes of motion, and, since the abandonment, some fifty years ago, of the theory of a vital essence or principle,—which had itself superseded an earlier doctrine of a vital entity or substance,—science has become accustomed to correlating the vital forces with the physical and the chemical, and to looking upon all phenomena as different manifestations of a common activity, varying only in intensity and range.

This is, after all, merely a return to a method which has prevailed at often-recurring periods,—the method of reducing all scientific facts to a common denominator. No phase of philosophical thought is more persistent than this tendency to find a fundamental unity underlying all diversity,—to clear away perplexing mysteries by diffusing them through a universal solvent. Thus biology has had to pass several times through a period in which the best intellects and the most serious workers were devoted to a search for an elixir of life,—something which should embody the principle of creative power. These endeavors, however, like the efforts of the alchemists of old, have always ended in philosophical abstractions rather than in a concrete result upon which science can lay its material hand.

This proved to be the case with the notion which Coleridge worked out in his " Theory of Life,"—a vein which many philosophizers had followed before his time and one which some occasionally dig at even now. The idea they seek to develop is that which Herbert Spencer himself expressed in one of his early essays, when he said: " The characteristic which, manifested in a high degree, we call Life, is a characteristic manifested only in a lower degree by so-called inanimate objects."

But this conception was too indefinitely homogeneous to rest quietly in Mr. Spencer's mind. We all know how it subsequently evolved into the famous definition, given in his " Principles of Biology," namely, that life is " the definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external co-existences and sequences." This idea is very different from the ideas which were previously entertained and which various authors had attempted to record in brief sentences and even single words. Bichat's definition of life was: " the sum of the functions which resist death." De Blainville's was: "the twofold internal movement of composition and decomposition at once general and continuous." Lewes's was: " a series of definite and successive changes, both of structure and composition, which take place within an individual without destroying its identity." All of these definitions are open to serious objection, as has been shown very clearly by Dr. Drysdale in his inaugural address as President of the Liverpool Biological Society. He himself proposes, as being most closely in accordance with the latest development of the protoplasmic theory, the definition of life as " the consumption and regeneration of protoplasm in co-operation with external conditions, pabulum and stimuli," which, however, he thinks may be further simplified as follows: " Life is the interaction of protoplasm with the environment."

Now, all definitions are true only from fixed points of observation. They vary both in time and in space,—that is, as we pass from the knowledge of one period to that of another period, or as we pass from the domain of one sort of learning to the domain of another. Thus, while Dr. Drysdale's definition of life seems to suit pretty well the present knowledge of a worker in the microscopical realm, I can see that it may be very unsatisfactory to the biologist in a broader field and that it may be totally inadequate to the wants of the investigator of the future, whether in one field or another. For our present purposes, however, it may be good enough, and if we apply the test which it furnishes to our little diatom, we shall find that we have under consideration a really living thing.

This conclusion of course assumes that the diatom possesses, in addition to the hard framework or shell, of which I have already spoken, a body of plastic substance called protoplasm. This, upon close examination, we easily learn to be the case. Very simple methods of investigation show that every frustule (as each individual cell is called) is in reality a glass box enclosing a semi-fluid, nearly transparent, but somewhat granular material, containing, besides the oily-looking spots or vacuoles to which I have before referred, more or less of a yellowish or brownish-green substance, which gives its general color to the whole organism. There is reason to believe that the semi-fluid material also forms an enveloping layer on the outside of the siliceous carapace of all diatoms, and in many instances a similar glycerin-like matter permanently encloses a whole colony of otherwise separate frustules, which passively spend their existence within its restraining grasp. Now, chemical tests disclose the fact that the colloidal mass within the transparent valves is composed of carbon, oxygen, hydrogen, and nitrogen in proportions and relations which characterize an organic substance, and a great number of converging facts, derived from long-continued observation, go to prove that this substance is the seat of all the changes, chemical and physical, which constitute what Dr. Drysdale calls the "interaction of protoplasm with the environment." In other words, it is the consumption and regeneration of this substance "in co-operation with external conditions, pabulum and stimuli," which make up the sum of phenomena embraced in this humble creature's life-history. We therefore conclude that this substance is protoplasm.

It is through and by this protoplasm that the diatom responds to the influences of heat and light, that it receives and assimilates its food, that it moves from place to place as we have seen the boat-like specimen in the Croton water doing, that it grows and reproduces its kind. It was because of its agency in these matters that Prof. Huxley called protoplasm "the physical basis of life," though its name really means "primary formative matter," and Beale's designation of it, bioplasm, more definitely expresses the idea of its being a *life* plasma.

But the fact that the living portion of the diatom consists in the main of protoplasm, is not enough to enable us to answer the question whether the diatom is an animal or a vegetable, since protoplasm is common to both kingdoms of the organic world and enters into the composition of all animate things, high and low. Not only is it apparently the essential part of the desmid, the diatom, the amœba, and the rest of the protophyta and the protozoa (the so-called "lowest" living creatures), but it appears to be the seat of all vital action in the water-weed and the fish that swims beside it, the shrub and the reptile that crawls at its root, the tree and the quadruped that enjoys its shelter,—even in man himself, who excels all and rules all. In Nitella, Valisneria, or Anacharis you may see the colorless current circling in every cell, building and unbuilding with a chemistry beyond our ken, and in all the higher animals it seems to be the matrix in which are fashioned the tissues and the bones, the source also of the contractility of the muscles and the sensibility of the nerves. In your own warm blood you will find protoplasm, in the form of the "white corpuscles" which creep and crawl with an activity and independence quite mystifying to the observer, but doubtless with a useful and important purpose, if we only knew what it was; and if you could look into your own wondrous brain you would probably find protoplasm in some way underlying all consciousness and thought.

But when I thus talk of protoplasm, I use the word as a generic term, in the same manner as I should speak of tissue or muscle. There is a difference between the ideal, or philosophical, protoplasm, and the real, or physiological, protoplasm. The philosophers have created for themselves, by an *a priori* process, a substance which is absolutely homogeneous and structureless, and which is identical in composition and attributes throughout the whole realm of animate nature. On this hypothetical basis they have undertaken to erect a monistic system in which animals and plants actually arise from the same root-stock and are really quickened by the same vital stream. I have no preconceived dislike to such a theory, if it can be proved true; but, unfortunately, the inductive methods of physiology do not confirm this deductive conclusion of philosophy. The reason of course is that philosophy has assumed false premises. There is in fact no one protoplasm ascertained to be common to all living things. The latest science proves conclusively that what Huxley laid stress upon as the physical basis of life, and Beale staked his theory of "vital power" upon, as the true "germinal matter," are not structureless colloids, alike wherever found, but that they are complex in structure and various in chemical composition,—in short, that there are probably as many different protoplasms as there are organisms.

How, then, are we to tell whether our diatom is animal or vegetable? Here is another of those points at which ignorance has been accustomed to think itself wise, but where wisdom has come to admit itself ignorant. Prof. Huxley set forth the situation of this matter most admirably in his lecture entitled "The Border Territory between the Animal and the Vegetable Kingdoms," and there has been no essential change in the case since he therein stated it. Naturalists had been in the habit, from the days of Cuvier, of relying upon four proofs which they considered conclusive of the animal nature of any organism. These were (1) the possession of an alimentary cavity, (2) the presence of muscles for locomotion and of nerves for sensibility, (3) the existence of nitrogen as a constituent element of the body-substance, and (4) the exercise of the function of respiration,—the absorption of oxygen and the exhalation of carbonic acid. But all of these distinctions have been shown to be subject to so many exceptions as to destroy their value as tests. For example, the reproductive bodies set free by certain algæ, which, from their resemblance to animals, have been given the name *zoöspores*, are as active in their movements as any animalcules, and to all appearances exercise quite as much volition. They also appear to search for food and are provided with internal spaces which Ehrenberg, not altogether unreasonably, took to be stomachs, and upon the existence of which he founded his family of the *polygastrica*, a division of the animal kingdom in which he included, with numerous zoöspores, not only true animalcules but also all diatoms. It is not yet certain that zoöspores are really destitute of a digestive system, and, as to muscles and nerves, they are certainly as well endowed as are the lowest known animals. On the other hand, many parasitical animals, and the males of most rotifers, or wheel animalcules (which occupy a comparatively high position in the scale of organization), have no digestive apparatus whatever, as far as can be discovered, while the fresh-water hydras and many other lowly animal forms receive their food as well at one point as at another, and in fact perform the act of digestion throughout the whole body. So Cuvier's and Ehrenberg's principal criteria of animality have broken down and disappeared from the domain of biology, and along with them have gone all the other old-time tests. Darwin's researches on insectivorous plants gave a fatal blow to the theories built upon sensitiveness and response to stimuli, on the power of complex motion directed to a definite end, and on the appropriation and assimilation of organic food.

For a long time the existence of chlorophyll in an organism was deemed conclusive evidence of its vegetable nature, for chlorophyll is what gives the green color to all the higher kinds of plants, and chemistry had shown that chlorophyll was the seat of those operations which separated the carbon from carbonic acid and built it into the woody substance of the plant, and carbon was regarded as belonging strictly to the vegetable world. But, alas for consistency, it was found that some plants do not contain chlorophyll, and, still worse, that there are certain undoubted animals which are possessed of it and that in their economy it performs the very same duty that it performs in plants.

I would not have it understood from all this that there is a border country into which organisms may wander from the animal and the vegetable kingdoms and therein lose all definite character and all trace of their origin; or that, by crossing this no-man's land, the former inhabitants of one domain may become thoroughly naturalized in the other. There is no such magic about this curious region. Its perplexities and uncertainties mainly grow out of the fact that it is the place where the frayed-out edges of the two kingdoms come together to form a hazy mixture of intermingled fringes. The ravelled threads have not necessarily lost their identity, though we are unable to disentangle them. While there are many living forms which at present cannot be definitely classed with either animals or vegetables, experience leads us to think that, in most cases, if we could trace out the complete life-histories of the doubtful organisms occupying this middle ground, we should find their lines of relationship leading pretty clearly in one or the other direction. At any rate we should learn that what had an animal origin continues as animal and ends as animal ; that what began as vegetable remains vegetable to the last ;—both completing sooner or later a circle of existence limited by a law of inheritance of which we have not as yet found the secret.

The difficulty with this matter, as well as with the subject of vitality, is that we look for single distinguishing signs when we ought to take into consideration a whole series of phenomena at once. Thus life would prove to be not an entity, an essence, or even a principle, but rather *a process*. In like manner, the criterion of animal life, as distinguished from vegetable, would not be found in assimilation, sensation, self-motion, or any other one thing, but in a group of actions and attributes, by their sum-total turning the scale to the animal side.

In his interesting discussion of this topic, Prof. Huxley reaches the conclusion, now generally accepted, that the nearest approach to a definite dividing line is in the fact that the plant can make the peculiar nitrogenous substance called protein, while the animal must get it from the vegetable realm. "Thus," he says, "the plant is the ideal *prolétaire* of the living world, the worker who produces ; the animal, the ideal aristocrat, who mostly occupies himself in consuming."

But even the distinction here attempted needs to be fortified by other considerations when we come to particular instances, since Darwin has shown that certain of the higher plants eat, as well as manufacture, protein, and the same fact has been demonstrated as to fungi and many other thallophytes. There is, however, no reason to suppose that diatoms are eaters, although the wanderings of the free forms have every appearance of being directed in search of food. But to the best of our knowledge and belief their quest is for inorganic pabulum, if, indeed, it has direct relation to food at all and is not, after all, merely one of those curious modes of dispersion with which we are familiar amongst spores and seeds. As far as we know, the diatom protoplasm has no proclivity for cannibalism, as all animal protoplasms seem to have. Taking this negative quality for what it is worth, and adding it to the general sum of the diatom's other characteristics which common sense somehow recognizes as belonging to the vegetable kingdom, we arrive at a decision that the object of our consideration is a plant and not an animal.

This may not be a strictly scientific way of settling the question, but how else are we to dispose of it when so great a stickler for inductive methods, as Prof. Huxley, declares that the latest information on this subject tends to the conclusion "that the difference between animal and plant is one of degree, rather than of kind; and that the problem whether, in a given case, an organism is an animal or a plant, may be essentially insoluble"?

Having made up our minds that diatoms lie within the boundaries of the vegetable kingdom, we shall have no difficulty in referring them to that sub-kingdom which includes all non-vascular, or, in other words, leafless and rootless plants,—called *thallophyta*. In this sub-kingdom is the well-known class *Algæ*, which embraces all aquatic thallophytes, and to which therefore the diatoms must belong. Indeed, they constitute a very important sub-class of algæ, which derives its name from them,—the *diatomaceæ*.

The diatomaceæ themselves get their name from the Greek word *διατομος*, which means *cut through*, *cut in two*, or *cut up*, and which was applied to them with reference to the bead-like manner in which the individuals of many genera cling together in fragile strings. These are the forms which earliest attracted attention, and which in common language were described as "brittle-worts," an appellation intended to connote the same characteristic as is denoted by the Greek name. The latter possesses additional appropriateness because of the fact that each frustule is bivalvular in structure, and from the still further fact that one of its modes of reproduction is a cutting in two of every parent cell to form twin descendants. When this process continues through several generations without an actual separation, the result is a loosely united filament, fillet, or flabel, according to whether the parent form was round, square, or wedge-shaped. The string, band, or fan thus produced will be *cut into* at regular intervals and may easily be *cut up*, or broken up, by the application of any external force.

Reproduction by self-division is not at all peculiar to this sub-class, nor even to the vegetable kingdom. Animals, as well as plants, commonly multiply by simple fission, and amongst the true infusoria, or animalcules, the operation is so rapid that, in some genera (as, for example, the vorticellæ), one may witness within an hour the complete bisection of a single vigorous creature into two lively counterparts. The process in the plant-world is generally much slower, but it passes through essentially the same steps and may be traced with equal clearness and certainty. In fact, at their foundation all modes of reproduction are but forms of fission,—the division of one into two or more,—and the ultimate nature of the process is not changed by the fact that the resulting two are often so dissimilar in size and other attributes that we feel bound to regard one as the parent and the other as the offspring. In other words, it is none the less fission because it takes the form we call budding.

I have a strong liking for the system which classifies this whole matter under the two heads, continuous gemmation and discontinuous gemmation,—the former covering all cases in which the bud or fruit remains permanently attached to the parent stock, and the latter those cases in which it is set free to shift for itself. Examples of continuous gemmation are found among those non-vascular algæ which are nevertheless multicellular in habit, as well as among those animals whose individuality is wholly subordinated to a commensal mode of existence. Under the first head we have such lowly plants as the net-like hydrodictyon, the thread-like spyrogyra, and the chain-like diatoms; under the second we find all such perplexing creatures as the sponges, corals, and zoöphytes.

Continuous gemmation gives rise to very interesting and complicated relations which involve another insoluble biological puzzle,—as to what constitutes an individual. When one regards the cell-units, with their circumscribed and apparently complete cell-functions, he is disposed to credit them with the real individuality; but when he looks to the mutual interdependence which usually exists between the cells which retain a physical connection with one another, he inclines to expand the idea so as to include all the members of any communal aggregation, if he does not stretch it still further, as some authors do, so as to cover all the products of fission or gemmation within a continuous series, whether remaining united or not. In such cases, however as those of the filamentous and flabellate diatoms, in which there is no absolutely necessary connection between one cell and another, and where there is no known reason why any single frustule would not go on in the performance of all essential functions if it were entirely separated from its sister cells, we seem to be quite justified in regarding the type as physiologically unicellular, even though the anatomical units are not always physically solitary or free. There is at least no evidence that those diatoms which are found within a *thallus* (as already mentioned) have anything more than a mechanical connection with one another, and vital independence is after all the best test we have of their actual individuality.

For some as yet unexplained reason, multiplication by fission sooner or later results in an exhaustion of the vital powers, which would lead to a rupture of the line of descent if it were not for the introduction at this point of the phenomena of conjugation, which, in some mysterious way, give fresh impetus to the reproductive energy. This new departure is brought about by the merging of two organisms into one and the formation from their combined substance of an enlarged and reinvigorated mother-cell, called a zygospore, which becomes the progenitor of a new family, descending from it by the original process of self-division. But the exact nature and office of the zygospore are enveloped in great uncertainty, which has been deepened rather than elucidated by a good deal of hasty inference which has been put upon record as established fact. Thus, it has been asserted that two zygospores sometimes arise from a single union, and also that conjugation results in the production of a "sporangial frustule," which undergoes in itself a segmentation which ends in the formation of true spores, which are set free by the rupture of the containing envelope and which then establish large numbers of new centres of diatom-life. These and other reputed phases of the reproductive process rest upon observations which are more than doubtful, but even if they shall be at last accepted as true, the entire matter will still be found to be reducible to modes of gemmation, either continuous or discontinuous.

As has been indicated already, the medium through which the vital forces work out their wonderful effects is the internal protoplasmic substance of the diatom, otherwise known as the endochrome. It is this mysterious, active matter which, with a chemistry peculiar to itself, gathers up the soluble silicates from the water in which it lives, and builds them into its enclosing tissue or film to form its beautiful glass-like shell, and it is this same restless and expanding endochrome which, in multiplying itself by binary subdivision, pushes apart the valves of its containing case and, as fast as it thus gains room, constructs in the enlarging chamber new siliceous walls encasing the nascent pair of diatoms into which the growing frustule is divided. Thus it comes about, by imperceptibly fine transitions, that the crystal jewel-case and its delicate, living contents are, at one and the same time, transformed, by the natural magic in which the microscopical world abounds, into duplicate descendants hardly distinguishable from each other and closely resembling in every particular the parent form whose individuality is lost in the new units which have taken its place. This remarkable operation is going on every minute, and in countless centres of vital activity throughout the whole world, and of course it has been going on for numberless ages since the first diatom or its evolutionary progenitor made its appearance in the waters of the earth. There is exceedingly strong probability too that this dividing and subdividing will continue during all time to come; and so, whether we regard the matter retrospectively or in anticipation, we perceive a practically endless chain of diatom-life, through which threads an unbroken line of protoplasmic succession. In the higher orders of living things one generation passes entirely away and the following generation sooner or later becomes the head of the family or race. But amongst the lowest creatures, when one bit of animate jelly becomes two bits of animate jelly, the distinction of generations cannot be preserved and there is a nearly strict continuity and identity throughout the genetic line from beginning to end. In other words, the stream of living matter flows on forever, its component substance never disposed twice in exactly the same manner, yet always essentially the same stream. Some portion of it undergoes chemical transformation from time to time, and the waste is supplied by acquisitions of new material, as the water of a river is evaporated and replenished, but the identity of the stream is, in a sense, never lost. On this conception has been erected an ingenious theory of immortality, in which the ideal protoplasm figures, not quite accurately, perhaps, as the one material thing which is the same yesterday, to-day, and forever.

I have already said, however, that the ideal protoplasm of the philosophers and the actual protoplasm known to the biologists are two very different matters. The former, you will remember, is a colorless, homogeneous, structureless colloid, like glycerin ; but the veritable thing which we are able to get under the microscope is always much less simple in appearance and is generally complicated with other substances. The endochrome of the diatom, for example, is usually spoken of as if it were wholly protoplasm, when in fact it is made up of soft parts and harder parts, transparent spots and nearly opaque spots, liquids, semi-liquids, and solids, together with the green chlorophyll and a brown coloring matter, and, in addition to the vacuoles of which I spoke some time ago, veritable oil drops, which are supposed to correspond with the starch-granules of the higher plants. Under the microscope the endochrome therefore looks like what it really is,—a mixture of numerous substances of various colors and consistencies, with, however, a tendency to greater and greater density towards a certain central spot which has always been an object of great interest to investigators. This area of condensation is known as the *nucleus*. Formerly undue mystery was attached to it, as the supposed shrine of the vital spirit. Here, it was fancied, life had been traced to its ultimate hiding-place. It was believed that there could not be a living unit without its nucleus, and, as the anatomical unit was taken to be a closed vesicle, called a cell, all living creatures were, in the last analysis, reduced to a single cell with its nucleus, or to an aggregate of such cells. But by and by it was found that the enclosing vesicle was no essential part of the ultimate unit,—that in fact it was a product of the enclosed protoplasm and, being later in time, must be subordinate in importance. Then the cell-theory was modified into the protoplasm-theory, and the unit became a lump of protoplasm with its nucleus. But, just as the increasing power of the telescope has compelled a change in our ideas of the nebulæ, by making wha were formerly mere condensations of light resolve themselves into numberless clusters of universes and worlds, with their own centres of force and activity, so the improvement of the microscope has forced upon biologists a recasting of their theories of the nucleus, by enabling them to resolve it into component parts, and to show that within the so-called nucleus a still deeper nucleus exists, and another within this, and so on down, until the powers of the lens are exhausted and the observer can discern at last only a "germinal spot," or point, where somehow, but he knows not how, vital energy emerges or at least manifests itself.

Further than all this, it has been discovered that numerous organisms exist, in which it is impossible to make out anything at all corresponding to this specialized region; and so the sweeping generalizations which were not long ago accepted, as to the absolute necessity of a nucleus to every living unit, have been completely discredited. Still, a great deal of attention is bestowed upon it in such organisms as do possess it, because in such cases it is evidently the seat of greatest vital activity.

In the diatoms, the first indication we have that self-division is about to take place is the appearance of a sort of uneasiness within the nucleus and the formation of a constriction about the middle of the endochrome. This is at the beginning a mere indentation of the outline, but it gradually deepens and deepens until it finally results in the cleaving of the endochrome in twain. It is one of the most impressive sights a man can witness,—this kneading and moulding of the primal matter of a living organism by an invisible agency, under whose mysterious excitement it trembles and surges and at last rends itself apart. One can hardly hope to come nearer than this to the actual first cause of the organic world.

Having once seen this manifestation of efficient energy within the diatom-shell, we shall not much wonder that the free frustules move from place to place. We may, however, entertain a lively curiosity as to the direct means by which their locomotion is accomplished, although, in the present state of knowledge, I am sorry to say, that curiosity cannot be satisfied.

Amongst the lowest known living things two modes of locomotion prevail. When the organism consists of a wholly soft and mobile material, as is the case with the amœbæ and many vegetable spores, its progression is a form of slow creeping by means of extemporized limbs, or pseudopodia, which are projected as wanted and withdrawn into the general mass after they have once been used. When the creature is of a firmer structure, with an enveloping sack or skin, its movement is that of swimming, accomplished by the use of permanent hair-like filaments, called cilia, or whip-like lashes known as flagella, which act against the water and propel the creature with considerable velocity.

But the motion of the free diatoms is like neither the quick and nervous swimming, effected by cilia or flagella, nor the slow and measured crawling, performed by pseudopodia. It is in fact a somewhat jerky sort of glide. There are, nevertheless, advocates of the existence both of cilia and of pseudopodia as the means of the diatom's propulsion, although no certain glimpse has ever been obtained of either kind of organ.

In the genus *Navicula*, which includes most of the motile forms, a pretty good magnifying power discloses a central spot, or nodule, in the siliceous valve, with a line, or, in some cases, a double or bifurcate line, extending from it in either direction to the narrowed ends, as the frustule lies with its boat-like outline towards us. This median line is believed to be a lapped or rolled seam between two contiguous plates of which the valve is composed. Whether the edges are rolled so tightly as to form a closed joint, or the union is so loose as to leave an open slit, is still a debatable question ; but there seems to be no room for doubt that the thickened welt, to which the name *raphe* has been given, has with it a narrow groove of more or less depth. Now, the advocates of the pseudopod theory of locomotion commonly adhere to the belief in an actual cleft, through which the feet are supposed to be protruded from within the diatom; while the believers in the existence of cilia are generally disposed to accept either a closed or an open furrow as the seat of these oar-like appendages. Since the diatom is really a bivalve, you may begin to wonder why the workers over this problem have not located the organs of locomotion along the suture, or line of junction, between the two valves. But the objection to doing this is that the edges of the two valves are not actually in contact, but rather overlap, like the sections of a telescope tube, the diameter of one valve being slightly greater than that of the other. This overlapping is quite extensive in the larger forms, and gives rise to the appearance of a broad band or hoop encircling the frustule.

Unless, therefore, the raphe is accompanied by an open slit, the diatom is a tightly closed box with its living substance shut up within. When binary subdivision takes place, the bottom and the top of the box slide apart, while a new top is built on to the old bottom and a new bottom on to the old top;—all inside of the telescopic tubes just mentioned, which are simultaneously extended and duplicated by depositions of new siliceous material upon the surface of the enclosed vegetating protoplasm. When the new frustules are completely formed they are set free by the slipping apart of the telescopic tubes, which, in the case of the free diatoms, usually fall away as genuine hoops, but in the case of the filamentous forms more generally remain adherent to the new frustules.

I have spoken of the living substance of the diatom as being sealed up within its glass case; but this view of the matter must be taken with some qualification, since the vital functions could not proceed unless there were communication of some kind between the endochrome and its environment. The silex-coated cell needs to be pervious to liquids and gases, as much as if it had only a cellulose wall, like most other plant-cells. From what we know of vegetable physiology generally, we do not run much risk in assuming that a constant interchange of elements takes place between the active body within and the world of inert matter without, by means of what is known as osmose.

This presumption has furnished the basis for a third theory of diatom-motion, which assumes that when endosmose occurs at one end of the frustule exosmose occurs at the other, and that the diatom is accordingly partly drawn and partly pushed along by this sucking and ejecting operation. It is held that the flow is not always in the same direction through the cell, but is subject to alternation, which some observers believe to be at regular intervals under all ordinary circumstances, though it is assumed to be more likely that the direction, duration, and change of the current depend upon some subtle and inconstant cause, like the action of light or of heat.

It is well known that all protoplasmic bodies are delicately sensitive to external stimuli, of which light is one of the most active and potent. The researches of Strasburger into "the action of light and of heat upon swarmspores" have shown that it is the actinic end of the spectrum which exerts the irritating influence which results in their migration, while the green, yellow and red rays are inactive or neutral. Like the movement of swarmspores, as well as that of desmids, the locomotion of diatoms is influenced by light. If water containing these organisms is shaken up and poured out into a shallow vessel and set in a bright place, the diatoms will quickly separate themselves from the dirt and débris with which they have become mixed, and, rising to the surface, will gather together on the side of the vessel most under the influence of the light. The philosophy of this operation appears to be that the light promotes the chemical action, whatever it may be, within the protoplasmic contents of the frustule, which develops a force that reacts upon the water and results in the propulsion of the diatom in the direction of the light. I cannot myself understand why such a result should be produced if the cause of locomotion were the direct action of pseudopodia or cilia, unless we are to admit a certain degree of purposeful control of those organs towards the definite end of seeking the light,—which calls for an exercise of choice on the part of the diatom, at least equal to the apparent volition involved in the food-seeking movements of unquestioned animalcules. On some such theory as that of chemical or osmotic action promoted by light, however, I can easily imagine a reasonable explanation of the phenomenon not inconsistent with the generally accepted belief in the diatom's essentially vegetable nature.

By adopting this hypothesis, as I understand so high an authority as Prof. H. L. Smith has done, I confess that it seems to me we best get rid of that baffling question as to volition; for if the diatom's movements are merely a species of heliotropism, there is no more room for will or mind in the matter than there is in the case of any of the shrubs which turn their flowers or leaves in a given direction to the sun. Surely the evidence of choice in the action of the diatom is no greater than it is in the wonderful discrimination exercised by the roots, tendrils, and tentacles of higher plants, as shown by the delicate experiments of Charles Darwin and his son. I am aware, however, that it is laid down, as a fundamental axiom of psychology, that the function of selective discrimination is the root-principle of mind. But this train of thought leads to deeper questions than it is proper for me to enter upon at this time. I have endeavored, thus far, to confine myself mainly to those phases of my subject which come naturally within the province of biology, or which present themselves to the mere observer with the microscope. While it is both easy and agreeable to wander in the paths of speculation, we must now keep to the direct line of tangible investigation, which leads us back to the consideration of our little silex-coated cell and its physical substance and structure.

From what has been said concerning the architecture of the typical frustule, you will have inferred that whenever, by any means, its organic material is destroyed, its two valves will fall apart, and that, if the diatom is in an advanced stage of incomplete subdivision, it will break up into four valves and two hoops. To such constituent parts the microscopist commonly reduces his diatomaceous material, by treatment with acids, for purposes of permanent mounting and preservation. Nature, also, is constantly removing the soft and perishable endochrome from diatoms which have run their life's course, and is steadily depositing their nearly indestructible remains at the bottom of almost every permanent body of water. As diatoms have swarmed in river, lake, and sea for countless ages, at least since the glacial epoch, their flinty shells have come to form beds and strata of very considerable extent in numerous parts of the world. Since the fresh-water, salt-water, and brackish-water deposits are very dissimilar in character, as are also the prevailing forms of different periods, these diatomaceous (or "infusorial") earths supply chapters in the history of our globe which are of very great interest and importance, but which some geologist will need to expound to you.

Amongst the largest and best-known of these deposits are that which underlies the city of Richmond, Virginia, and its vicinity, and the one near Virginia City, Nevada. The "Richmond earth" forms a stratum of from 8 to 30 feet in thickness, lying near the surface and extending throughout the eastern part of Virginia and portions of Maryland. There is some reason to suppose that this extensive deposit is related to if not actually connected with deposits recently discovered, at depths of several hundred feet, at Atlantic City and other points in Eastern New Jersey. The forms prevailing in these deposits are of the kinds peculiar to salt water, and their accumulation, in these immense beds of wide extent and great thickness, is evidence of a long-continued submergence of the regions in which they are found beneath an arm of the sea.

The Nevada deposit is of very pure fresh-water forms, and was laid down in one of two great intra-glacial lakes, which geologists tell us were nearly as large as Lake Superior, one of which filled the Utah and the other the Nevada basin. The Nevada deposit has been worked commercially for a number of years, as the source of the polishing-powder which goes by the trade name of "Electro-Silicon." This and other diatomaceous earths are also employed to some extent, I believe, to form an absorbent base for certain high explosives. Indeed, very many of these earths are valuable articles of commerce, and I understand that at least one business house in this city makes a specialty of the trade in them. They furnish silica in a finely-divided form, suitable, amongst other things, for the manufacture of the silicate of soda or of potash, —otherwise known as "soluble glass,"—which is an ingredient in the glazing of pottery, in artificial stones, and in certain cements and paints.

But it is not because of their practical usefulness that diatomaceous earths are of interest to us. Our attention is now fixed upon diatoms merely as objects of scientific investigation and study. Such they have been, in varying measure, in both their recent and their fossil forms, from almost the dawn of microscopical science, a little over two centuries ago,—observers having been attracted to them mainly by the beauty and variety of their shapes, of which you will presently be enabled to judge for yourselves, by means of the photographs which will be thrown upon the screen.

Under the microscopical powers of early days the valves of all but the very largest species appeared as simple in structure as if made of perfectly plain transparent glass. Some of the coarsest, particularly the discoidal forms, displayed upon their surface a dotting or embossing, with occasionally a rayed or more complicated pattern. A few of the angular forms presented a structure of coarse hexagonal netting, while some of the elongated and boat-shaped kinds were seen to be possessed of stout ribs running at right angles to the median line, or keel. At a later period, not only was the mere magnifying power of the microscope greatly increased, but, what proved to be of much more importance, methods of illumination were devised which enabled the observer to throw beams of light of different sorts upon the object at various angles of incidence. By this means it was discovered that lined shadows were cast upon the surface of valves which had previously appeared entirely smooth and clear. It was found that these shadows are caused by shallow furrows running, not only lengthwise of the valve, but also at right angles to the median line or even obliquely to it. For a long time it was regarded as the acme of manipulative skill to display this simple system of striation upon the larger and coarser forms upon which the distance between the lines ranges from the 20,000th to the 50,000th of an inch. By slow degrees the microscopist attained to the ability to show at once two or more systems of lines, producing a cross-hatching with square, lozenge, or hexagonal interspaces, and at about the same time it began to be possible to discern upon some of the smaller specimens a striation having only the 80,000th or the 90,000th of an inch between lines. This was the maximum of attainment about thirty years ago. Since then progress has been slow in this department of microscopy and each small step achieved has caused a disproportionate amount of labor and discussion. But after a while an advance was made to the resolution of lines less than the 100,000th of an inch apart, upon such fine species as *Frustulia saxonica* and *Amphipleura pellucida*, and the methods which rendered this progress possible brought double systems of lines to view on those diatoms which had before shown only one system (like *Surrirella gemma*), and raised to the rank of well-defined dots the interspaces in the previous cross-hatching upon the more robust species, such as *Pleurosigma angulatum*. Then it was that microscopists ventured on the important generalization that the typical form of marking, throughout the whole subclass of diatomaceæ, is a series of dots, oftenest arranged in formal rows, but sometimes scattered irregularly over the shell.

As to the precise nature of these dots, there has always been, and is now, a wide difference of opinion, although I venture to think there is no scientific puzzle to the solution of which more intelligent effort has been devoted or over which a more earnest contention has prevailed. The combatants have arrayed themselves in three armies, defending respectively the theory of bosses, of pittings, and of perforations. Until very recently the preponderance of opinion has been with the advocates of the existence of hemispherical protuberances from the outer surface of the valve. The valve itself has generally been taken to be a single layer of silex. But of late a good deal of evidence has accumulated to show that it is composed of at least two layers and perhaps three, and the idea is rapidly gaining ground that the dots are perforations of the middle layer, if there are three layers, or of the inner one, if there are only two. The outermost lamina and the innermost also, if the threefold theory holds, are supposed to be exceedingly thin, the main weight of material being in the perforated layer between. In fact, the outer layers are regarded as mere membranes overlying a sieve-like wall, of which the areolæ may be round, square, or hexagonal in form.

This last-named theory accords best of all with our belief in the vegetable nature of the diatoms and what we know to be the requirements of the vegetable cell. The sum and substance of this theory is that the cell-wall is not a solid and impervious mass of silex, as was formerly supposed, but that the arrangement of layers which I have described gives it a semi-punctate structure which, while affording all necessary strength, allows full play to the vegetative processes which, through osmotic action or otherwise, depend upon communication between the enclosed endochrome and the exterior world.

But all this brings us once more face to face with the biological problems with which we began the consideration of this subject this evening. As I predicted at the beginning of this lecture, our latest and most extended knowledge, like our earliest and simplest, ends at the everlasting interrogation-mark. There never can be a finality to human research. Physicists speak with some confidence of an ultimate indivisible unit, the size of which they even undertake to estimate in a rough sort of way; and yet if, in the course of ages to come, the power of the microscope should actually reach that degree of development which was falsely claimed for it a century and a half ago (when Joseph Highmore and others declared that the lenses of that day enabled one to see "the atoms of Epicurus" and "the subtile matter of Des Cartes"), I have no idea that there would be a cessation of microscopical endeavor, or that there would be any general concurrence in the belief that the final unit of all material things had been reached. You may be sure there would still be a goodly number of men endowed with that high order of inquisitiveness which finds its full satisfaction in merely solving problems, and who would persist in peering and prying, determined to find something beyond the so-called end.

Of this class are the men who have worked away at the diatom-markings, through good report and evil report, encouraged and sustained by an abiding faith in the intrinsic value of pure truth. To one unfamiliar with microscopical science the length of time and amount of labor, on the part of both the worker with and the constructor of lenses, which were required to accomplish the progress in mere technical achievement which I have briefly described, must be a matter of profound surprise and wonder; and even after one has in a measure realized that many years of patient and persistent effort were consumed in getting over the ground between merely seeing plain lines the 50,000th of an inch apart, and breaking those lines up into visible dots having a distance of the 50,000th of an inch between their centres (which is in most cases the equivalent of resolving lines the 100,000th of an inch apart), he may still be unable to appreciate the importance of the accomplishment or to believe that the result could warrant the necessary expenditure of energy. But the pursuit of knowledge for the sole sake of knowledge has been justified over and over again by the discovery that what was sought with entirely disinterested motive and with no utilitarian aim, has proved to be a precious boon and blessing to all mankind. And so the enthusiasts who used to spend their time "fighting objectives," and who braved the jeers of their more practical brethren, have now the satisfaction of knowing that their exacting demands for improved apparatus with which to resolve more and more difficult tests, have been the incentive under which the opticians have produced lenses of wider and wider angle of aperture, with better and better correction of aberrations. The result has been, first, the working out of the very ingenious homogeneous immersion principle and, more lately, of the wonderfully delicate apochromatic combination, in the application of which to the microscope objective a revolutionary theory in optics has been developed, while, at the same time, the whole science of bacteriology has been rendered practicable, and the mysteries of disease and death have been disclosed to seers like Pasteur and Koch, for the benefit of us and all coming generations.

ON THE EFFECTS OF HYDROXYLAMINE AS A PARALYZING AGENT FOR CONTRACTILE ELEMENTS.[1]

BY E. A. SCHULTZE.

(*Read November 20th*, 1891.)

The preparation for microscopical study of animals having exceedingly contractile elements, and which when killed are, in consequence of the irritating properties of the embedding material, often rendered unrecognizable, may be added to the more difficult methods employed in the art of preservation.

Thus, for instance, in preparing slides of infusoria great difficulties are met in fixing Stentor, Vorticella, Spirostoma, etc., and it is always a matter of chance if one or the other of these animals is secured in a partially extended state by the methods in use up to the present time. Similar difficulties are encountered in fixing Hydrozoa, and especially Actinozoa, Planariæ, Rotifera, and all kinds of mollusca, etc., all of which shrink more or less under the influence of the preservative reagents.

In order to overcome as far as possible these difficulties which occur in course of scientific investigation, and especially in slides prepared for school use, two methods have been adopted which in some few cases have proved successful.

At first the attempt was made to instantly kill metabolic animals in a distended state by means of extremely effective agents, such as Lang's solution, which may be successfully used on Planariæ, osmic acid for many Protozoa, corrosive sublimate, and other boiling reagents. But as the effects produced by these methods, despite their excellent preserving qualities, are generally restricted, the trial was made to paralyze the contractile elements by means

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[1] Abstract and translation from an article by Dr. Bruno Hofer in Zeitschrift für wissenschaftliche Mikroskopie, vii. 318 (1890).

of proper poisons, and then to fix the paralyzed animal. Satisfactory results were thus obtained by the use of chloral and different alkaloids, such as cocaine, antipyrine, antifebrine, etc., with or without subsequent poisoning. These paralyzing methods, which, moreover, are not always effective, have the great disadvantage that, through the action of the paralyzing reagents, which are in most cases specific protoplasmic poisons, a simultaneous swelling of the protoplasm occurs, so that, although the topographical conditions are retained, the histological details are in many cases destroyed.

On that account a method is to be desired which will permit metabolic animal forms to be fixed in a distended state, and at the same time sufficiently insure their preservation, especially in the case of those animals which have hitherto resisted all attempts towards preservation. These results are to be obtained, as I have subsequently shown in a series of experiments, with the aid of hydroxylamine, *i.e.*, with its hydrochlorate or sulphate, by means of which the smooth and striated muscles of many Metazoa are paralyzed to such an extent that a subsequent contraction, while fixing them afterward, is hardly perceptible. A sufficient paralysis is also obtained before a swelling of the protoplasm in the cells of the paralyzed object is noticeable.

A series of careful examinations with abundant material will have to be made to determine to what extent hydroxylamine poisoning may be used. The favorable results that I have obtained with Protozoa, Hydrozoa, Actinozoa, Planariæ, Annelida, Rotifera, Mollusca, etc., lead me to believe that hydroxylamine, as a paralyzing agent, will be more generally used.

The following directions may be recommended in using hydroxylamine:

One per cent of the crystals of the commercial hydrochlorate, which are usually impure, is dissolved in fresh water, and enough carbonate of soda added to render the solution neutral. This solution may be kept on hand in large quantities for use at any time. Distilled water must not be used in preparing it, but in the case of marine forms salt water must necessarily take the place of fresh. It is not advisable to eliminate the hydroxylamine from the hydrochlorate solution by adding an excess of carbonate of soda, as the liquid then obtained would over-excite the animal.

After the animals have been paralyzed in the neutral hydrochlorate solution they are immediately covered with the fixing medium and thereby killed.

The number of fixing reagents that may be used is of course limited. For, hydroxylamine being a powerful reducing medium, all easily reducible agents, such as osmic acid, corrosive sublimate, chloride of gold, of platinum, etc., cannot be directly applied. The hydroxylamine must first be worked out with water. Alcohol, acetic and picric acids, and mixtures of these two acids may be directly applied, and with these a good histological slide may always be obtained.

The strength of the solution depends, of course, on the nature of the animal to be mounted. In the case of a few special objects I find the following directions may be respectively used :

1. *Stentor cœruleus.*—Place the Stentors for ten or fifteen minutes in a 0.25-per-cent solution of the hydrochlorate. A large proportion of the animals soon stretch themselves out and remain in the semi-distended condition which free-swimming Stentors usually show. No subsequent contraction occurs. The paralyzing effect of the hydroxylamine is soon apparent, but is, however, not sufficiently complete to commence the fixing process. The paralysis must first extend to the cilia. After some ten minutes the cilia of the peristome move irregularly and slower, and finally cease moving altogether. This change must be carefully noted, for at this step the Stentors are suddenly flooded with a concentrated solution of picric acid mixed with a 5-per-cent solution of acetic acid. The majority of the Stentors are now pear-shaped; a few are distended their full length ; while others have the same round shape that Stentors assume when fixed before having been previously paralyzed. The peristome cilia of each individual remain extended and are not drawn back. Sometimes the smaller forms are killed inside of ten minutes through the action of the hydroxylamine, the protoplasm swells, and the animals are entirely deformed. It is consequently always necessary to observe the action of the hydroxylamine from time to time through the microscope, and to add the picric acid before the protoplasm in the larger forms appears to swell; for if left too long the hydroxylamine will act as a poison on the protoplasm, as has been shown by Loew in his experiments with vegetable protoplasm. If the action be stopped, how-

ever, at the right moment, the histological details will be preserved. The Stentors may then be washed in alcohol of 70 per cent, and stained in a rose-red solution of borax-carmine in hydrochloric alcohol of 70 per cent. A satisfactory stain will be obtained in about one hour's time. The Stentors being likely tô contract if transferred from absolute alcohol directly to oil of cloves, it is advisable to place them in oil of cloves strongly diluted with absolute alcohol, which latter is allowed to evaporate. This proceeding must be followed when mounting the specimens in Canada balsam. If all the above-mentioned details are adhered to, better slides will be obtained than have been produced by any other method.

2. *Spirostomum teres*.—These extraordinarily sensitive infusorians may be treated in the same manner.

3. *Carchesium polypinum*.—The difficulty in preparing *Carchesium* and many other Vorticellidæ lies in the fact that the muscles of the peduncles strongly contract when brought in contact with the preserving liquid, in consequence of which the individuals of a colony are drawn together and the natural bell-shaped form becomes rounded. To overcome this place the *Carchesia* in a 0.2-per-cent solution of hydrochloric hydroxylamine. The peduncles cease their periodic contractions after one or two minutes, and remain distended. After about five minutes the cilia move more slowly, and ten minutes later the individuals are ready to be killed, like the Stentors, by means of picric-acetic acid.

4. *Hydra grisea*.—Although this object is a comparatively easy one to prepare with any good paralyzing agent, I wished to try the hydroxylamine-poisoning process, in order to study the effects it would have on all the different muscles. Besides, the effects on *Hydra* of a 0.25-per-cent solution of hydroxylamine chloride are such that not only the body proper remains distended, but the mouth also sometimes remains open.

5. *Dendrocœlum lacteum*.—In spite of the fact that very good results in preparing sections of Planaria may be obtained with the use of Lang's solution, the latter is unfit for mounting whole specimens, because the usually thick and massive animals, which must be pressed for this purpose, cannot become flattened after they have become hard. It is therefore necessary to place the live animal under the cover glass, press it slightly, and then flow in

the preserving liquid. But, on account of the irritation to which the animal is subjected by this method, abnormal contractions usually occur. It is consequently advisable to first paralyze the muscular system with hydroxylamine, then to flatten the animal under the cover glass, and finally kill it with picric-acetic acid. For paralyzing *Dendrocœlum lacteum* ten or fifteen minutes are sufficient, with a 0.5-per-cent solution of hydroxylamine chloride. The moment the animal stops moving is the best time to kill it.

6. *Hirudo medicinalis.*—To produce good sections of leeches the body must show no contraction after being killed. Chloroform as a paralyzing agent cannot be recommended, as, on account of excessive irritation, the muscles of the leech are often torn. When placed in a 1-per-cent solution of hydroxylamine chloride, the animals stretch themselves out to their full normal length after from one-half to two hours' time, and remain in this state after the fixing medium is added, which may be either alcohol or picric-acetic acid.

7. *Naïs proboscidea.*—*Naïs* has a tendency, when placed in the preserving fluid, to roll itself up sideways and perceptibly shorten its segments. A side view of the body is of course advantageous or the study of the nervous system, but the segmental organs are not visible in this position, as they are covered by the intestines. In order to properly see them the animal must be fixed on its belly or back, when the entire segmental structure is shown. Place the *Naïs* in a 0.1-per-cent solution of hydroxylamine chloride. After twenty or thirty minutes the skin muscles are so lame that the animal hardly moves, and may be fixed on the slide in any position with picric-acetic acid. The specific muscle-paralyzing action of hydroxylamine is especially noticeable in *Naïs proboscidea*, for the animal may remain one hour and a half in the hydroxylamine solution without the ciliary motion in the rectum entirely ceasing, while the skin muscles have become incapable of contraction after about half an hour. Moreover, *Naïs* is able to recover its natural condition if transferred to pure water. The ciliary motion of the rectum again becomes active, and later the skin muscles regain their contractile ability. It is consequently possible, after thoroughly washing the paralyzed animal for about ten minutes, to kill it with other reagents than picric-acetic acid—

for instance with osmic acid, a proceeding to be recommended for studying the segmental canal.

8. *Rotifera.*—The action of hydroxylamine on Rotifers, of which *Noteus quadricornis*, *Squamella bractea*, and *Salpina spinigera* were examined, is also advantageous. After applying a 0.1-per-cent solution the cilia of the discs, as well as the muscles of the tail-like foot, become so lame that both wheel-organ and foot are not drawn in when being fixed with picric-acetic acid.

9. *Mollusca.*—For *Anodonta cygnea* and *Helix pomatia* I recommend a ½ to 1 per cent solution. Both specimens were entirely paralyzed after from ten to twenty hours. The snail had stretched itself out of its house as it usually does while moving in life. The mussel had extended its foot, and the closing muscles of the shell were completely paralyzed. While afterwards fixing in alcohol the animals remained unchanged.

The aforementioned examples are illustrations of the fact that hydroxylamine possesses a paralyzing power in contractile elements, and that it may be used very successfully in mounting.

PROCEEDINGS.

Meeting of October 2d, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Twenty-five persons present.

Dr. Charles Lehlbach was elected a resident member.

The Recording Secretary read a communication from the Scientific Alliance of New York requesting the Society to unite in arranging a mutual programme.

On motion it was resolved that the matter be referred to the Board of Managers to report at the next meeting.

The Corresponding Secretary announced a donation of diatomaceous material from Mr. K. M. Cunningham, of Mobile, Alabama, accompanied by the following communication dated August 11th, 1891:

"To-day I mailed to your address a specimen of a new diatomaceous material find, recently brought to light by myself. This material is sufficiently cleaned to mount directly. It is from the west bank of the Mobile River, and is a tidal marsh mud taken from three to five feet below the surface, and has probably not been seen heretofore by diatom admirers. Four or five forms occur in great abundance—*Campylodiscus*, *Actinocyclus*, *Terpsinoe*, with a sprinkling of others.

"The material will make elegant balsam or dry mounts for condensed surface illumination for binocular. It is a cleaning by Dr. Geo. H. Taylor, of Mobile, and is of unusual interest before acid treatment, as it shows a fair mixture of a wide variety of rhizopods, sponge spicules and diatoms, not to mention a great variety of transparent plant tissues of great diversity of cellular structure, with scales of mica, which polarize very prettily."

Mr. Hyatt announced the finding of marine forms of diatoms in the filter beds of the city water works of Poughkeepsie, New York.

Dr. E. G. Love addressed the Society on "The History and Development of the Microscope up to the time of Achromatism." This address was a most interesting and able explication of the subject, and was beautifully illustrated by the projection of fifty lantern slides of diagrams, antique instruments and accessories.

Meeting of October 16th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Twenty-eight persons present.

The Corresponding Secretary announced the donation to the Society of seventy-five slides of diatoms by Mr. Henry C. Bennett, prepared by him and accompanied by the following communication :

"I prepared the slides from cleaned material obtained from abroad, and they comprise deposits from districts that have received much attention from diatomists, and which have been described in scientific publications. The cleaned diatomaceous material I obtained from M. J. Tempère, 168 Rue St. Antoine, Paris, France, who at intervals of about three months issues a series of twelve tubes of cleaned diatoms in liquid, each tube holding about one-half of a drachm."

OBJECTS EXHIBITED.

1–4. Four new forms of aquatic animal life from the Morris and Essex Canal, N. J.: by Stephen Helm.

5. *Bacillaria paradoxa*, living, from the Morris and Essex Canal: by James Walker.

6. The Worker Ant, *Myrmica scabrinodis* Nyl.: by J. L. Zabriskie.

7. Sting of Wasp, with air in the longitudinal canal of one lance, showing branches of the canal to the barbs: by J. D. Mallonee.

Meeting of November 6th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Thirty-three persons present.

Dr. J. A. Gottlieb was elected a resident member.

The following persons were appointed by the chair Committee on Annual Reception: Anthony Woodward, Dr. Edward G. Love, and Charles S. Shultz.

OBJECTS EXHIBITED.

1. *Cordylophora lacustris:* by H. Calef.

2. Transverse sections of Antennæ of House-fly, *Musca*

domestica, showing grooves, horny discs, and fine hairs : by L. RIEDERER.

3. Sagittal sections of head of Stable-fly, *Stomoxys calcitrans:* by L. RIEDERER.

4. *Trichina spiralis* in human muscle: by J. A. GOTTLIEB.

5. One of the new forms of aquatic life exhibited at the last meeting: by STEPHEN HELM.

6. Section of leaf of Oleander showing stomata: by F. W. LEGGETT.

7. Section of leaf of Rubber Plant showing stomata: by F. W. LEGGETT.

8. Portion of stem of Sleepy Catch-fly, *Silene antirrhina* L., with captive insect: by J. L. ZABRISKIE.

9. Leaf-blade of Long-leaved Sun-dew, *Drosera longifolia* L., with captive insect: by J. L. ZABRISKIE.

Dr. Gottlieb gave a very interesting account of the nature and action of *Trichina*, and stated concerning the exhibit that it was taken from the biceps muscle at the autopsy of an Italian who entered Bellevue Hospital under the Doctor's care in the spring of 1890, and who died three weeks after, suffering from trichinosis.

Mr. Riederer explained his exhibits, using in illustration excellent colored drawings of his own preparation.

Mr. Zabriskie exhibited in connection with his slides herbarium specimens of *Silene antirrhina* L., *Drosera rotundifolia* L., *D. longifolia* L., and *D. filiformis* Raf.

Mr. Hyatt stated that the glandular hairs of the leaf of *Drosera* will not move on contact with inorganic matter, but that they will contract upon a minute piece of fresh meat in the space of twenty seconds; and further, that in his experience the insects most abundantly captured by *Drosera* are ants.

Dr. N. L. Britton gave an interesting description of a large insectivorous plant, of the genus *Roridula*, living specimens of which he had seen at the Royal Gardens at Edinburgh. The plant is a native of Tasmania. It is a branching bush, with filiform leaves, more slender than those of *Drosera*, and, like the latter, furnished with glandular hairs with which it captures flies.

Meeting of November 20th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Forty persons present.

Mr. M. A. Gottlieb was elected a resident member.

The Vice-President reported the decision of the Board of Managers, that it is desirable that the programme of the Society be published in the Bulletin of the Scientific Alliance.

On motion it was resolved that the report be adopted, and that the necessary expense be met from the funds of the Society.

On motion it was resolved that the Society hold an Annual Reception.

The chair appointed the following as Committee on Nomination of Officers: Walter H. Mead, William G. De Witt, and F. W. Devoe.

The Corresponding Secretary announced the donation to the Society, by Mr. K. M. Cunningham, of Mobile, Alabama, of our prepared slides of rhizopods and two vials of material, accompanied by the following communication dated November 14th, 1891:

"The preparations are the outcome of my most recent find of a diatom-bearing material on the eastern edge of a marsh bordering the Mobile River. The vegetable growth, mostly marsh grasses, rests upon a stratum of a very soft, oozy mud, through which a pole may be readily pushed for a depth of six feet. When withdrawn, the soft mud is scraped off and subjected to the usual treatment for the removal and concentration of diatoms.

"This mud proved to be of unusual richness in variety of micro-organic remains, as may be attested by an examination of the slides prepared from the same. Associated together may be found marine and fresh-water species of diatoms, several interesting varieties of sponge spicules, very numerous tests or carapaces of fresh-water rhizopods, and several species of marine foraminifera. Also there may be seen varieties of pollen grains or spore capsules, many plates of mica, and of less interest the tissues of plants of a partially siliceous nature—*Phytolitharia* (Ehrenberg).

"I have prepared, in a probably unusual manner, a set of four slides to illustrate some of the features connected with this special deposit. On two slides I show selected rhizopods, to be viewed strictly by polarized light; and two slides of deposit strewn so as to show the various associated micro-organisms by polarized light. These slides have no cover glasses, but are covered by a thin film of mica, with the object of intensifying the brilliancy of the prismatic effects. Under this arrangement we are provided with a kaleidoscopic effect of color, produced by the polarized light when the polarizing prism is revolved.

"I have also sent two vials, one containing the rhizopod, foraminifera, and mica material, the other containing the marine and fresh-water diatoms, concentrated from the mud already alluded to. The diatoms are a water-washed concentration by Dr. Geo. H. Taylor, of Mobile, without use of acids. He is now engaged on the reduction of a large bucketful of the deposit to the same state as that shown by the slide of diatoms prepared from the material in the vial sent herewith. The diatoms indicate an aggregation of about fifty marine and fresh-water species—*Actinocyclus Ehrenbergii*, *Campylodiscus crebrosus*, *Nitzschia circumsuta*, and *Terpsinoe musica*. Another interesting feature is that *Triceratium favus* is absolutely absent, and that *Cymatopleura elliptica* and a pretty *Acanthes* are seen in every slide of the material, while they are almost unknown as occurring in all previous gatherings tributary to Mobile until this locality was casually met."

OBJECTS EXHIBITED.

1. Vanadamite from Arizona: by E. C. Bolles.

2. Percylite from Arizona, together with a large series of minerals in minute paper boxes : by E. C. Bolles.

3. Rhizopods from marsh mud, Mobile River, Alabama, prepared and donated by K. M. Cunningham: by J. L. Zabriskie.

4. A slug-like form of aquatic life: by Stephen Helm.

5. An undescribed form of aquatic life, formerly exhibited as No. 4: by Stephen Helm.

6. An undescribed form of aquatic life resembling *Cordylophora lacustris:* by Stephen Helm:

7. *Hydra viridis:* by Stephen Helm.

8. Young Hydro-medusæ, living: by L. Riederer.

9. Poison from stems of grapes: by L. RIEDERER.

10. Transverse section of leaf of Oleander with stomata: by E. G. LOVE.

11. Section of agate: by J. D. HYATT.

Mr. E. A. Schultze read a translation from *Zeitschrift für wissenschaftliche Mikroskopie*, entitled "On the Effects of Hydroxylamine as a Paralyzing Agent for Contractile Elements." This translation is published in full in this number of the JOURNAL, p. 28.

Rev. Dr. Bolles explained at length the advantages of the minute square paper boxes containing the mineralogical specimens exhibited by him. A short section of a small cylinder of wood is glued in the bottom of each box; a disc of black cardboard is glued on top of the wood, and the specimen is attached to the black disc.

This was followed by a discussion on the sweating of cells containing dry mounts, and especially on the disadvantages of wax cells, which discussion was participated in by Messrs. Cox, Bolles, Hyatt, Leggett, and Zabriskie.

Dr. E. G. Love stated concerning his exhibit that the peculiar appearance of the stomata of the Oleander was due to the fact that the stomata are each seated at the bottom of a little depression in the surface of the leaf, the depressions being lined with minute hairs. Dr. Carpenter mentions this in his work on the microscope, and it probably occurs in only a few genera of plants.

Mr. Hyatt said of his beautiful section of agate that it was composed of aggregated clusters of minute crystals of quartz, showing hexagonal structure of the crystals.

PUBLICATIONS RECEIVED.

The Microscope: Vol. XI., Nos. 8—11 (August—November, 1891).

American Monthly Microscopical Journal: Vol. XII., Nos. 10, 11 (October, November, 1891).

Anthony's Photographic Bulletin: Vol. XXII., Nos. 19—23 (October 10—December 12, 1891).

Botanical Gazette: Vol. XVI., Nos. 11, 12 (November, December, 1891).

Bulletin of the Torrey Botanical Club: Vol. XVIII., Nos. 10—12 (October—December, 1891).

Insect Life: Vol. IV., Nos. 1—4 (October, November, 1891).

Psyche: Vol. VI., Nos. 187, 188 (November, December, 1891).

West American Scientist: Vol. VII., No. 63 (October, 1891).

Natural Science Association of Staten Island, Proceedings: Meetings of October 10, November 14, 1891.

San Francisco Microscopical Society, Proceedings: Meetings of October 7—November 18, 1891.

Journal of the Elisha Mitchell Scientific Society: Part 1, 1891.

Journal of the New Jersey Natural History Society: Vol. II., No. 2 (January, 1891).

Kansas City Scientist: Vol. V., No. 10 (October, 1891).

Bulletin of Michigan Agricultural Experiment Station: Nos. 75—77 (July—November, 1891).

Bulletin of Cornell University Agricultural Experiment Station: No. 32 (October, 1891).

The Microscope and Histology, Part 1: From the author, Dr. S. H. Gage (1891).

The Eleventh Census, An Address: From the author, Hon. Robert P. Porter (October, 1891).

Journal of the Royal Microscopical Society: Part 5, 1891.

International Journal of Microscopy and Natural Science: Vol. I., Nos. 10—12 (October—December, 1891).

Grevillea: No. 94 (December, 1891).

The Naturalist: Nos. 195, 196 (October, November, 1891).

Transactions of the Canadian Institute: Vol. II., Part 1 (October, 1891).

The Ottawa Naturalist: Vol. V., Nos. 6, 7 (October, November, 1891).

The Victorian Naturalist: Vol. VIII., Nos. 5, 6 (September, October, 1891).

Brooklyn Medical Journal: Vol. V., Nos. 11, 12 (November, December, 1891).

Indiana Medical Journal: Vol. X., Nos. 4—6 (October—December, 1891).

Hahnemannian Monthly: Vol. XXVI., Nos. 10—12 (October—December, 1891).

The Satellite: Vol. V., Nos. 2, 3 (October, November, 1891).

Electrical Engineer: Vol. XII., Nos. 179—189 (October 7—December 16, 1891).

American Lancet: Vol. XV., Nos. 11, 12 (November, December, 1891).

National Druggist: Vol. XIX., Nos. 8—12 (October 15—December 15, 1891).

Johns Hopkins University Circulars: Vol. XI., Nos. 92—94 (November, December, 1891).

Mining and Scientific Review: Vol. XXVII., Nos. 14—23 (October 8—December 10, 1891).

Bulletin de la Société Belge de Microscopie: Vol. XVII., No. 10 (October, 1891).

Bulletin de la Société Royale de Botanique de Belgique: Vol. XXX., Part 1 (1891). Comptes-Rendus (July 19, 1891).

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Nuovo Giornale Botanico Italiano: Vol. XXIII., No. 4 (October, 1891).

La Notarisia: Vol. VI., No. 26 (August, 1891).

Jahrbücher des Nassauischen Vereins für Naturkunde: Vol. XLIV. (1891).

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Naturwissenschaftlicher Verein, Frankfurt (Oder), Helios: Vol. IX., Nos. 4—6 (July—September, 1891). Societatum Litteræ: Vol. V., Nos. 5—8 (May—August, 1891).

Revisio Generum Plantarum, Part I. By Dr. Otto Kuntze. From the author (1891).

Sociedad Cientifica "Antonio Alzate," Memorias: Vol. IV., Nos. 11, 12 (May, June, 1891).

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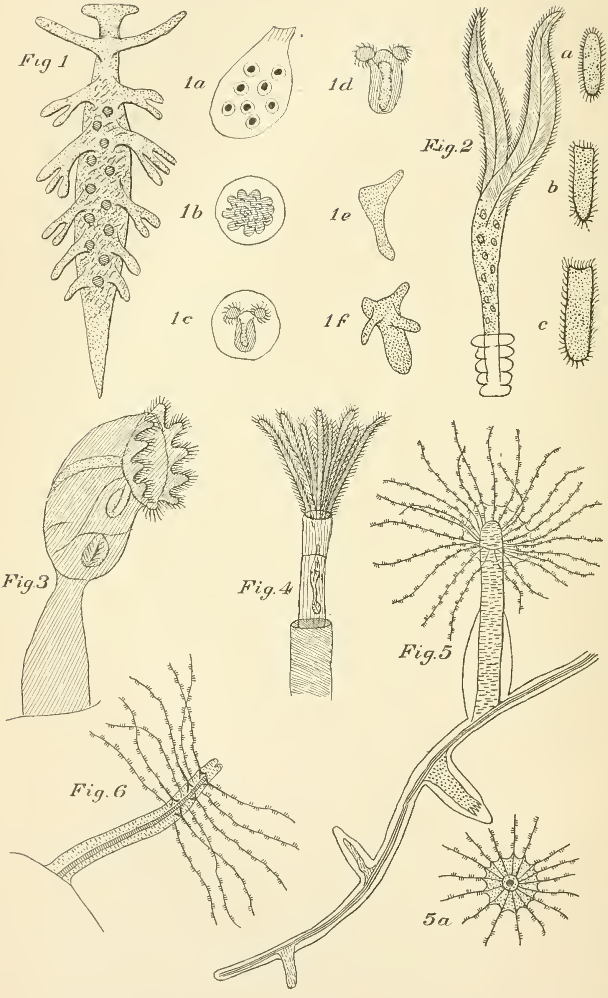
American Metrological Society, Metrical Tables (1891).



HELM ON AQUATIC LIFE.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. VIII. APRIL, 1892. No. 2.

CORDYLOPHORA LACUSTRIS, AND FIVE NEW FORMS OF ANIMAL LIFE.

BY STEPHEN HELM.

(*Read December 4th*, 1891.)

In the latter part of September last I explored the portion of the Morris & Essex Canal lying between Pamrapo and Newark Bay, N. J. On first inspection the result was disappointing, but a more careful examination revealed isolated specimens of two forms (Pl. 29, Figs. 3 and 4) which were new to me. Thinking it probable that another part of the same canal might perhaps yield better results, I, on another occasion, proceeded to that section lying between Greenville and Claremont.

Here, to my intense satisfaction, I found the same two forms in considerable abundance, and, to my delight, three others which were also new to me (Pl. 29, Figs. 1, 2, 5). The question then arose, What are they? After carefully searching through all the literature on the subject at my command, after communication

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Explanation of Plate 29.

FIG. 1. The molluscan designated as No. 1. 1*a*. Egg-cluster as first observed. 1*b*. Egg, with mulberry-shaped contents. 1*c*. The same advanced to a rotifer-like form. 1*d*. The free swimming "rotifer." 1*e*. The same at time of attachment. 1*f*. The same with budding processes.—FIG. 2. *Lagotia cœruleus* Helm. 2 *a*, *b*, *c*. Stages of development (after Wright).—FIG. 3. *Urnatella Walkerii* Helm.—FIG. 4. *Octocella libertas* Helm.—FIG. 5. *Cordylophora coronata* Helm. 5*a*. The same: view of tentacles, web, and oral aperture from above.—FIG. 6. *Cordylophora lacustris* Allman.

with many microscopists of large experience, and after considerable correspondence, I fail to find any record of these specific forms. I am, therefore, driven to the conclusion that they are new to this country, and probably new to science, and the pleasurable duty of introducing them devolves on me.

Should the publication of this paper, however, lead to their identification, I shall be glad to receive any communication on the subject, and shall even then have the satisfaction of rescuing from partial oblivion forms which ought not to remain in obscurity.

One of the gentlemen whose counsel I sought was Dr. A. C. Stokes, of Trenton, N. J., editor of *The Microscope*, and a corresponding member of this Society. He very courteously replied that all except No. 5 were new to him, and that he thought, from my drawing, was *Cordylophora lacustris;* and if not, then it was an allied species.

I have since had considerable correspondence with him, and, although personally a stranger, he has evinced intense interest in my finds; and whilst he is a very busy man, I hope to have the advantage of his critical experience in the preparation of the more technical descriptions of these forms, which I propose to prepare during the remaining winter months.

As to the names which I have attached to four of the five forms, I wish explicitly to state that they are provisional only, and are given pending the settlement of the question whether they are new or only rare species.

The remaining form, though unquestionably a molluscan, differs so widely from hitherto described forms that it seems to demand a niche for itself. I therefore await results, and shall, whilst endeavoring to complete my observations, in the meantime designate it as No. 1.

On my first introduction to it, all I saw were two processes, standing out from confervoid and other growth, on the stem of a plant I was examining for other objects. A current was being produced as powerful as that of *Melicerta* and other large Rotifera, and presently more processes, and finally an entire animal crept into the field of view—an animal so unlike anything I had seen before, or even remembered to have read of, that I was at first amazed and then intensely interested. For its size

Fig. 2.

Fig. 3

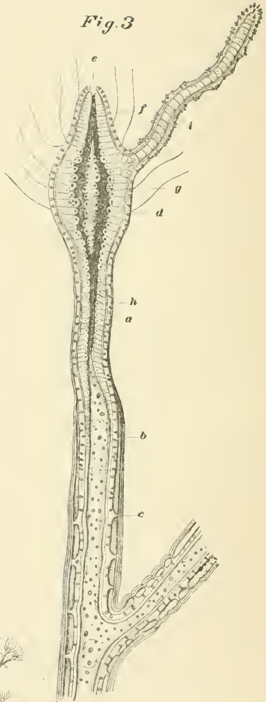
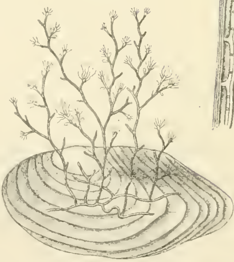


Fig. 1



CORDYLOPHORA LACUSTRIS.

—one-fourth of an inch in length—and means of locomotion, it moves pretty rapidly and without any apparent effort, its motion being the easy, firm, sliding movement so familiar in the slug and snail.

The processes seem to develop with the growth of the animal, the maximum number I have seen being seven pairs. The two anterior processes are more pointed than any of the others, and are generally directed forward. Of the remainder, the second pair is forked for about one-half of the long diameter ; the third pair divided into three ; the fourth into two again; whilst the remainder are single, the posterior pair being considerably smaller than the others. They are all slightly inclined backward as the animal moves along. The body terminates in a pointed tail equal to about one-third of its length.

The current is produced by innumerable "papillæ," which move with a sort of undulatory motion and apparently cover every portion of the body. The first impression produced is that of cilia, and in certain lights it is difficult to persuade one's self they are not, as when seen edgewise they are very thin. They are often quiescent, and what purpose their motion serves I cannot imagine, as the animal seems to feed slug-fashion ; and though I have not yet made out its mouth, its possession of a lingual membrane presupposes the existence of one.

I have not absolutely satisfied myself as to the method of reproduction, but after many observations have arrived at certain conclusions. The body is composed of sarcode, and in the tail a rapid circulation may be seen; but the central portion of the body is so opaque that very little can be made out without dissection, and until my stock increases I am loath to sacrifice many in that way. Underneath the frog-like pigment cells of the back I have observed many round cells, and, suspecting them to be immature egg clusters, I isolated two specimens and found my suspicions

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Explanation of Plate 30. (After Allman.)

Fig. 1. *Cordylophora lacustris* Allman, attached to a dead valve of *Anodon cygneus*. Reduced two-thirds natural size.—Fig. 2. A branch, magnified, with the polyps in various states of expansion, and with the reproductive capsules more or less developed. —Fig. 3. Longitudinal section of polyp, to show the details of its structure. *a*. Ectoderm. *b*. Polypary. *c*. Processes from the ectoderm attached to inner surface of the polypary. *d*. Endoderm. *e*. Mouth. *f*. Post-buccal cavity. *g*. Stomach. *h*. Common canal of the cœnosarc. *i*. Muscles.

confirmed by the deposition within three or four days of several clusters, containing from four to eighteen eggs each (Fig. 1*a*). These I carefully watched, and after some days observed :

1. The dense contents gradually assumed a mulberry shape (Fig. 1*b*), and then there set in a rapid revolution of the cell contents.

2. A development of a rotifer-like form (Fig. 1*c*) with two strongly ciliated heads, always in motion, but still within the egg.

3. The rotifer-like form escaped (Fig. 1*d*) and became a free swimmer. It now had a kind of tail in process of development.

4. The ciliated heads disappeared, and attached by the tail it assumed the form shown in Fig. 1*e*.

Unfortunately, I am not able to devote continuous observation to my specimens, hence my uncertainty ; but I have further seen what I believe to be developed from Fig. 1*e*—a form (Fig. 1*f*) with one pair of processes, and another with three pairs, my first specimen having six pairs.

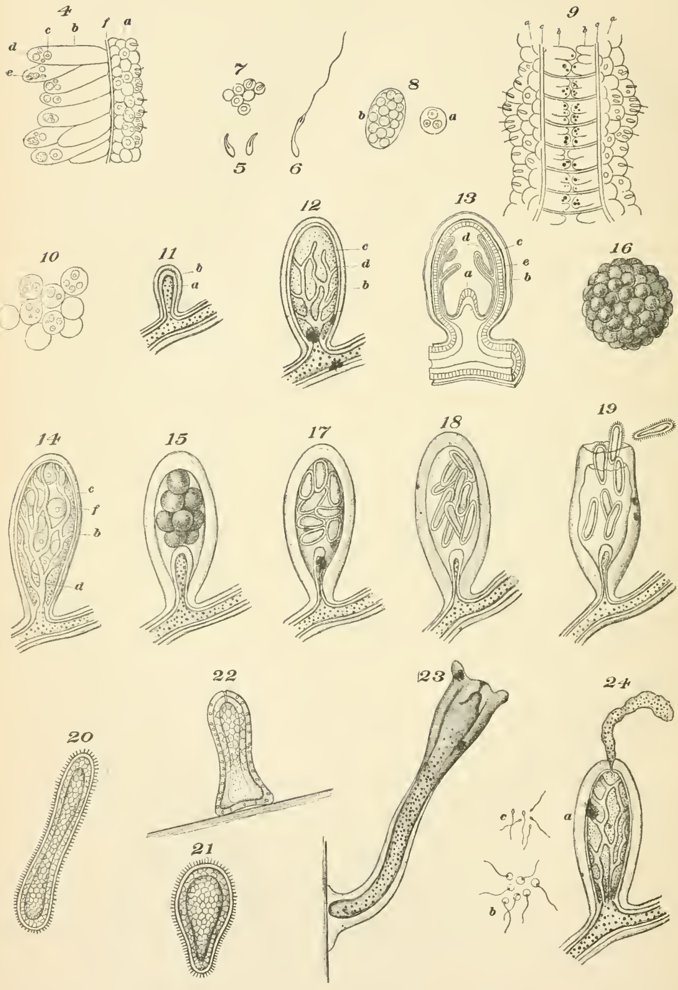
LAGOTIA CÆRULEUS sp. n. (Pl. 29, Fig. 2).

Figure 2 must undoubtedly be referred to the genus *Lagotia* Wright described in " Pritchard's Infusoria," and figured on Plate 31, Figs. 7–13. His description of *L. producta* is as follows :

" Neck of sheath exceedingly prolonged, annulated sheath of a pale yellow-brown color. Animalcule (= zoöid) two or three times the length of the sheath, attenuated ; ciliated lobes erect, divergent, and re-curved at tips ; color of zoöid, deep blackish-green.

" Dr. Wright observed the development in this species of ciliated embryos, which, after passing through the stages seen in Figs. 2 *a*, *b*, *c*, and carrying on an active existence as free ciliated animals, form an attachment to some surface, and proceed to develop a sheath and the characteristic ciliary lobes. The transformation from ciliated embryos to *Lagotia producta* transpired in the course of a night, the sheath even during that time being completed with its rings."

I have given Dr. Wright's history of *L. producta*, as it is the nearest to *L. cæruleus*, and answers for it with the following exceptions : *L. cæruleus* is of a delicate blue throughout—sheath and body ; *producta* sheath " pale yellow-brown ; body, blackish-



CORDYLOPHORA LACUSTRIS.

green." *L. cœruleus* is found in brackish waters, *L. producta* is a marine form.

L. cœruleus possesses, moreover, a strongly defined median line in each ot its lobes, but no such line is shown in Pritchard.

No vent is mentioned by Wright in any of the species of the genus, viz.: *L. viridis, hyalina, atro-purpurea*, and *producta ;* there is one in *cœruleus*, by which excrement is voided, at the base of the lobes, but it can only be seen when in action.

URNATELLA WALKERII sp. n. (Pl. 29, Fig. 3).

The polyzoön represented in Fig. 3 I have characterized as *Walkerii* after my friend who was with me when it was captured. It is a pretty and very polite form, very shy, and about the one-thirtieth of an inch in length when extended. Its politeness consists in very frequently bowing body and stem from its base, and then returning to an erect position.

It is almost identical with *U. gracilis* Leidy, save that *gracilis* has several constrictions in the stem, whilst *Walkerii* has the stem perfectly plain and somewhat tapering. Leidy says of *L. gracilis*: " The longest stems consist of a dozen joints, and measure about

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Explanation of Plate 31. (After Allman.)

Cordylophora lacustris. FIG. 4. Portion of the walls of the stomach highly magnified *a*. Ectoderm, its cells containing thread-cells. *b*. Endoderm composed of elongated cells, with true secreting cells in their interior. *c*. Secreting cells with evident nucleus. *d*. Secreting cells with nucleus obscured. *e*. Granular mass. *f*. Muscles.—FIG. 5. Thread-cells before exsertion of filament.—FIG. 6. Thread-cells after exsertion of filament.—FIG. 7. Cells liberated under pressure from the ectoderm, some with a thread-cell, others with a nucleus.—FIG. 8. Cells liberated by pressure from endoderm of stomach.—FIG. 9. Portion of tentacle near its root. *a*. Ectoderm with thread-cells. *b*. Endoderm. *c*. Muscular fibres.—FIG. 10. Cells containing secondary cells from endoderm.—In FIGS. 11-14 the letters indicate : *a*. Diverticulum from the cœnosarc. *b*. External investment of the reproductive capsule. *c*. Cellular sac. *d*. Ramified canals. *e*. Structureless sac secreted outside of the cellular sac.—FIG. 11. Reproductive capsule, very early stage.—FIG. 12. The same, more advanced.—FIG. 13. Ideal longitudinal section of the same at the same stage.—FIG. 14. The capsule more advanced, the ova being visible.—FIG. 15. The same still further advanced, the ova lying on the extremity of the diverticulum.—FIG. 16. More magnified view of ovum, segmentation into a mulberry-like mass.—FIG. 17. Capsule still further advanced, ova elongated.—FIG. 18. The same, ova swarming in interior.—FIG. 19. The same, sac ruptured, ova escaping as free ciliated infusoria.—FIG 20. Embryo just after escape.—FIG. 21. The same, assuming pyriform figure.—FIG. 22. The same after locomotive stage, fixed by one extremity.—FIG. 23. Further development, tentacula budding, stem surrounded by a delicate polypary.—FIG. 24. Male capsule. *a*. Contents escaping under slight pressure. *b*. Caudate cells liberated from capsule. *c*. Spermatozoa.

the one-eighth of an inch in length ; the shortest stems have one-third the number of joints." From the construction of the stems he further argues : "As in the other fresh-water polyzoa, the polyps die on the approach of winter, but the headless stems appear to remain securely anchored and ready to reproduce the polyps in the spring."

From my short acquaintance with the new form, I am not at present able to confirm or reject Leidy's theory; but he was a very careful observer, and his recent death was a great loss to science.

In *U. Walkerii* the tentacula are from eight to ten in number, and unusually short and stumpy, with thirty or forty cilia on each side. There is an upward circulation—shown in the left of the figure—a crushing apparatus in the œsophagus, whilst the gizzard performs its functions with a quick revolving motion.

Octocella Libertas sp. n. (Pl. 29, Fig. 4).

This beautiful little polyzoön I have named *Octocella* from its possession of eight tentacles, and *libertas* in recognition of its being found in the shadow of the Statue of Liberty.

The process known as "introversion" is remarkable in this form, whilst it is also a fine example of ciliary action. It is, when extended, very clear, and is provided with a crushing apparatus in the œsophagus, by which the food is prepared for the action of the gizzard beneath. But the structure and mode of reproduction in the Polyzoa have been so frequently and so fully described by able writers that it would be presumptuous in me to enter the lists, unless our small friend should manifest some undescribed peculiarities.

Cordylophora Coronata sp. n. (Pl. 29, Fig. 5).

This member of the group Hydroida must at once take rank as one of the most attractive forms I have beheld in an experience of thirty-five years. As it seems hardy, it is a very valuable addition to our "exhibition objects." I have now in my aquaria some of my original gathering, made more than two months ago.

When first found, as I did not then happen to be one of the select few who have been favored with a sight of *C. lacustris*, it was taken for that form ; but on hunting it up in the *Philosophical Transactions*, 1853, I found that, whatever it was, it was not that, the number and position of the tentacula alone precluding that possibility.

Like the typical Hydra, it rises on an elongated stem, and extends tentacles armed with bundles of thread-cells, also Hydra-fashion; but then all resemblance ceases. Its tentacles range from twelve to thirty in number, and spring from a continuous ring around the upper portion of what may be called the head, and just below the mouth. A short distance from the base they are connected by a beautifully delicate "web," thus forming a perfect funnel (see Fig. 5*a*, which is a view from above). This web-like joining of the tentacles doubtless aids in their more rapid contraction when alarmed, and would seem to foreshadow the similar connection shown in *Plumatella* and other polyzoöns. Notwithstanding their number, and the absence of highly developed muscular power as seen in the Rotifera and Polyzoa, they appear to be under absolute control.

The thread-cells are very numerous, ranging from eighty to one hundred bundles on each of the tentacula. I have reason to believe that reproduction is effected in a similar manner to that of *C. lacustris*. Indeed, I have already noted some points of resemblance, and when my observations are completed I hope to have the pleasure of laying them before the Society.

CORDYLOPHORA LACUSTRIS Allman (Pls. 30, 31).

I have now to narrate a singular coincidence which occurred in connection with the discovery of the preceding forms.

Whilst looking over my stock of *C. coronata* I noticed one different to all the rest, and on fishing it out and giving it time to recover from its surprise, to my utter amazement I found I had before me a solitary specimen of *C. lacustris*. As I have before said, I had not previously seen it nor Dr. Allman's memoir, and should not have known it but for my recent searches and the drawings I had made.

Had a choice been given me, it would have been this form above all others, and more especially for the purpose of comparison; and, therefore, my pleasure on seeing it gradually unfold itself in all its beauty can be more easily imagined than described. Fearing I might lose it, I exhibited it, without remarks, at the Society's meeting on November 6th, 1891.[1]

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[1] This specimen was exhibited by Mr. Horace W. Calef for Mr. Helm.—ED.

As *C. lacustris*—according to Dr. Stokes—has only been found three times before in this country, twice by the late Prof. Leidy and once by Mr. Carter of Johns Hopkins University; as Dr. Allman's paper is the only standard authority upon it, and almost as rare as is the animal itself; and believing it will be fully appreciated by microscopists generally, and at the same time afford a convenient opportunity for comparison with the new form, the authorities of the Society have kindly consented to reproduce the plates of Dr. Allman's paper, as read before the Royal Society, and published in *Phil. Trans.* for 1853.

The only additional remark I have to make is on the difference between my illustration of the perfect animal, and Dr. Allman's. My drawing is an almost exact reproduction—making some allowance for perspective—of the position of its twelve tentacula during the fifteen days I had it under observation. As it lived so long, I was indulging the hope that it might bud and multiply; but when it did collapse, in a few hours there was no trace of its existence left behind. Never did I so sincerely mourn the loss of a specimen, and although I spent many, many hours in searching, I could not find another.

NOTE.—Since the reading of this paper I have met an article by the Rev. Thomas Hincks, B.A., published in the *Popular Science Review* for 1870, describing a polyzoön named *Valkeria pustulosa*, which in some respects very closely resembles *Octocella libertas;* but the woodcut is very indistinct, whilst there is no mention made of a tube. If Mr. Hincks be living, perhaps he may be able to throw some light on the subject.

PROCEEDINGS.

Meeting of December 4th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Seventeen persons present.

Messrs. Stephen Helm and Alfred Kroger were elected Resident Members.

Mr. Walter H. Mead, chairman of the Committee on Nomination of Officers, presented the report of the Committee, nominating officers for the coming year.

The Corresponding Secretary read a communication from Mr. G. R. Lumsden, of Greenville, Conn., donating to the Society a packet of diatomaceous material from a peat bog at Amherst, Nova Scotia.

On motion the thanks of the Society were tendered Mr. Lumsden for this donation.

Dr. N. L. Britton read a paper entitled "The North American Species of the genus Scirpus." This paper was illustrated by many herbarium specimens, and the fruit of two species under microscopes, as noticed in the programme.

Mr. Stephen Helm read a paper entitled "*Cordylophora lacustris* and five new forms of Animal Life." This paper was illustrated by original drawings and by objects under microscopes, and is published in this number of the Journal, p. 43.

OBJECTS EXHIBITED.

1. Head of the Spider, *Attus tripunctatus* Hentz, female, showing the eight eyes, palpi, falces, and fangs: by J. L. Zabriskie.
2. Section of an Ammonite from Würtemberg, Germany, being a cast composed of iron pyrites: by J. D. Hyatt.
3. Section of Agate, regular greenish aggregations covered with a dense pubescence: by J. D. Hyatt.
4. "Slug-form" of aquatic life, designated as "No. 1": by James Walker for Stephen Helm.
5. *Cordylophora coronata* n. sp., from the Morris & Essex Canal: by Stephen Helm.

6. Achene of *Eleocharis mutata :* by N. L. Britton.
7. Achene of *Scirpus microcarpus* Presl.: by N. L. Britton.

Meeting of December 18th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Thirty-three persons present.

Mr. Charles F. Cox delivered a lecture entitled "What is a Diatom?" This lecture was illustrated by one hundred stereopticon projections of diatoms, and is published entire in the January number of this volume of the Journal.

On motion the thanks of the Society were tendered Mr. Cox for this interesting, valuable, and beautifully illustrated lecture.

On motion it was resolved that when the Society adjourns it adjourn to meet on the evening of January 5th, 1892.

Meeting of January 5th, 1892.

The President, Mr. P. H. Dudley, in the chair.

Twenty-eight persons present.

Prof. Henry M. Rusby, M.D., and Mr. J. W. Lloyd were elected Resident Members.

The Annual Reports of the Treasurer and the Committee on Publications were presented and adopted.

This being the designated time for the election of officers, the chair appointed Dr. Edw. G. Love and the Rev. Geo. E. F. Haas tellers, and at the close of the polls the following persons were declared elected as officers of the Society for the coming year:

President, J. D. Hyatt.
Vice-President, Charles S. Shultz.
Recording Secretary, George E. Ashby.
Corresponding Secretary, J. L. Zabriskie.
Treasurer, James Walker.
Librarian, Ludwig Riederer.
Curator, George E. Ashby.
Auditors, F. W. Devoe. W. E. Damon. F. W. Leggett.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, dated Mobile, Alabama, December 4th, 1891, donating slides and material to the Society as follows:

"The slides and rock specimens are sent with the view of putting on record some new discoveries in microgeology of this character. Some years ago I donated a thin section of an indurated silicious sedimentary rock which I regarded as a tripoli, as the specimen seemed to show innumerable spicular spaces filled with air. I also sent smoothed specimens to exhibit the superficial aspect as opaque objects. I even then suspected that the rock contained polycistinous bodies. While in Meridian, Miss., during last October, I secured additional specimens of the rock, varying in density. A few days ago it occurred to me to test what I could find in the way of remains of Microzoa in the softer and chalkier specimens. I brushed down in water the surfaces of three different pieces, and was gratified by finding Polycistina and curious sponge spicules, gemmules, and plates of silex containing acicular inclusions. In pursuing this work I made the experimental slides sent to the Society, and on each slide I have noted with a small dot of india ink the situations of various specimens of Polycistina. About seventy-five organisms are shown.

"In the rock specimens sent there are three grades of hardness, and the two soft specimens were used by me in securing the specimens on the slides. The material occurs in great stratified beds with horizontal planes, which are shown very numerously in Clarke Co., Miss., north of Enterprise, in the deeper cuts of the Mobile & Ohio Railroad.

"Some years ago, in attempts to make magnifying glasses, I gave the optical polish to the lenses with this same tripoli stone scraped to a fine flour. I believe the slides will demonstrate something entirely new in the microscopical material line, as I have reason to believe that the composition of this rock had not been previously determined under micro-analysis by any one even in the State of Mississippi."

On motion the thanks of the Society were tendered Mr. Cunningham for these donations.

The President, Mr. P. H. Dudley, delivered his Annual Address, entitled "Structure in Steel," illustrated by numerous specimens.

OBJECTS EXHIBITED.

1–35. Specimens of Steel, illustrating the Annual Address: by P. H. Dudley.

36. Polycistina from Enterprise, Miss., prepared and donated to the Society by Mr. K. M. Cunningham: by J. L. Zabriskie.

37. A new Microscopical Lamp, manufactured by James Stratton & Son: by J. L. Zabriskie.

38. Transverse section of stem of Wistaria, double stained: by Frank D. Skeel.

39. Transverse section of quill of Porcupine, double stained: by J. D. Hyatt.

Mr. Zabriskie remarked concerning the microscopical lamp invented and manufactured by James Stratton & Son, 207 Spencer street, Brooklyn: It is remarkable for its compactness, its ease and variety of adjustments, its efficiency, and its very moderate cost. It stands upon a marbleized slate base three and one-half inches square. From one corner of this base rises a firm metal post three inches in height. A joint at the upper extremity of this post carries a two-jointed metallic arm, which in turn supports a bull's-eye lens nearly three inches in diameter, and the lamp-bowl surmounted by its glass chimney and japanned metallic shade. All the metal parts, excepting the base, burner, and japanned shade, are nickel-plated. The range of motion in the two-jointed arm, and the angle at which the lamp-bowl can be safely inclined when elevated, give a surprising variety of elevations and inclinations for the body of light passing through the bull's-eye. Discs of ground and blue glass are supplied for the conical opening of the metallic shade, which discs can be adjusted or removed with the greatest facility. The metallic shade fits loosely upon the burner of the lamp, and is also separate from the metal mounting of the bull's-eye. So that the varying effects of light, from the flat side or from the edge of the flame, can be obtained by merely revolving the lamp-bowl, while the shade, the bull's-eye, and all the appliances of the microscope itself remain in their last appointed positions. And further, if light is desired momentarily upon the table, it is only necessary to revolve the metallic shade alone, and space near the hands, or of any other reasonably required position, can be instantly illuminated without disturbing any other adjustments. It is evidently a most desirable and satisfactory lamp.

Meeting of January 15th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Thirty-three persons present.

The following appointments were made by the chair:

Committee on Admissions: F. W. Devoe, William E. Damon, George F. Kunz, William Wales, F. D. Skeel.

Committee on Publications: J. L. Zabriskie, William G. De Witt, Walter H. Mead, John L. Wall, Charles F. Cox.

F. D. Skeel and Walter H. Mead were added to the Committee on Annual Reception.

Dr. A. A. Julien read a paper, entitled "A Fungus in Silicified Wood from Arizona and Texas." This paper was illustrated by twenty-three photomicrographs and by objects under microscopes, as noted below.

OBJECTS EXHIBITED.

1. Galvanoplastic reproduction of the Permian Reptile, *Seeleya pusilla*, from Bohemia.
2. Restoration in bronze of the complete Reptile.
3. Artificial Rubies, and thirteen prints illustrating Rubies.
4. Piece of a crucible used in the manufacture, with Rubies adhering.
5. Entomological preparations in solution, by Dr. Fischer, of Bohemia, showing the developing stages of a Cockchafer, from the egg to the imago.
6. Preparations in solution, by Dr. Fischer, of Termites in all stages.
7. Angle-measuring apparatus by Fuess, of Berlin.
8. "Dreh-Apparat," devised by Prof. C. Klein, of Berlin.
9. Small pocket lens made of Feldspar.
10. Specimens of thin Quartz, which when pressed with a pin-point always break into the rhombohedral cleavages.
11. Prism made of crystal of Iceland Spar.

12. True Ruby in matrix of limestone from Burmah.
13. Artificial Emeralds.
14. Rainbow Agate.
15. Zuñi Bread.
16. The new Nachet Grand Petrographical Microscope, with Dr. Koch's Microscope Lamp.

Exhibits 1–16 all by GEORGE F. KUNZ.

17. Macrospore of *Siderothrix* in Silicified Wood: by A. A. JULIEN.
18. Macrospore germinating in Silicified Wood: by A. A. JULIEN.
19. Crystals of Calcium Oxalate in Silicified Wood: by A. A. JULIEN.
20. The parasitic Wasp, *Hyptia* sp.: by J. L. ZABRISKIE.

Mr. Kunz furnished the following explanation of his exhibits:

"The researches on the production or synthesis of the ruby have been carried on in the laboratory of the Musée d'Histoire Naturelle of Paris from 1887 to 1890, and to some extent since then. In the first work published by them, M. Fremy and M. Verneil announced that they had obtained rubies approaching a lively red color, made in a crucible of refractory porcelain containing a mixture of aluminate of lead and bichromate of potash, the silica of the crucible uniting with the lead of the lead aluminate and forming a fusible silicate of lead, and the alumina crystallizing as rubies. The crystals formed in quantity and were of a good rose color, but were always lamellar and friable.

"In a second work published by them, it was announced that they had made transparent rubies that were brilliant, crystallizing as rhombohedrons, the crystals being of a purity equal to that of natural rubies. These were made in a refractory crucible, at a high temperature, containing a mixture of alumina with a little potash, fluoride, or barium, and bichromate of potash. It was found indispensable to pass a current of air through the crucible. The alumina combined with the potash and the air passing through the crucible, causing at a very high temperature the hydrofluoric acid to separate from the barium and form an alkaline fluoride, the rubies remaining in a state of absolute purity in a matrix of alumina.

"Every time the fluoride or alumina was elevated to a temperature of 1,500° C., the influence of the humid air always caused the formation of the rubies and the separation of the hydrofluoric acid. And at the close of their studies on the Synthesis of the Ruby they announce that rubies can be made in two different ways: by the decomposition of the alkaline aluminate by the influence of hydrofluoric acid, or by merely heating the fluoride of aluminum to a temperature equal to that of its disintegration.

"The illustrations which I exhibit this evening I have taken from 'The Synthesis of the Ruby,' by E. Fremy, 1891, 4to, page 58, plate 21, published by Vve. Ch. Dunod, Paris. Some of the largest rubies figured on these plates have been magnified sixty diameters, *hence their true diameter is from one to two millimetres*—one-twenty-fifth to one-twelfth of an inch. M. Fremy did not succeed in obtaining crystals weighing more than fifty-five milligrammes—one-fourth of a carat—each, before cutting, and the rubies, in the jewelry figured on these plates, were natural crystals, not cut gems. *Up to the present time he has not produced rubies of sufficient size to warrant their sale in the gem markets.*

"Prof. Dr. Anton Fritsch, Director of the Royal Geological Survey of Bohemia, has prepared, in all, two series, by the galvanoplastic process, of reproductions of the Permian reptiles of Bohemia. Many of these are exceedingly small, and the markings of their remains in the rocks are very delicate. The smallest and most interesting of the group is the *Seeleya pusilla*, which I show this evening under a three-inch objective. The entire reptile measures less than one inch in length. Dr. Fritsch has also restored twelve of the more important reptiles, and has arranged them on a fac-simile of Permian rock. Under a three-inch objective the complete reptile is shown, the dentition being remarkably perfect, as well as all the vertebræ and the feet. A photograph of this I have brought with me this evening, and also one of the isolated reptiles—*Ricnadon*—of this group.

"The optician, Ivan Werlein, of Paris, while making some plates of quartz for a new galvanometer, found it necessary to cut these sections parallel to the rhombohedron, making the sections the thinness of less than one-tenth of a millimetre, or one-two-hundredth of an inch, of three inches in length and one-half an inch in width. These plates of quartz were coated on the one side by a thin deposit of silver, the current being measured by the deflections of the plate. Of great interest is the fact that these thin plates of quartz, when punctured by a pin or needle-point, separate with rhombohedral cleavages, showing that quartz, the cleavage of which is otherwise never very facile, when prepared in these sections is one of the most highly cleavable of all minerals.

"To increase the sensibility of the tourmaline forceps, Werlein has attached to one of the tourmalines a small condenser of didymium glass, producing excellent results.

"Dreh-Apparat—turning apparatus—devised by Prof. C. Klein, of Berlin, and made by Fuess, of Berlin. Described in *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin*, Sitzung der physikalische-mathematischen Classe vom 30. April. 'Krystallographisch-optische Untersuchungen. Ueber Construction und Verwendung von Drehapparaten zur optischen Untersuchung von Krystallen in Medien ähnlicher Brechbarkeit,' von Carl Klein, pages 1 to 10. Used to examine entire crystals, fragments, and minerals cut into gem form, under the polariscope and microscope.

"Axis-measuring apparatus on the Adam principle, made by Fuess, of Berlin, Germany, for examining the optical properties of minute scales of fragments of minerals. Described in *Ueber Mikroskope für Krystallographische und Petrographische Untersuchungen*, von R. Fuess, Berlin, S. W., 108 Alte Jacob Strasse, pages 25 to 28, 1891.

"In connection with these two pieces of apparatus, I would remark that Pulfrich gives a list of twenty-six liquids of varying refractive indices, 1.5381 dispersion equalling 0.0142 to iodide of mercury dissolved in aniline and chinoline refractive indices 2.2, and when dissolved with lepodine a still higher index.

"Pocket lens, one-fourth inch, made of oligoclase feldspar from Bakersville, North Carolina, described by George F. Kunz in *Amer. Jour. of Sci.*, series iii., vol. xxxvi., page 222.

"Artificial Ruby, made by E. Fremy. Two series of slides of detached crystals, and one piece of crucible with rubies adhering. Described by E. Fremy in 'Synthesis of the Ruby,' Paris, 1891, page 58, plate 21, published by Vve. Ch. Dunod.

"After listening to Dr. Julien's paper, I would state that I visited the localities last summer, and conform with the observations made by Dr. Julien, that the formation in which the wood is found is of considerable extent, and has been traced in New Mexico and Arizona for some hundreds of miles, and had been referred to the Chinarump Group of the Jura Trias by Major J. W. Powell. My observations of the locality lead me to the conclusion that silicious water was the silicifying agent. The trees, having fallen into water, had partly rotted, and only after sinking in the swamp, lake, or river had silicification set in. The trees on the lower levels in the so-called parks did not really belong there, nor had they come from any of the layers of rock from the same level, but from the top strata, in some places one hundred feet above where they lie at present. I observed trees *in situ* only in this upper layer. One tree *in situ* measured over one hundred feet in length. From the total absence of roots and branches and bark, I conclude that the wood had not been silicified in the same manner as the agatized woods of Yellowstone Park and Colorado, where the logs or trees are generally hollow, inasmuch as all the Arizona trees must have silicified in a recumbent position, having fallen in some unknown lake, sea, river, or swamp. And, further, that as there was no bark on any of the trees, they must have rotted, and in some of the masses examined at least four or five inches of the bark and outer rings of the tree were missing. They were silicified in water highly charged with oxide of iron, the red or yellow color varying according to the amount of oxide present, probably by decomposition of a variable amount of vegetable matter. The presence of the fungus *zoöglia*, described by Dr. Julien, has probably induced the precipitation of silica from the water in which the tree trunks lay."

Mr. Zabriskie said of his exhibit: "This small parasite, collected at Fisher's Island, L. I., is one of the most curiously formed parasitic wasps of our fauna. The slender petiole of the abdomen, instead of being placed in the usual position, is inserted high up on the back, at the base of the metathorax. The abdomen is greatly compressed, and the area of its side is only one-fourth of the corresponding area of the thorax, causing the abdomen to appear ridiculously small. The anterior wings possess only one cell—the costal cell—and are furnished with costal, subcostal, and basal nervures, and with a prominent stigma. The abdomen is so highly polished that, when looking in the microscope, the observer can see, reflected from the side of the abdomen, a perfect inverted image of the body of the microscope, the observer's head, and any object near it, especially the hand, when moved near the face.

"In a case is also exhibited another species of *Hyptia*, collected at Flatbush, L.I., differing in coloration, but quite similar in size and form to the first specimen. Also in the same case a specimen of *Evania appendigaster* L., collected in the City Hall Park, New York City. It will be seen that this *Evania* resembles very closely the two specimens of *Hyptia* in general form and in the insertion of the petiole of the abdomen, but it is of twice their size, differs in the neuration of the wings, and has the posterior legs relatively much longer.

"Only one species of *Evania* is recorded for the United States, and it is parasitic on the cockroach. Three species of *Hyptia* are recorded for the United States, but their habits are not reported."

Meeting of February 5th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-one persons present.

The Corresponding Secretary read the following communications from Mr. K. M. Cunningham, of Mobile, Ala., accompanying donations to the Society :

"January 15th, 1892.

"EXPLANATORY NOTES ON SLIDES DONATED TO NEW YORK MICROSCOPICAL SOCIETY.

"Two slides of fresh-water diatoms, derived from subsoil at Tuscaloosa, Ala., within a park enclosure facing grounds of Alabama Asylum for the Insane ; material excavated from a drainage ditch through the oak grove. The associated species are few, viz. : *Navicula viridis*, *Stauroneis phœnicenteron*, *Nitzschia amphioxys*, *Eunotia diodon*, and sponge spicules ; the locality is the site of a former muck basin ; the deposit may be said to be common to all low drainage areas about Tuscaloosa traversed by spring branches, the formed earth carrying a large proportion of vegetable débris.

"Five slides illustrating vegetable or plant structure in Alabama coal; all of the specimens being derived from a non-coking, semi-bituminous coal from the Deer Creek coal vein, Walker Co., Ala. This variety of coal burns quietly, without bituminous intumescence, thus leaving foliated plates of a whitish shale, which can be readily separated into thin pellicles, and from these pellicles there can be isolated two specific kinds of vegetable structures, derived from stems, branches, or trunks of coal-forming plants; and a third kind of vegetable structure, shown in tlide labelled 'Fossil Sporangia.' When isolated from the burned coal shale in their unbroken state, they are very minute, oval, scale-like porcelain plates, having a collapsed appearance, and when first enclosed in balsam show numerous dark annular spaces which become semi-transparent rings when the air is expelled from the sporangium. These minute bodies may be construed as a key to one of the associated phenomena of the formation of coal strata in geologic time, in this wise: they aid in proving that coal is a sedimentary aggregation of microscopic plant particles, in connection with larger or grosser vegetable particles, readily visible to the eye, such as the seal-like impressions of Sigillaria stems, the fossil 'charcoal' commonly seen on the deposition layers of the bituminous coals of Alabama, and in the pyritized shales occurring interbedded in the coal, which show clearly vegetable structure in profusion, but of little structural interest under the microscope. An analogy between the formation of coal strata, recent marine muds, and fossil diatomaceous strata has, by the discovery of the fossil sporangia in coal, been suggested to me, in this sense: that in all preliminary cleanings of Mobile Bay marine muds, of the marsh muds, and of the several fresh-water fossil diatomaceous earths recently examined by me, there is a moderate proportion of vegetable débris of plant tissues, but more particularly and invariably an abundance of coniferous or pine-pollen grains, which are of such a special bilobated structure as not to be readily confounded with any other organic structures, vegetable or mineral; and as these pine-pollen grains are abundant in the Montgomery, Ala., diatomaceous earth, which is also exceedingly rich in fresh-water diatoms, and its period of deposition antecedent to that of the overlying gravel beds and alluvial sands, the association of the pollen grains with the diatoms proves them to be of contemporaneous growth and deposition; and the survival of the pollen from decay may be attributable to their resinous nature, which is likewise a characteristic of the spores of the present fern-vegetation of the earth, as well as that of the carboniferous period in geology.

"One slide of macrospores. These interesting fossil plant remains were isolated from a shale from Ontario, Canada, by crushing the shale transversely to its layers. Under a high power they show spinous processes regularly distributed over their surfaces. When a single specimen is ignited on mica, it melts to a shapeless bituminous mass and is reduced to ash. The slide is sent for comparison with the fossil sporangia from Alabama coal.

"Four slides derived from a study of material from borings of a now celebrated artesian well at Mobile, Ala., 850 feet in depth, recently finished. One shows a group of forty foraminifera of a single species, being very nearly the only microscopic animal remains permeating 500 feet of greensand strata. Two of the slides show a sand of high specific gravity, composed of myriads of spherules, octahedral and dodecahedral crystals of pyrite, also perfect microscopic quartz crystals, polished agate and sand grains, and grains of magnetite, all associated together. One slide of magnetite grains, including iron scales from boring tubes. These grains were separated from the pyrites sand with a small magnet, and as mounted will serve to illustrate a number of interesting experiments under the microscope. For example, when the grains are evenly scattered on the slide the effect of the union of the grains may be noted when a small horseshoe magnet is applied to the under side of the slide. If one leg or pole is presented, the grains stand in vertical chains; and if the magnet is moved in rapid circles, double or multiple images of the grain chains succeed each other in waltzing style; if the slide is held in a vertical plane, and both poles applied to the cover glass, a single chain of grains is lifted to top of cell and drops at once on removal of the magnet. The grains may be scattered by tapping with the thumb nail, and each grain may be examined for mineralogical character. When this pyrites sand is heated red-hot, the crystals and spherules of pyrite are turned to a red oxide soluble in water. Grains not soluble are attracted by the magnet, while as unburned crystals of pyrite the magnet has no influence on them.

"Four slides to illustrate and place on record for the first time the occurrence of a new deposit of tripoli, being a marine fossil sedimentary rock recently discovered by me, its true character having been misunderstood until I demonstrated it by microscopic analysis. Its geographical position is indicated as follows: It occurs at the Big McGrew's Shoal on the Tombigbee River, Clarke Co., Ala., one mile by land northeasterly from St. Stephens, or three miles by river. This shoal is now being blasted out and improved under Government supervision, and specimens of the different rocks forming the obstruction were forwarded to U. S. Engineer's office at Mobile, where I casually found it. At this time it seems to have an unique interest, as I know of no other rock or tripoli similar to it in mineral or fossil composition. Its uniqueness lies in the fact that it is a tripoli that breaks down easily to a mud in water, and is very rich in marine fossil Diatoms, Polycistina, Foraminifera, sponge spicules and gemmules, plant débris, and mineral grains, notably crystalline chloritic grains; and that the Diatoms, Polycistina, and Foraminifera are infiltrated by transparent mineral, decussating, crystalline plates, not readily soluble in acids, thus nearly obliterating the sculptural markings on their surfaces, and thus practically being *petrified* Diatoms, Polycistina, and Foraminifera. The slides sent were made by rubbing the dry tripoli powder, after cold acid treatment, on chamois skin, to remove the undesirable amorphous particles of silica. The Diatoms, Polycistina, and Foraminifera survived this polishing ordeal, thus attesting their toughness through petrifaction. Species of the following genera may be seen on the slides, viz.: *Coscinodiscus*, from very large to small species; *Triceratium*, triangular and square forms; and a *Biddulphia* and *Cyclotella*. The Polycistina and Foraminifera do not require special mention. The reticulation on the *Coscinodisci* can be made out with a one-sixth objective and good daylight. Another matter of interest that this new find revives is the fact that Dr. C. G. Ehrenberg, in his 'Micro-Geologie,' listed many of the living fresh-water diatoms from the Tombigbee River and Sintabogue Creek in this immediate neighborhood, but must have failed to get samples of this marine tripoli, as it would have been a 'capital prize' on account of its richness in organic fossil remains.

"One slide showing a thin section made from an opalized or indurated form of the same tripoli stone referred to above.

"I followed the borings of the artesian well in the hope of corroborating the occurrence of marine diatomaceous clays, such as occur on the Atlantic seaboard artesian-well area, but found the various strata, penetrated to a depth of 850 feet, absolutely void of diatomaceous forms. The last stratum of clay penetrated, before reaching the water sands, contained plant débris and fossil pollen grains alone. Bits of amber and pieces of pyritized coniferous wood and lignite were freely washed up, and generally secured by the curious spectators at the completion of the well.

"I forward also several specimen packets of the crude material from which most of the slides commented upon herein were made."

"January 20th, 1892.

"I mail with this a package of raw material:

"1. A piece of coal shale—burned—from Deer Creek, Walker Co., Alabama coal. With an inch hand magnifier an abundance of the fossil sporangial bodies may be seen *in situ*. It is from this coal that I prepared the slide showing the spores in the fossil sporangial capsules, on the slide labelled 'Fossil Sporangia.'

"2. A specimen from the recently discovered locality in Clarke Co., Ala., near St. Stephens, of which I sent the Society four prepared slides of a new tripoli of the marine sedimentary class of rocks. The stratum belongs to the cretaceous rocks of Alabama.

"3. A packet of the pyritous sand and micro-minerals, of which I sent two slides previously."

"February 1st, 1892.

"I send the following specimens:

"1. From McGrew's Shoal, Tombigbee River, near St. Stephens, Ala. The rock will interest the diatomist and petrologist, as it is a composite rock of marine sedimentary origin. It will make a fine polariscope object, as a thin section will probably show Diatoms, Polycistina, Foraminifera, and sections of larger shells, the whole silicified and strongly crystalline in structure. It is from the same formation as the marine tripoli previously sent to the Society.

"2. A cement stone from Sendai, Japan. This was sent me by M. J. Tempère, Paris, joint editor of the 'Diatoms of Yeddo and Japan,' as a return for Montgomery earth. It can be used as thin sections, from which much may be learned of the internal structure of the Diatoms and Polycistina contained therein. Being of a flinty nature, it will take a vitreous polish, bringing out the internal structure as seldom seen in diatom slides.

"3. A piece of coniferous wood, derived from a vein of lignite, ejected from the depth of about 700 feet from the new artesian well recently finished at Mobile.

"4. A piece of genuine lignite coal, also from the artesian well, at a depth of 700 feet. When brushed down in water it furnishes fine slides, showing plant structures: as scalariform tissues, pitted ducts, reticulated tissue, and spores and capsules of several kinds. It is best studied with a high power. The whole is interesting when viewed in its mineralogical relation to bituminous coal and the immense period separating them geologically."

OBJECTS EXHIBITED.

1. Serial sections through the body, next and posterior to the gill covers, of the fish *Atherina* sp., Dotted Silverside: by L. Riederer.

2. Serial sections of the vertebral column of the same: by L. Riederer.

3. Serial sections of the same, showing gill arches: by L. Riederer.

4. Section of fossil Coral: by T. B. Briggs.

5. Crystals on under surface of glass covering a daguerreotype taken in 1850: by T. B. Briggs.

6. Larva of the wood-boring wasp, *Crabro sexmaculatus* Say: by J. L. Zabriskie.

PUBLICATIONS RECEIVED.

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American Monthly Microscopical Journal: Vol. XII., No. 12—Vol. XIII., No. 2 (December, 1891—February, 1892).

The Botanical Gazette: Vol. XVII., Nos. 1—3 (January—March, 1892).

Bulletin of the Torrey Botanical Club: Vol. XIX., Nos. 2, 3 (February, March, 1892).

Anthony's Photographic Bulletin: Vol. XXII., No. 24—Vol. XXIII., No. 5 (December 26, 1891—March 12, 1892).

Insect Life: Vol. IV., Nos. 5, 6 (December, 1891).

Psyche: Vol. VI., Nos. 189—191 (January—March, 1892).

St. Louis Club of Microscopists: Proceedings (January 5, 1892).

San Francisco Microscopical Society: Proceedings (December 2, 1891—March 2, 1892).

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Minnesota Academy of Natural Sciences: Bulletin, Vol. III., No. 2 (1891).

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School of Mines Quarterly: Vol. XIII., Nos. 1, 2 (November, 1891—January, 1892).

American Museum of Natural History: Bulletin, Vol. III., No. 2 (December, 1891).

Bulletin of the Essex Institute: Vol. XXIII., Nos. 7—12 (July—December, 1891).

Colorado Scientific Society: Proceedings, Vol. III., Part 3 (1890).

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Iowa Agricultural Experiment Station: Bulletins, No. 15 (November, 1891).

Texas Agricultural Experiment Station: Fourth Annual Report (1891); Bulletins, Nos. 18, 19 (October, December, 1891).

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Journal of the Quekett Microscopical Club: Vol. IV., No. 30 (January, 1892).

International Journal of Microscopy and Natural Science: Vol. II., No. 13 (January, 1892).

The Naturalist: Nos. 197—200 (December, 1891—March, 1892).

The Canadian Record of Science: Vol. IV., No. 8 (October, 1891).

The Ottawa Naturalist: Vol. V., Nos. 8—11 (December, 1891—March, 1892).

Historical and Scientific Society of Manitoba: Annual Report (1890); Surface Geology of the Red River (1891); The First Recorder of Rupert's Land (1890).

Records of the Australian Museum: Vol. I., No. 10 (December, 1891).

The Victorian Naturalist: Vol. VIII., Nos. 7—9 (November, 1891—January, 1892).

Transactions of the Royal Society of South Australia: Vol. XIV., Part 1 (July, 1891).

Le Diatomiste: No. 7 (December, 1891).

Mémoires de la Société des Sciences Naturelles de la Creuse: Vol. VII., No. 1 (1891).

Bulletin de la Société d'Étude des Sciences Naturelles de Béziers: Vol. XIII. (1890).

Bulletin de la Société Belge de Microscopie: Vol. XVIII., Nos. 1—4 (October—December, 1891).

Wissenschaftlicher Club in Wien: Monatsblätter, Vol. XIII., Nos. 3—5 (December, 1891—February, 1892); Jahresbericht (1891-92).

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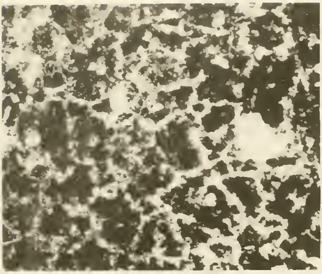

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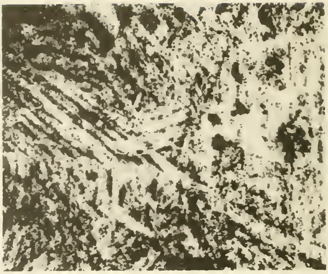

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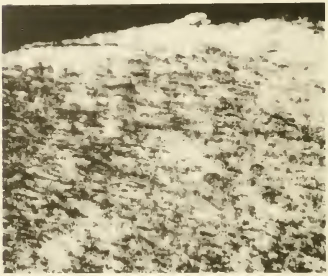

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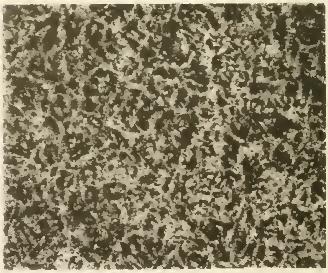

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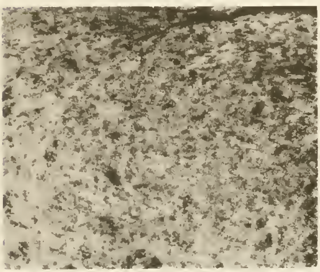

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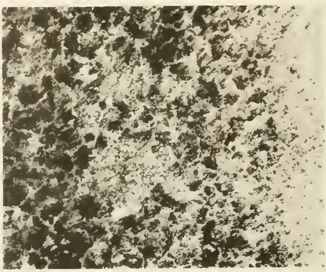

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DUDLEY ON STRUCTURE IN STEEL.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. VIII. JULY, 1892. No. 3.

STRUCTURE IN STEEL.

ANNUAL ADDRESS OF THE PRESIDENT, P. H. DUDLEY.

(Read January 5th, 1892.)

Steel being an inorganic compound, the fact is overlooked that when molten the enormous forces of crystallization are only held in check by the intense heat, and, as the steel cools, more or less structure is produced.

Conditions which would affect the fineness or coarseness of texture in rail steel were given in my previous paper upon the same

Explanation of Plate 32.

FIG. 1 is from the exterior surface of a 50 carbon Bessemer rail ingot. The white lines enclosing the mineral aggregates, in this case, indicate more strongly the polyhedral than the columnar structure of the ingot. — FIG. 2 is from a .03 nickel armor plate ingot. The polygonal structure is large, from one twentieth to one-tenth of an inch in diameter. The junction of three polygons is shown near the centre of the figure. The carbide of iron (?) is distributed in thin laminæ, a small amount of the charcoal, work, and heat treatment rendering the steel homogeneous and exceedingly tough.— FIG. 3 is from fluid, compressed, open-hearth steel, after the first hydraulic forging. The carbide of iron is well distributed, though it has not reached the homogeneous condition it will have after further forging and heat treatment.—FIGS. 4, 5, and 6 are from a .26 carbon Bessemer steel rail, from the Boston & Albany Railroad, after ten years' service. Fig. 6 shows the structure in the head of the rail, the polygons being nearly as coarse as in the structure of Fig. 1. The white lines show the distribution of the carbide of iron, while the interior portions of the aggregates are much softer (?), and break down near the upper surface of the rails, from the load of the passing wheels, as shown in Fig. 4, and then flow off to the side of the rail, as shown in Fig. 5, large pieces eventually becoming detached. The structure of the surface of the rail is broken down for one-twentieth of an inch in depth, the rail having lost three fourths of an inch in height in ten years' service. The metal in flowing soon reaches its percentage of elongation, and cracks, or shears from the metal underneath. (See Figs. 4, 5.)—FIG. 7 is from a rail made in 1866, and was in service over twenty years, under heavy traffic. The structure is very fine, and the loads upon the wheels have affected the metal but little over one-hundredth of an inch in depth from the surface.—FIG. 8 is from a .60 carbon rail head, the structure hardly traceable, fine, and dense.

subject. Similar conditions generally apply to other grades of steel, so far as the texture is concerned.

The fact of the great forces of crystallization present in molten steel prevents finding steel after casting to be a homogeneous, structureless compound, but it is composed of several, with more or less structural detail. In other words, our steel ingots are built up of great numbers of mineral aggregates, and to bring the steel into the highest physical condition we must reduce or render the mass as homogeneous as possible and give toughness to the metal as well.

The wonderful and important property of carbon uniting with iron at temperatures below fusion has long been known, especially in regard to tool steels; another property being that this union lowers the melting point of iron and renders it possible to cast it as iron, or, when the carbon is present in lesser quantities, to cast the product as steel.

The first-mentioned property of carbon forms new structure and compounds at different temperatures, or diffuses the carbon in a different manner, and can hold the structure of different temperatures when suddenly cooled.

Another useful property of the compound of carbon and iron is that of hardening upon being heated to a cherry red and suddenly quenching in water, oil, molten lead, and several other similar media. Certain degrees of hardness can be given to steel, according to the use the steel is to subserve.

The same fact seems to be true of the open-hearth and Bessemer steels, and advantage is now taken of it to improve the quality of large masses of steel by heat treatment, as well as depending upon chemical composition and mechanical work. This heat treatment consists in raising the temperature of the steel to the degree which gives the desired structure, and then fixing this structure, which will be hard but more or less brittle, by cooling quickly in some media. To give toughness to the steel it is then annealed at a temperature below quenching. This permits some rearrangement of the compounds. A part of the hardening carbon is converted into cement carbon, which lessens the hardness and brittleness of the remaining hardening carbon.

The results already reached of improving the physical properties of steel of the same chemical composition by heat treatment are so important that all nations have modified the construction of their ordnance from solid guns to the system of built-up guns, each part not being too large to receive the full benefit of heat treatment.

To illustrate the changes in the structure of steel by mechanical work and heat treatment, I have specimens of open-hearth compressed steel for ordnance—

1. From the ingot.
2. After hydraulic forging.
3. After heat treatment.

These are designated as specimens Nos. 1, 2, and 3.

The steel contains about .40 carbon, and after being poured into the cylindrical ingot mould, 30 inches in diameter and 18 feet long, was put under compression of 2,000 pounds per square inch to prevent the formation of blow holes or a pipe in the ingot. The steel was several hours in setting; many more in cooling, and, notwithstanding the compression, the facets of the imperfect crystals are from one-twentieth to one-tenth of an inch square and distinctly foliated, fracture occurring through this structure instead of through the crystals. In turning such steel under heavy feed the imperfect crystals often tear out instead of cutting through. The tensile strength of such steel rarely reaches 40,000 pounds and has but little elongation in a test specimen. The structure, as shown in specimen No. 1, is very coarse.

Specimen No. 2 is a tensile test bar taken from the steel after heating and forging. Though the coarse structure has been somewhat reduced, the exterior of the bar has a reticulated surface, showing the elongation of the bar is more decided through the foliated structure than through the crystals, and that the steel is not in its best condition.

Specimen No. 3 is a tensile test bar after heat treatment. The tensile strength is over 100,000 pounds per square inch, and the test bar is very smooth on the surface. The crystalline structure has been very completely reduced. The steel has not only high elastic limits, but when they are reached the metal will give many per cent of elongation before fracture occurs. The end of the broken test bar has a decided silky fracture, showing the metal to be very uniform in structure and in excellent condition for severe service, as in ordnance. For projectiles the steel could be much harder.

Specimen No. 4 under the microscope is an etched piece of metal from specimen No. 1 as it came from the ingot. Bright lines forming polygonal structures enclosing the imperfect crystals are quite distinct, while more delicate lines, extending from the polygonal structures into the crystals, can also be seen at a few points. The mottled appearance of most of the interior of the crystals, caused by bright metallic points, may not, in the plane of one etching, be traced to the polygonal lines.

Specimen No. 5 is an etched piece from specimen No. 2. The polygonal lines cannot be traced, because the coarse structure is reduced. The bright lines are abundant and interspersed through the steel in every direction as rather thick laminæ. Specimen No. 2, the test bar after testing, shows the steel to have a rough and reticulated surface on account of not being homogeneous. This is the poor structure of soft rails and those which do not wear well.

Specimen No. 6 is an etched piece from test bar No. 3. The bright lines are no longer distinct, but are well dispersed through the steel, and the structure is homogeneous, which explains the smooth appearance of the broken test bar.

In specimen No. 7—an etched piece of metal from a Bessemer .50 carbon rail ingot by another method of treatment—the lines forming the polygonal structure have been more deeply etched than the other portions of the steel.

The polyhedral structure of the Bessemer rail ingot is very clearly indicated, as specimens Nos. 8 and 9 will confirm. The ingot was not compressed, as that would add largely to the cost of the rails and limit the output. The same objections would apply to subsequent heat treatment of the rails, and we are obliged to resort to other methods of reducing the coarse structure in the ingot to a finer and more enduring one for the rails.

The acid Bessemer process for producing steel is a very rapid one, by blowing air of 25 to 28 pounds pressure per square inch through a bath of molten cast iron in a converter to decarbonize it, though really burning out first the silicon, then the carbon, leaving in the bath the iron partially oxidized, all of the phosphorus, sulphur, copper, and traces of other minerals contained in the ores and fuel. To convert this molten metal into steel of the required grade a definite weight of molten spiegel mixture is added.

This contains the desired carbon, manganese, and silicon to produce the grade of steel desired.

The product is then poured from the converter into the casting ladle, and from the latter into cast-iron ingot moulds of 14½ or 16 inches square, or 16 by 19 inches on the base, as the case may be. These moulds stand vertically in pits and are filled with 4 or 5 feet of molten metal. Chilling and congelation begin as soon as the metal is poured; crystallization forming structure in the ingot, the character of which is dependent upon the grade of the steel, its impurities, size of the ingot, rate of solidification, and particularly the rate of cooling.

In Bessemer rail-steel ingots of 14½ inches or 16 inches square on the base, of the grades of .50 and .60 carbon, the chilling of the exterior surfaces in contact with the mould induces a decided columnar structure, extending at right angles from the mould 1 to 3 inches into the interior of the ingot, then there is more decidedly polyhedral structure to the centre of the ingot. In the upper portion of the ingot a pipe is apt to develop, also gas cavities. In the pipe and cavities traces of crystals are present, the former especially often being studded with perfect forms of pine-tree crystals.

In the blow holes, in the columnar structures of the grades of steel mentioned, I have always found traces of crystallization. There seem to be two systems, in which the main axes are in parallel rows, the lateral axes appearing at right angles to the main axes, forming a series of projecting points at right angles to one another in two directions; in the other system the base of the points seemingly being surrounded by hexagons.

Specimen No. 10 shows the decided columnar structure of the exterior of a .60 carbon ingot. In another specimen of a lower grade of steel blow holes have formed in the columnar structure.

Returning to specimens Nos. 8 and 9, which formed a transverse section from the exterior to the centre of the ingot, the exterior blow holes may be noticed, though the columnar structure has been modified by long-continued heat, while the polyhedral structure has been more strongly developed than usual. The mould could not be stripped from this ingot, and was broken under a drop, and in doing so the ingot was broken. The ingot was many hours in cooling, and quite well-developed octahedral crystals formed, producing a structure which was not strong under shock, fracture taking place between instead of through the crystals. So well-defined structure I have only found in a rail head once and that was the rejected rail from which specimen No. 2, described in my previous paper, was taken. It is a form of structure I do not wish to find either in the ingot or in the rail. Several attempts were made to break up the structure as formed in the rail head, and while a considerable modification was made, removing some of the brittleness of the metal, the structure was not completely effaced. It seems much safer to prevent its formation than to try and break it up afterwards.

In specimen No. 9, of the same ingot, in one of the gas cavities you will see the well-developed pine-tree crystals. The same form of crystals also studded the pipe which formed in the upper part of the ingot.

In the practice of making rails, the ingots as soon as stripped, 8 to 12 minutes after casting, are charged into a reheating furnace or soaking pit to equalize the temperature before blooming. In the latter operation many of the gas cavities and portions of the pipe become closed. The portion of the bloom in which the pipe is not closed is cut out. It is often the case that the interior of the ingot is not fully solidified upon reaching the blooming train, more or less segregation having taken place, producing an ent rely different structure in the centre of the rail. This is not desirable, as the rails are liable to be brittle. Specimens Nos. 11, 12, and 13 are pieces from such rails which failed to stand a drop test of 2,000 pounds falling 20 feet, the rail butt resting upon steel supports of 4 feet span. Before placing the rail upon the supports the base is stamped into inch sections, so the percentage of elongation can be ascertained ; any rail failing to give five per cent elongation, the entire rails of the heat are rejected. The carbon and manganese are usually much greater in the central portions of such ingots. In specimen No. 11 the average carbon of the heat was .48 and the manganese .90. In the centre of the ingot the carbon was .60 and the manganese 1 48 per cent. In specimen No. 12 segregation occurred in the metal forming the centre of the head of the rail, the surrounding metal also being weak and easily fractured.

Specimen No. 14 shows a piece of tough rail which was placed upon the side, the drop of 2,000 pounds falling 20 feet upon the upper edge of base and side of the head, causing the lower edge of the base to elongate 18 per cent per inch for at least 6 inches in length. The rail rebounding from the blocks after the drop struck, it dropped to the foundation of the ingots supporting the blocks, the base wedging between two ingots. The fall of the rebounded drop broke out this piece containing the inch spacings. The fracture in this case is much coarser than would have been the case had the rail failed under the full drop.

Specimens Nos. 15, 16, 17, 18, and 19 are longitudinal sections of pit-test ingots, showing the piping and the gas cavities which are liable to form. In rolling these for bending tests they are not allowed to cool and some of these cavities are closed.

Nos. 15, 16, and 17 are from the same heat of steel, Nos. 15 and 16 being the parts of the same ingot.

Specimen No. 17 is an ingot on which I made the experiment of seeing how much additional carbon would be absorbed by having one side of the mould a plate of carbon. The steel, as poured into the ingot, contained .48 of carbon, was chilled in less than ten minutes, remained in the mould and was cooled in two hours. The first sixteenth inch averaged 1.48 of carbon, the second sixteenth inch .81, and the third was nearly normal. This shows a very rapid and unexpected rate of absorption of carbon, and we can readily understand the diffusion of carbon from the walls surrounding crystals to the crystals, or vice versa, at temperature below fusion. This can also be understood by the process of cementation imparting carbon to iron plates, to make crucible steel. The process of making molten steel take up an additional amount of carbon by absorption permits of graduations of carbon in the same ingot.

Specimens Nos. 18 and 19 are from the same heat of steel, though in No. 18 a small amount (one hundredth of one per cent) of aluminium was added to see its effect upon lessening the blow holes and gas cavities in the steel. The former were reduced, the latter prevented, though the pipe of the ingot was increased. The tensile strength and elongation of the metal were slightly augmented.

With the rapid output of the rail mills, and only 11 passes in the rail trains, it seems important, in order to secure a good wearing rail of dense metal in the head, to start with a good chemical composition as a basis; the carbon .50 or more; to make a small texture in the ingot; avoid long or over-heating; have a section of rail with a thin head to be well worked, a thick base and heavy web to equalize the heat in the section to give toughness to the metal and not brittleness.

The foliated structure we see between the crystals, and a similar structure which has built them up, become reduced to more delicate laminæ as the imperfect crystals are broken up by mechanical work. The soft steels do not have sufficient cohesion to prevent flow under the loads of the present day. To give such steel strength mechanical work must be done upon the plates, or some elements added which will modify the structure or increase the cohesion of the laminæ.

The first steel rails of only .25 to .4 of carbon, with thin heads, thick bases and webs, made with 23 passes in the rail train, had fine structure in the heads and were excellent rails, though in a few years the sections were not stiff enough for the increasing traffic. Noticing that the rate of wear was very slow in the head, the conclusion was soon reached that massive heads, thin bases and webs would give the longest service. This soon became the style of all new sections. The structure, from a fine one in the heads of old rails, became coarse in the new and wore out at much faster rate. Then a hasty conclusion was reached, from an insufficient investigation, that a small amount of carbon in the rails, low manganese, silicon and phosphorus not exceeding .10, would make better wearing rails than higher grades of steel. We have had an era of massive heads, coarse structure, and soft rails which have not given long service. The metal not only rapidly abrades, but flows, and is forced from the rails. This is illustrated by specimens Nos. 20, 21, and 22. Slower-wearing rails are shown in specimens Nos. 23 and 24, the latter having had double the number of years' service of Nos. 20, 21, and 22.

Specimens Nos. 25, 26, 27, 28, and 29 are some of the sections I have introduced with thinner and broader heads to insure fine structure, as the rails are made by the present rapid methods.

The chemical composition has also been changed to one much harder than formerly, the product in these sections being tough and not brittle. In .60 carbon rails an elongation of 10 to 18 per cent per inch is secured in the section of the rail under drop tests, often exceeding the elongation of rails much lower in carbon.

It will take many years of experience in the use of high-grade steel rails to convince some people that hard steel can be a material which is tough and not brittle, and one which, when the elastic limits are exceeded, will still elongate to any per cent before rupture.

One of the best illustrations of hard and tough structure in steel is in the modern armor-piercing projectiles. A 6-inch 100-pound conical projectile, fired with a velocity of 2,150 feet per second, striking a steel armor plate with 2,800 foot tons of energy, can be partially embedded therein and rebound with its point hardly dulled or its polish diminished.

Specimen No. 30 is a piece of nickel armor plate steel of fine structure, the tensile strength averaging over 200,000 pounds per square inch, with a limited elongation of 1 to 2 per cent. Only half of this tensile strength is obtained in thick armor plates.

The size and character of the grain in rail steel is a matter of vital importance for the safety and economy of railroad operations. It is the fine texture of the steel rail which has rendered possible the development of our railway system to 163,000 miles of main tracks and 45,000 miles of sidings. In 1890, 1,100,000 tons of steel rails were put into railway tracks, and 3,125,000 tons used for structural purposes. It is hardly a quarter of a century since Bessemer-steel rails were first used to replace iron rails, and in this brief time oceans and continents are crossed, and the nations of the globe are in touch through the fine structure of steel.

LIST OF SPECIMENS.

1. Compressed steel for ordnance, from ingot.
2. Test bar from same steel after the hydraulic forging.
3. Test bar from same steel after heat treatment.
4. Specimen of etched steel from No. 1.
5. Specimen of etched steel from No. 2.
6. Specimen of etched steel from No. 3.
7. Specimen of etched steel from Bessemer rail ingot.
8. Piece of Bessemer rail ingot.
9. Piece of Bessemer rail ingot, showing pine-tree crystals.

10. Columnar structure of exterior portion of the ingot.

11, 12, 13. Webs and flanges of broken rails, showing texture of the metal.

14. Flanges of a .60 carbon rail, showing an elongation of 18 per cent per inch.

15, 16, 17, 18, 19 Sections of pit-test ingots, showing the gas bubbles, blow holes, and piping.

20. Section of worn 72-pound rail from outside of curve.

21. Section of worn 72-pound rail from inside of curve.

22. Section of unworn 72-pound rail.

23. Section of worn 63-pound rail from tangent.

24. Section of worn 63-pound rail from tangent.

25. Section of 70-pound rail, thin, broad head.

26. Section of 75-pound rail, thin, broad head.

27. Section of 80-pound rail, thin, broad head.

28. Section of 95-pound rail, thin, broad head.

29. Section of 100-pound rail, thin, broad head.

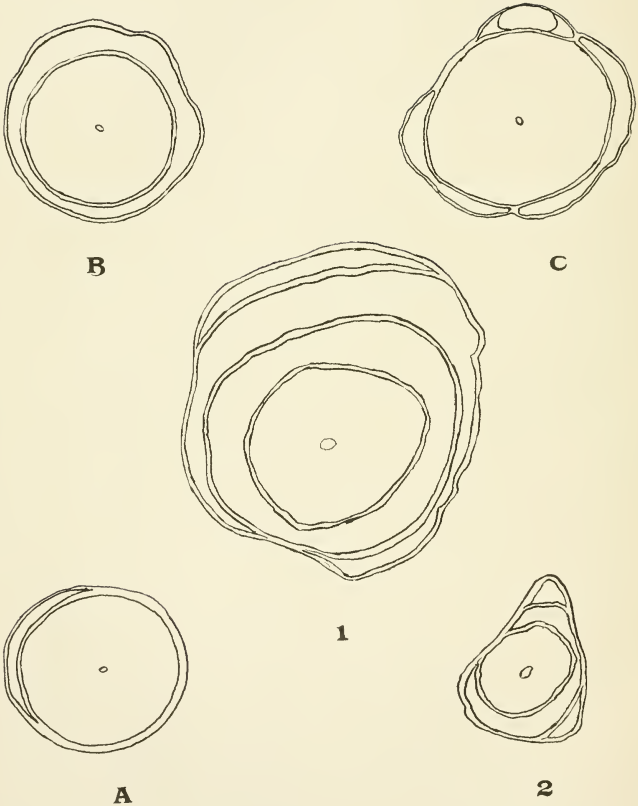
30. Section of 105-pound rail, deep, narrow head.

31. Specular iron ore.

32. Hematite iron ore.

33, 34. Octahedral crystals of magnetite.

35. Spiegeleisen.



CURTISS ON WISTARIA.

THE ANATOMY OF THE STEM OF WISTARIA SINENSIS.

BY CARLTON C. CURTISS.

(Read May 6th, 1892.)

About a year ago Dr. N. L. Britton received a letter calling his attention to the growth of the *Wistaria sinensis*, and asking an explanation of the apparently anomalous development. Under his direction some study has been given to the anatomical features of the plant with a view to the solution of this question. A gross examination of the anatomy of a transvèrse section of the older stems (Fig. 1) shows at once a deviation from the normal growths of the phanerogams, but the deviation is not apparent in the younger stems. In the latter the orientation appears normal, the products of the plerom, periblem, and dematogen being perfectly developed and presenting regular growth. For several years, usually twelve or more, this continues, after which time a new cambium zone is formed outside the primary bast and the old cambium dies. Growth now continues normally for a series of years, usually not more than eight. In all cases examined the duration of this secondary growth was several years less than that of the primary. In time this secondary cambium dies and a new one arises with the usual increase as mentioned above. This method of development continues through life, stems twenty-five years old showing four or more bast zones. In stems, however, which have been subjected to pressure while growing and thus have had their symmetrical development checked, the secondary cambium zone appears at a much earliei age, even at the end of the fourth or fifth year.

Such are the apparent features of the plant. A microscopical

Explanation of Plate 33.

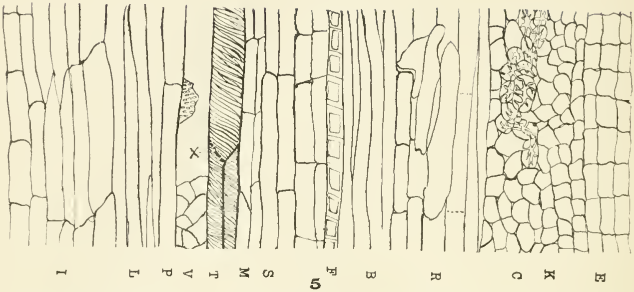
FIG. 1. Cross-section of a stem of *Wistaria sinensis* thirty years old, showing three and portions of a fourth zone of bast.—FIG. 2. Cross-section of a six-year-old stem, interlocked with other branches.—FIG. A. Stem twelve years old, showing the beginning of the anomalous growth.—FIG. B. Same stem thirty centimetres below A, showing complete formation of a new cambium.—FIG. C. Cross-section of a seventeen-year-old stem, much twisted and compressed. All the figures natural size.

examination of its anatomy will make more apparent the law of growth and explain somewhat its cause. Beginning, then, with the pith, the structure in no way differs from normal dicotyledons. The cells are hexagonal and arranged in longitudinal rows The faces are approximately equal and finely pitted. The annual growth produces little displacement in the cells—at least no radical distortion. Numerous resin canals traverse the pith. These passages seem due to absorption of the contiguous cell walls, their length varying from a single cell to an indefinite number. The products of assimilation largely disappear by the end of the second year, though in older stems the pith sometimes appears heterogeneous. The pith finally becomes dark colored, partly from the infiltration of dyes from the duramen, but largely from degradation of tissue. At the periphery of the pith the cells grow smaller, thicker, and become elongated longitudinally, forming a well-marked medullary sheath. Projecting into this sheath appear numerous bundles of tracheids, the nucleus of the fibro-vascular bundles; a radial section through one of these bundles often showing from ten to fourteen of these small, delicate-walled vessels, with right-hand spirals rising in exceptionally regular and easy ascent. These tracheids appear rarely in the wood. They are at once recognized by their small size (12 μ, with a length of 150 μ), and by the fact that the septa always join the lateral walls at right angles.

In discussing the elements of the xylem Sanio's classification will be followed. Though somewhat empirical, it furnishes a nomenclature more readily followed and understood than De Bary's or Sachs'. The tissue presents the forms found in many dicotyledonous woods—pitted vessels, spiral tracheids, libriform tissue, and bundle parenchyma (Figs. 5, 6, 7, and 8). These drawings, while *ad naturam delineatæ*, are intended simply to illustrate the characteristic features of the stem, all repetition of the same tissue and anatomical detail being omitted for clearness. The cambium tissue indicated at M is composed of lenticular cells perhaps more regular than here represented, being distorted somewhat in cutting. The differentiation of the cambium seems to follow no law. Bundles of the various elements are found irregularly associated. Usually arrayed in radial groups in the annual growth, they rarely present the same combination of bundles for a series of years. During the first and second years the libriform tissue composes the bulk of the fundamental mass; in the succeeding annual zones it diminishes and may nearly disappear, being replaced by tracheids and vessels. The spiral tracheids figured at T are perhaps the most abundant tissue in the plant. Retaining their original cambium form, they illustrate especially well the transition from tracheid to vessel. If they exist as vessels their irregular course indicates at once where the septa were, as at X. As noted above, they differ from the spiral tracheids of the medullary sheath in their large and thickened walls, while the spirals often branch and the vessels become pitted (Fig. 9). No measurements will be given when the individual element is figured, the illustrations being designed to represent the average size of the cells. The pitted vessels, a small one of which is figured at V, are the most noticeable of the individual elements, being easily seen with the eye, and usually forming, after the sixth year, the bulk of the wood. They have much the same arrangement as in the *Quercus rubra*, the concentric circles seemingly confined to the autumn wood and figuring sparingly in the denser portions. The size of the ducts varies; comparatively small in the first zone, they increase annually and reach their maximum growth in from eight to ten years, often having a diameter of from 300 to 400 μ. The walls are much pitted with discoid markings. Fig. 10 represents a vessel separated by Schultze's fluid and viewed from without. The halos seem to be oval, arranged in rows, and alternating in the rows with one another. The canals are narrow slits, usually extending quite across the disc, and are partially concealed by the thickening membrane of the vessel. Tyloses is the rule with these vessels. The walls of the intruded parenchyma often become much thickened and pitted. The frequency is probably due to the fact that parenchyma usually borders these vessels, and the numerous slits afford it an easy ingress. These large and numerous tubes serve important mechanical ends in giving lightness and strength to the plant. A rough measurement of a cross-section places the area of the tubes as one-third that of the plant.

The wood parenchyma shows at P. In the variation of its dimensions and form it well exemplifies its name—*parenkeo.* The cells are irregularly pitted when contiguous to vessels or medullary rays, and show a slight tendency to border pits when adjoining elements so marked. At I another very common form is shown. These latter cells would correspond to Sanio's intermediate tissue, in that they are libriform, contain food, and have all the characteristics of parenchyma; but in no case could oblique, slit-like markings be found. The libriform tissue, L, affords excellent examples of sclerenchyma. The cells appear stratified, showing a lignified outer wall, a thicker middle layer, and a homogeneous gelatinous inner layer (Fig. 11). The fibres often appear filled with the granular residue of the cell contents. In no case examined did they show striation or pitting. In the first year their growth appears very regular, but thereafter the ends extend themselves at sharp angles radially and tangentially. Thus the wood offers much resistance to splitting along any plane and gives great toughness to the vine.

The medullary rays extend in uni- or multi-seriate radial rows through the wood, the wider bands extending to the pith, while narrow ones appear between, formed each succeeding year as the dilatation of the stem continues. In tangential section their mode of origin from the cambium cell is evident. Considering now the phloem, it will be seen to be composed of bundles of sclerenchyma alternating with rows of parenchyma and sieve tubes. The regularity of this arrangement is often interrupted by the unequal growth of the parenchyma and the dilatation of the medullary ray. The sclerenchyma, B, resembles closely the fibres of the xylem. They exceed it, however, in length, but not in thickness (Fig. 13). The outer layer is less lignified than that of the wood, while the cartilaginous layer is greatly developed, often filling irregularly the entire lumen. Apparently there is no middle lamina (Fig. 14). Scattered through the sclerenchyma are fibres containing crystals. These septate cells were not without occurrence in the wood, especially in the older zone. In the bast they appear the first year and become at once its most pronounced feature. These crystal-bearing fibres seem to arise directly from the cambium, and have the general form of the bast. After the formation of the crystals each is separated by transverse divisions of the fibre. From twenty to thirty of these crystals appear in a fibre, each chamber being nicely proportioned to the size of the crystal. The fibres are not lignified,



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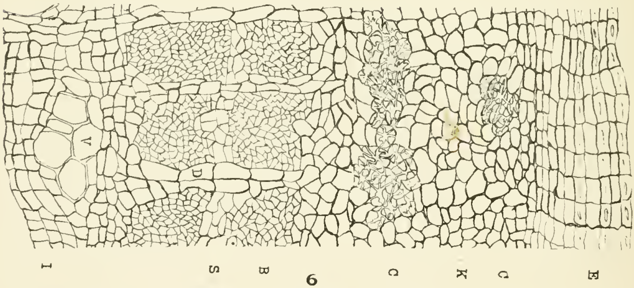

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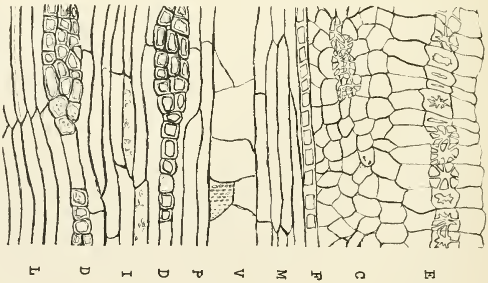
D

E



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CURTISS ON WISTARIA.

the walls remaining exceedingly delicate and transparent. Crystals appear in this delicate cellulose sack, embedded in a gelatinous medium which completely fills the chamber. About the crystal is a film which on treatment with iodine shows the reaction of cellulose (Fig. 15). The crystals belong to the monoclinic system, though the corners are often blunted and irregular forms result (Fig. 16). Crystals also appear irregularly scattered through the parenchyma. With the sclerenchyma alternates the soft bast, S. With the pressure of growth these cells are much distorted, and the delicate sieve tubes are so much compressed as to lose all trace of structure and perhaps entirely disappear. These tubes, in the cases where examination is possible, appear in the parenchyma adjoining the liber fibres, and thus correspond to the annual zones. Their lateral walls seem to be destitute of plates and the cribrose septa are nearly horizontal. They greatly exceed the parenchyma in length, but have about the same transverse measurements. These bundles of parenchyma and sclerenchyma correspond closely and, I believe, exactly with the annual zones of the wood; the outer ones being compact, with an excess of fibre, while the inner bundles of the phloem are generally characterized by an absence of fibre and the soft bast is multiplied to several layers, giving a loose structure. This development presents a striking parallel to the dense heart growth of the xylem and its later light structure. A marked characteristic of the phloem is the presence of resin receptacles. These are arranged in concentric circles following the parenchyma in its growth, but never appearing in the medullary ray. As viewed in cross-section they occupy from one to several cells and give a banded structure to the bast. The resin has the appearance of gamboge. It is an exceedingly inert mass, little affected by strong acids, and slowly dissolves in

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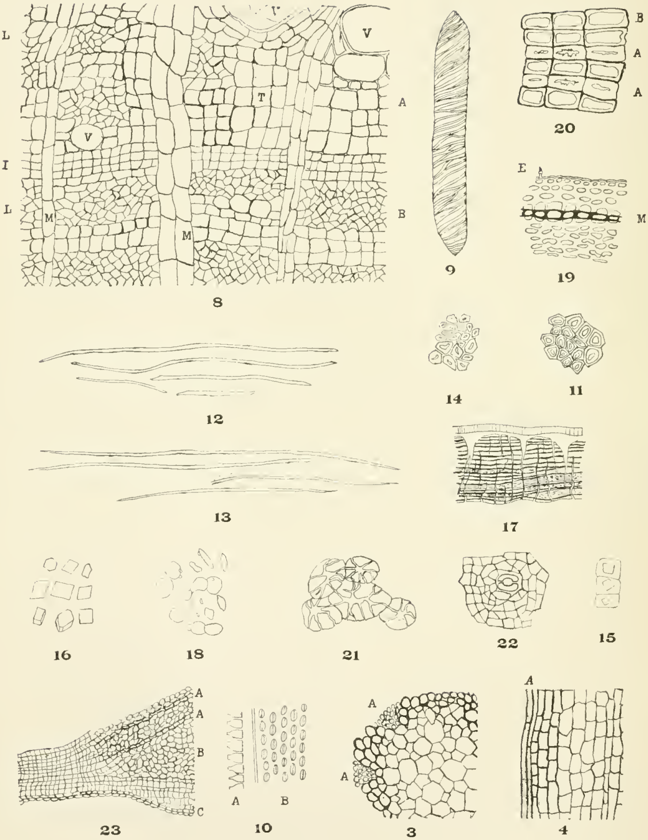
Explanation of Plate 34.

FIG. 5. Cross-section of stem. E, cork; K, parenchyma of periblem; C, cortical sheath; R, resin sack; B, bast fibre; F, crystal fibre; S, parenchyma of the bast; M, cambium tissue; T, a portion of three tracheids, showing at X an absorbed septum; V, trachea with tyloses, and a portion of its pitted wall; P and I, forms of wood parenchyma; L, liber fibre. × 500.—FIG. 6. Cross-section of stem lettered as in Fig. 5. D, medullary ray. × 300.—FIG. 7. Tangential section lettered as in Fig. 5, showing a layer of much thickened cork cells with pits. × 500.—FIGS. D and E Radial and cross-sections of medullary ray, showing pitted walls. × 500.

Schultze's solution, losing its orange color and disappearing as an amber fluid. It is not improbable that this gum has the medicinal properties of gamboge, as Ottow found a poisonous glucoside in the bark of the *Wistaria*. Mention is not made of the properties of this poison, and it may have no connection with the resin, which does not occur in the bark. The latter term, however, may have been loosely used to include the inner cortex. The origin of these cells is lysigenetic. In the young bast and pith single cells of parenchyma are found filled with the resin; but with growth, either through rupture or dissolution of contiguous walls, the resin spreads, forming irregular branching passages. In the pith the resin slowly disappears before the period of degradation begins, but remains a constant feature of the phloem. The dilatation of the bast becomes very noticeable with the advance of age, forming the triangular white spots of the cortex (Fig. 17). This enlargement is brought about largely by the medullary rays, and usually by the multi-seriate ones. These broaden as they are pushed out by the successive annual zones, and by radial bipartition of the individual cells the original size of the cell is approximately maintained. These huge wedge-shaped masses of parenchyma often constitute the larger part of the bast, and so intermingle with the parenchyma of the outer cortical zone as to leave no line of demarkation between them.

Considering now the periblem, it is seen to consist entirely of parenchyma. The cells are filled with plastids containing chlorophyll, protein matter, and starch granules. These plastids are circular or lenticular in form, often showing starch embedding in or adhering to their surfaces. Fig. 18 illustrates the forms of plastids and starch granules found in the plant. The first change in this external cortical zone is the formation of the phellogenetic meristem. This takes place in the external layer of cells during the first year (Fig. 19). The development at first is entirely centripetal. Of the two cells formed by the first division, the outer one eventually becomes cork, while the inner one continues to grow and again divides, the inner one ever remaining active. But after the fourth or fifth year the development changes and becomes reciprocal. Now the inner of the cells formed by the division of the mother cell is no longer meristematic, but becomes the first layer of the phelloderm. With the next division of the mother cell the outer cell is added to the cork, and, thus alternating, the successive zones are formed until about eight layers of phelloderm appear, when the growth once more becomes centripetal and so continues. In the younger stems a layer of cork is added each year. This appears to continue through life, for in the periderms of older stems the layers of cork so closely correspond to the annual zones that the loss of bark would easily explain the deficit. Thus the plant seems to be exceptionally regular in the formation of all its parts. The cork cells are tabular, appearing at first with delicate walls filled with sap (Fig. 20). If complete suberification of the walls results the cell contents remain as a brown, resinous mass, filling the cell. Sanio holds that air never appears in those cells which contain this residue of cell life. But cases are not wanting in which the contents seem to have drawn away from the walls, leaving an air cavity. This separation may be due to the disturbance of the cell either from chemical reaction or cutting. In many cells the cutinization is slight, in which case the inner lamina grows to the exclusion of nearly the entire lumen and becomes much furrowed by canals (E). It is worthy of note that these thickened and brown-colored cells usually alternate, giving a marked stratified appearance to the cork. The walls are transparent, even in the oldest cells, readily showing through the green of the phelloderm. They adhere strongly by their tangential walls, and when the pressure of growth finally severs them they curl back from the break, causing the scale-like appearance of the bark. Contemporaneous with the cork-meristem appears the first trace of the cortical sheath. Certain cells of the parenchyma adjoining or near the bast begin to thicken, and eventually become short-celled sclerenchyma, the lumen being nearly excluded and the pit canals much branched (Fig. 21). A zone more or less interrupted is formed, sharply separating the plerom and the periblem. Secondary bundles often arise outside the primary groups. This element is a very characteristic feature of the outer cortex, and affords exceptionally good material for the study of the origin and the development of sclerenchyma. The dilatation of the fundamental mass of the periblem keeps pace with the growth of the stem. In so doing there is a loss in the thickness of the cell wall until these cells resemble perfectly those of the parenchyma of the phloem. In case of the commingling of the elements in this way groups of cells are moved from the cortical sheath, and in the phloem occasionally they undergo sclerosis. In the dermatogen is found but a single uniseriate zone. Growth continues apparently during the first year only, when life is cut off by the completion of the first layer of cork. Many of the cells are prolonged into hair-like trichomes, which probably assist the stoma in supplying the plant with air. No intercellular spaces occur save where stomata are formed. The cells are nearly rectangular, their superficial walls being much thickened and completely cutinized. They contain colorless granules and sap, starch however being found in the guard cells of the stoma (Fig. 22). With the formation of the cork a change occurs in those cells below the stoma in or near the meristem. As the cork is formed these cells exceed the growth of the periderm, and thus is formed a double convex swelling which pushes up the stoma long before death ensues (Fig. 23). At the phelloderm the cells are regularly arranged in rows containing a few granules and filled with a colorless sap. Outside of these are the complementary cells, with corners more or less rounded, and in structure similar to the cork. As in the cork, some are filled with the dried remains of cell life, but, being irregularly placed among the transparent cells, they present a mottled rather than a banded structure. This mass of loose complementary tissue is held together by layers of flat cells which alternate with them. These tabular cells adhere strongly by their radial walls, but, owing to their irregular tangential surfaces, they do not interfere with the access of air to the phelloderm. These cortical pores increase with the dilatation of the periderm, attaining in transverse diameter a length of five or six millimetres. The lenticles of the older stems are abundant and apparently exceed the stoma of the younger growths, and it seems not improbable that they are often formed under the trichomes which thickly beset the epidermis. In looking over the literature on the *Wistaria*, as noted in the *Botanischer Jahresbericht*, I find only incidental references made to it, as already noted. Both De Bary and Sachs, in their "Handbook of Physiological Botany," relying largely on the examinations of Eichler, Crüger, and Müller, place the origin



CURTISS ON WISTARIA.

of the successive rings of thickening in the older zones of the secondary bast. From examination of many sections taken from stems varying in age from four to twenty-five years, it seems impossible that the conclusions of the authors mentioned can be correct. The law may be true for the lians, with which they chiefly worked, and it is possible that the *Wistaria*, under different conditions of climate and soil, may conform to the above law. The cortical sheath of the *Wistaria* gives an unmistakable landmark by which to locate growth. This is always near the periblem and plerom boundary. No amount of it is found in any other place. If De Bary's position were true this sheath could never appear in the phloem that has been cut off externally by wood. It would ever be pushed out with the periblem by the new growth. But not a section of the interstratified phloem has been examined that does not reveal the cortical sheath on the periphery of the bast. It may be advanced that with the formation of the new cambium dilatation of the adjoining parenchyma and sclerosis follow. In this case the process could easily be noted, and, secondly, the dilatation would present features distinct from that manifest in stems where growth is yet normal. As a matter of fact, the structure of the included bast zones differs in no respect from that of the regular growth. The same widening of the medullary ray, and the completed sclerosis, etc., are always present. Again, in sections taken from the angles formed by the commingling of two bast zones, the sclerosis is seen to curve

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Explanation of Plate 35.

Fig. 3. Cross-section of pith, showing fibro-vascular bundle, A, in the medullary sheath. × 200.—Fig. 4. Radial section of pith. A, spiral tracheids. × 200.—Fig. 8. Cross-section of xylem, showing A, autumn growth, and B, denser wood. × 500.—Fig. 9. Tracheid with anastomosing spirals. × 500.—Fig. 10. A, longitudinal section of tracheæ, showing forms of pits and canals ; B, transverse view, showing the thickening portion encroaching upon the slit-like canals. × 500.—Fig. 11. Cross-section of liber fibres, showing stratification. × 500.—Fig. 12. Liber fibres separated by maceration. × 66.—Fig. 13. Bast fibres separated by maceration. × 66.—Fig. 14. Bast fibres, cross-section showing two layers. × 500.—Fig. 15. Three sacks of the crystal fibre swollen by maceration. × 500.—Fig. 16. Crystal forms. × 500.—Fig. 17. Cross-section of inner and outer cortex, showing the dilatation of the medullary ray. The heavy horizontal lines and the dotted spaces represent the relative amounts of parenchyma in the bast. × 12. —Fig. 18. Plastids and starch granules. × 500.—Fig. 19. Cross-section of stem, showing the cork meristem in the third layer of cells, and the epidermis with trichome, E. × 300.—Fig. 20. Cross-section of cork cells. A, A, the much-thickened cells ; B, those completely suberized. × 500.—Fig. 21. Short sclerenchyma. × 500.—Fig. 22. Stoma of stem. × 300.—Fig. 23. Lenticle. A, A, tabular cells radially joined to retain in place the loose cells ; C, phelloderm. × 200.

around from the outer bast in a clearly marked line to the outer periphery of the included bast. But one explanation can account for this, namely, that the new zone of growth arises in the periblem near the cortical sheath. Here, moreover, are all the elements necessary for growth—a living parenchyma rich in chlorophyll, starch, and protein matter. Only in a single stem was this growth seen to be in process. In this case the cambium seems to have risen on a line with the cortical sheath, for the wood fibres were interrupted by the bundles of sclerenchyma. This may be the place of new growth, since in removing the inner cortex from the wood the line of separation is always dentate, which outline the sclerotic bundles crowding into the wood tissue would exactly produce. It is not always apparent, however, that the dentation is due to this mode of development. The cause of the anomalous growth is doubtless due to pressure. As the annual zones are pushed out greater and greater resistance is offered to radial extension by the bast. The sinuous course, in the older stems, of the medullary ray would be indicative of this, but it is to be noted that the irregularity is almost entirely confined to the corrugated, gnarled stems and therefore is in great measure due to torsion. The radial distortion of the parenchyma and the collapse of the sieve tubes indicate more strongly the pressure of growth. Finally, as regards the fact that the secondary growths are less than those of the primary, it may be held that the plant reaches its maturity at about the twelfth year. Now the potential of the plant life is lower, new elements are added with less vigor, and consequently it can force back the bast for a shorter period.

Reviewing the elements of the stem, one cannot fail to be impressed with the wonderful regularity, economy, and fitness manifested in the arrangement of the tissue. The xylem, phloem, and periblem each receives its proportional annual increase, developing all its parts with a precision truly wonderful. The tough strands of the sclerenchyma were needed at first to give a strong rope of support to the vine with its heavy foliage ; but with the advance of age the complement of this was needed, lightness as well as increased facilities for the transmission of food. Now appear the larger elements—the tracheæ, hollow cylinders of support, made more light by their sculptured walls, while the tracheids with their thickened walls afford a roadway for the rapid transmission of food. From an eighteen-year-old stem a quarter-section was taken, so as to secure all the elements in their relative proportion. From this the specific gravity was found to be only two and a half times that of cork. Thus at once is secured a stem of great strength and unusual lightness. But truly the most wonderful element is the bast, so fine that J. J. Rein, in a paper on the textile plants of Japan, credits the Japanese with attempting its manufacture into linen. This seems very feasible, for the elements have a diameter of 12 μ and reach a length of 230 μ, in appearance and measurements corresponding closely with *Linum usitatissimum* (Fig. 13). In their strength they exceed all the other elements of the stem. From some rather unsatisfactory tests of the sustaining power of the bast it was found that a piece two millimetres wide and one millimetre thick would sustain a weight of twenty-two and seventy-three hundredths kilos, more than one-fifth of the sustaining strength of soft iron. Here again the adaptability of the plant to its mode of life is manifest. The strength of the bast cylinder alone would doubtless be sufficient to meet all strains brought to bear upon it; but considering the older stems, often surrounded by several concentric cylinders, the strongest form of structure possible, the utility of the arrangement to the plant is obvious. At the low estimate given above, an old stem before me showing three bast zones would have a sustaining power of over half a ton. There now remains for consideration the life of the plant—by no means its least interesting feature. For in the adaptation of its growth to meet the strain laid upon it, there arose in the bast such a barrier to development that the life of the plant must cease or the restraint be overcome. And so, to secure to itself at once its element of strength and life, the barrier wall is left unbroken and life begins anew beyond the bast and without restraint.

PROCEEDINGS.

Meeting of February 19th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Sixty persons present.

Prof. Samuel Lockwood, Ph.D., addressed the Society on "The Blood after Electrocution." This address referred especially to the appearances of the corpuscles of the blood of Kemmler, the first victim in the State of New York of the infliction of the death penalty by means of the electric current.

Dr. Lockwood maintained that the condition of the red corpuscles of the blood, taken from the head of the victim in the direct path of the current five minutes after electrocution, shows the effect of the dreadful shock. "Here is an exhibit of an astonishing catastrophe. In no instance has a single corpuscle escaped damage. All are reduced fully one-third in size. Many of them look as if they were smashed. From some the protoplasm exudes like the pulp from a crushed grape. Many are reduced to mere granules, and distortion is general."

The address was illustrated by lantern projections of photomicrographs of blood corpuscles from various animals, from normal human blood, and from Kemmler's blood, and also by preparations under microscopes as indicated below.

OBJECTS EXHIBITED.

1. Blood of Frog.
2. Blood of Alligator.
3. Blood of Pigeon.
4. Blood of Dog.
5. Normal human blood.
6. Kemmler's blood, from the thigh.
7. Kemmler's blood, from the head.

All by Samuel Lockwood.

Meeting of March 4th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Fifteen persons present.

OBJECTS EXHIBITED.

1. *Navicula trinodis*, from Ashbourne, Pa.

2. *Coscinodiscus excavatus*, from artesian well at Beach Haven, N. J.

3. *Triceratium* (new species), from the same.

Exhibits 1–3 prepared by Dr. C. Henry Kain and exhibited by E. A. Schultze.

4. Wood fibre from coal, Deer Creek, Walker Co., Ala.

5. Sporangia from the same.

6. Macrospores from shale, Ontario, Canada.

Exhibits 4–6 prepared by K. M. Cunningham and exhibited by Geo. E. Ashby.

Meeting of March 18th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Fourteen persons present.

OBJECTS EXHIBITED.

1. Serial sections of the fish, *Atherina* sp. (Silversides), through the gills: by L. Riederer.

2. Serial sections of the same, through the head: by L. Riederer.

3. Serial sections of the same, through the eye: by L. Riederer.

4. Malachite, from Arizona: by Geo. E. Ashby.

5. Brucite, from Hoboken, N. J.: by Geo. E. Ashby.

6. Sea-sand, mounted movable in fluid: by J. D. Hyatt.

7. Fresh-water Diatoms, from Montgomery, Ala., prepared in monobromide by Dr. Ward, of Poughkeepsie: by J. D. Hyatt.

8. Pigeon-post film, used in the siege of Paris: by J. D. Hyatt.

9. Twenty-five Photomicrographs of various preparations: by Frank D. Skeel.

Meeting of April 1st, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Forty persons present.

Dr. Carl Heitzmann addressed the Society on "Fallacy of the

Cell-Theory." This address was illustrated by microscopical preparations as stated below.

OBJECTS EXHIBITED.

1. Cornea of Cat, with basis substance stained with chloride of gold showing reticulum.

2. Cornea of Cat, stained with nitrate of silver.

3. Section of human tooth with silver amalgam, showing reticulum in the dentine.

4. Dentine of human tooth, showing effect of amalgam.

All by DR. CARL HEITZMANN.

MEETING OF APRIL 15TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Fifteen persons present.

OBJECTS EXHIBITED.

1. Aventurine Feldspar (Sunstone), from Sussex Co., N. J.: by JAMES WALKER.

2. Section of the same by polarized light: by JAMES WALKER.

3. *Megalotrocha.*—Rotifer colony—illustrating a convenient method of transportation and exhibition: by JAMES WALKER.

Mr. Walker explained the ingenious and convenient method of handling the colony of Rotifers exhibited by him. A microscopical cover glass is attached to one end of a thread by means of a minute piece of wax. The cover glass is suspended in the water of an aquarium. The thread passes over the edge of the aquarium, and at the end, hanging outside, a balancing weight, consisting of a small shot or any other convenient minute object, retains the cover glass in any desired position in the water. When a colony has attached itself to the cover glass, glass and colony can be transported by transferring them uninjured to a bottle of water, and they can be conveniently retained in any position for examination on the stage of the microscope by transferring them from the bottle to a stage tank.

Mr. Walker also described the piece of apparatus, constructed by himself, for revolving the polarizing prism on the microscope. A small shaft is attached to the substage, carrying at one end a milled head, slightly projecting beyond the microscope stage, and having at the other end a pinion engaging in a crown-wheel, fastened to the tube containing the prism.

Annual Exhibition, April 22d, 1892.

The Thirteenth Annual Exhibition of the Society was held at the American Museum of Natural History, Central Park, New York City, on the evening of April 22d, 1892.

The objects exhibited, as noted in the programme below, were displayed in the large hall of the first floor of the Museum. During the evening there were three exhibitions of thirty minutes each in the spacious Lecture Room adjoining, as follows: At 8 clock—Exhibition of Lantern Slides of Photomicrographs, by E. G. Love. At 9 o'clock—Exhibition of Lantern Slides of Diatoms, by C. F. Cox. At 10 o'clock—Exhibition of Microscopic Objects with polarized light by E. C. Bolles.

PROGRAMME.

1. Old Microscopes and Accessories (Alcove No. 1). Loaned by C. F. Cox, J. L. Zabriskie, Wm. Wales, F. D. Skeel, L. Schöney, and the American Museum of Natural History: by Wm. Wales.

2. Method of Grinding and Mounting Lenses for the Microscope (Alcove No. 1): by Wm. Wales.

3. Transverse Section of the Pad of a Cat's Foot, showing "touch" corpuscles: by Geo. E. Ashby.

4. Saws of Rose Saw-fly: by Geo. E. Ashby.

5. Transverse Section of the Stem of Cycas revoluta: by Geo. E. Ashby.

6. Revolving Stage with eleven objects: by Thos. Taylor.

7. Sponge Spicules, Barbadoes: by E. J. Wright.

8. Crystallized Zinc Oxide: by Frederick Kato.

9. Hydromagnesite, Hoboken, N. J.: by J. W. Freckelton.

10. Sunstone, a variety of Feldspar, Sussex County, N. J.: by A. H. Ehrman.

11. Arachnoidiscus in situ on Seaweed: by F. E. Bloodgood.

12. Microphotograph, The Madonna, Raphael: by A. Woodward.

13. Crystals of Chlorate of Potash, with polarized light: by A. WOODWARD.

14. Scales of Morpho Butterfly from Brazil: by WM. BEUTENMÜLLER.

15. Section of Cornstalk: by WM. BEUTENMÜLLER.

16. Vinegar Eels, living: by ALFRED BEUTENMÜLLER.

17. The Oyster, examined microscopically and otherwise (Alcove No. 2): by GEO. W. KOSMAK.

18. Bouquet made from Butterfly Scales: by E. A. SCHULTZE.

19. Arranged Diatoms from Santa Monica, Cal.: by E. A. SCHULTZE.

20. Stellate Hairs on Leaf of Deutzia scabra, with polarized light: by J. L. WALL.

21. Pollen Grains of Lavatera in situ: by H. C. BENNETT.

22. The Diamond Beetle, *Entimus imperialis*: by M. H. EISNER.

23. Silicious Cuticle of Equisetum, with polarized light: by M. H. EISNER.

24. Case for Microscope and Accessories, made of mother-of-pearl: by M. H. EISNER.

25. Cutting, Staining, and Mounting of Serial Sections by the Paraffin Process (Alcove No. 3): by L. RIEDERER.

26. Section of the Abdomen of a Dragon-fly: by L. RIEDERER.

27. Transverse Sections of the Tongue of a Butterfly, *Colias Philodice*: by L. RIEDERER.

28. "Sea Spider," *Phoxichilidium*: by L. RIEDERER.

29. Chromatophores or Pigment Cells in skin of common Shrimp, *Crangon vulgare*: by HEINRICH RIES.

30. Red Earth-mite, *Trombidium*: by WM. HUCKEL.

31. Yellow Ochre, pseudomorph after Siderite, New York City: by JAMES WALKER.

32. Sections of Dumortierite in Orthoclase, Oligoclase, Fibrolite, Serpentine, Scapolite, and Mica with inclusions, shown with automatic revolving stage and polariscope: by JAMES WALKER.

33. Specimens illustrating successive stages in Grinding and Mounting Rock Sections: by JAMES WALKER.

Microphotography (Alcove No. 4), Apparatus and Slides: by S. N. AYRES:

34. Bird's-eye View of the Columbian Exposition.
35. The Dream of Pharaoh's Wife.
36. Portrait of Child.
37. Foes or Friends.

38. Influenza Microbes: by L. SCHÖNEY.

39. Trichinæ Spiralis in Human Muscle: by J. A. GOTTLIEB.

40. Photomicrographs: by J. A. GOTTLIEB.

41. Cutting, Grinding, and Mounting of Rock Sections (Alcove No. 5): by J. D. HYATT.

42. Section of Agate, with polarized light: by J. D. HYATT.

43. Vibratile Cilia of Mussel, *Mytilus*: by J. D. HYATT.

44. Circulation of Blood in a Frog's Foot: by J. D. HYATT.

45. Porpita Linnæana, a Hydrozoan, allied to the Portuguese Man-of-war: by L. P. GRATACAP.

46. Pond Life: by THOS. CRAIG.

47. Skin of Leptosynapta, showing Anchors and Plates: by W. C. KERR.

48. Section of Scotch Coal, Stigmaria: by H. W. CALEF.

49. Fern-leaf Crystals of Gold: by G. S. WOOLMAN.

50. Head of Mosquito: by G. S. WOOLMAN.

51. Human Blood on Holman's Slide: by F. H. LEGGETT.

52. Circulation in Nitella: by F. W. DEVOE.

53. Circulation in Vallisneria: by F. W. DEVOE.

54. Crystals obtained from the Blood of a Caterpillar, with polarized light: by SAMUEL LOCKWOOD.

55. Native Crystallized Gold, Colorado. Slide mounted with removable cover glass: by A. H. CHESTER.

56–59. Pond Life, including the following forms recently discovered by the exhibitor: *Lagotia cæruleus*, *Urnatella Walkerii*, *Octocella libertas*, and *Cordylophora coronata* (Alcove No. 6): by STEPHEN HELM.

60. A Series of Drawings of the Lower Forms of Animal Life (Alcove No. 6): by STEPHEN HELM.

61. Head of a Tape Worm: by MISS M. V. WORSTELL.

62. Luxullianite, with polarized light: by MISS M. V. WORSTELL.

63. Hydroid, Obelia, showing Polypites, Gonophore, and attached Diatoms: by G. S. STANTON.

64. Iodo-Sulphate of Quinine, with polarized light: by GEO. M. HOPKINS.

65. Autograph of the Electric Spark: by GEO. M. HOPKINS.

66. Arranged Group of Diatoms, illuminated by Parabola: by C. F. COX.

67. Crystals of Quinidine, with polarized light: by C. F. COX.

68. Trichomes and Transverse Section of the Leaf of the Long Moss, *Tillandsia usneoides* L., from Florida, with polarized light: by J. L. ZABRISKIE.

69. A new Microscope Lamp: by J. L. ZABRISKIE.

70. Photomicrographic Apparatus with Photomicrographs (Alcove No. 7): by E. G. LOVE.

71. Palate of Whelk, *Buccinum undatum*: by E. G. LOVE.

72. Section of the Ovary of Indian Pipe, *Monotropa uniflora*: by E. G. LOVE.

73. Section of Echinus Spine, *Echinometra lucunter*, with polarized light: by E. G. LOVE.

74. Finest Manchester Muslin: by E. G. LOVE.

75. Human Hair from Beard: by E. G. LOVE.

76. Suction Cup from Arm of Devil-fish, *Architeuthis princeps*: by WM. E. DAMON:

77. Skin of Sole: by W. H. MEAD.

78. The Ruby: by GEO. F. KUNZ.

Etchings of Steel, showing Structure (Alcove No. 8): prepared by P. H. DUDLEY and exhibited for him by THOS. B. BRIGGS:

79. Exterior columnar Structure of a .50 per cent carbon Bessemer Rail Ingot.

80. A .26 per cent carbon Bessemer Rail Head, which is so coarse that it wears rapidly under heavy traffic.

81. A good low-carbon Rail, the carbon being nearly all combined.

82. Dense Structure of a .60 per cent carbon Rail.

83. A 3 per cent nickel Armor-plate Ingot.

84. Ordnance .40 per cent carbon steel, after hydraulic forging.

85. Photomicrographs showing structure of steel.

86. Section of Retina of Human Eye, showing Rods and Cones: by F. D. Skeel.

87. Section of Human Eye, showing cancerous growth (*Melano-sarcoma*): by F. D. Skeel.

88. Cheese Mites, *Acarus domesticus*: by W. D. Macdonald.

89. A Series of Photomicrographs, made by the late Dr. J. J. Woodward (Alcove No. 9): by C. F. Cox and E. G. Love.

90. Polycystina, Barbadoes: by H. F. Crosby.

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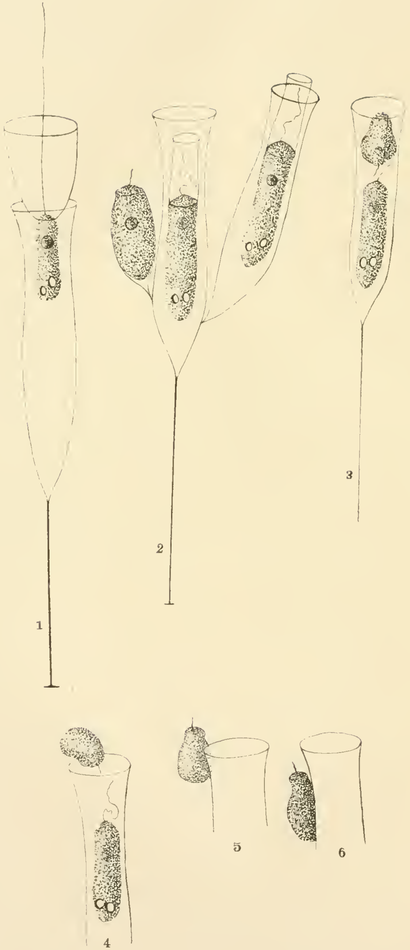


SALPINGŒCA GRACILIS.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. VIII. OCTOBER, 1892. No. 4.

A NOTE ON A VARIETY OF SALPINGŒCA GRACILIS J.-CLK.

BY ALFRED C. STOKES, M.D.,

Corresponding Member of the New-York Microscopical Society.

(*Presented June 17th*, 1892.)

In October of last year (1891) I received, through the kindness of Mr. Stephen Helm, a gathering made from the Morris and Essex Canal near Claremont, N. J. The collection was an exceedingly rich one, containing several microscopic animals which up to that time had not been seen by any human eye. These are in the care of my courteous correspondent, and have been by him referred to in a recent number of this JOURNAL. It is consequently not to these remarkable and remarkably interesting creatures that I wish now to refer, but to a minute member of the group of charming Infusoria classed together by systematists in the order Choano-Flagellata, or "the collared monads." These beautiful little creatures have long been particularly interesting to me, not only on account of their attractive and artistic forms, their unusual habits and characteristic structure, but because they are especially American Infusoria, although many have been found in Europe. They were originally discovered here

Explanation of Plate 36.

FIG. 1—*Salpingœca gracilis* J.-Clk. Typical form.

FIG. 2—A small colony of the brackish-water variety, with two loricæ, and with an embryo recently escaped from the parent sheath and secreting its lorica.

FIG. 3—Embryo soon after separation from the parent.

FIGS. 4, 5, and 6—Embryos leaving the parent lorica to assume a position externally adherent.

by the late Professor H. James-Clark, who connected them in an intimate manner with the microscopic structure of the sponges. They have been studied by Stein, by Saville Kent, and by Butschli in Europe, but in this country, the land in which they were first found and in whose fresh and salt waters they are in profusion, microscopists have almost entirely neglected them ; yet they are worthy of every attention. The explanation of this apparent neglect seems to lie in the small size of the infusorians, and in the consequent demand for high-power objectives in their study.

The twigs and other objects in the water from the Morris and Essex Canal sent me by my correspondent, were adorned with a great number, indeed with hundreds, of a species of *Salpingœca* so nearly resembling James-Clark's *Salpingœca gracilis* that I had no hesitation in identifying it as that form. But almost at once there entered two facts which gave me pause. First, the animalcule had a habit which has not thus far been recorded with *Salpingœca gracilis* nor with any other member of the class; or perhaps I should express it as a modification of a habit common to all, but a modification until now not recorded and presumably not observed. And second, the water, when allowed to evaporate in a watch glass, deposited crystals of common salt ; it was brackish water, but without this accidental occurrence I should have called it sweet, although I was surprised to find many apparently salt-water Infusoria in it, and was at a loss to explain their presence. This adds another element of interest to the *Salpingœca* which, although undoubtedly *Salpingœca gracilis*, has been modified in habit, presumably by the condition of the water, without a corresponding change in the form of body or of lorica. It has assumed another and more complex condition, and seems to be in a transition stage between a salt-water variety of *Salpingœca gracilis* and a distinct species. The addition of a pedicle to each lorica, each of which except the founder of the colony is now sessile, would force it into a new species.

The common and abundant form of the *Salpingœca gracilis* is that shown in Plate 36, Fig. 1. It is a solitary animal, rarely being found in near proximity with its fellows of the same species. It may often be seen scattered singly along a thread of alga or of some similar object in fresh water, but it is usually averse to company. In the brackish water sent me by Mr. Helm I have found this form standing beside the variety just referred to and shown in Fig. 2, where, from the retiring, solitary creature, it is becoming a social colony like so many others of its congeners.

Of course it is not possible to imagine the cause that induced the embryo of the original aspirant after colonial honors to cling to the lorica of the parent and there produce a lorica of its own; and what induced other embryos to follow suit is as obscure; but each lorica with its enclosed animalcule represents a mature and full-grown embryo which, for some reason unknown, had not wandered, as is the usual custom, to found a home at a distance. It will be noticed that the appearance of the imperfectly formed colony is sufficiently different from the original, fresh-water individual to set the investigator to thinking ; and while it would scarcely in this condition be figured and described as a new species, yet it is not unreasonable to suppose that it is on its way to that end, and that at some time in the near future it will merit a place in at least a provisional, working list of species. In these transition forms the primary, original foot-stalk answers for a support to the entire community, as it will probably continue to do, but the individuals of the group will in time, and perhaps in not a remote time, learn that they can obtain a better and a more constant food supply by elongating a foot-stalk from the posterior extremity of each constituent member. The colony, now irregular and incomplete, will then be symmetrical and regular in contour, as all similar colonies prefer to be, and each member will have the same opportunity to get food as every other one. Each individual of all such colonies is really independent of all others in the community, and its food supply depends upon its individual efforts. To have one or more deprived of its necessary aliment would be to weaken it, and to weaken its offspring so that the embryos would degenerate rather than develop upward ; it would undergo degeneration rather than evolutionary advance.

The embryo that discovered there were advantages to be obtained by clinging to the parent's lorica, and thus sparing itself the trouble and the exhaustion of secreting a foot-stalk of its own, seems to have transmitted, in even a very short time, the new habit to its embryo, and these imperfect colonies are therefore in process of formation. A habit which seems to have been so easily acquired, and especially a habit which must be so beneficial to the animal, is not going to be forgotten nor abandoned. Thus far there has been no tendency, in the hundred or more colonies which I have seen, to produce other than an irregular form in which the loricæ are attached tó one another by what seems to be a haphazard arrangement, producing an unsymmetrical and ungraceful result. Yet in some of these larger colonies there is also visible what it needed but little acumen, in one familiar with the appearance and the habit of this infusorial class, to predict, adding still another feature of great interest to these special, intermediate forms. In some of these collections of irregularly adherent loricæ or one two of the constituent animals has actually secreted a minute, secondary pedicle by means of which it is attached to the supporting lorica, be that the parent sheath or that of a member of the cluster (see the lateral zooid in Fig. 2). Here is a variety within a variety, and, if the apparent desire to change continues, the secondary pedicle will become a permanent feature, and the point of adherence will also be changed from a point on another lorica to the top of the primary pedicle, and another species will have been formed, or at least a closely connecting, varietal link between the fresh-water *Salpingœca gracilis* and a salt-water representative which has not yet been found, probably because, with the exception of James-Clark, no microscopist in this country has paid the least attention to the Choana-Flagellata of salt water. The field is entirely unoccupied, and is at the disposal of any microscopist that is properly equipped with objectives and so situated that he has access to the ocean.

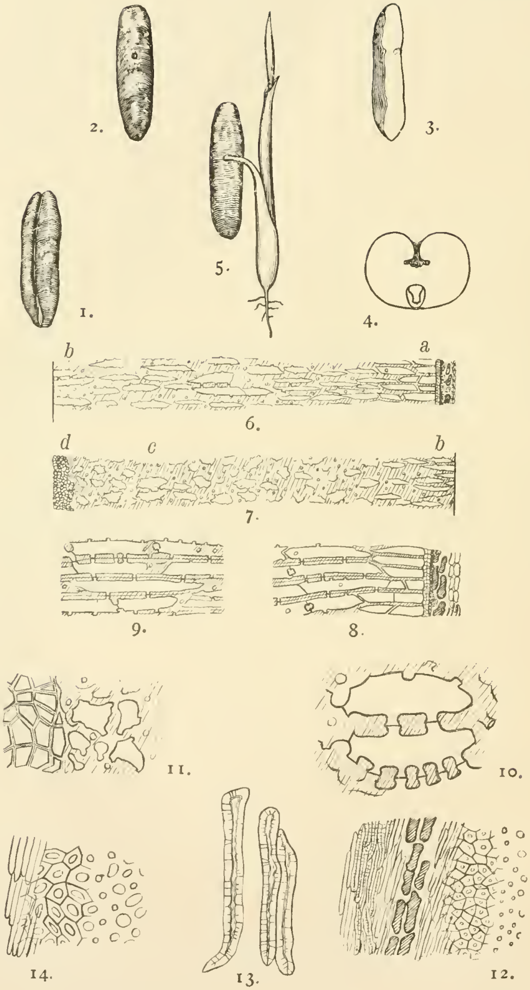
But this is not all. If it was it would be interesting and suggestive, at least to the writer; but there is more which is still more surprising to the student of these special Infusoria. The animal has actually made alterations in the mode of its reproduction, thus adapting its manner of increase to its new and improved manner of living. With all other members of this group of animals, the reproduction is by the transverse fission of the parent's body; the latter divides into two parts, the one remaining in the old lorica, the other swimming off to find a new location and there producing a new lorica. The free-swimming portion dashes out of the parent sheath with great rapidity. It leaps out with indescribable activity and is gone like a flash. In appearance it is a simple *Monad*, having an ovate body and a long, anterior flagellum, the flagellum always being at the front. To all appearance it is a *Monad*, and, if its origin were not known, the observer would be excusable for so classifying it. The monadiform germ of the fresh-water *Salpingœca gracilis* is exceedingly active for a short time, when it settles down in some pleasant spot and develops a foot-stalk and a lorica like its parent's. But this brackish-water variety has here made a change. It reproduces itself by transverse fission, it is true, but its flagellum, instead of being at the frontal extremity, is at the opposite pole; and instead of being several times longer than the body bearing it, is shorter than half that body width. This is shown in Fig. 3, where the parent is retracted into the back part of the lorica, and the young, monadiform germ is in the front and apparently upside down. It remains in this position for a few moments, and then, with great deliberateness and slowness, glides up the inner wall of the lorica and gently over the edge (as shown in Figs. 4 and 5), when its stiff, motionless little flagellum gets in the proper position, because its owner then places itself right side up. Clinging closely to the parent's lorica, it slowly glides along the outer surface, as in Fig. 6, until it reaches an acceptable resting point, when it proceeds to secrete its lorica, as shown on the left-hand side of Fig. 2. Here, instead of the wild if uncertain and wavering dash for liberty as performed by the embryos of the ordinary forms of the fresh-water members of the group, the movements are exceedingly deliberate and slow, the change being a surprising one to the microscopist that has become familiar with the hurrying and skurrying of the ordinary embryo.

How these movements are effected I have not been able to learn. They are slow and continuous, but there is no apparent movement of the protoplasm, and no visible amœboid projections of the endoplasm. The movement also takes place as well when the animals are upside down as when they are in the right position, performed as well against gravity as in its direction. It is probable that the wave-like movements of the lower surface of the embryo needed to produce the onward progression are so minute that they are concealed by the mass of protoplasm above, although this is almost entirely transparent.

These facts seem interesting and provocative of thought. That a little creature like this, whose protoplasmic body is only $\frac{1}{1125}$ inch in length, should deliberately change its habit of living alone and at a distance from its kindred, is interesting; but that it should permanently modify the actions of its embryo so as to bring about those altered conditions, is startling.

A recent writer lays it down as a broad and undisputed proposition that changes in form resulting in new species are not the result of slow modifications extending through countless ages, and which those that speculate on the changes induced by the visits of insects so warmly contend for. Changes, the author asserts, are by leaps and not by slow modification. There seems a greater energy at work at times than at others in producing change. It thus seems pleasant to imagine that, in finding this infusorian undergoing its changes into at least a distinct variety, one of these leaps might be actually in the process of taking place.

The irregular colonies which I have referred to are to be seen in many sizes, from a young cluster of two (the parent and the newly matured infusorian) to older clusters of a dozen or more members, some clinging to the body of the original or parent sheath, others adherent to the more recently formed lorica.



PHŒNIX DACTYLIFERA L.

NOTES ON THE STRUCTURE OF THE FRUIT-STONE OF THE DATE, PHŒNIX DACTYLIFERA L.

BY J. L. ZABRISKIE.

(*Read June 3d*, 1892.)

The sculpturing of cell walls, resulting from thickening deposits, always presents an interesting field of microscopic investigation in vegetable structure. The variety of form exhibited, the beauty of tracery and regularity of deposit, as seen in many spiral and annulated vessels, the surprising adaptations to the necessities of the organization, continually encourage examination. A striking example of this thickening of cell walls is afforded by the endosperm of the fruit-stone of the Date.

The stone is fusiform with irregularly rounded ends (Plate 37, Fig. 1). A thin, firm, uniformly light-brown outer coating covers all the surface, excepting that occupied by the deep longitudinal cleft, extending the entire length of one side of the stone, and filled with a dark-brown, soft, cellular structure. When the stem end of the fruit-stone is uppermost, at the lower end of the cleft will be found a little, hard, grooved, conical prominence, projecting downward and indicating the distal end of the fruit, opposite the stem. On the side directly opposite the cleft, and usually a little above the middle of the stone, may be noticed a small circular depression enclosing a hemispherical prominence and indicating the position of the embryo within (Fig 2). A longitudinal section of the entire stone through the cleft (Fig. 3) shows the position of the embryo, which is seated, entirely free excepting a slight detachment at its inner end, in a little ovoid cavity. A transverse section through the entire stone and through the embryo (Fig. 4) shows the inner lateral enlargements

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Explanation of Plate 37.

FIG. 1—Fruit-stone of the date, showing longitudinal cleft and conical prominence. FIG. 2—The same, showing the position of the embryo. FIG. 3—Longitudinal section, showing the embryo in its cavity. FIG. 4—Transverse section, showing the same. × 3. FIG. 5—The fruit-stone germinating. (Figs. 1, 2, 3, and 5 all natural size.) FIGS. 6 and 7—A continuous narrow band of the transverse section of the stone, from the seed coats *a* through *b* and *c* to the soft structure of the cleft at *d*. × 50. FIG. 8—A portion of the transverse section at *a*. × 100. FIG. 9—A portion of the same at *b*. × 100. FIG. 10—Two cells of the same at *c*. × 200. FIG. 11—A portion of the same at *d*. × 200. FIG. 12—Longitudinal-tangential section, showing outer seed coats on the left hand and beginnings of the spindle cells on the right hand. × 75. FIG. 13—Three cells from the same section with abundant capillary canals. × 200. FIG. 14—A portion of the middle of the same section. × 200.

of the cleft, filled with the brown cellular tissue. In germination the embryo issues from the little depression (Fig. 5), the root descends into the soil, the plumule rises with its successive leaves, but the extremity of the single seed leaf remains within the stone.

The entire mass of the stone, excepting the firm brown coating, the embryonal cavity, and the cellular structure of the cleft, is a remarkably uniform, bluish-white endosperm, without flaw or blemish, nearly as hard as bone. The cells of this endosperm are of various sizes and forms, but many of them are long spindles, and the "grain" of the entire inner structure, caused by the adjoining rows of cells, considering their longer diameters, always lies in the direction of radii, converging from the hard outer coat toward a longitudinal axis, lying within the cellular structure of the cleft. Therefore the sections must lie in the planes of these radii, or in planes perpendicular to the radii, to avoid the confusion resulting from cutting the cells obliquely.

All the sections exhibited are taken at the middle of the stone, slightly below the position of the embryo. The transverse section extends entirely across the solid substance of the endosperm from the hard outer coating to the soft tissue of the cleft. The longitudinal-radial section extends in the plane of one of the radii, running from the hard coat to the long axis. And the longitudinal-tangential section lies in a plane perpendicular to such radii. These last sections were obtained by shaving off the hard coat longitudinally for only a slight depth. Deeper cutting, of course, gradually approaches the position of a longitudinal-radial section.

In preparing the sections the stone was split open by the blow of a hammer on a knife blade, applied longitudinally and transversely, and the pieces were macerated for a few days in cold water, with one drop of carbolic acid solution to the ounce to prevent putrefaction, or in a moderately strong solution of caustic soda. Either process will soften the stone sufficiently for cutting, but the soda more rapidly disintegrates the layers of the outer brown coating, thus preventing the view of these cells in their natural position. The sections were cut free-hand with a razor. The necessarily varying thickness of such a section is very instructive. In the thicker portions of the section the relations of the cells to each other will be seen, where they lie in several layers; while the internal structure of the several cells will be more clearly discerned where, at the edges, the section thins away almost infinitesimally. The sections were cleared of cell-contents by boiling in a dilute solution of caustic soda, stained with hæmatoxylin, and mounted in balsam.

Figs. 6 and 7 represent a continuous narrow strip of the transverse section, running from *a*, through *b* and *c*, to *d*—from the brown seed coats to the soft tissue of the cleft. The cells of the seed coats will be mentioned more conveniently under a consideration of the longitudinal-tangential section. Just within the seed coats at *a* is a structure of peculiar cells, bounding the entire circumference of the endosperm, which, from their form, may be termed palisade cells. They are uniformly thickened cells with smooth walls. They vary in length. Some of them are nearly cubical. But the majority of them are hexagonal prisms, with a nearly flat outer end, next the seed coats, and an obliquely truncated end, within, toward the endosperm.

Immediately succeeding these last lie the "spindle cells," slightly overlapping each other, and with their long diameters all directed toward the long axis of the stone. In the figures the clear spaces represent the interior of the cells, and the oblique shading represents the cut surface of the adjoining thickened cell walls. In a general view of the section, next after the striking appearance of the cell cavities, the attention is arrested by the appearance of an immense number of little circles irregularly scattered through the structure. These circles are the sections of the deep and remarkably uniform pores, extending from the interior of the cells, through the thickened cell walls, to the middle lamella between two adjoining cells. This explanation is easily demonstrated by a view of the uncleared cell contents in some of the thicker portions of the section. The cell contents take the stain more deeply than the cell walls, and occasionally, where a cell has not been cut open by the section, the soda treatment has failed to expel the contents, and these contents then form a distinct dark-colored cast of the cell cavity. This cast is somewhat cigar-shaped and studded with numerous prominent projections, like stout projecting nail heads. These nail heads are evidently the casts of the cell contents filling the pores. And the little circles abounding through the structure are the sections of these pores in various positions, now emptied of their contents.

The spindle cells extend within from the palisade cells at *a* (Figs. 6, 7), through more than one-half of the entire radius of the stone, for a short distance beyond the line *b*. Succeeding this another form of cells will be met. They are very irregular in outline, have the cell walls more thickened than any of the others, and are supplied with an immense number of pores extending in every direction. Although very variable, the majority of them are sub-globular, and hence they may be termed the globular cells. They are most prominent about the position *c* of Fig 7. At last, at *d*, the structure filling the cleft is reached—a mass of brown, thick-walled, but soft polygonal cells.

Fig 8 is an enlarged view of a small portion of the transverse section, corresponding with *a* of Fig. 6. On the right are seen the sections of cells of the seed coats. Next these are the palisade cells, with thickened, smooth, entire walls. Then come the spindle cells, at first having but few pores, but with pores increasing in number as the cells are viewed in succession, until the position *b*, Fig. 6, is reached, where they are very numerous. In a thin portion of the section, as represented in Fig 8, the middle lamella between two adjoining cell walls is plainly seen, showing that pores from adjoining cells meet at, but never pass through, the lamella, which remains as a thin membrane entirely closing each cell. Occasionally an oblique septum will be found in a spindle cell, as in two instances in Fig. 8, like a little disc on a slender shaft. This appearance is caused by the section of a thickened septum, with a pore on either side next the cell wall. Fig. 9 is an enlarged view of a few cells, also from the transverse section, taken near the position *b*. The walls are more thickened, and the pores are far more numerous. Fig. 10 gives an enlarged view of two of the globular cells at the position of *c*, Fig. 7. They are not as globular as usual, but they show the structure well. The surrounding walls are excessively thickened, and the pores are very numerous. This is the most dense portion of the entire internal structure. The appearance of the wall between the two cells, and of the outer wall of the lower cell, is of quite frequent occurrence. The middle lamella is stouter through this dense portion of the endosperm than at other positions, and takes the stain deeply. And the pores sometimes, as in this case, are so frequent and so close together, that the section of the adjoining portions of the cell wall gives the appearance of beads strung on a stout wire. Fig. 11 shows a few of the polygonal cells of the brown substance of the cleft, taken from the last portion of the transverse section at *d*, Fig. 7.

The longitudinal-radial section so closely resembles the transverse section that it would be very difficult to distinguish them if the labels were removed from the respective slides. Therefore the description of one will answer well for the other, showing that the cells of the inner structure are successively prisms, spindles, and irregular globular cavities.

The longitudinal-tangential section presents quite a different appearance. Fig. 12 shows a small portion of such section, taken quite near the surface of the stone, but after several successive slices have been removed. The left-hand portion of the figure represents the outermost layers of the seed coats. First are found long, fusiform, hyaline cells, presenting no marked structure with high magnification. Then succeed still longer, attenuated cells, with much thickened cell walls, minute lumen, and exceedingly abundant capillary canals running from the lumen to the middle lamella, there meeting similar canals from adjoining cells. Fig. 13 gives an enlarged view of three such canal cells. These cells and the succeeding cells of the seed coats do not always lie parallel with the longitudinal axis of the stone. Usually they are longitudinal, but frequently they are disposed in groups, which branch at various angles, until sometimes they are directly transverse, parallel with the smaller circumference of the stone. Next within the canal cells follow large, irregularly elliptical, dark-brown cells, with slightly pitted walls, and usually disposed in two layers. Then follow more dense tissues, of short, fusiform, hyaline, and light-brown polygonal cells, until we come to the outer ends of the palisade cells of the endosperm, and, as the section dips a little deeper, the outer extremities of the spindles are seen as little circles, of various sizes according to the position in which they happen to be cut, and all imbedded in the dense structure of the thickened cell walls. Fig. 14 gives an enlarged view of the cut outer ends of these palisade cells and spindle cells, as they appear in this longitudinal-tangential section.

The hard structure furnished by the thickened walls of this endosperm is said to be pure cellulose. The interesting fact alone remains to be mentioned that the extremity of the seed leaf, remaining in the germinating date-stone, enlarges, dissolves the hard cellulose, and conveys it as nourishment to the growing plantlet, until the entire stone is emptied of its contents. This action, however, although strikingly displayed in this case, is not peculiar to the date-stone alone. It is common in some form to seeds provided with an endosperm, which take up their nourishment in germination from the endosperm by special organs, which are always parts of leaves.

PROCEEDINGS.

Meeting of May 6th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-six persons present.

Dr. Carl Heitzmann was elected a Resident Member of the Society.

On motion the thanks of the Society were tendered Mr. Morris K. Jesup, President of the Board of Trustees of the American Museum of Natural History, for his kindness in granting the use of the Halls of the Museum Building on the occasion of the late Annual Exhibition of the Society; and also to Messrs. Louis P. Gratacap and William Wallace for their invaluable assistance on the same occasion.

Mr. Carlton C. Curtiss read a paper entitled "The Anatomy of the Stem of *Wistaria Sinensis*." This paper is published in full in this volume of the Journal, p. 79, and was illustrated by microscopical sections of the wood of the stem, as indicated below.

OBJECTS EXHIBITED.

1. Transverse section of one-year-old stem of *Wistaria Sinensis*, showing pith, medullary sheath, xylem, phloem, periblem, and dermatogen.

2. Transverse section of the wood, showing transition from duramen to alburnum.

3. Radial section, showing spiral tracheids of medullary sheath.

4. Tangential section, showing wood-elements, tyloses, medullary ray, etc.

5. Tracheids, isolated by Schultze's fluid.

6. Tracheæ, showing halo, canal, and thickening membrane.

7. Transverse section, showing cork, bast, etc.

8. Radial section, showing crystal and resin sacs of bast.

9. Tangential section, showing origin of cambium.

10. Transverse section, showing beginning of anomalous growth.

11. Transverse section, showing growth from cork to bast to wood to bast to wood, illustrating the theory of the paper.

Exhibits 1–11 by Carlton C. Curtiss.

12. Transverse section of stem of *Amphilophium,* and two photomicrographs of the same: by E. G. Love.

Meeting of May 20th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-six persons present.

Mr. George W. Kosmak was elected a Resident Member of the Society.

Mr. William Wales, referring to the letter of Mr. H. R. Spencer, dated Buffalo, N. Y., January 27th, 1891, and published in the Proceedings of the American Society of Microscopists, said that he desired to verify the statement of that letter that Mr. Spencer, Senior, who was the father of the manufacture of microscope objectives in this country, constructed lenses of fluorspar at that time—the summer of 1860. From his personal knowledge he could verify the fact that Mr. Spencer made the said one-eighth objective for Dr. Rufus King Brown, and also a one-quarter objective, of 175° air angle, with perfect color correction, containing a fluorspar lens, for Dr. Louis Tice, which objective is now in the possession of Dr. Charles E. West, of Brooklyn.

The Corresponding Secretary presented a communication, dated May 5th, 1892, from Mr. K. M. Cunningham, of Mobile, Ala., describing seven slides prepared by Mr. Cunningham, and donated by him to the Cabinet of the Society, as follows:

"1. A slide of diatoms from Selma, Ala. The city overlooks a high chalk bluff on Alabama River, and at numerous points on the bluff fresh water constantly trickles down its face. Wherever this is the case there is a streak of living diatoms in constant growth on the chalk. The species associated, as shown on the slide, are as follows: *Synedra fulgens*, *Cymbella cymbiformis*, *Cocconema lanceolatum*, *Navicula parva*, *N. veneta*, *Gomphonema capitatum*, *Nitzschia panduriformis*, *Suriella ovata*, a *Cocconeis*, and two species of *Melosira*.

"2. A slide of silicified coniferous wood, derived from gravel of river drift overlying chalk at Gainesville, Ala. A fine polariscope object.

"3. A slide of fossil marine diatoms, completely pyritized, and which completely dissolve in nitric acid, leaving no structural traces. These diatoms were derived from a stratum of miocene clay encountered at a depth of 700 feet in the third artesian well, recently finished at Mobile. This find of mine corroborates a fact of geological interest, as pyritized diatoms were recently found near the Atlantic seaboard, in artesian borings, at Brentford and Clayton, contiguous to the Delaware River. The diatoms, as mounted, are relucent like gold when examined by surface condensed light, and species of the following genera may be seen: *Coscinodiscus*, *Actinophticus*, *Triceratium*, *Pleurosigma*, *Navicula*, and *Synedra*, indicated by outline and surface depressions, as the specific reticulation is masked by the pyritous deposit.

"4. A slide to place upon record the character of the marine sedimentary silicious deposit from St. Stephens and vicinity, Alabama. This tripoli is one of the strata composing that portion of the tertiary formation known as the buhrstone, which traverses the States of South Carolina, Georgia, Alabama, and Mississippi. On this slide may be seen about 175 selected diatoms, polycistina, and foraminifera, showing their metamorphosed state by mineral infiltration.

"5. A slide showing numerous polycistina from the same sedimentary stratum. On the same slide the crystalline grains show bands of prismatic colors arranged axially. Under polarized light the bands of color waves travel from the periphery to the centre, or *vice versa*, as the polarizer is revolved from right to left, or the reverse, offering a prettier phenomenon than is offered by common silicious sands.

"6. A slide showing two species of foraminifera from Bon Secour Bay, inside Mobile Bay. These shells seem to be built up with minute plates of mica, well marked under polarized light by color contrasts.

"7. A slide showing inclusions in flint. This slide was prepared as follows: Very thin flakes were detached from a flint nodule, put on the slide, and immersed in gelatin. After twenty-four hours the gelatin had dried to a thin pellicular coating, after a manner polishing the flint chips. A drop of balsam was then added and the cover glass put on. The gelatin pellicle prevented the penetration of the balsam, and assisted in retention of air in the various spicular spaces. The slide shows a variety of organic inclusions, and an ink dot marks the spot where three *Xanthidia* are grouped together, and can be easily found with a one-sixth objective. It is nearly as easy to trace out the inclusions when so mounted as it would be with a polished section of flint."

Dr. E. G. Love exhibited on the screen, with appropriate descriptions, projections of 100 lantern slides of photomicrographs of various objects.

Meeting of June 3d, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Sixteen persons present.

Rev. J. L. Zabriskie read a paper entitled "Notes on the Structure of the Fruit-stone of the Date, *Phœnix dactylifera* L.," published in this volume of the Journal, p. 107, and illustrated by diagrams and microscopical preparations, as noted below.

OBJECTS EXHIBITED.

1. Sections of Cementstone from Sandai, Japan, prepared from material donated to the Society by Mr. K. M. Cunningham: by James Walker.

2. Section from fossiliferous Chert, prepared from material donated to the Society by Mr. Cunningham from St. Stephens, Ala., of concretionary structure, and a replacement of some fossil forms of Chalcedony: by James Walker.

3. Transverse section of the Fruit-stone of the Date, *Phœnix dactylifera* L.

4. Longitudinal-radial section of the same.

5. Longitudinal-tangential section of the same.

6. Transverse section of the same, showing the embryo *in situ*.

Exhibits 3–6 by J. L. ZABRISKIE.

Mr. James Walker donated to the Cabinet of the Society the two slides donated by him, as stated above.

MEETING OF JUNE 17TH, 1892.

In the absence of the President and Vice-President, Rev. J. L. Zabriskie was elected chairman.

Twelve persons present.

The Corresponding Secretary presented a paper by Dr. Alfred C. Stokes, entitled "A Note on a variety of *Salpingœca gracilis* J.-Clk." This paper was illustrated by beautiful drawings, and is published in this volume of the JOURNAL, p. 101.

OBJECTS EXHIBITED.

1. *Nitella*, showing unusually fine circulation.
2. *Melicerta ringens.*
3. A colony of *Limnias ceratophylli.*
4. Larva of *Dytiscus marginalis*, young.

Exhibits 1–4 by STEPHEN HELM.

5. Section of fossil Coral from Chautauqua, N. Y.: by JAMES WALKER.

PUBLICATIONS RECEIVED.

The American Monthly MicroscopicalJournal: Vol. XIII., Nos. 6—8 (June—August, 1892).

The Microscope: Vol. XII., Nos. 6—8 (June—August, 1892).

School of Mines Quarterly: Vol. XIII., No. 4 (July, 1892).

Bulletin of the Torrey Botanical Club: Vol. XIX., Nos. 7, 8 (July, August, 1892).

Missouri Botanical Garden: Third Annual Report (1892).

Anthony's Photographic Bulletin: Vol. XXIII., Nos. 11—16 (June 11—August 27, 1892).

The Observer: Vol. III., Nos. 1—8 (January—August, 1892).

Insect Life: Vol. IV., Nos. 9—12 (June—August, 1892).

Psyche: Vol. VI., Nos. 195, 196 (July, August, 1892).

Cornell University Experiment Station: Bulletins 38—41 (June—August, 1892).

Natural Science Association of Staten Island: Proceedings (June, 1892).

San Francisco Microscopical Society; Proceedings: Meetings of May 4—August 17, 1892).

Massachusetts Horticultural Society; Transactions: Part 1, 1892.

Bulletin of the Essex Institute: Vol. XXIV., Nos. 1—3 (January—March, 1892).

New York Academy of Sciences; Transactions: Vol. XI., Nos. 3—5, (1892).

American Academy of Arts and Sciences; Proceedings: Vol. XXVI. (1892).

American Museum of Natural History: Annual Report (1892).

Michigan Flora: From the authors, W. J. Beal and C. F. Wheeler (1892).

United States Department of Agriculture: Division of Vegetable Pathology, Bulletin 1 (1891); Report of the Microscopist (1892).

The Ottawa Naturalist: Vol. VI., Nos. 3, 4 (July, August, 1892).

Canadian Institute: Transactions, Vol. IV., Part 2 (April, 1892): Annual Archæological Report (1892): Appeal on the Rectification of Parliament (1892).

The Nova Scotia Institute of Science: Proceedings; Vol. I., Part 1 (1891).

Journal of the Royal Microscopical Society: Parts 3, 4 (June—August, 1892): Charter, By-Laws, and List of Fellows (1892).

International Journal of Microscopy and Natural Science: Vol. II., Part 15 (July, 1892).

Manchester Microscopical Society: Transactions and Annual Report (1891).

Journal of the Quekett Microscopical Club: Vol. V., No. 31 (July, 1892).

The Naturalist: Nos. 203, 205 (June—August, 1892).

Royal Society of New South Wales; Journal and Proceedings: Vol. XXV. (1891).

The Victorian Naturalist: Vol. IX., No. 1 (May, 1892).

Records of the Australian Museum: Vol. II., No. 1 (April, 1892).

Annual of the Universal Medical Sciences: Vols. I—V. (1892).

The Satellite: Vol. V., Nos. 11, 12 (July, August, 1892).

The Hahnemannian Monthly: Vol. XXVII., Nos. 7—9 (July—September, 1892).

Indiana Medical Journal: Vol. XI., Nos. 1—2 (July—August, 1892).

Brooklyn Medical Journal: Vol. VI., Nos. 7—9 (July—September, 1892).

Johns Hopkins University Circulars: Vol. XI., No. 100 (July, 1892).

Le Diatomiste: No. 9 (June, 1892).

Revue Internationale de Bibliographie Médicale: Vol. XIII., Nos. 11—13 (June 10—July 10, 1892).

American Lancet: Vol. XVI., Nos. 7, 8 (July, August, 1892).

National Druggist: Vol. XX., No. 12—Vol. XXI., Nos. 1—4 (June 15—August 15, 1892).

Mining and Scientific Review: Vol. XXVIII., No. 23—Vol. XXIX., No. 8 (June 9—August 25, 1892).

Weekly Bulletin: Vol. I., No. 47—Vol. II., No. 58 (June 11—August 27, 1892).

Bulletin de la Société Belge de Microscopie: Vol. XVIII., Nos. 6, 7 (1892).

Bulletin de la Société Royale de Botanique de Belgique: Vol. XXX., Parts 2 (1891); Vol. XXXI., Parts 1, 2 (1892).

Bulletin de la Société d'Etudes Scientifiques d'Angers: Vol XX (1892).

Mémoires de la Société Nationale des Sciences Naturelles de Cherbourg: Vol. VII., No. 3 (1891).

Académie d'Hippone: Comptes Rendus (1891).

Gesellschaft der Naturwissenschaften zu Marburg: Sitzungsberichte (1891).

Jahresbericht der Naturhistorischen Gesellschaft zu Hannover: Vols. XL., XLI. (1892).

Wissenschaftlicher Club in Wien: Monatsblätter; Vol. XIII., Nos. 9, 10 (June, July, 1892): Ausserordentliche Beilage; Vol. XIII., Nos. 3, 4 (1892).

Bollettino della Società Africana d'Italia: Vol. XI., Nos. 3—6 (March—June, 1892).

Bollettino della Società Botanico Italiano: Nos. 5, 6 (1892).

La Nuovo Notarisia: Vol. III. (July, 1892).

Nuovo Giornale Botanico Italiana: Vol. XXIV., No. 3 (July, 1892).

Bulletin de la Société Impériale des Naturalistes de Moscou: Nos. 1—4, (1892).

Memorias de la Sociedad Cientifica "Antonio Alzate": Vol. V., Nos. 7—12 (1892).

Revista del Museo de la Plata: Vol. II. (1891).

INDEX TO VOLUME VIII.