

SCIENCE

EDITORIAL COMMITTEE: S. NEWCOMB, Mathematics; R. S. WOODWARD, Mechanics; E. C. PICKERING, Astronomy; T. C. MENDENHALL, Physics; R. H. THURSTON, Engineering; IRA REMSEN, Chemistry; J. LE CONTE, Geology; W. M. DAVIS, Physiography; O. C. MARSH, Paleontology; W. K. BROOKS, C. HART MERRIAM, Zoology; S. H. SCUDDER, Entomology; C. E. BESSEY, N. L. BRITTON, Botany; HENRY F. OSBORN, General Biology; C. S. MINOT, Embryology, Histology; H. P. BOWDITCH, Physiology; J. S. BILLINGS, Hygiene; J. MCKEEN CATTELL, Psychology; DANIEL G. BRINTON, J. W. POWELL, Anthropology.

FRIDAY, AUGUST 19, 1898.

CONTENTS:

<i>Doctorates Conferred by American Universities for Scientific Research</i>	197
<i>The Beginnings of Laboratory Teaching in America: PROFESSOR FRANK P. WHITMAN</i>	201
<i>Hydraulic Illustration of the Wheatestone Bridge: PROFESSOR WILLIAM HALLOCK</i>	206
<i>The Echelon Spectroscope: DR. C. RIBORG MANN</i>	208
<i>The Relation of Science Education in the Secondary Schools to that in the College and the University: PROFESSOR PAUL C. FREER</i>	210
<i>Lacoe Collection in the National Museum</i>	213
<i>A New Name for the Georgia Old Field Mouse: OUTRAM BANGS</i>	214
<i>Botanical Notes:—</i>	
<i>Seeds and Very Low Temperatures; The Scientific Work in the Department of Agriculture; Botanical Papers in the Nebraska Academy of Sciences; The Ovary of Opuntia: PROFESSOR CHARLES E. BESSEY</i>	215
<i>Current Notes on Anthropology:—</i>	
<i>On Pygmy Races; Unsolved Problems of Anthropology; About the Hittites: PROFESSOR D. G. BRINTON</i>	217
<i>Scientific Notes and News</i>	218
<i>University and Educational News</i>	223
<i>Discussion and Correspondence:—</i>	
<i>Observations on Blue Jays: DR. HIRAM M. STANLEY</i>	223
<i>Scientific Literature:—</i>	
<i>Milhaud's La certitude logique et Le rational: PROFESSOR J. H. HYSLOP. Duss on the Flore phanérogamique des Antilles Françaises</i>	224
<i>Scientific Journals</i>	225
<i>Societies and Academies:—</i>	
<i>The American Association for the Advancement of Science</i>	226

DOCTORATES CONFERRED BY AMERICAN UNIVERSITIES FOR SCIENTIFIC RESEARCH.

THE development of the American university during the past twenty-five years may perhaps be regarded as the great achievement of the nation. The foundations laid at Harvard and at Johns Hopkins within the life-time of those students now profiting from them have been built upon, until we have now a score of universities, as places for research, equal to Oxford, and half a dozen rivalling those of Germany. The American college, though founded upon the English system, was of native growth, and the university based upon this college, though influenced by German methods, is distinctly national, while, at the same time, our different institutions show a marked individuality. The American university is definitely a place for research, where both teachers and students are engaged in research or in learning the methods of research. The results of the work of the students is in large measure summarized by the theses for the doctorate, and it is interesting to know what is the outcome of the past year's research.

It appears, from a somewhat careful enquiry, that eighteen leading universities conferred the Ph. D. degree on 234 candidates. The degree was not given last year by Indiana, Illinois, Kansas, Texas, Colorado, Missouri, Tulane or the Catholic University

of America. The doctorates conferred by the several universities are classified in the accompanying table :

Universities.	Humanities.	History and Economics.	Sciences.	Total.
Chicago.....	12	12	12	36
Yale	19	4	11	34
Johns Hopkins	11	3	19	33
Harvard	12	3	11	26
Pennsylvania	9	7	8	24
Columbia	7	5	10	22
Cornell	7	1	11	19
Clark.....	.....	.....	12	12
Michigan.....	6	1	.....	7
New York.....	4	.....	1	5
Wisconsin	2	1	2	5
Bryn Mawr.....	1	1	1	3
Leland Stanford, Jr.....	.....	.....	2	2
Nebraska .....	.....	.....	2	2
Brown.....	.....	.....	1	1
California.....	.....	.....	1	1
Columbian .....	.....	.....	1	1
Minnesota.....	1	.....	.....	1
Total number of Ph.D. degrees conferred.....	91	38	105	234

It is gratifying for the scientific student to note that 105 degrees were conferred in the sciences. The number of degrees in science surpasses or approximately equals the number in the humanities in all the universities except Yale, Michigan and New York, and in nearly all cases exceeds the number in history and economics. The universities vary somewhat, the sciences being relatively favored at Johns Hopkins, the humanities at Yale, and history and economics at Chicago. Princeton conferred one D. Sc., and is not included in the table. The standards of the universities vary somewhat, and it is unfortunate that in certain cases the theses are not printed. It is a sign of progress that the Ph. D. degree *causa honoris* was apparently not given last year by any important institution.

There are probably not as many as one thousand men of science in the United States

engaged in original research, and the forces are consequently greatly strengthened by one hundred recruits—not including those from Germany and elsewhere—in a single year. The distribution of these students among the different sciences was as follows :

Chemistry.....	27
Psychology.....	18
Zoology.....	12
Mathematics.....	11
Physics.....	11
Botany.....	11
Geology.....	6
Physiology.....	4
Astronomy.....	3
Anthropology	2

The names of those on whom the doctorate was conferred for work in these sciences, and the subjects of their theses, are as follows :

THE JOHNS HOPKINS UNIVERSITY.

Cleveland Abbe, Jr. : Geology, Some Maryland Rivers and their Development : A Contribution to the Physiographic History of Maryland.

Howard Bell Arbuckle : Chemistry, A Redetermination of the Atomic Weights of Zinc and Cadmium.

Charles Gilpin Cook : Chemistry, Some Double Halides of Tin with the Aliphatic Amines and with Tetramethylammonium.

Frederick Henry Duryea Crane : Chemistry, A Contribution to the Knowledge of Tellurium.

Gilman Arthur Drew : Zoology, The Anatomy, Habits and Embryology of *Yoldia limatula*, Say.

John Eiesland : Mathematics, On a Certain Class of Functions with Line-Singularities.

Charles Wilson Greene : Physiology, On the Relations of the Inorganic Salts found in Blood to the Automatic Activity of a Strip of Cardiac Muscle.

James Graham Hardy : Mathematics, On One-Variable Displacements in a Space of Four Dimensions, and on Curves of Triple Curvature.

Caleb Notbohm Harrison : Physics, The Arc-Spectra of the Elements Lanthanum, Vanadium, Zirconium.

William App Jones : Chemistry, A Contribution to the Knowledge of Dicarboxyl Cuprous Chloride.

Arthur Gray Leonard : Geology, The Basic Rocks of Northeastern Maryland and their Relation to the Granite.

Charles Elwood Mendenhall : Physics, A Bolomet-

ric Study of the Spectrum of an Absolutely Black Body between the Temperature of 300° to 1100° Centigrade.

Samuel Alfred Mitchell : Astronomy, I. The Theory of the Concave Grating ; II. Use of the Concave Grating in Stellar Spectroscopy.

Cleophas Cisney O'Harra : Geology, The Geology of Alleghany County, Maryland.

Thomas Dobbin Penniman : Physics, Some new Methods for the Determination and Comparison of Self Inductance, Mutual Inductance and Capacity, together with some Actual Measurements.

Edward Rhoads : Physics, The Effect of the Fibrous Structure of Sheet Iron on the Changes in the Length accompanying its Magnetization.

Garnett Ryland : Chemistry, A Contribution to the Study of Liquid Mixtures of Constant Boiling Point.

Charles William Waidner : Physics, A Recalculation of the Mechanical Equivalent of Heat.

Albert Francis Zahm : Physics, Determination of the Resistance of the Air at Speeds of 200 to 500 Miles an Hour, with Notes on two New Methods of Measuring Projectile Velocities inside and outside the Gun.

UNIVERSITY OF CHICAGO.

Samuel Jackson Holmes : The Early Development of *Planorbis trivolvis*.

Henry Chandler Cowles : An Ecological Study of the Sand Dune Flora of Northern Indiana.

Herbert Ellsworth Slaughter : The Cross Ratio Group of 120 Quadratic Cremona Transformations of the Plane.

William L. Bray : The Xerophytic Flora of the Texan Plains.

Otis William Caldwell : Morphology of *Lemna*, with Ecological Notes.

Otto Knute Olaf Folin : On Urethanes.

Edwin Sheldon Johnson, Jr. : Thickness of the Black Spot in Liquid Films.

Herbert Newby McCoy : On the Hydrochlorides of Carbophenylimide Derivatives.

William Dayton Merrell : Contribution to the Life History of *Silphium*.

Amy Eliza Tanner : Imagery, with Special Reference to Association of Ideas.

William Douwes Zoethout : The Physiological Effects of High Temperatures and Lack of Oxygen upon Lower Organisms.

CLARK UNIVERSITY.

Frederick C. Ferry : Mathematics, Geometry on the Cubic Scroll of the First Kind.

Ernest W. Rettger : Mathematics, On Lie's Theory of Continuous Groups.

Benjamin F. Sharpe : Physics, An Instrument and Method for the Measurement of Sound.

Frederick L. Burk : Psychology, From Fundamental to Accessory in Nerve-Muscle Structure and Function.

F. E. Bolton : Psychology, Some Hydro-psychoses.

Linus W. Kline : Psychology, Migration vs. Love of Home.

J. Richard Street : Psychology, A Genetic Study of Immortality.

Daniel E. Phillips : Psychology, The Teaching Instinct.

F. W. Colegrove : Psychology, Memory as a Function of Age.

E. W. Bohannon : Psychology, Motor-Education.

Cephas Guillet : Psychology, Instincts in Children and Animals Compared.

H. S. Curtis : Psychology, Inhibition Experimentally and Theoretically Considered.

CORNELL UNIVERSITY.

Samuel Jackson Barnett : On the Surface Tension of Liquids under the Influence of Electrostatic Induction.

Isaac Madison Bently : The Qualitative Fidelity of the Memory Image.

Hector Russell Carveth : Single Differences of Potential.

Charles Worthington Comstock : The Application of Quaternions to the Analysis of Internal Stress.

Benjamin Minge Duggar : Studies on the Morphology of the Gametophyte, and Development of the Sporangium, in some Angiosperms.

Eleanor Acheson McCulloch Gamble : The Applicability of Weber's Law to Smell.

Cyril George Hopkins : The Chemistry of the Corn Kernel.

James George Needham : A Genealogic Study of Dragon-fly Wing Venation.

Stella Emily Sharp : Individual Psychology.

John Ferguson Snell : Potassium Chloride in Aqueous Acetone.

HARVARD UNIVERSITY.

Frank Watts Bancroft : Zoology and Physiology, Ovogenesis in *Distaplia* with Remarks on other Species.

Harry Yandell Benedict : Celestial Mechanics, The Variation of Latitude.

William Burdelle Bentley : Organic Chemistry, Tribrombenzol and Derivatives.

Joseph William Blankinship : Botany, Isolation as a Criterion of Species.

Donald Frank Campbell : Mathematics, On Linear Differential Equations of the Third and Fourth Orders, in whose Solutions exist certain Homogeneous Relations.

Allerton Seward Cushman : Chemistry, The Atomic Weight of Nickel.

James Edwin Lough : Psychology, The Intensity of Sensation : An Experimental Essay in Physiological Psychology.

Frank Russell : Somatology, A Study of a Collection of Eskimo Crania from Labrador, with Observations on the prevailing System of Craniometry.

Charles Augustus Soch : Organic Chemistry, Action of Sodium Nitromalonic Aldehyde on Ketones and Ketone Acids.

Leon Mendez Solomons : Psychology, The Fusion of Touch Sensations.

Frederick Clayton Waite : Zoology, The Structure and Development of the Antennal Glands in *Homarus americanus* Milne-Edwards.

YALE UNIVERSITY.

Alice Hopkins Albro : Chemistry, The Original and Chemical Relationship of some Products of Proteolytic Cleavage.

Martha Austin : The Estimation of Manganese in Analysis.

Bayard Barnes : Chemistry, Investigations in Organic Chemistry.

George Francis Eaton : The Prehistoric Fauna of Block Island, as indicated by its Ancient Shell Heaps.

Harry Ward Foote : Investigations in Chemistry and Mineralogy.

Yandell Henderson : Chemico-Physiological Studies on the Derivatives of the Proteids.

George Tucker Sellow : On the Complex Number.

George Pratt Starkweather : The Thermodynamic Relations for Water Steam.

Wendell Melville Strong : On the Necessity of Continuity in Euclid's Geometry.

Willard Gibbs Van Name : On the Embryology of a Marine Planarian.

Jacob Westlund : Some new Equations of Transformation.

COLUMBIA UNIVERSITY.

Gary Nathan Calkins : Zoology, Mitosis in *Noctiluca miliaris* and its Bearing on the Nuclear Relations of the Protozoa and Metazoa.

Wilber Dwight Engle : Chemistry, Some Thiocyanates.

Abel Joel Grout : Botany, A Revision of the North American Isotheciaceæ and Brachytheciæ.

Marshall Avery Howe : Botany, The Hepaticæ of California.

Wilfrid Lay : Psychology, Mental Imagery.

Albert Prescott Matthews : Physiology, The Structural Changes of the Pancreas Cell, with some General Considerations on Cell Metabolism.

John Alexander Matthews : Chemistry, On the Action of Fatty Nitrils upon Aromatic Acids.

Per Axel Rydberg : Botany, A Revision of the North American Potentillæ.

Frank Schlesinger : Astronomy, The Præsepe Group ; Measurement and Reduction of the Rutherford Photographs.

Edward Lee Thorndike : Psychology, Animal Intelligence.

UNIVERSITY OF PENNSYLVANIA.

Elizabeth Allen Atkinson : Metal Separations by Means of Hydrobromic Acid Gas: Indium in Tungsten Minerals.

Frederick Ehrenfeld : A Study of the Igneous Rocks of York Haven and Stony Brook, Pa., and their Accompanying Formations.

William Mason Grosvenor, Jr. : Electrolytic Reductions.

Harold Heath : The Development of Ischonochiton.

Victor Lenher : The Atomic Mass and Derivatives of Selenium.

Joseph Merritt Matthews : Derivatives of the Tetrahalides of Zirconium, Thorium and Lead.

Edward Anson Partridge : On the Mathematical Theory of the Geometric Chuck.

George William Sargent : The Quantitative Determination of Boric Acid in Tourmaline.

George Edward Thomas : The Atomic Mass of Tungsten and the Preparation of Sodium Pertungstate by means of the Electric Current.

LELAND STANFORD, JUNIOR, UNIVERSITY.

George Clinton Price : Development of the Excretory Organs of a Myxinoid, *Bdellostoma Stouti*.

Walter Robert Shaw : Observations on the Fertilization of the Egg-cell in the genus *Onoclea*.

UNIVERSITY OF NEBRASKA.

Frederic Edward Clements : The Phyto-geography of Nebraska.

Albert Luther Candy : A General Theorem relating to Transversals and its Consequences.

UNIVERSITY OF WISCONSIN.

Ernest Robertson Buckley : Geology, The Building and Monumental Stone of Wisconsin.

Samuel Weidman : Geology, The Geology of the pre-Cambrian Igneous Rocks of the Fox River Valley, Wisconsin.

BROWN UNIVERSITY.

Frederic Slocum : The Harmonic Analysis of the Tides and a Discussion of the Tides of Narragansett Bay.

BRYN MAWR COLLEGE.

Esther F. Byrnes : Morphology, The Maturation and Fertilization of the Egg of *Limax*.

UNIVERSITY OF CALIFORNIA.

Willis Linn Jepson : Botany, Flora of Western Middle California.

COLUMBIAN UNIVERSITY, WASHINGTON, D. C.

Cabell Whitehead : Chemistry, A Study of the Tellurides : their Formation and Chemical Properties.

NEW YORK UNIVERSITY.

William Lawrence A. Dalton : Psychology, Experimental Studies in Association and Memory.

THE BEGINNINGS OF LABORATORY TEACHING IN AMERICA.

THE American Association for the Advancement of Science celebrates this year its fiftieth anniversary. The epoch thus commemorated is notable in more than one way as that of a scientific awakening in this country. The foundation of the Association; the welcome given to Agassiz, whose first lectures were delivered at the Lowell Institute in 1846; the enthusiasm greeting the astronomical pilgrimages of O. M. Mitchell, to quote but a few out of many indications, show an aroused public sentiment with regard to natural science.

In no way is this movement more striking than in the effect upon scientific teaching in the colleges. For many years this had been nearly at a standstill. The methods seem to have been everywhere much the same. Instruction was by text-book and lecture. The lectures were illustrated, the illustrations of the spectacular sort. The magnitude or brilliancy of a lecture experiment was often as highly valued as its actual illustrative character. Thus the compound blowpipe and the mammoth batteries of Robert Hare were eagerly welcomed by Benjamin Silliman, with a keen appreciation of effects, and he points with a just pride to the hugeness of the electromagnet constructed for Yale College under the direction of Joseph Henry.

The Yale catalogue of 1822 announces that "The junior class attends a course of experimental natural philosophy; and the

senior class the courses in chemistry, mineralogy, geology and the principles of natural philosophy."

All these courses were under the charge of Professor Silliman, and the above formula remains practically unchanged in the catalogues for upwards of twenty-five years, or until after the founding of the Scientific School. Other college catalogues, Amherst, Bowdoin, Brown, Harvard, Princeton, tell a similar story.

At Dartmouth, as at Yale, the necessity of providing for medical students required the maintenance of a somewhat high scientific standard, and a brief summary of the progress of chemical teaching at Dartmouth probably gives an idea of the best opportunities of the day.

Lectures on chemistry were given at Dartmouth before the opening of the present century, the lecturer holding the double title—varying somewhat from year to year—of professor (or lecturer) on chemistry and medicine.

In 1820 James Freeman Dana is professor of chemistry, mineralogy and the application of science to the arts; in 1822 professor of chemistry, mineralogy, pharmacy and legal medicine. The number of departments under control of one man sufficiently indicates the paucity of the courses.

In 1825 Professor Dana published an 'Epitome of Chemical Philosophy.' This appears to be the first mention of a text-book in chemistry, though these were probably in use before. In 1833 Turner's Chemistry was used, and then successively Kane's, Fownes' and Silliman's. Through much of this period a small fee is charged students attending the chemical lectures, which are given in connection with the text-book.

In the catalogue for 1851-52 the statement is made that 'the chemical laboratory is amply furnished with apparatus and chemicals for illustration of lectures in that