PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

VOLUME V.

FEBRUARY 11, 1888, TO JANUARY 10, 1890.

WASHINGTON:
PRINTED FOR THE SOCIETY.
1890

PUBLICATION COMMITTEE.

R. E. C. STEARNS, *Chairman.*

FREDERIC A. LUCAS,	L. O. HOWARD,
RICHARD RATHBUN,	FRANK H. KNOWLTON

CONTENTS.

Addresses and Communications:

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*Author's separates of the papers especially enumerated were published on the dates given in the parentheses following the author's name.

LIST OF THE OFFICERS AND COUNCIL

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

Elected January 12, 1889.

OFFICERS.

PRESIDENT.

LESTER F. WARD.

VICE-PRESIDENTS.

CHARLES V. RILEY,
FRANK BAKER,
RICHARD RATHBUN,
C. HART MERRIAM.

SECRETARIES.

JOHN B. SMITH,[*]
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TREASURER.

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RICHARD RATHBUN,
CHARLES V. RILEY,
JOHN B. SMITH,
R. E. C. STEARNS,
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CHAS. D. WALCOTT,
CHARLES A. WHITE,[†]
GEORGE VASEY.

STANDING COMMITTEES—1889.

Committee on Communications.

FREDERIC A. LUCAS, *Chairman.*

L. O HOWARD.
CHAS. D. WALCOTT.

Committee on Publications.

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FRANK H. KNOWLTON.

Committee on Trees and Shrubs of Washington.

LESTER F. WARD, *Chairman.*

WILLIAM MITH,
GEORGE VASEY.
FRANK H. KNOWLTON,
F. LAMSON SCRIBNER.

Members of Joint Commission.

LESTER F. WARD,
C. HART MERRIAM,
RICHARD RATHBUN,

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[*] Mr. Smith resigned his office in February and Mr. L. O. Howard was elected by the Council to fill the vacancy.

[†] Ex-Presidents of the Society.

LIST OF THE OFFICERS AND COUNCIL
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON.

Elected January 10, 1890.

OFFICERS.

PRESIDENT.

LESTER F. WARD.

VICE-PRESIDENTS.

CHARLES V. RILEY,
C. HART MERRIAM,
FRANK BAKER,
RICHARD RATHBUN.

SECRETARIES.

L. O. HOWARD,
FREDERIC A. LUCAS.

TREASURER.

FRANK H. KNOWLTON.

COUNCIL.

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G. BROWN GOODE,*
L. O. HOWARD,
FRANK H. KNOWLTON,
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C. HART MERRIAM,
RICHARD RATHBUN,
CHARLES V. RILEY,
R. E. C STEARNS,
FREDERICK W. TRUE,
CHAS. D WALCOTT,
CHARLES. A. WHITE,*
GEORGE VASEY.

STANDING COMMITTEES—1890.

Committee on Communications.

FREDERIC A. LUCAS, *Chairman.*

L. O. HOWARD,
CHAS. D. WALCOTT.

Committee on Publications.

R. E. C. STEARNS, *Chairman.*

FREDERIC A. LUCAS,
RICHARD RATHBUN,
L. O. HOWARD,
FRANK H. KNOWLTON.

Committee on Trees and Shrubs of Washington.

LESTER F. WARD, *Chairman.*

WILLIAM SMITH,
GEORGE VASEY,
FRANK H. KNOWLTON,
THEODORE HOLM.

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* Ex-Presidents of the Society.

JOINT COMMISSION OF THE SCIENTIFIC SOCIETIES OF WASHINGTON.

The following gentlemen represent for the year, 1890, their respective Societies upon the Joint Commission formed in February, 1888.

Anthropological Society	Dr. Robert Fletcher, Washington Mathews, Col. Garrick Mallery.
Biological Society	Lester F. Ward, C. Hart Merriam, R. Rathbun,
Chemical Society	Dr. C. A. Crampton. F. W. Clarke, H. W. Wiley.
Geographic Society	G. G. Hubbard, Henry Gannett, Everett Hayden.
Philosophical Society	Capt. C. E. Dutton, W. C. Winlock, Marcus Baker.

PROCEEDINGS.

One Hundred and Twenty-first Meeting,
February 11, 1888.

The President in the chair, and twenty-two members present.

The President announced the death of Dr. Asa Gray, of Cambridge, and of Mr. G. W. Tryon, of Philadelphia.

Dr. C. Hart Merriam presented a communication entitled A New Fox from California.[*] Discussed by Mr. Ward and Mr. Fernow.

Mr. Robert T. Hill read a paper on The Variations of Exogyra costata, and a second paper entitled Gryphea pitcheri. Discussed by Dr. Dall.

Prof. C. V. Riley read a communication on The Insectivorous Habits of the English Sparrow.[†] Discussed by Mr. Fernow and Mr. Hallock.

A paper by Dr. Theodore Gill—The Characters of the Family Elacatidæ[‡]—was read by Dr. T. H. Bean.

One Hundred and Twenty-second Meeting,
February 25, 1888.

Vice-President Ward in the chair, and thirty-four members present.

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[*] 1888. Merriam, C. Hart. Description of a new Fox from Southern California [*Vulpes macrotis*] Proc. Biol. Soc. Washn., Vol. iv, pp. 135–138.

[†] 1889. Riley, C. V. The Insectivorous Habits of the English Sparrow. Bulletin No. 1. Division of Ornithology, U. S. Dept. Agric., pp. 111–133. Issued June 24, 1889.

[‡] 1888. Gill, Theodore. The Characteristics of the Elacatids Proc. U. S. Nat. Mus., Vol. x, 612–614, 1887, pl. xxxix. Issued Sept. 19, 1888.

Mr. F. W. True read a paper on the CHANGES IN THE CATALOGUES OF AMERICAN MAMMALS SINCE 1877.

On motion of Mr. Goode, Mr. True was requested to complete the review for presentation at a future meeting,

Dr. T. H. Bean presented a paper entitled DISTRIBUTION AND SOME CHARACTERS OF OUR SALMONIDÆ.* Discussed by Dr. Vasey, Dr. Merriam, and Messrs. Goode, Cope, and True.

Dr. Cooper Curtice read a paper on SOME EARLY STAGES IN THE LIFE HISTORY OF TÆNIA PECTINATA.† Discussed by a number of members, among them Messrs. True, Cope, Riley, Mason, Goode, Howard, Merriam, and VanDeman.

ONE HUNDRED AND TWENTY-THIRD MEETING,
March 10, 1888.

The President in the chair, and thirty-five members present.

Mr. F. W. True completed his review of the CHANGES IN THE CATALOGUES OF NORTH AMERICAN MAMMALS SINCE 1877. Discussed by Messrs. Goode, Dall, and Merriam.

Dr. Theodore Gill presented a review of THE CLASSIFICATION OF THE COTTOIDEOUS FISHES.‡

Dr. George Vasey read a paper on the FOREIGN TREES AND SHRUBS CULTIVATED IN THE DISTRICT OF COLUMBIA. Discussed by Messrs. True, Vasey, Riley, Stejneger, and VanDeman.

Dr. C. H. Merriam read a DESCRIPTION OF A NEW SPECIES OF AMERICAN SKUNK.

ONE HUNDRED AND TWENTY-FOURTH MEETING,
March 24, 1888.

Vice-President Riley in the chair, and thirty-three members present.

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* 1888. American Naturalist, April.

† 1888. The Life History of *Tænia pectinata* Science, Vol. xi, p. 137, March 23, 1888.

‡ 1889. Proc. U. S. Nat. Mus.

Dr. Cooper Curtice read a paper on TÆNIA FIMBRIATA, A NEW PARASITE OF SHEEP.*

Mr. Charles Hallock presented a paper entitled THE REVERSION OF DOMESTICATED ANIMALS TO A WILD STATE. Discussed by Dr. Merriam, Prof. Cope, Dr. Curtice, and Mr. VanDeman.

ONE HUNDRED AND TWENTY-FIFTH MEETING.

April 7, 1888.

The President in the chair, and thirty-nine members present.

The President announced that the Council recommend that the Society participate in the joint commission of the scientific societies of Washington, and, upon motion, it was resolved that the Society adopt the recommendation of the Council.

The President appointed Messrs. Richard Rathbun and C. Hart Merriam to act with himself as commissioners from the Biological Society.

Captain J. W. Collins read a paper entitled THE WORK OF THE SCHOONER GRAMPUS IN FISH CULTURE.†

Mr. Chas. D. Walcott presented a communication on CAMBRIAN FOSSILS FROM MOUNT STEPHENS, N. W. TERRITORY OF CANADA.‡

Prof. C. V. Riley gave SOME NOTES FROM EMIN PASHA'S TRAVELS IN CENTRAL AFRICA.

Dr. Theobald Smith presented a paper on THE DESTRUCTION OF PATHOGENIC BACTERIA IN THE ANIMAL ORGANISM. Discussed by Dr. Salmon.

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* 1888. *Tænia fimbriata*; The Tape-worm in Sheep. Science, Vol. xi, p. 261, June 1, 1888.

Also, Rept. Bureau Animal Industry, Dept. Agric., 1887–1888, pp. 167–187, plate.

† 1888. Forest and Stream, May 10.

‡ 1888. Am. Journ. Sci., Vol. 36, pp. 161–166.

ONE HUNDRED AND TWENTY-SIXTH MEETING.

April 21, 1888.

The President in the chair, and thirty-five members present.

Mr. F. W. True read a communication on THE AFFINITIES OF THE WHITE WHALE. Discussed by Dr. Merriam and Dr. Dall.

Dr. C. Hart Merriam presented notes on A BAT NEW TO THE UNITED STATES, AND NEW LOCALITIES FOR OTHER NORTH AMERICAN MAMMALS. Discussed by Mr. True.

Prof. C. V. Riley read a paper entitled NOTES ON PLATYPSYLLUS.* Discussed by Mr. Dall.

Dr. Geo. Vasey read Part II of his paper on FOREIGN TREES AND SHRUBS CULTIVATED IN THE DISTRICT OF COLUMBIA. Discussed by Messrs. VanDeman, Ward, and Riley.

ONE HUNDRED AND TWENTY-SEVENTH MEETING,

May 5, 1888.

The President in the chair, and twenty-two members present.

Dr. R. E. C. Stearns read a paper on INSTANCES OF MUTATION IN SPECIFIC DISTRIBUTION AMONG SHELLS. Discussed by Mr. Lucas.

Mr. C. L. Hopkins presented NOTES UPON POLLENATION OF THE NAVEL ORANGES. Discussed by Messrs. Ward, VanDeman, Alwood and Dall.

Dr. C. Hart Merriam read A DESCRIPTION OF A NEW MEADOW MOUSE WITH REMARKS ON THE SUB-GENUS PEDOMYS.† Discussed by Mr. True.

Prof. L. F. Ward presented a communication entitled ON SOME CHARACTERISTICS OF THE FLORA OF THE POTOMAC FORMATION.

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* 1889. Insect Life, Vol. I, p. 300.

† 1888. Merriam, C. Hart. Description of a new Prairie Meadow Mouse (*Arvicola austerus minor*) from Dakota and Minnesota Am. Nat., July, 1888, 598–601, figs. of skull and teeth.

One Hundred and Twenty-eighth Meeting,
May 19, 1888.

The President in the chair, and twenty-two members present.

Mr. F. W. True read some Notes on the Hawaiian Bat. Discussed by Mr. Stejneger.

Mr. W. T. Hornaday read a paper on Man-eating Crocodiles.

Dr. C. Hart Merriam presented notes on The North American Kangaroo-rats belonging to the genus Dipodomys. Discussed by Mr. True, Prof. Cope, and Prof. Riley.

Mr. F. A. Lucas read a paper on The Affinities of Chamæa. Discussed by Mr. Stejneger.

One Hundred and Twenty-ninth Meeting,
June 2, 1888.

The President in the chair, and twenty-four members present.

Mr. F. H. Knowlton read a paper on The Fossil Wood of the Yellowstone National Park. Discussed by Messrs. Ward, Gill, Merriam, and Rathbun.

Mr. W. B. Alwood presented a paper on The Artificial Pollenation of Wheat.

Mr. F. A. Lucas noted Some Abnormalities in the Ribs of Birds.* Discussed by Dr. Gill.

One Hundred and Thirtieth Meeting,
October 20, 1888.

The President in the chair, and twenty-nine members present.

Mr. L. O. Howard exhibited and explained An Apparatus for the Study of Underground Insects and Plant Roots. Discussed by Dr. Merriam and Mr. Ward.

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* 1888. The Auk, July.

Mr. Lester F. Ward read a paper on THE KING DEVIL.* Discussed by Dr. Merriam and Messrs. Seaman and Ulke.

Mr. Jno. B. Smith read a paper entitled SOME REMARKS ON SEXUAL CHARACTERS IN LACHNOSTERNA.† Discussed by Messrs. Ward, Ulke, and Mann.

Dr. Theodore Gill gave a review of THE FAMILIES OF FISHES. Discussed by Messrs. Ward, Mann, Stejneger, Dall, and Fernow.

ONE HUNDRED AND THIRTY-FIRST MEETING,

November 3, 1888.

The President in the chair, and twenty-one members present.

Mr. F. H. Knowlton presented a paper on FOSSIL WOOD AND LIGNITES OF THE POTOMAC FORMATION.‡

Mr. W. H. Dall read a paper entitled THE MODIFICATIONS OF THE GILL IN UNIVALVE MOLLUSKS.§

Dr. Theodore Gill described THE CHARACTERISTICS OF THE FAMILY SCATOPHAGIDÆ.

Dr. C. Hart Merriam described A NEW SPECIES OF ARVICOLA FROM THE BLACK HILLS OF DAKOTA.||

ONE HUNDRED AND THIRTY-SECOND MEETING.

November 17, 1888.

The President in the chair, and forty persons present.

Mr. Lester F. Ward read a paper on A COMPREHENSIVE

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* 1889. Botanical Gazette, Vol. XIV, pp. 10–17, January.

† 1888. Insect Life, Vol. I, p. 180, December.

‡ 1888. The American Geologist, Vol. III, No. 2. pp. 99–106.

§ 1889. Results incorporated in Report on Blake Gasteropods, Bull. Mus. Comp. Zool., Vol. XVIII.

|| 1888. Merriam, C. Hart. Description of a New Species of Meadow Mouse [*Arvicola longicauda*] from the Black Hills of Dakota <Am. Nat., Oct. 1888, 934–935, figs. of teeth.

TYPE OF FOSSIL CRYPTOGAMIC LIFE FROM THE FORT UNION GROUPS.*

Dr. Cooper Curtice described the SEXUAL DIFFERENCES IN TRICOCEPHALI.

ONE HUNDRED AND THIRTY-THIRD MEETING,

December 1, 1888.

Vice-President Ward in the Chair, and twenty-eight persons present.

Dr. Gill read a paper ON THE RELATIONS OF THE PSYCHROLUTIDÆ.†

Dr. C. Hart Merriam gave a description of A NEW GROUND SQUIRREL FROM CALIFORNIA.‡ Discussed by Prof. Riley and Mr. True.

Mr. F. W. True made some REMARKS ON THE DEER OF CENTRAL AMERICA.§ Discussed by Dr. Merriam.

Prof. C. V. Riley read a paper entitled NOTES ON THE ECONOMY OF THALESSA AND TREMEX.||

Mr. B. E. Fernow discussed THE CAUSES OF CONFIGURATION OF TREES. Discussed by Prof. Riley and Mr. Ward.

ONE HUNDRED AND THIRTY-FOURTH MEETING.

December 15, 1888

Vice-President Ward in the chair, and twenty-nine persons present.

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* 1888. Abstract in Proc. Am. Ass. Adv. Sci. Vol. XXXVII, pp. 199–201.

† 1888. Proc. U. S. Nat. Mus.

‡ 1888. Merriam C. Hart. Description of a new Spermophile from California. (*Spermophilus beldingi*). <Annals N. Y. Acad. Sci. IV, 317–321, fig. skull. Separates issued December.

§ 1888. Proc. U. S. Nat. Mus., pp. 417–424.

|| 1888. Insect Life, Vol. I, p. 168.

Mr. L. F. Ward read a paper on FORTUITOUS VARIATION AS ILLUSTRATED BY THE GENUS EUPATORIUM, WITH EXHIBITION OF SPECIMENS.* Discussed by Dr. Merriam, Mr. Goode, Prof. Riley, and by Messrs. Stejneger, Vasey, Mann, and Seaman.

Prof. Riley read a NOTE ON A HUMAN PARASITE.

Mr. E. S. Burgess presented a paper on the discovery of ASTER SHORTII NEAR WASHINGTON. Discussed by Dr. Vasey.

ONE HUNDRED AND THIRTY-FIFTH MEETING,
December 29, 1888.

Vice-President Merriam in the chair, and forty-nine members present.

Dr. Theobald Smith read a paper on CONTAGION AND INFECTION FROM A BIOLOGICAL STANDPOINT. Discussed by Dr. Prentiss and Dr. Schaeffer.

Mr. F. A. Lucas presented some NOTES ON THE DISEASES OF MENAGERIE ANIMALS. Discussed by Dr. Merriam, Dr. Salmon, Prof. Atwater, and Messrs. Goode, Hornaday, and True.

Mr. Th. Holm read NOTES ON HYDROCOTYLE AMERICANA.†

ONE HUNDRED AND THIRTY-SIXTH MEETING,
January 12, 1889.

(Ninth Annual Meeting.)

The President in the chair, and forty members present.

The following amendment to the Constitution was proposed by the President :

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* 1889. Abstract in Nature (London), July 25, p. 310.

† 1889. Proc. U. S. Nat. Mus., xi, pp. 455-462, Plates xlvi, xlvii.

In Article X, first line, substitute for "two," the word "three," so that the phrase shall read "*the annual fee* [shall be] *three dollars*."

The annual reports of the Secretary and Treasurer were read and accepted.

The following board of officers was elected for the ensuing year:

President—Lester F. Ward.

Vice-Presidents—Prof. C. V. Riley, Richard Rathbun, Dr. C. Hart Merriam, and Dr. Frank Baker.

Secretaries—F. A. Lucas, Jno. B. Smith.

Treasurer—F. H. Knowlton.

Additional Members of the Council—Dr. T. H. Bean, Dr. R. E. C. Stearns, F. W. True, Dr. Geo. Vasey, C. D. Walcott.

One Hundred and Thirty-seventh Meeting,
January 26, 1889.

The President in the chair, and twenty-seven persons present.

Dr. Cooper Curtice read a paper On the Sheep Tick—Melophagus ovinus Linn.[*] Discussed by Prof. Riley, Mr. Howard, and Dr. Merriam.

Dr. George Vasey gave some notes on New Species of North American Gramineæ of the last twelve years. Discussed by Mr. Ward.

Mr. Th. Holm presented a communication entitled Contributions to the Morphology of the Genus Carex. Discussed by Dr. Vasey, and Messrs. Ward, Coville, and Mann.

Dr. C. Hart Merriam called attention to A New Species of Pika (Lagomys).[†] Discussed by Mr. Knowlton.

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[*] 1890 (?). In process of publication in Bull.—, Bureau Animal Industry, U. S. Dept. Agric.

[†] 1889. Merriam, C. Hart. Description of a New Species of Pika (*Lagomys schisticeps*) from the Sierra Nevada Mountains in California. <North American Fauna, No. 2, Oct. 1889, 11–13, pl. viii, figs. 1–6 (skull).

ONE HUNDRED AND THIRTY-EIGHTH MEETING,

February 9, 1889.

The President in the chair, and thirty-seven persons present.

The amendment to the constitution proposed at the annual meeting was brought up for discussion and adopted.

Mr. B. T. Galloway described A DISEASE OF THE SYCAMORE.* Discussed by Mr. Crozier and Dr. Vasey.

Dr. Thomas Taylor exhibited and Described A NEW FREEZING MICROTOME.†. Discussed by Dr. Th. Smith.

Mr. A. A. Crozier discussed THE INFLUENCE OF FOREIGN POLLEN ON FRUIT. Discussed by Prof. Riley, and Messrs. Seaman and Hopkins.

Mr. J. N. Rose read a paper on THE GEOGRAPHICAL DISTRIBUTION OF THE UMBELLIFERÆ.‡ Discussed by Dr. Merriam.

Dr. C. Hart Merriam gave a description of A NEW AND REMARKABLE VOLE FROM BRITISH COLUMBIA.§ Discussed by Mr. True.

ONE HUNDRED AND THIRTY-NINTH MEETING,

February 23, 1889.

The President in the chair, and twenty-six persons present.

The President announced that the council had elected Mr. L. O. Howard recording secretary in place of Jno. B. Smith resigned.

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* 1888. Reproduced in a paper by Miss E. A. Southworth in Ann. Rept. Dept. Agr.

† 1888. Science, Dec. 21.

‡ 1888. Coulter and Rose. Revision of the N. A. Umbelliferæ. < Herbarium of Wabash College, December.

§ 1889. Merriam, C. Hart. [Included in] Description of a new Genus (*Phenacomys*), and four new Species of Arvicolinæ. < N. Am. Fauna, No. 2, Oct., 1889, 27–35 pls. ii iii, iv, vi, and vii.

Mr. E. M. Hasbrouck gave a communication entitled A NEW SPECIES OF MARYLAND YELLOW-THROAT. Discussed by Dr. Merriam.

Mr. M. B. Waite read two short papers under the titles NOTES ON MELAMPSORA HYDRANGEÆ AND NOTES ON THE SEED-VESSELS OF THE LOP-REED, PHRYNE LEPTOSTACHYA. Discussed by Mr. Ward.

Mr. C. D. Walcott gave a note ON THE GENUS OLENOIDES OF MEEK.* Discussed by Mr. Ward.

Mr. L. Stejneger presented some NOTES ON PALLAS' CORMORANT.† Discussed by Mr. Lucas.

Mr. F. V. Coville read a paper entitled THE FRUIT OF STIPA SPARTEA. Discussed by Dr. Curtice and Mr. Waite.

Dr. Merriam exhibited specimens of a new species of Ground Hog or Marmot of the genus *Arctomys*.‡

ONE HUNDRED AND FORTIETH MEETING,

March 9, 1889.

The President in the chair, and thirty-four persons present.

Prof. W. B. Barrows read a paper on DANGEROUS SEED-PLANTING BY THE CROW. Discussed by Drs. Merriam and Vasey, and Messrs. Seaman, True, Ward, and Howard.

Dr. C. Hart Merriam described A NEW SPECIES OF GROUND SQUIRREL FROM WESTERN ARIZONA.§

Mr. C. D. Walcott presented a communication entitled THE GENUS OLENELLUS OF HALL.||

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* 1888. Proc. U. S. Nat. Mus., p. 442.

† 1889. Proc. U. S. Nat. Mus.

‡ 1889. Merriam, C. Hart. Description of a New Marmot [*Arctomys dacota*] from the Black Hills of Dakota. < N. Am. Fauna, No. 2, Oct. 1889, 7–9, pl. viii, figs 7 and 8.

§ 1889. Merriam, C. Hart. Description of a new Species of Ground Squirrel [*Tamias leucurus*] from the arid lands of the Southwest <N. Am. Fauna, No. 2, Oct., 1889, 19–21.

|| To be published in 10th Ann. Rept. U. S. Geol. Surv.

ONE HUNDRED AND FORTY-FIRST MEETING,
March 23, 1889.

The President in the chair, and thirty-four persons present.

Mr. W. H. Seaman read a paper on OUR PRESENT KNOWLEDGE OF THE ROTIFERA. Discussed by Mr. Knowlton.

Mr. C. L. Hopkins presented A POINT OF DEFINITION relative to the use of the terms *hybrid* and *cross*.

Mr. W. H. Dall described THE REPRODUCTIVE ORGANS IN CERTAIN FORMS OF GASTEROPODA.*

ONE HUNDRED AND FORTY-SECOND MEETING,
April 6, 1889.

The President in the chair, and fifteen members present.

On account of the small attendance and the absence of paper-readers (due to very inclement weather), the program was postponed until the following meeting.

ONE HUNDRED AND FORTY-THIRD MEETING,
April 20, 1889.

The President in the chair, and twenty-one members present.

The death of Dr. J. H. Kidder, an active member of the Society was announced by the President.

Mr. J. F. James presented a paper entitled THE EFFECT OF RAIN UPON EARTH-WORMS.† Discussed by Drs. Merriam and W. H. Fox, and Messrs. True and Ward.

Mr. F. W. True read a paper on the OCCURRENCE OF SOWERBY'S WHALE ON THE COAST OF NEW JERSEY. Discussed by Drs. Merriam and Curtice.

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*1889. Incorporated in Report on Blake Gasteropoda, Bull. Mus Comp. Zool., Cambridge, Mass., Vol. XVIII.

† 1889. Am. Nat., August. Issued Dec. 15, 1889

Dr. C. Hart Merriam described A NEW GENUS AND TWO NEW SPECIES OF LEMMING MOUSE OR VOLE FROM BRITISH AMERICA.* (*Phenacomys celatus and P. latimanus*). Discussed by Mr. True.

Mr. Th. Holm spoke on THE GERMINATION OF SARRACENIA, RHEUM, PELTANDRA, HEMEROCALLIS, AND CYPERUS. Discussed by Mr. Ward.

ONE HUNDRED AND FORTY-FOURTH MEETING,

May 4, 1889.

The President in the chair, and twenty-eight members present.

Mr. W. T. Hornaday exhibited and discussed a living specimen of THE BLACK-FOOTED FERRET (*Putorius nigripes*. Discussed by Dr. Merriam.

Mr. B. E. Fernow read a paper on ANNUAL RING-GROWTH IN TREES. Discussed by Dr. Vasey, and Messrs. Vandeman, Ward, and True.

Dr. Theobald Smith presented a communication on PARASITIC PROTOZOA (*Coccidia*) IN THE RENAL EPITHELIUM OF THE MOUSE.† Discussed by Drs. Baker and Curtice.

Mr. H. E. VanDeman described THE TROPICAL FRUITS OF THE LAKE WORTH REGION.

ONE HUNDRED AND FORTY-FIFTH MEETING,

May 18, 1889.

The President in the chair, and thirty-one members present.

Dr. C. Hart Merriam described TWO NEW SPECIES OF SPERMOPHILE FROM THE DESERTS BORDERING THE LOWER

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* 1889. Merriam, C. Hart. Description of *Phenacomys celatus*. N. Am. Fauna, No. 2, Oct. 1889, 33–34.

† 1889. Journal. Comp. Med. and Surg. July.

COLORADO RIVER IN CALIFORNIA AND ARIZONA. (*Spermophilus mohavensis* and *S. neglectus*).* Discussed by Mr. True.

Dr. Cooper Curtice presented a paper entitled HOW ENTOZOA CAUSE DISEASE. Discussed by Mr. Seaman, and Dr. Th. Smith.

Mr. F. W. True exhibited and discussed A SKULL OF A FEMALE NARWHAL WITH TWO WELL-DEVELOPED TUSKS. Discussed by Drs. Curtice, Merriam, Gill, and Messrs. Ward, True, and Murdoch.

Mr. L. O. Howard presented NOTES ON SPIDER BITES.† Discussed by Drs. Merriam, Fletcher, Smith, Marx, and Fox.

ONE HUNDRED AND FORTY-SIXTH MEETING,

June 1, 1889.

The President in the chair, and thirty members present.

Dr. C. Hart Merriam presented A REVISION OF THE GRASSHOPPER MICE AND POCKET MICE WITH DESCRIPTIONS OF NEW SPECIES.‡ Discussed by Mr. True.

Mr. C. D. Walcott read a paper entitled DESCRIPTIONS OF NEW GENERA AND SPECIES OF LOWER CAMBRIAN FOSSILS.§

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* 1889. Merriam, C. Hart. Description of a new Spermophile from Southern California [*Spermophilus mohavensis*]. N. Am. Fauna, No. 2, Oct. 1889, 15–16.

1889. Merriam, C. Hart. Description of a new Spermophile from Northwestern Arizona [*Spermophilus neglectus*]. N. Am. Fauna, No. 2, Oct. 1889, 17.

† 1888. Insect Life, Vol. I, p. 347.

‡ 1889. Merriam C. Hart. Descriptions of two new species and one new subspecies of Grasshopper Mouse, with a diagnosis of the genus Onychomys, and a synopsis of the species and subspecies. N. Am. Fauna, No. 2, Oct. 1889, 1–5, pl. I and figs. in text.

1889. Merriam C. Hart. Preliminary Revision of the N. A. Pocket Mice (Genera *Perognathus et Cricetodipus* Auct.) with descriptions of new species and subspecies and a key to the known forms. N. Am. Fauna, No. 1, Oct. 1889, 1–29, pl. I–IV.

§ 1889. Proc. U. S. Nat. Mus. Vol. 12, pp. 34–46.

Mr. J. F. James read a paper on THE FLORAS OF SOUTHERN OHIO AND EASTERN MARYLAND. Discussed by Messrs. Dall, Gill, Fernow, Merriam, and Ward.

Mr. V. A. Moore presented some NOTES ON THE MORPHOLOGY OF PODOPHYLLUM PELTATUM.

ONE HUNDRED AND FORTY-SEVENTH MEETING,
October 19, 1889.

The President in the chair, and twenty-four members present.

Dr. C. Hart Merriam described A NEW SPERMOPHILE FROM THE PAINTED DESERT, ARIZONA.

Mr. Th. Holm presented a paper on the ANCESTORS OF LIRIODENDRON TULIPIFERÆ. Discussed by Dr. Vasey, and Messrs. C. D. White, and Ward.

Dr. Theodore Gill spoke ON THE DACTYLOPTEROIDEA.

ONE HUNDRED AND FORTY-EIGHTH MEETING,
November 2, 1889.

The President in the chair, and twenty-seven members present.

Prof. C. V. Riley read a paper on THE REMARKABLE INCREASE OF VEDALIA CARDINALIS IN CALIFORNIA.

Dr. W. H. Dall read NOTES ON THE GENUS GEMMA, DESHAYES.

Dr. George Marx read a paper entitled A NEW SPIDER AND ITS INFLUENCE ON CLASSIFICATION.

Dr. C. Hart Merriam presented a communication entitled REMARKS ON THE SPOTTED SKUNKS (GENUS SPILOGALE) WITH DESCRIPTIONS OF NEW SPECIES. Discussed by Mr. True and Dr. Gill.

ONE HUNDRED AND FORTY-NINTH MEETING,

November 16, 1889.

(Postponed Ninth Anniversary Meeting.)

The ninth anniversary meeting (postponed from its regular date on account of Mr. Dall's illness) was held in the law lecture hall of Columbian University, Nov. 16, 1889. A large audience of members and guests was present.

The former President, Mr. W. H. Dall, delivered an address entitled DEEP SEA MOLLUSKS AND THE CONDITIONS UNDER WHICH THEY LIVE.*

ONE HUNDRED AND FIFTIETH MEETING,

November 30, 1889.

The President in the chair, and thirty-eight members present.

Dr. D. E. Salmon read a paper entitled GENERAL REMARKS ON TEXAS FEVER.†

Dr. Theobald Smith followed with a paper on THE MICRO-ORGANISMS OF TEXAS FEVER.‡ The discussion upon both papers was participated in by Prof. Riley, and Drs. Curtice, Salmon, and Smith.

Mr. C. D. Walcott described A NEW GENUS AND SPECIES OF BRACHIOPOD FROM THE TRENTON LIMESTONE.§

ONE HUNDRED AND FIFTY-FIRST MEETING,

December 14, 1889

The President in the chair, and one hundred and four persons present.

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* Published in this volume. See pp. 1-22.

† 1890. Report Proceedings Public Health Assoc. for 1889 (In press).

‡ 1889. Medical News, Nov. 4.

§ 1889. Proc. U. S. Nat. Mus., Vol. 12.

Dr. C. Hart Merriam delivered an address on the GENERAL RESULTS OF A BIOLOGICAL SURVEY OF THE SAN FRANCISCO MOUNTAIN REGIONS. Discussed by Messrs. Walcott, Diller, VanDeman, and Ward.

ONE HUNDRED AND FIFTY-SECOND MEETING.

December 28, 1889.

Vice-President Merriam in the chair, and nineteen members present.

Dr. A. F. A. King read a paper on THE FLIGHT OF YOUNG BIRDS. Discussed by Messrs. VanDeman, Merriam, Simpson, and Wood.

Mr. M. B. Waite spoke ON A METHOD BY WHICH THE SEEDS OF PILEA PUMILA ARE EJECTED.

Dr. C. Hart Merriam described A NEW RED-BACKED MOUSE FROM COLORADO.

Mr. Th. Holm presented a paper on the GENERIC CHARACTERS OF THE GRAMMINEÆ AND CYPERACEÆ. Discussed by Messrs. Waite, Merriam, Howard, and Seaman.

ONE HUNDRED AND FIFTY-THIRD MEETING,

January 10, 1890.

(Tenth Annual Meeting).

The President occupied the chair, and nineteen members were present.

The annual reports of the Secretary and Treasurer were read and accepted.

The following board of officers was elected for the ensuing year:

President.—Lester F. Ward.

Vice-Presidents.—Prof. C. V. Riley, Dr. C. Hart Merriam, Richard Rathbun, and Dr. Frank Baker.

Secretaries.—F. A. Lucas, and L. O. Howard.

Treasurer.—F. H. Knowlton.

Additional Members of the Council.—C. D. Walcott, F. W. True, Dr. T. H. Bean, Dr. Geo. Vasey, and Dr. R. E. C. Stearns.

ONE HUNDRED AND FIFTY-FOURTH MEETING.

January 24, 1890.

(Tenth Anniversary Meeting.)

The tenth anniversary meeting was held in the law lecture room of Columbian University, January 24, 1890; one hundred and three members and guests present.

The President, Lester F. Ward, delivered his annual address on the subject THE COURSE OF BIOLOGIC EVOLUTION.*

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* Published in this volume. See p. 23.

DEEP SEA MOLLUSKS AND THE CONDITIONS UNDER WHICH THEY EXIST.*

By William Healey Dall.

I propose on the present occasion to lay before you a statement of the conditions which characterize the life of Mollusks in the Deep Sea, so far as they are known to us, and to discuss briefly the effect of these conditions upon the animals subjected to them; the contrast which their life presents to that of shallow-water mollusks ; the peculiarities preserved or the modifications induced by the special environment ; together with some notes on interesting or remarkable forms discovered in deep water.

Once for all, it must be understood that exploration of the deep sea fauna has only begun ; that the area swept by the trawl and dredge compared with that which remains unknown, is almost infinitesimal ; and, of the material secured by dredging, a large portion is fragmentary and imperfect. In short what we know about the deep-sea mollusks can only be regarded as a foretaste of that knowledge which future years may be expected to supply.

In an address of this sort bibliographical references would be out of place. I will only say that the literature of the subject is almost wholly confined to the publications of the last twenty years, and consists in large part of the reports by various spec-

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* Annual Presidential Address delivered at the Ninth Anniversary Meeting of the Biological Society, November 16, 1889, in the law lecture room of the Columbian University.

ialists on such voyages as those of the British vessels, *Lightning*, *Porcupine*, *Valorous* and *Challenger;* the French *Talisman*, and *Travilléur;* the Norwegian, North Atlantic Expedition ; and the explorations of our own Coast Survey, Fish Commission, and Navy on the *Blake*, the *Fish Hawk*, the *Albatross*, and other well known vessels. The most distinguished naturalists of this country and of Europe have added to their reputation by the investigation of the wonderful fauna revealed by these explorations. The most extensive and important single series of Scientific Reports ever published as the result of a single expedition are those which bear the name of the Challenger upon their capacious covers. Next to these come the Reports of the United States Fish Commission, under the leadership of Prof. Baird, and then follows a host of minor documents which it is impossible to enumerate at the present time.

What I have to present to you this evening is rather a discussion of conditions and principles than an exhibit of particular facts or observations.

In order that their existence may be maintained the abyssal mollusks require oxygen to ærate their circulation, food to eat, and a foothold upon which they may establish themselves. It is necessary that the conditions should be such as will not prevent the development of the eggs by which successive generations are propagated, and that they do permit it may be assumed from the very fact that mollusks in large numbers have been shown beyond all question to exist on the oceanic floor wherever this has been explored.

Formerly when dredging with the usual appliances in small boats, one hundred fathoms (six hundred feet) was considered extremely deep. If one stands at the foot of the great Washington obelisk and looks up, the idea of collecting a satisfactory representation of the insects and plants on the ground at its base by dragging a six foot trawl or dredge by a line let down from the apex of the monument, strikes one as preposterous. Yet the monument is less than one hundred fathoms high. Multiply this height ten or fifteen times and the idea seems, if possible, still more unreasonable, yet it is a fact that successful dredging has been done from a height above the sea-bottom of not less than twenty-five times the height of the Washington monument. Living animals have been secured from a depth equalling the distance from the Capitol to Rock Creek, or from the Washington monument to the mansion at Arlington, that is to say about two and a half miles.

It is therefore evident that in speaking of dredging, we must revise our terms and define them so as to conform more nearly to the new conditions under which such work is done.

The waters immediately adjacent to the shores were long ago divided by Forbes and other pioneers in marine exploration into zones or areas according to the conditions characterizing them ; as, for instance, the Laminarian zone or region of brown kelp, the Coralline zone or region of stony algæ, &c. But for general purposes and to contrast the areas of the whole sea, one with another according to their chief characteristics, we may now divide the entire sea bottom into three regions.

The first is that to which light can penetrate and therefore where marine vegetation can exist. This is the Litoral region and in a general way, modified by especial conditions at particular places, it may be regarded as extending from the actual shore out to the limit of one hundred fathoms. Beyond this it is practically certain that no light reaches the bottom of the sea and no sea weeds grow. Outside of this the borders of the continents slope gradually to the bottom of the ocean, which is found usually at a depth of about 2,500 fathoms.

On the upper parts of these continental slopes the conditions are often very favorable for marine life. Currents of comparatively warm water, like the Gulf Stream, sweep along bringing fresh pure water and supplies of food to the animals along their track. The division between the abysses and the slopes is rather a matter of temperature than of mere depth. But the temperature itself is somewhat dependent on the depth, the influence of the great warm currents rarely extending below seven or eight hundred fathoms and this depth corresponds roughly to a temperature of about forty degrees Fahrenheit. Below this it diminishes as the depth increases, at the rate of about one-tenth of a degree to one hundred fathoms until the freezing point is reached, though there is no reason to suppose that the abyssal water ever actually becomes congealed.

To this cold dark area of the Ocean bottom has been applied the name of the Benthal or Abyssal region.

To the region, chiefly on the continental slopes, between the Litoral and Abyssal regions, I gave some years ago the name of the Archibenthal Region.

These divisions have been recognized by various writers and have had several terms applied to them. Those I have mentioned seem to me as characteristic as any, and in some respects more convenient than any I have heard used.

Let us now consider the conditions under which life exists in the Abyssal and Archibenthal regions. It may be premised that the differences between them are largely of degree and not of kind and do not require that the two regions should be considered separately.

The chief characteristics reside in the composition of the sea water, including its contained gases; in the dynamic status of the deeps, especially in relation to temperature and pressure;

in the mechanical qualities of the materials of which the oceanic floor is composed; and, lastly, in the food supply.

As determined by physicists and chemists the water of the deep sea varies in the proportions of mineral salts, carbonic acid and air contained in it very much as does the surface water. In general at the surface the warmer water of the tropics has the more salt and the less nitrogen. When carried by currents to the Polar regions, and cooled, this tropical water sinks to the bottom carrying its excess of salt along with it. The Polar waters are less saline and contain more nitrogen. The proportion of atmospheric air in the water is found strictly related to the temperature, the pressure at great depths being regarded as having no bearing on the question. The amount of oxygen in the sea water diminishes gradually as we descend from the surface until about 350 fathoms is reached, when it ceases to change or at most increases slightly until the bottom is attained.

Carbonic acid, according to Tornœ, does not exist in a free state in sea water, but only in the form of carbonates or to a less degree of bicarbonates. Unless the decomposition of animal matter in some manner sets free the carbonic acid, this conclusion is one which cannot be adopted without question, especially when we consider the great difficulties which are encountered in any attempt to obtain, or when obtained to analyze, abyssal water. The effect of erosion on the shells dredged, from the deeps, even when they contain the living animal, is so strongly marked, the devices for protection against erosion are so recognizable in various species, that the biologist may well call the physicist to a halt, while the latter re-examines his data. It is certain that erosive agencies, of which the effects are indistinguishable from those known to be due to carbonic acid in other instances, are extremely active in the deeps.

In general it seems as if we might safely assume that the composition of abyssal sea water shows no very important differences from that of other sea water and that the animals existing in it are not exposed to any peculiar influences arising from this source alone.

This cannot be said of the physical conditions. Everyone knows how oppressive to the bather is the weight of the sea water at only a few feet below the surface, and how difficult it is to dive, still more to remain on the bottom, if only for a few seconds.

But it is difficult to convey any adequate idea of the pressure at such a depth as 2,000 fathoms, or about two miles below the surface.

Rope made impervious by tarring is said to have become reduced one-third in its diameter by a descent into these depths. Any hollow object not pervious or elastic, is at once crushed. There is no doubt that at some points on the ocean floor the pressure may amount to several tons to the square inch.

If we recall that the average pressure in steam boilers is probably much less than one hundred pounds to the square inch it may help toward an appreciation of the abyssal conditions.

The inevitable conclusion is, therefore, that all the animals living under these conditions must have their tissues so constituted as to permit the free permeation of the water through every part in order that the pressure may be equalized. How this is possible without putting an end to all organic functions is perhaps the greatest mystery of abyssal life. How can a large egg, like those of various deep-sea animals, pass through the stages of segmentation and development, with every molecule of its structure in actual contact with ordinary sea water and every solid particle subjected to a pressure of say a thousand pounds to the square inch?

Such questions are much easier to ask than to answer, in fact no attempt at an answer has, so far as I am aware, ever been offered to biologists.

The looseness of tissue necessary to such a permeation is conspicuous in abyssal animals, whose flabby and gelatinous appearance when they reach the surface is notorious. It is perhaps most noticeable in the fishes, which nevertheless are often armed with formidable teeth. But under the great pressures of the deeps it is quite conceivable that each of these loose and half dissolving muscles may be compressed and reduced to a condition resembling steel wire ; and that the organization thus sustained may be as lithe and sinewy in its native haunts as its shallow water relatives are in theirs.

It is well known how great an influence on the distribution of shallow water species is exerted by the temperature of the water in which they live. No doubt the differences of temperature affect the nervous system, the rate of muscular contraction, and the motions of the cilia by which in mollusks many of the functions of life are aided or wholly carried on.

But it is probable that the influence of temperature is far more effectively exerted upon the development of the ova, and hence upon the propagation of the species, than directly upon the parents. It is probable that most adult mollusks could endure a very wide range of temperature if the individuals were subjected to the changes by extremely slow degrees. But it has been shown that a difference of one or two degrees below a certain point on the thermometric scale, will destroy the embryos of *Ostrea* or prevent their development so that they perish. In this way the spread of the species may be effectually checked, though the adult shellfish may flourish without difficulty in the same region.

In the shallower parts of the Archibenthal Region, a few great currents, like the Gulf Stream, may reach, for a small part of their course, the ocean floor and sweep it clean of sediment and detritus, if not entirely of living beings. Such mechanical effect as is produced must be of a rather steady and uniform nature for considerable periods and in no respect resemble the crushing and grinding which take place on every exposed beach on which the sea rolls up. In fact, regarded as individuals, the mollusks in the path of the Gulf Stream and other great currents, have little or nothing to fear from the mechanical attrition which plays so large a part in the shallows. On the other hand wherever the force of the stream is not sufficient to sweep the bottom clean, the supplies of oxygen and food brought by it to the colonies along its path so far exceed the normal for quiet waters, that the animals thus favored flourish and multiply in a manner never seen in quiet deeps.

The influence of darkness upon the inhabitants of the Abyssal Region has often been expatiated upon. The absence of visual organs or their preternaturally excessive development beyond the normal of the groups to which the individuals belong is evidence enough that the deeps are markedly darker than the shallows. But this evidence proves too much for the claim that the deeps are mathematically dark. Whatever notions may be entertained or conclusions deduced by the physicist from the premises, the presence of large and remarkably developed eyes in many abyssal animals shows that light of some sort exists even on the oceanic floor. It is inconceivable that these organs should be developed without any light and if the experiments and reasoning of the physicist result in the apparent demonstration of absolute darkness in the depths, the facts of nature show that in his premises or his experiments there lurks some vitiating error. It is ridiculous to suppose that the phosphorescence of certain animals in the deep sea fauna is a factor of sufficient importance to bring about the development of enormous and exquisitely constructed eyes in a multitude of deep sea species. A greater or general phosphorescence, such as would amount to a general illumination, has never been claimed by any scientific biologist and, as a theory, requires a mass of proof which seems unlikely to be forthcoming.

In general then we find the physical conditions simpler than those of the shallows and yet much more energetic. The effect of temperature is marked in the distribution of life over cold and warmer areas of sea bottom. The relative importance of the effects of pressure, partial darkness and of the quietness of abyssal waters, our knowledge is yet too imperfect to allow us to precisely estimate. All doubtless have their effect; some of the effects are more obvious than others, but it is by no means certain that the most obvious are necessarily the most important to the organisms concerned.

The mechanical character of the sea bottom is of greater importance than is generally realized. In a very small proportion of its extent the sea bottom is composed of bare or nearly bare rock. Away from the shores such a bottom is usually situated in the trough of some great current like the Gulf Stream, and then seems to be nearly bare of animal life. In other cases it may be found on the walls of sub-marine cliffs, which for obvious reasons can hardly be explored for marine life with our present appliances.

The rest of the bottom consists of solid matter in different stages of sub-division, from something which may be described as calcareous gravel to an impalpable mud which may or may not be dotted with concretions of manganese, iron or other mineral matter. The gravels are chiefly confined to the archibenthal region, the true deeps are generally carpeted with a viscid layer of the finest possible calcareous mud or clay. The latter formation is meagre in its fauna as clay is when it occurs in shallow water.

Certain forms of mollusk-life flourish in a soft bottom especially the *Nuculidæ* and their allies which are notably abundant in the depths as well as in the muddy shallows of the Litoral Region. Others require some solid substance upon which to perch, a stone, a bit of wood, a spine from some dead Echinoderm, something they must have for themselves and for their eggs which shall raise them above the muddy floor. In regions where such objects are rare or absent on the sea bottom such mollusks are equally rare or wanting. Most ingenious are the shifts made in many cases, as when we find *Lepetella* safely housed in the tubes of dead Annelids or Hydroids, and *Choristes* taking refuge in the empty ovicapsules of rays or sharks. Small hermit crabs take to the tooth-shells (*Dentalium*) or to the tubular Pteropods (*Cuvierina*); or *Amalthea* roosts on an *Echinus* spine and builds for itself a platform as it grows, recalling the arboreal houses of some Oriental savages.

In the Archibenthal Region there is a more or less constant drift of debris from the adjacent shallows which gradually forms banks of considerable magnitude.

The action of erosion and solution for some reason seems less potent here than in either the shallower or the deeper parts of the sea. In the shallower parts the excess of motion, in the deeps the excess of the eroding agent, may account for this. The fact is known to me from the study of many specimens from both regions and is beyond question.

A feature in forming certain of these banks, to which attention has hitherto not been directed, is worthy of mention. This is the habit of certain fishes, which exist in vast numbers, of frequenting certain areas where they eject the broken shells of mollusks, corals, barnacles and other creatures which they have cracked, swallowed and cleansed of their soft tissues by digestion. We have learned from Darwin of the marvelous work of the earthworm in Britain. The ejectamenta of a single fish of moderate size in one day would far exceed the accumulations of many earthworms for much longer time. Now, in examining critically large quantities of material dredged from the bottom I have found that from certain areas almost entirely composed of these ejectamenta. In the interstices some small creatures hide but the tooth marks of the fish were upon nearly every fragment. As for a pint of fragments of a given species, this bottom-stuff would rarely contain half a dozen specimens which had been taken alive by the dredge (most frequently the species did not occur at all living in the material so dredged), it was obviously impossible that the shells could have been captured and afterward voided on the same spot. It seemed more likely from all the facts that these fishes after feeding to repletion repair in large schools to certain areas to enjoy the pleasures of digestion. There would be nothing improbable in the fish of a limited region preferring some special locality for this purpose; and the result might be the accumulation of a veritable bank, of which nearly the whole had at some time or other passed through the intestine of a fish. At all events, whatever explanation be offered of them, it is certain that such accumulations do occur at certain localities, as shown by the dredgings of the Fish Commission off the eastern coast of the United States.

The last condition remaining to be considered is that of the food supply. It has long since been pointed out that marine vegetation ceases to exist within a limit of six hundred feet below the surface. Whatever light exists in the depths, it is not of a nature to meet the needs of vegetation. Whether any other factor joins with the absence of light to discourage algal growth is yet unknown but not intrinsically improbable. The mollusks which belong to groups known as phytophagous in shallow water, in the deeps appear to live chiefly on foraminifera which they swallow in immense quantities. The results of this diet are evident in the greatly increased caliber of the intestine relatively to the size of the animal, in the diminution of the masticatory organs, teeth and jaws, and in the prolongation of the termination of the intestine as a free tube to a length which will carry the effete matters out of the nuchal commissure, and thus free from their injurious effects the branchial organs, which are usually seated in this space. The quantity of nutriment in the protoplasm of foraminifera is so small that a much larger mass in proportion of these organisms must be swallowed and their remains consequently ejected afterward, than if the food consisted of the tissues of algæ.

But the great mass of abyssal mollusks are members of those groups which in shallow waters are normally carnivorous, and to a great extent prey upon one another. In the deeps however this reciprocal destruction is unnecessary.

Those who have become familiar with surface collection on the sea alone can realize the immense quantity of organisms which exist in the water on or near the surface. These are frequently numerous enough to reduce the water to the consistency of soup, for miles in extent and to a considerable depth. Millions of these creatures are constantly sinking from the region where they naturally belong, either from injury or exhaustion, and thus raining slowly but constantly upon the bottom. This fact is not new and is admitted to be unquestionable by all biologists. Hence in many regions of the sea bottom the resident fauna have, as it were, only to lie still and hold their mouths open.

One of the facts which attracted my attention when I first begun to study deep sea mollusks was the singularly small number which showed signs of having been drilled or attacked by other mollusks. Apart from those showing the marks of fish teeth or the dental machinery of echinoderms, it is extremely rare to find drilled bivalves or univalves such as make up the great mass of the jetsam on every sandy beach. Such cases occur, but the occurrence is always exceptional and the holes which are most often found in abyssal shells are those which are due either to the friction of some hermit crab or to the erosive properties of the secretions of certain annelids which fix their irregular tubes upon the outer surface of the shell. These injuries cannot easily be confounded with the circular drill holes of carnivorous gastropods.

Having handled more deep sea mollusks than any other naturalist now living, and spent, probably, more time over material procured by the dredge from shallow water, than anyone else of my acquaintance, I do not feel that I am presumptious in affirming the remarkable difference which obtains in this respect between the dead material from the Litoral and from the extra-Litoral regions, respectively.

This brings me to a conclusion which I have elsewhere published with less detail. The animals belonging to the mollusca which are found in the Archibenthal and Abyssal regions, especially the latter, do not live in a perpetual state of conflict with one another. A certain amount of contention and destruction doubtless goes on, but on the whole the struggle for existence is against the peculiarities of the environment and not between the individual mollusks of the area concerned. It is an industrial community, feeding, propagating and dying in the persons of its members and not a scene of carnage where the strong preys upon his molluscan brother who may chance to be weaker. Depredations on this community are doubtless committed by deep sea fishes and echini, perhaps by other organisms, but the inroads are not so important as to seriously modify the course of evolution and influence specific characteristics.

Hence the course of evolution and modification, though still complex, is certainly much less so than in the shallower parts of the ocean. For this reason we may hope to penetrate more deeply into its mysteries with deep sea animals than with those less fortunately situated. In this opportunity, to me, lies the chief importance of research into the biology of deep sea mollusks. Nowhere else may we hope to find the action and reaction of the contending forces less obscure, and modification in most cases has not extended so far that we cannot compare the deep sea forms with their shallow-water analogues and draw valuable conclusions.

While we are not yet in a position to formulate conclusions covering all the details of abyssal mollusk-life in certain instances results suggest themselves.

Deep sea mollusks of course did not originate in the depths. They are the descendents of those venturesome or unfortunate individuals who, by circumstances carried beyond their depth, managed to adapt themselves to their new surroundings, survive and propagate. Many species must have been eliminated to begin with. Others more plastic, or more numerous in individuals, survived the shock and have gradually spread over great areas of the oceanic floor. In accordance with these not unreasonable assumptions we should expect to find among the newer comers at least some characters which were assumed under the stress of the struggle for existence in the shallows, and which, through specific inertia, have not become wholly obsolete in the new environment. We should also expect to find a certain proportion of Archibenthal species in any given area, identical with or closely related to the analogous Litoral region forms of the adjacent shores.

In the Abyssal region alone should we expect to find that any considerable proportion of the fauna has lost all its litoral characteristics, assumed characters in keeping with its environment and become disseminated over the ocean bottom throughout a large part of its extent. These expectations in the main are fairly satisfied by the facts as far as the latter are positively ascertained.

With the lesser need of protection from enemies and competitors would necessarily be related a less rigorous elimination of characters which in struggle and competition might prove sources of weakness. The limits of uninjurious variation would be relaxed at the same time and to the same extent. We find as we should expect that the deep sea mollusks are more variable in their ornamentation and other superficial characters than those from shallow water. In some species the balance of characters is fairly well maintained ; in others variation runs riot, and it is impossible to say what amount of it should constitute a basis for specific subdivisions among individuals.

In general deep sea shells present pale or delicately tinted color patterns, are white, or owe their color to the tinting of the epidermis. This may be due directly to the absence of light. Sunlight, when present, seems to have a stimulating effect in developing colors as is shown by the greater brightness of tropical litoral shells whatever their colors. It operates indirectly by promoting the development of color in algæ which are fed upon by phytophagous mollusks, and affect the coloration of the latter directly through the assimilation of the coloring matter of the food, mechanically.

Indirectly, through the influence of protective mimicry, the coloration of shells which frequent beds of seaweed or rocks covered with stony algæ, is often modified in harmony with the environment even when the species is not phytophagous.

In the deeps these influences are wanting and the development of color is necessarily the result either of uneradicated hereditary tendency, or of some physical features of the environment which operate mechanically and are not yet understood.

The colors chiefly effected by deep sea mollusks are pink or reddish straw color, salmon color, and various shades of brown. These are found in the shell and are more or less permanent. The epidermis of deep sea shells is usually pale yellowish, but frequently is of a delicate apple green, such as is seen in many fresh water species; and sometimes of a beautiful rich dark chestnut brown, a color also not rare among land and fresh water species. The most common pattern when any exists is that formed by squarish dark spots which occasionally become fused into bands. Among the Archibenthal species found in depths from 100 to 300 fathoms this pattern of brown squarish spots arranged in spiral series is notable in such forms as *Scaphella junonia*, *Aurinia dubia*, *Halia priamus*, *Conus mazeí*, etc. Instances of the green epidermis are afforded by the various species of *Nuculidæ*, *Turcicula* and *Buccinidæ*.

The thick and solid layers of aragonite, of which many shallow water species are chiefly built up, are represented in deep water forms by much thinner layers, while the nacreous layers are, if not more solid in abyssal shells, at least more brilliant and conspicuous, perhaps because less masked by aragonitic deposits. A very large proportion of the deep water shells are pearly and derive their beauty from the brilliance of their nacre.

In the matter of sculpture the mechanical effect of the pressure operates against the development of weight and thickness in benthal shells since the whole must be permeable. It is probable too that the soft and sticky character of the abyssal ooze would put the possessor of an unusually heavy shell at a considerable disadvantage in getting about on the bottom. Any impermeable shelly structure on the ocean floor would have to be strong enough to sustain without crushing a weight hardly less than that borne by the rail under the driving wheel of an ordinary locomotive. It is sufficiently obvious from a mere statement of the case, that none of them can be impermeable.

The heavy knobs or arborescent varices of shallow water Murices are represented in their deep water congeners by extremely thin and delicate spines and slender processes. These are probably all reminiscences of shallow water ancestors, as it is difficult to imagine any cause which in the abysses would lead to a development of such defenses *de novo*.

The sculpture most usual on deep water shells is of a kind which serves to strengthen the structure, much like the ridges which give rigidity to corrugated iron work or the curves used by architects in wrought iron beams. Spiral or longitudinal hollow riblets, a transverse lattice work of elevated laminæ such as are developed for similar reasons on the frail larval shells of many gastropods, a recurvature of the margin of the aperture in forms which in the Litoral region never develop such recurvature ;—these are instances in point.

Beside these there are small props and buttresses developed which serve the same purpose of strengthening the frail structure at its points of least resistance. Such is the garland of little knobs so commonly found in front of the suture in abyssal shells of many and diverse groups.

It is not intended to suggest that the methods above indicated have not been developed also in shallow water forms and for similar reasons. The distinction which I would point out is that in Litoral species, as a rule, these devices are subsidiary to the much simpler course of strengthening the shell by adding to its thickness. In the abyssal forms, for reasons already explained, this mode is not practicable and consequently we have the one without the other.

The operculum is generally horny in abyssal mollusks, frequently disproportionately small, compared with that of congeneric litoral species, and in a remarkably large number of cases is absent altogether.

The genus most abundantly represented of all is *Mangilia*, which is entirely without an operculum, and affords a conspicuous example of the obsolescence of protective devices, originally acquired in shallow water, resulting from long residence in the deeps.

In the Unio and Melania of fresh water streams and the pondsnails of our lakes and ponds, the waters of which from the decay of vegetable matter are overcharged with carbonic acid, we find a dense thin greenish epidermis developed as a protection against erosion. In the deep sea where every portion of the shell must be permeated by the surrounding element to equalize the external pressure, and where carbonic acid exercises its usual malign influence on the limy parts of all organisms, we find a strikingly similar protective epidermis developed in most unexpected places. Thus it comes about that in the *Trochi*, *Pleurotomidæ* and other characteristic abyssal animals we find those puzzling and remarkable counterparts of land and fresh water shells which have astonished every student of the mollusca who has seen them. These deep water species imitate in almost all superficial characters of the shell the biologically wholly different pondsnails and landsnails.

Similar exigencies of the environment have provoked similar mechanical responses in the shelly parts, a result wholly in harmony with the modern postulates in biological science.

As might be expected of descendents with modification there are greater similarities between the larval shells of benthal species and those of their shallow water relations, than between the parts of the shell, which are of later growth in the same forms. There is one notable difference however. In the deep water forms the nucleus is frequently larger than in their shallow water analogues. It would seem as if the conditions of the depths were such, that, of a small number of large larvæ, more are likely to survive than of a larger number of smaller ones ; or at least that that form of larval growth is more useful to the species.

These details will serve to show the multiplicity of facts to be accounted for and the opportunity for advancing science by a study of abyssal conditions and their effects upon the animals subjected to them. Without claiming any unique importance for the theories advanced in the foregoing remarks it may still be said that the subject is one of the very greatest interest. Perhaps experiments upon shallow water forms, artificially subjected to pressure may at some future time enable us to penetrate more deeply into the mysteries of life in the abysses.

The attempt to prepare a summary of bathymetrical data for the deep sea fauna of any region yet investigated, is most unsatisfactory in its outcome from the paucity of data. Most of the species of any collection are represented by the shells alone, which may have been—as millions are daily—disgorged by fishes, and never have lived at the depth from which they were dredged. We are yet ignorant as to whether the abyssal and archibenthal faunæ shade gradually into one another, as seems most probable ; or whether there is any line of depth, coincident with a temperature limit, which really fixes a boundary for the abyssal fauna.

Then, again, the difficulty and time involved in a cast of over one thousand fathoms are so much greater than if it were made in half that depth, that it is impossible to say what proportion of the disparity in population between the Archibenthal and Abyssal areas, which dredgings seem to indicate, is due to the fact that the latter have been far less efficiently explored. The only thing of which I feel confident is that it is yet too early for extensive numerical comparisons or deductions based wholly on statistics. I shall therefore content myself here with a very modest table, which is intended to illustrate the peculiarities of the collection made during the past ten years by the U. S. Steamer *Blake* and recently reported on by me.

It is probable that it is a fair example of abyssal mollusk faunas, but this cannot be claimed with certainty.

The first table shows the general numerical results for the *Blake* collection, assorted among the great systematic groups and the three bathymetric zones or areas. The second table shows the proportion to the whole population of the abyssal region borne by those genera which exceed a single species. The result here shown is that less than thirty-seven per cent. of the genera comprise more than sixty-eight per cent. of the species ; and out of these, three families, *Pleurotomidæ*, *Ledidæ*, *Dentaliidæ* furnish nearly twenty-eight per cent. of the species of the abyssal fauna collected by the *Blake*.

TABLE I.

General Numerical Results.

Groups	No. of Genera	No. of Species	Species in the			Species common to		Abyssal Fauna	
			Litoral Area	Archib. Area	Abyssal Area	Two Areas	All Areas	Families.	Genera
Brachiopods	7	13	8	12	3	8	2	2	3
Pelecypods	52	170	98	114	31	64	10	15	19
Scaphopods	2	35	17	28	12	17	5	1	2
Gastropods	119	491	280	222	83	161	32	29	41
Totals	180	709	403	376	129	250	49	47	65

TABLE II.

Genera represented by more than one Species in the Abyssal Area.

Genera.	No. of Species.	Genera.	No. of Species.
Mangilia	17	Fluxina	2
Margarita	5	Liotia	2
Pleurotoma	4	Leptothyra	2
Drillia	3	Cocculina	2
Marginella	3		
Scala	3	Leda	5
Calliostoma	3	Limopsis	3
Triforis	3	Pecten	3
Actæon	3	Abra	2
Utriculus	2	Myonera	2
Fusus	2		
Columbella	2	Dentalium	8
Benthonella	2	Cadulus	4

Total, 24 Genera and 87 Species.

For the naturalist of to-day the most interesting feature of abyssal life is not that it furnishes him with singular and archaic forms, useful in his study of extinct genera; nor the beauty and rarity of the creatures living under such unusual conditions. The most important characteristic of abyssal life is, that it, and it alone, exhibits a fauna in which reciprocal struggle is nearly eliminated from the factors inducing variation and modification. There is no mimicry or sexual selection, where all is dark. Indeed, if it could be shown that the deeps are absolutely dark, the acknowledged development there, by some animals, of large and supersensitive eyes, might be a proof of the Lamarkian doctrine of development consequent on effort, as opposed to the views of Darwin, that it is solely the result of selection conscious or unconscious and the survival of the fittest.

In the struggle for life of the abyssal animal, he is pitted against the physical character of his environment, and not against his neighbor or the rest of the fauna. Hence we should have, and really do have, the process of evolution less obscured by complications in the abysses than is possible elsewhere. From a study of these animals in the light of their environment, much may be hoped toward the elucidation of great questions in Biology, and naturalists everywhere should strive to promote deep sea dredging as essential to the progress of Science.

THE COURSE OF BIOLOGIC EVOLUTION*.

By Lester F. Ward.

That organic forms are the product of evolution is now not only generally accepted by educated people, but is also fairly well understood as a general proposition. But the special nature of the evolutionary process, particularly the *modus operandi* of the laws of development, is only vaguely or crudely comprehended by any but specialists in some branch of biology, and is not clearly understood by all of these. In proof this I recall a lecture by Henry Ward Beecher, delivered in this city within a year of his death, in which he attempted to expound the modern scientific doctrine of evolution, but in which he showed that he had no adequate idea of what is meant by the arborescent, much less by the dichotomous character of the process of organic development, and seemed to suppose that the progress from monad to man had been one continuous ascending series. He mentioned, for example, as among the ancestors of man, a number of animals belonging to the Ungulata, Carnivora, etc., which are known to be entirely off the anthropogenetic line.

Such crude exposition of so important a law as that of evolution can only react against the progress of its acceptance as a scientific truth, and there seems to be great need that the ex-

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act nature of this law be worked out, and that all attempts to popularize it be correct and be accompanied by the necessary qualifications and an explanation of important subordinate laws. Only thus can the coarse and repugnant conceptions which seem to be taking possession of the popular mind be removed.

EXTINCTION OF TRUNK LINES OF DESCENT.

It is especially important that the first great qualifying principle, which I propose to call *the law of the extinction of trunk lines of descent*, be made clear, since it lops off at one stroke, the most serious of all popular misconceptions. I shall assume that the principle of genealogic dichotomy is clear to the minds of all, since it is nothing more than the simple law of tocogonic descent as exemplified in every human genealogy and every family register applied to all life, except that it relates to species instead of individuals.

Sympodial Dichotomy.—But while organic phylogeny is, in a certain sense, arborescent and dichotomous it cannot be directly compared to any ordinary tree nor even to a plant that branches in a strictly forking or dichotomous manner, such as an *Anychia*, for example. It resembles more nearly that form of indeterminate growth which is termed *sympodial*, in which, instead of the two forks being equal and divergent, one of them has to be regarded as the main trunk and the other as a branch, but in which the branch possesses the greater vigor and vitality and virtually becomes the main trunk, the true stem dwindling, and either dying out entirely or continuing as a reduced and degenerate form. There are many plants, such as the common grape-vine, the houseleek, the heliotrope, and the for-get-me-not, that exhibit this sympodial dichotomy.

Types of Structure.—In studying the operation of this law in biology a number of important facts are to be noted. It is first necessary to consider what may be called *types of structure*. These, in our illustration of sympodial dichotomy, represent first, the main trunk, and afterward the successive branches which become virtually the main trunk. Except in parasitism and other anomalous cases, the development along the main trunk is in the nature of an ascending series of forms, in the sense that the structure grows more and more perfect. There is a differentiation of organs and functions and an integration of parts into organisms of higher and higher capacity, but all are constructed upon the same general plan and represent a single and uniform type. This process of perfectionment in the organisms of original type constituting the main trunk proceeds as far as the nature of that type of structure will permit. The branch which is to constitute the new and higher type is ultimately developed out of this original trunk, but there is no fixed time for its appearance. The original type may have reached its maximum development and remained stationary for any length of time, or it may have already begun to decline before this takes place. In fact it may never take place, but such organisms perish and leave us no history. The branch must possess a higher type of structure, otherwise it must dwindle and also disappear. To give it fresh vigor and power to continue the stock it must have acquired, through the known laws of variation and selection, some advantageous character not possessed by the original type, to which its superior vigor is due. It then in turn continues to develop and goes on improving in the same manner as the main trunk did before it, until, like that, it reaches the maximum limit to its capacity for progress, *i. e.*, until nothing more can come from that type of structure. Like its ancestor, too, it then remains stationary for an indefinite period and eventually declines, and either persists in a degenerate form or dies out altogether. A second branch endowed with still higher capacities is developed from the first and this repeats the process, and so on indefinitely, higher and higher types being successively developed, carrying up the system by this process of ascending sympodial dichotomy.

Persistence of unspecialized Types.—It often happens that the highest organisms of the more ancient types become extinct while the lower or less perfect ones persist and are found mingled with organisms of the higher types that are the dominant forms of life at subsequent epochs. This fact has led those who did not understand the law of types, as just stated, into doubts relative to the fact of development, since the certainty that organisms belonging to types that still exist, but of much higher rank, formerly inhabited the globe gave rise to the belief that there has been degeneracy instead of progress. To escape this error it is necessary to understand that progress takes place primarily through the development of new and higher types of structure, embodying successively higher and higher capacity for improvement, and that the archaic forms belonging to lower types, and therefore, as it were, upon a lower plane of life, unable to compete with those of higher type, are repressed and only appear among the latter as humble, and, as regards their own ancestors, really degenerate forms.

We thus have a series of epochs in the earth's history during each of which a different type has predominated, each later type being higher in its capacity for improvement than its predecessor. You are all more or less familiar with the successive reigns of articulates in the Cambrian, mollusks in the Silurian, fishes in the Devonian, reptiles in the Mesozoic, and mammals in the Cenozoic ; and you have doubtless frequently heard astonishment expressed at the great perfection to which the articulated type attained in the Trilobite, the molluscan type in the Ammonite, the piscine type in the Ganoid, the reptilian type in the Dinosaur, and the mammalian type in the mastodon, the highest expressions of all of which belong to geologic periods, and whose living representatives, with few exceptions, belong to the humbler forms of life.

DEVELOPMENT IN PLANTS.

As a specialist only in the lower of the two great kingdoms it is not my place to enter into details respecting the working of these several laws in the animal kingdom, even if I were competent to do so. My illustrations must therefore be chiefly drawn from plants.

It is well known that the three principal groups of modern cryptogams, the ferns, Lycopodiaceæ, and Equisetaceæ, represent the degenerate descendants of a vegetation which formed extensive forests in Carboniferous time, and Hugh Miller, Dr. Lindley, and some more recent authors have used this fact in the manner above referred to, as demonstrating that the life-series of the globe is as likely to be a descending as an ascending one, and that development as a general principle is not proved. Of course it is now well understood that natural selection does not necessarily produce an ascending series, as for example, in parasitic degeneration. But the principle which I have formulated to-night of type degeneracy has been almost entirely ignored, although it is alone able to explain the most important facts that seem opposed to evolution in general. The modern degenerate cryptogamic vegetation is one of those facts and to it I must devote a few moments of explanation.

The so-called natural system of classification in botany is based primarily upon the reproductive function. As founded by Jussieu it was exclusively so based, but De Candolle undertook to introduce a new principle, viz., that of the structure of the axis or trunk, by which he separated exogenous from endogenous plants, and supposed that this line could be drawn between monocotyledons and dicotyledons, erroneously including the gymnosperms in the latter of these groups. The weight of his authority not only long retarded the discovery of the true position of the gymnosperms as the immediate descendants of the crytogams, but it had the further effect of barring out the important truth which vegetable paleontology has at last made clear that there once existed a large class of exogenous cryptogams.

Origin of Exogeny.—It has long been known that the Stigmarias of the coal measures possessed an exogenous structure, and as early as 1839 Brongniart discovered that the stems of *Sigillaria elegans* consisted of a medullary center surrounded by a thin exogenous zone within a thick cortex. The woody zone was shown to be composed of distinct wedges separated by medullary rays. It is now known that nearly or quite all coal plants having the external characters of Sigillaria have this exogenous zone. It was also early discovered that certain coal plants with the general appearance of Calamites exhibit an exogenous structure, and it was at first supposed that these must be something very different, and they were accordingly called *Calamodendron*. Professor Williamson has shown that all true calamites have an exogenous structure of a very definite character. He has also proved that the distinction drawn between Sigillaria and Lepidodendron based on this character is not tenable, since some true Lepidodendra also show the woody zone and medullary rays.

When Brongniart had made the discovery referred to he changed his mind with regard to the plants of the coal measures, and ever afterward maintained that Sigillaria and Calamodendron must be phanerogams, referring them to the Coniferæ. This complete reversal of his former logical and correct views was due to the preconceived opinion that exogenous growth was necessarily correlated with coniferous and dicotyledonous plants, as taught by De Candolle, and there is still a French school of vegetable paleontologists, who, as disciples of Brongniart, continue to maintain that Sigillaria must be placed in an entirely different class from Lepidodendron, and Calamodendron from Calamites, and who are disposed to deny the cryptogamic character of all forms possessing an exogenous structure.

Now the truth seems to be that in the process of development in plants the exogenous structure has been attained in varying degrees along several ascending lines, and that there is a different kind of exogeny in the calamite, the lepidophyte, the cycad, the conifer, and the dicotyledon, while something resembling exogeny has been shown to occur in certain fossil ferns and in certain living monocotyledons. Exogenous cryptogams probably no longer exist. The reign of the cryptogam has come to an end. It occurred in remote Carboniferous times when these plants constituted the greater part of the earth's vegetation. It was then that certain types of the Lycopodiaceæ and Equisetaceæ became forest trees and were supported by exogenous trunks. These types have long since disappeared according to the law of the extinction of trunk lines of descent, and it is only the earlier and simpler types that have come down to us according to the law of the persistence of unspecialized types. The filicine, equisetian, and lycopodian types continued to develop until they reached the highest state attainable by plants having that structure. They even acquired the exogenous character, but only in a rudimentary form.

It would be wholly misleading to place the exogeny of these plants on a par with that of the modern exogen. In the pine and the oak, as every one knows, the bulk of the trunk consists of what we call *wood*, that is, of concentric layers of thick-walled vascular cells, giving to the trunk great strength and resistance, and although in the great sequoias and in the cork-oak the cortical portion, or bark, may attain a thickness of over a foot, still this is a relatively small portion of the entire trunk, and contributes comparatively little to its support. Now, if we imagine a tree in which the bark constitutes the bulk of the trunk and the wood only a comparatively narrow zone close to the central pith, we shall have some idea of the exogenous cryptogamic forest tree of the Carboniferous age. Something approaching it can be seen on a small scale in the first year's growth of a modern exogen, and in most herbaceous plants of that type, and we have another approach to it in the trunks of living cycads.

But when we speak of such thick bark it must not be supposed that we mean the dry corky and flaky exterior which is popularly called bark. This, in the modern exogen, constitutes the greater part of the bark of old trees, but is really the cast-off and, to a greater or less extent, dead matter pushed outward by the annual growth of the bast and liber, or the true live bark of the tree. For every exogen is also an endogen outside of the cambium layer. The bark grows by the deposition of new matter to its interior. It was even so with the exogenous cryptogam, only the endogenous or cortical portion, *i. e.*, the bark, then constituted the greater part of the trunk, whereas it now forms only a thin zone at the periphery.

This difference of degree is so great that it practically amounts to a difference of type, and far back in early Carboniferous time the new type had begun to appear, seemingly along two independent lines, the one typified by the form called Noeggerathia and leading to the modern Cycadaceæ, the other by the form called Cordaites leading to the modern Coniferæ, which two great families rivaled each other for the mastery of the vegetable world during Mesozoic times.

Origin of Phænogamy—Gymnospermy.—It is, however, doubtful whether this great advance in the direction of strength and stability of trunk would have alone sufficed to give these new types the victory in the struggle with the tree-ferns, calamites, and lepidophytes of that epoch. Correlated with it was a still greater advance in the structure of their reproductive organs. The highest types of modern cryptogams only occupy the stage called *heterospory*, i. e., the possession of two kinds of spores, the microspore, or male, and the macrospore, or female spore. That stage was reached by all the higher types of Carboniferous cryptogams. But by a series of steps, which recent researches have enabled us to trace in living forms, the passage was made in that early day from heterosporous cryptogamy to true gymnospermy, and the barrier was crossed which separates the cryptogam from the phanerogam. The origin of true flowers, albeit they were minute, inconspicuous, and devoid of color, fragrance, or beauty, took place at that ancient date. They were some such flowers as our sago-palms and our pines and cedars have to-day. Many fruits have been preserved for us in the coal measures and some of them closely resemble those of the ginkgo or maiden-hair tree. There are other strong proofs that the earliest Coniferæ belonged to the yew tribe of the ginkgo type, a type which is now nearly extinct, having but this single living representative. It was this type, and not the true pines and firs, that represented the conifers during the Jurassic period when the cycadean vegetation predominated over all other forms. And yet this solitary survivor of that long line of ancestors, this waning, tottering, dying ginkgo, with its perfect nut and ample deciduous foliage, may be properly regarded as the highest type of conifers, while the pines, spruces, and junipers must be looked upon as somewhat lower types, persisting according to the law already explained.

Angiospermy.—The next great step was from gymnospermy to angiospermy, the beginnings of which are buried in obscurity. In the gymnosperm the tender developing ovule and maturing seed is exposed to every rude element that besets the life of a plant. Thus exposed it is impossible for it to attain that delicacy of organization necessary to the highest perfection of vegetable growth. Protection of the germ thus early became the great desideratum. When it was first attained we know not, but there are some uncertain indications that angiospermous plants existed in Carboniferous time. But if so they did not belong to the higher or exogenous types. The struggles for the protection of the trunk on the one hand, and for the protection of the germ on the other, were independent struggles. Progress toward exogeny had nothing to do with progress toward angiospermy, and if the latter was attained during Carboniferous or early Mesozoic time it was attained only by endogenous plants, and the earliest angiosperms were endogens and not exogens. That is, the lower type from the standpoint of internal structure became the higher type from the standpoint of floral structure. Progress could therefore only be slow. What was gained by the one was lost by the other. Not until both these steps should be taken by the same type of plants could any new departure take place, and the history of plants shows that it was not until this combination occurred that the great revolution in the vegetable world was brought about.

Exogenous Angiospermy.—The time came at last, we know not at what precise period, when exogenous plants acquired a closed ovary. This is the highest type of vegetation yet reached, and the proofs of its potency confront us every time we behold a modern forest of dicotyledonous trees. The great variety, beauty, strength, and grandeur of this now dominant vegetation amply attest the efficacy of exogeny combined with angiospermy in the attainment of vegetal perfection. Yet the time that elapsed from the beginning of either of these advances, taken alone, to that at which their fortunate combination took place was enormous. Not in the great coal period nor its closing Permian stage; not in the Trias which succeeded did there come forth a single exogenous plant whose germ was thus protected. The great and abundant fossil floras of the Rhetic and Lias of India, Australia, Bavaria, Sweden, and their near equivalents in Virginia and North Carolina, the Connecticut valley, and in both Old and New Mexico, have none of them yielded a trace of any such plant. The same is true of the equally abundant Oolitic floras of Yorkshire, France, Italy, Siberia, and Japan. Not even the highest Jurassic strata of any part of the world have with certainty produced an exogenous angiosperm. The oldest formation at which such plants occur is that on which our own city, the nation's capital, stands, viz., the Potomac formation, whose geological position is doubtful as yet, but if Jurassic, centainly represents the extreme uppermost part of that system. By the author of its flora, Professor Fontaine, it is regarded as the equivalent of the Wealden, which is now commonly supposed to be the fresh water equivalent of the Neocomian or lowest member of the Cretaceous. So late did this now overshadowing type of plant life appear upon the globe. The rapidity with which it advanced, conquering and supplanting all rivals, may be better understood when we remember that it forms eighty-five per cent. of the flora of the Dakota group, which corresponds to the Middle Cretaceous.

A new and vigorous type of vegetation had been developed, the genealogical vine had put forth a fresh branch, the plant world had acquired a new lease of life, and it seems to us, looking back over its history, to have actually taken a leap forward at about this epoch, and ever after to have marched on with enormous strides.

Development of Floral Envelopes.—The resources of improvement in organization were, however, not yet exhausted. The germ was, indeed, now protected, and might acquire within its safe chamber all the subtle shades of perfection possible, but the delicate floral organs by which the fecundation of this germ was accomplished were still exposed, as indeed, it would seem, to a greater or less extent, they must always be. Yet means of their better protection were possible and were gradually adopted.

Apetaly.—The very earliest flowers were probably destitute of any protecting envelopes (achlamydeous), and some such still exist, but most of the lowest types of dicotyledonous plants are provided with one floral envelope, sometimes reduced to a few mere scales, sometimes with several distinct sepals in a whorl around the essential organs, sometimes with these united at the base, and occasionally with a bell-shaped, funnel-shaped, or even tubular calyx. Such plants are called apetalous or monochlamydeous. Paleontology shows that those forms which are now apetalous, especially those in which the flowers are borne in catkins, or are nearly altogether naked, prevailed in early times over those provided with two sets of floral envelopes, which is far from being the case at present. Our law, too, is here again exemplified in the great perfection attained in those early times by such apetalous trees as the poplar, the plane-tree, the fig-tree, the laurel and the sassafras.

Polypetaly.—The next step was the development of a second floral envelope, which, however, had its beginnings in small, strap-shaped, or even bristle-shaped petals. In our current botanies as prepared by Gray, De Candolle, and Bentham and Hooker, the plants having separate petals, or polypetalous plants, such as the rose, buttercup, mallow, etc., are placed before those having the corolla all in one piece, like the morning-glory, honeysuckle, etc. This position is given them to indicate that the authors of these books regarded them as of higher rank. But the geological history of plants teaches that such, at least, was not the order of nature in their development. It shows that polypetalous plants were very early developed. We find them at the earliest epoch at which dicotyledons begin to appear in any great abundance. It is true that we rarely find the flowers, and cannot say with certainty that they were the same as they are to-day. It is quite possible that trees of Cretaceous time whose leaves resemble those of modern polypetalous genera may have then had wholly apetalous flowers, but this is as yet mere speculation.

In this group we have another fine illustration of the law which I have stated, according to which the highest attainable development of any given type of structure is early and rapidly acquired. We are in the habit of regarding our magnolias, our tulip-trees, and the Australian eucalypts, as among the finest specimens of polypetalous plants, and yet the genera Magnolia, Liriodendron, and Eucalyptus appear and are rather prominent in the Middle Cretaceous floras of Europe, Green-land, and America. There was some doubt until recently whether the Eucalyptus really was an American type, so remote is its present home. But during the past summer a member of this Society, Mr. David White, has conclusively demonstrated that these trees flourished in abundance on what is now Martha's Vineyard during the Cretaceous age. They probably extended over the entire western world in that vast antiquity before the human race had made its appearance on our planet.

Gamopetaly.—There was one other step to be taken, the step from the polypetalous to the gamopetalous flower, from a corolla consisting of numerous distinct petals forming a whorl around the stamens and pistil within the calyx, to a corolla consisting of a single piece in the form of a bell, a funnel, or a tube, more and more completely protecting the essential organs. The older botanies call such plants *monopetalous*, emphasizing the fact that the corolla is of one piece, but wholly ignoring the process by which it became so. In fact, by placing this group after the polypetalous one they suggest that they are lower in rank and that monopetalous plants may have become polypetalous by division of the corolla into numerous petals. The German investigators, however, have shown by embryological study that the movement has been in the other direction, the petals of polypetalous plants, having, as it were, united into a corolla, and this is confirmed by paleobotany in showing that polypetalous plants antedated monopetalous ones in the history of plant development. The later botanies, therefore, so far recognize this truth as to adopt the term *gamopetalous* to express this union or wedding of the petals.

The progress from polypetaly to gamopetaly had only begun when the geological record closed. Only a few gamopetalous fossil plants have been discovered. There is reason to believe that there were persimmons, whortleberries, olives, and arrowwoods, during Tertiary times, but most of these have small flowers, and in some of the living representatives the lobes of the corolla are cleft nearly to the base, suggesting that at an earlier period in their history they may have really been polypetalous. The more typical Gamopetalæ, with tubular or funnel-form corollas are for the most part unrepresented in the fossil state, and we must regard these plants as among the latest products of development in the vegetable kingdom.

Nature of Vegetal Development.—I have now endeavored to trace the progress of development in the vegetable kingdom from its earliest beginnings in cryptogamic life to its highest and latest expression in the gamopetalous dicotyledon, with a view especially to showing by what particular steps it has taken place, and how the two laws of the extinction of trunk lines of descent and the persistence of unspecialized types have combined to bring about the varied and abundant vegetation with which the earth is clothed. I have sought to emphasize the fact that this evolution has not been in a single ascending series, that the plants that have one after another succeeded to the mastery have each in turn attained the highest development possible to their respective types of structure and have then surrendered their sceptre forever to the new and more perfect types evolved from them, and have usually dwindled down to comparative insignificance but persisted on in some of their lowest forms. I have wished to make clear and patent the important but rather recondite and popularly little understood truth that biologic progress takes place through this sympodial dichotomy, and not by true dichotomy, much less by the ordinary monopodial branching represented by the common figure of a tree. In other words the phylogenetic tree is something considerably different from the common genealogical tree. It further and especially differs in being exceedingly irregular in the intervals of branching. Expressing the process in time we observe that vast periods pass in waiting for the working out of the most simple principle, which, when once hit upon, produces a complete and rapid revolution in an entire department of life. I can liken it in this respect only to the progress of mankind as brought about by great mechanical inventions made at irregular intervals and producing undreamed-of revolutions in the whole industrial frame-work of society. The length of the stationary periods in biologic evolution is determined by no fixed law. When a type of structure has advanced as far as it is capable of developing it remains stationary as long as nothing interferes with its continuance. If no change should take place in its environment it might continue for an indefinite period. As, by hypothesis, it can advance no farther it can only vary in the direction of deterioration or extinction. The type of structure once fixed can never change. Only the degree of vigor, luxuriance, or abundance can undergo modification. Deterioration is everywhere illustrated by the present cryptogamic vegetation. The Carboniferous forests of Lepidodendron and Calamites are represented by our little club-mosses and scouring rushes, although they must have descended from trunk lines which had not yet acquired the exogenous structure. Extinction is exemplified by the absence of exogenous cryptogams in the living flora, as also of most of the later cycadean and coniferous types. There are several interesting cases of partial and rapidly approaching extinction. Among such may be mentioned the maidenhair-tree, the mammoth and redwood trees, and also, it would seem, the tulip and plane trees, all of which in their turn dominated the vegetable kingdom, but now, though undiminished in vigor or structural perfection, have been restricted in range, reduced in number, and nearly crowded out of existence.

We have seen that the deterioration or extinction can be only brought about by a change of environment. The only cause for the predominance of a type is its greater adaptation to the existing environment. If undisturbed any given type of structure will equilibrate in the direction of greater adaptation until this is no longer possible. But complete adaptation, as I long ago pointed out,* is impossible. It is always possible for a new type to appear which shall respond more exactly to the surrounding conditions. The environment, it is true, may undergo unfavorable changes. The climate may change, or the type in its migrations may encounter unfriendly influences. Most effective of all is the ever-changing influence of the contemporary life with which a type must come into competition. It must, as we have seen, eventually encounter as a rival in the race for life, the new type which is to succeed it, endowed with elements of new life and with fresh powers both to overcome hostile influences and to utilize the resources of nature. Such superior types, as already shown, are ever and anon arising, proceeding from quarters least anticipated, appearing without regularity either as to place or time, springing sympodially from the original trunk, rising impiously above their parents, and ultimately overshadowing, repressing, crushing, and extinguishing the former lords of the vegetable kingdom. Such in brief is the generalized history of the rise and fall of empires in the world of plants.

What has thus far been said is perhaps sufficient to render clear to most minds the peculiar and complicated character of biologic evolution in general, and to show how widely it differs

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* American Naturalist, February 1881, p. 89.

not only from the current crude popular conception of it, but also from the ideas which prevail among well informed and even scientific persons. I need not, I am sure, apologize in this age of specialists, for having confined myself almost exclusively to that kingdom of life with which I am most familiar. I believe that I can safely assume that the zoologists present, in whatever branch, have been able to parallel all the illustrations which I have given by similar ones in their own departments, leading to the same general conclusion.

EXTRA NORMAL DEVELOPMENT.

Thus far I have only taken account of what may be called the normal or legitimate causes of such advantageous modifications of structure as have resulted in the successive upward steps which organic life has taken in the course of its history. But there is another class which may be called extra-normal, abnormal, or even illegitimate causes. Normal or legitimate causes are such as result in the production of characters which are of direct use to the organism. In extra-normal or illegitimate causes the characters produced are such as have only an indirect effect. Thus in the vegetable kingdom normal development tends chiefly in the direction of strengthening the stem, increasing the foliar surface, and protecting the germ and reproductive organs, *i. e.*, in the direction of strength, nutrition, and reproduction, these being the three prime essentials of existence. The various modes of strengthening the trunk, and especially the attainment of complete exogeny, as seen in the trees of the present day, directly improved the conditions of existence and the chances for further development. The gradual attainment of broad appendicular expansions called leaves increased more and more the power to decompose the carbonic dioxide of the air which is the chief nourishment of plants. The separation of the sexes, the transition from spore-bearing to seed-bearing plants, the development of a closed ovary for the protection of the germ, and of floral envelopes for the protection of the stamens and pistils, all tended to perfect the reproductive function and render a higher type possible. These influences were therefore all normal and legitimate in acting directly upon the essential properties of the organism; and had no extra-normal or illegitimate influences come in to modify the results these direct ends would have been the only ones attained. Vegetation would doubtless have still been green as now, there would have been forests of large trees with strong solid trunks and umbrageous foliage; there would have been green grass and rushes, rank and luxuriant herbage, stately palms and graceful ferns, even as now, but this would have been all. Two of the leading features of the actual vegetation would have been wanting, viz., showy and fragrant flowers and highly colored, pleasantly flavored, and nutritious fruits.

A large, showy, or fragrant blossom is of no direct use to a plant. Indeed its nourishment is an expense to the normal growth of the plant. Still greater is the cost of the abundant nutritious matter in many fruits. In both these cases the value to the plant is indirect, and when we study the subject deeply we find that the cause of the development of such organs is a sort of teleological or final cause. Beautiful flowers and edible fruits are extra-normal or illegitimate products of nature, and those who fail to see this have but a crude and imperfect conception of the course of evolution.

Fortuitous Variation.—In a certain sense every influence that affects an organism is legitimate, and we have seen that the several great types have been brought into existence by the improvement of the special opportunities offered by the environment. We have also seen that these opportunities have presented themselves at long and irregular intervals, and, as it were, by chance. In this sense there is only a difference of degree between these normal and legitimate influences and those which I have called extra normal or illegitimate. Their occurrence was fortuitous. They were the result of accidental variations in an advantageous direction seized upon by nature for the creation of higher types of life.

There is a school of evolutionists who maintain that this is the only way in which progress takes place. This is held to be the strictly Darwinian view, as opposed to the Lamarckian view that the "appetencies," as Lamarck called them, *i. e.*, the individual efforts, strivings, and struggles of the organism in advantageous directions, aid in determining what the new and improved type shall be. In a paper which I had the honor to read before this society over a year ago on "Fortuitous Variation as illustrated by the genus Eupatorium"* I endeavored to show that this fortuitous variation was often successful even when no apparent advantage could result therefrom. The tendency to vary is in all directions, as from the center toward the surface of a sphere, and variation will take place in every direction which does not prove so disadvantageous as to render life impossible. In by far the greater number of cases the advantage or disadvantage is slight or imperceptible, and changes go on without improvement or deterioration, causing a great number of equally vigorous forms to arise, all differing more or less from one another. This accounts chiefly for the varied and manifold in nature, and but for this law, hitherto, so far as I am aware, unobserved, nature would be

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* See abstract (all that was published) in Nature (London) for July 25, 1889 (Vol. XL, p. 310).

monotonous and uninteresting. From the esthetic point of view, therefore, this is the most important law of biology.

What is its importance from the scientific point of view? As you probably all know, there has been going on during several years past a very lively discussion of the principle of natural selection, and that principle has been vigorously attacked by a large and highly respectable class of working naturalists. Its vulnerable points have been fearlessly exposed and its defenders have been put to their wits' end to save it from serious impairment. It has seemed to me that their mode of defense was ill-chosen and that its weakness consisted in claiming too much for natural selection, more than it can justly be shown to accomplish. The weakest link in the chain is the first one, as Darwin himself admitted, and it seems strange that he, who maintained that the variations which natural selection seizes upon to the advantage of the organism are fortuitous, should not have conceived that these might go on as they begun for a long time and result in important changes that were neither beneficial nor injurious. Those who question the principle of natural selection insist with apparent justice that the incipient changes due to accidental variation during a single generation are utterly inadequate to perpetuate and multiply themselves, that their utility must be infinitesimal and practically nil; and they pertinently ask how the machinery of natural selection was ever set in motion. Strange as it may seem, the defenders of natural selection have thus far found no better answer to this argument than to deny its force and to maintain that every variation, however slight, if in the direction of utility, begins to operate from its inception and goes on increasing with cumulative strength. This answer is not satisfactory and its inadequacy has been sufficiently proved. It should be abandoned and some other substituted, and until this is done natural selection will continue to lack a solid basis upon which to rest.

But it seems to me that there is an answer to the objection, and one which fully meets it. This answer is nothing more nor less than the patent fact already stated that fortuitous variation actually does go on at all times, in many directions, and to great lengths, without any perceptible change in the degree of adaptation which the varying forms have to their environment. I have shown how this takes place in one important genus of plants, and it would be easy to extend the observation to almost any other genus. I doubt not that the animal kingdom is also full of examples.

Here then we have the solution of by far the worst difficulty in the way of natural selection. The beneficial effect need not be assumed to begin at the initial stage. It need not be felt until well-formed varieties have been developed without regard to any advantage in the particular differences which they present. There seems to be no flaw in this mode of solving this paramount problem, and if it is objected that it amounts to a new explanation of the origin of species, I am ready to admit it, and I believe that more species are produced by fortuitous variation than by natural selection. Natural selection is not primarily the cause of the origin of *species;* its mission is far higher. It is the cause of the origin of *types of structure*, such as those whose history I have endeavored to trace, and through which alone biologic evolution takes place.

Extra-Normal Influences in the Vegetable Kingdom.—Returning from this important digression to the subject of extra-normal influences in the vegetable kingdom, let us inquire more closely into their exact nature. As already remarked, the most important are those which have resulted in the development of beauty and fragrance in flowers and of bright colors and agreeable flavors in fruits. But these are by no means all, and we must thus account for most burs, spines, thorns, and other forbidding features, viscid and glandular hairs, as in the sundew, and irregular and peculiar forms of leaves, especially such as are seen in the pitcher-plants, and a great variety of other structures not connected with the reproductive function.

What then are these supra-normal or illegitimate causes which result in such peculiar products? In the first place they consist in special changes in the environment which are seized upon to the advantage of the plant. Plants in view of their stationary character, had especial need of two things, viz., *cross-fertilization* and *dissemination*. Growing together without power to change their position and mingle with remoter forms, there was perpetual danger that close interbreeding might deteriorate or destroy the stock. The seeds of such stationary organisms perpetually falling in the same spot tended to choke one another and to weaken and restrict the species. Every normal and legitimate means of averting these two dangers had been adopted by the earlier types of vegetation. The spores of cryptogams and the pollen of conifers were made so light that the winds would take them up and waft them to great distances. Certain grasses and other herbs were endowed with the peculiarity of being uprooted by the wind at the proper season and blown for miles over the plains, scattering their seeds. And even water had become and still remains a medium for the transportation of both pollen and seed from place to place and from shore to shore. But still these instrumentalities fell far short of the needs of the vegetable world in these directions. At last, and nearly at the same period in the earth's history, two new, and, one may almost say, unexpected agencies came forward, adapted respectively to the supply of these two prime necessities of the plant—viz., *insects* and *birds*.

Origin of Showy and Fragrant Flowers.—Away back in the dim darkness of the coal period when tree-ferns, calamites, and giant club-mosses, combined with archæ-typal yews to people the steaming swamps of a hot, cloud-laden island world, there existed a strange form of insect which can only be compared to the cockroaches of our day, but which seems to have embodied in its structure the beginnings of all the varied types of insect life, the promise and prophecy not only of our dragonflies and beetles, but also of our flies, bees, and butterflies. And during the long ages that followed, while the plant life was passing through the history which I have briefly sketched, the insect world was experiencing a similar unfolding, and new and improved types, very much as in plants, were coming into existence, attaining their maximum development, and giving way to still higher ones, until some time in the late Jurassic or early Cretaceous age forms began to appear which were adapted to obtain sustenance from the pollen, and perhaps from the stigmas of flowers. To do this they were obliged to pass from flower to flower and would unavoidably carry the dust that adhered to their heads, wings and feet from one flower to others more or less remote. Cross-fertilization, that "secret of Nature" discovered by Sprengel, was thus effected, and new vigor was instilled into those forms which for any reason had been so fortunate as to attract these winged friends. We can figure to ourselves a rivalry springing up among plants as to which should offer them the greatest inducement, and through the action of natural selection, which here found a typical field for its normal operation, the entire nature of flowers underwent a rapid change. To continue the figurative expression, all flowers vied to excel in beauty and attractiveness; for these tiny insects possess esthetic tastes which do not materially differ from those of mankind.

To size, showiness, and beauty of coloration, was often added fragrance which was especially successful with moths and other nocturnal insects. Many special inducements were held out. Sweet and nutritious nectars were secreted from the petals to lure on the unsuspecting creatures, and deep, and peculiar grooves, sacs, and spurs were developed to hold this nectar in large quantities. These nectaries were so adjusted that no bee could enter without passing directly over the stigma and brushing upon it the precious dust of other flowers. Wonderful contrivances thus came into existence to secure this supreme end of plant being, and the present world of flowers was ultimately evolved.

The profound modification accomplished by this agency was not confined to size, color, fragrance, and the secretion of nectar. The forms of flowers underwent in many cases a complete change, and an infinite number of wonderful irregularities appeared, varying from the slightest differences in the petals to the amazing abnormalities of the orchids, all calculated to adapt plants to the useful ministrations of insects, sometimes, as in the yucca, to those of a single species of insect without which reproduction is impossible.

And thus it has come about that the form of every flower has its special meaning which can be interpreted by those who have penetrated this great secret. We hear of the language of flowers—that the rose signifies beauty, the daisy innocence, the violet modesty, the myrtle love—but science has discovered a new and real language which the flower not only speaks but writes in clear characters, and which the botanist deciphers and reads by much the same methods that the assyriologist employs when he deciphers and reads the arrow-head inscriptions upon the tablets of Nineveh.

It is thus that flowers are accounted for by modern science in all their beauty and variety. The old idea that they were made for man to admire and enjoy is exploded, and yet it remains true that they were made to be admired and enjoyed by creatures capable of admiration and esthetic pleasure. It is not true that any flower was ever "born to blush unseen" or "waste its fragrance on the desert air." There is a standard of taste so universal that what pleases the bee, the ant, and the butterfly, also pleases the senses of man. Biology has overthrown the anthropocentric theory as astronomy has the geocentric, and every creature lives in and for itself and shares with man to some degree the sublime attributes of mind and soul.*

Origin of bright-colored and sweet-flavored fruits.—In seeking the origin of fruits we have to consider an almost parallel history of development to that which we have been studying in accounting for flowers. But here we must look to another kind of animal life, chiefly to the great family of birds. There were probably no bright-colored or sweet-flavored fruits until the close of Mesozoic time, because the future birds were as yet reptiles crawling over the ground or swimming in the waters, albeit some of them already possessed the inchoate attributes of their avian successors. Moreover, the vegetation of that early period was incapable of employing the intervention of winged life for its distribution. At first it consisted exclusively of spore-bearing plants whose dissemination was chiefly affected by the wind, and which depended upon the infinite multiplication of spores to make up for defective means of distribution. Later came on the gymnospermous types of cycadean and coniferous life, neither of which are now to any great extent adapted to the uses of the feathered world. Paleon-

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* Here and later on I use the term *soul* in the sense of conscious desire strong enough to induce active effort for its satisfaction.

tology, both vegetable and animal, thus doubly confirms the view that fruits, in the sense here employed, had their origin simultaneously with the appearance of birds, as flowers did with that of flower-frequenting insects, toward the close of Mesozoic time. Attracted by their bright colors correlated with pleasant flavors, birds learned to visit the plants that bore such fruits. Flying thence to distant parts and voiding the hard seeds of berries and stones of drupes, they became the effective instruments for the dissemination of these forms.

The great problem of distribution was thus solved by bird life as was that of cross-fertilization by insect life, and just as plants vied with one another to attract insects to their flowers, so did they also vie with one another to attract birds to their fruits. Here again it was the universal esthetic faculty that enabled the ancient bird life to prepare the earth for human habitation, and yet, no more than in the previous case was man the final cause. So uniform is the standard of taste throughout the psychic world that what contributes to the pleasure of a bird or an insect also supplies some esthetic want in the race of men.

ABNORMALITIES OF SEX.

There is one other abnormal or supra-normal influence in the organic world which is so important and so well illustrates the principle now under consideration, that it seems proper briefly to advert to it. I refer to the causes which in many cases, particularly in the animal kingdom, make one sex differ so widely from the other.

An array of facts taken from asexual life and from the very early stages of sexuality converge to show that primarily and normally the female is the main trunk line of development, while the male is merely accessory, and need have no importance apart from the reproductive function. Such restriction actually exists in a great many of the lower organisms and in some that are quite highly organized, while throughout the invertebrate world the physical superiority of the female is the rule and that of the male is almost unknown. Female superiority is also the rule and male superiority the exception among all vertebrates except birds and mammals, and sometimes occurs even in these. Normal or legitimate development would make it universal. But in most birds and mammals, the opposite state of things exists, viz., male superiority, and we are so much more familiar with these two highest types of life that the impression is almost universal that the male sex is in some way the primary and dominant one. I shall not waste your time in attempting to refute this popular impression. Those who defend it simply display their lack of acquaintance with the lower forms of life. My own attention was drawn to the subject by certain remarkable phenomena presented by plants, but a study of the very early stages of animal life is sufficient, with the least reflection, to set the whole question at rest.*

The problem is, therefore, to account for this apparently abrupt reversal of the normal process of development as it went on prior to the advent of birds and mammals. What was the extraneous and illegitimate agency which began to operate early in the development of avian and mammalian life? The one term which most nearly expresses it is *sexual selection*, proposed by Darwin. In my opinion the discovery of the principle of sexual selection has equal if not higher rank

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* For a fuller, though popular, treatment of this subject, see the *Forum* for November, 1888, Vol. VI, p. 266.

than that of natural selection, since its influence when fully understood will be found to be as great, and to Darwin alone is due the entire credit of making it known. Strangely enough Dr. Alfred Russel Wallace, who simultaneously and independently worked out the law of natural selection, is disposed, as shown by his recent work on Darwinism, to reject sexual selection altogether as a factor in biology ; yet to my mind, it remains debatable which of these two great laws has exerted the more profound effects in modifying the course of organic development. It certainly cannot be said of natural selection that it has produced a complete revolution in that course, or has, so to speak, reversed the wheels of biologic progress, as sexual selection has done ; not in the sense of producing a retrograde movement, but in that of shifting the axis of evolution, if I may be allowed the expression, from its normal position to a wholly abnormal one, and raising to a prime factor what was originally a mere incident in the history of organic life.

Female Selection.—But by sexual selection Darwin meant only *female selection*, which would be the more accurate expression. It was not until the era of birds and mammals that the female really began to exercise a choice, or if, as is proved in a few cases, the females of lower creatures did exercise a choice, the result was the same as in the higher, the superiority of the males.

You all understand this law too well to make any explanation of its operation necessary, and I only desire to bring it forward as one of the most important of all the abnormal or illegitimate influences that have brought about the present state of things. I also wish to point out its analogy to the other two influences which I have considered. For here again, size, strength, and beauty, as displayed in the males of so many animals and birds, are the products of a dawning and growing esthetic sentiment, the expression of a developing taste, which is so nearly identical with the most highly developed tastes of mankind that there are no higher objects of human admiration than the gorgeous plumage of birds or the graceful forms of animals—than, for example, the feathers of the ostrich or the antlers of the stag.

Male Selection.—The reign of female selection has been a long one, and throughout the two classes of animals in which it is chiefly displayed it still prevails in full force. It is probably still the dominant influence in the human race, even among its highest types, though here resulting more in mental than in physical superiority in men.

But there are signs that this may not always remain so. I long ago pointed out * that among the higher races of men a form of *male selection* has already begun to exert a strong influence. In civilized life the choosing is not left wholly to women, and with the progress of culture and refinement this mutuality of selection grows more and more marked. That male selection will prove equally effective with female selection is already proved by the ever increasing beauty of women under its influence; and those who think men perverse because they prefer beauty to all other qualities, or women trivial because they make their personal appearance a leading aim of life, have never learned the great law of nature which overrules all the trite maxims of the purists, that beauty means worth—perfection—and that beautiful companions insure perfect offspring, an improved posterity, and a better and nobler race, of men as well as women. And this is why the love of and preference for the beautiful has a higher and a deeper sanction in the everlasting order of things than can be given by any church, any court of law, or any code of morals.

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* Dynamic Sociology, 1883, Vol. I, p. 613.

THE PSYCHIC ELEMENT.

In all the cases considered of what I have denominated extra-normal or illegitimate influences affecting the course of biologic evolution, there is revealed to the careful student a common principle to which their peculiar character is due ; a certain element of power and independence which gives to them both their anomalous and eratic character among organic laws, and also their remarkable efficacy and success in accomplishing the ends of evolution itself. What is this common principle, this element of power? It is expressed in the single word *psychic*—I had almost said, in the one word *mind*. Philosophers correctly identify these conceptions, and anything that transcends the purely vital partakes of the attributes of mind. This new force, manifesting itself in at least three prominent ways at almost the same time in the earth's history, and producing such astonishing revolutions, was the psychic force beginning to respond to a long process of cephalization, or brain-enlargement, in the animal world. It represents the birth of the soul in nature ; it was the response to a demand for the satisfaction of wants, of instincts, of tastes ; it was the first expression of purpose and of will. For these are the attributes which led the bee to seek the nectar from the flower, the bird to visit the brilliant cluster of fruit, or the female of the higher creatures to choose the most beautiful male for its mate. And these are psychic qualities and represent the subjective half of the world of mind—the great heart of nature.

The strictly biologic record properly closes here. To show that this same force continues to produce its unlooked-for effects at a higher stage of development, operating from the objective side, through the intellect, or head of nature, and that the results have here been as much more surprising and far-reaching as the organisms through which they were accomplished were higher in the scale of development,* though an easy task, would not only carry me too far, but would trench upon the domain of anthropology and belong more properly to a sister society.

Cosmic Epochs.—Taking a retrospective view of the entire field of evolution and bearing in mind its uneven course as I have sought to depict it, there may be discerned, standing out prominently above all the minor fluctuations, a few great cosmic crises or epochs, in which the change appears so abrupt and so enormous as to suggest actual discontinuity. Three such cosmic epochs belong to the history of life on the globe. The first was the origin of life itself. The second was the origin of soul or will in nature. The third was the origin of thought or pure intellect. While I do not say that any of the factors producing these epochs came suddenly into existence, or that any definite lines exist separating life from soul or soul from intellect, theoretically speaking, the general fact remains that they are practically distinct principles, having diverse effects, originating at widely different periods in the earth's history, and succeeding one another in the order named. Of these three great principles, life, soul, and intellect, and of the cosmic epochs which they have produced, I have in the closing part of this address, attempted to consider the second only, and I have chosen it chiefly because its bearing upon evolution appears to have been wholly ignored or misunderstood. Soul or will is simply desire in the act of seeking satisfaction, and I once presented the evidence to show that this is a true natural force,† obeying all of the three Newtonian laws of motion; but its effects, compared with the other forces of cosmic and

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* This is the "indirect method of conation." See Dynamic Sociology, Vol. II, p. 99.

† Dynamic Sociology, Vol. II, p. 95.

organic evolution, appear to us erratic or even spasmodic. Nevertheless its potency is far greater and the ends attained through it are upon the whole the same. It owes this character to the fact that it is a psychic force as distinguished from either physical or vital forces. Its study is therefore a part of psychology, and from it we should learn that psychology is simply a branch of biology and its study should begin with animals and not with man. Finally, the peculiar character of this psychic influence is due to its being a product of higher organization. Mind is to biology what protoplasm is to chemistry. Psychology is transcendental biology.*

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* So called by Auguste Comte, who refused to recognize it as a distinct science. See his Philosophie Positive, Vol. IV, p. 342.

ALPHABETICAL INDEX.