SCIENCE

FRIDAY, MARCH 22, 1912

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INVESTIGATIONS OF THE CARNEGIE INSTITUTION[1]

THE past fiscal year has been, on the whole, the most fruitful year on record for the ten specially organized departments of research in the institution. Although some of these are not yet fully equipped, they are all so well organized and provided for that their energies may now be chiefly directed to the attainment of definite results.

A development of much interest in connection with these departments is that of cooperative effort coming through research associates and collaborators. The departmental facilities are already in considerable demand from capable investigators, and many of them are found desirous of using these facilities, not only to forward their own researches, but to collaborate in the researches proper of the departments. The favorable experience which has accrued in recent years in these matters indicates that it may be advantageous in the future to seek to secure an additional number of investigators who, by reason of their eminence, may collaborate effectively in this manner.

Each of these departments has now under way such a variety and complexity of work that it is difficult to summarize. Reference must be made, therefore, for matters of detail, to the reports of the directors of the departments, published in full in the current year book. Hence such allusions in the following paragraphs as are made to the progress of the year are necessarily brief and can deal only with the more salient

[1] From the Report of the President, Dr. R. S. Woodward, for the year 1911.

aspects of departmental affairs and researches.

DEPARTMENT OF BOTANICAL RESEARCH

The activities of this department now necessarily cover a wide range, since any successful attempt to solve the problems of the origin, development, migration, and modification under varying climatic conditions of plant life must require extensive field observations, much laboratory experimentation, and increasing application of the sciences of chemistry and physics. It is natural and proper, therefore, that the staff and collaborators of the department should include many specialists, and that they should approach the problems to be investigated from many points of view. Thus it happens that the investigations of the past year have embraced, among others, studies of the evaporation, the increasing salinity, and the changes in vegetation following close after the receding shores of the Salton Sea; of the influences of temperature, rainfall, sunlight, soil-moisture, etc., on plant organisms; of the effects following transplantation from low to high altitudes and from arid to humid localities; of the variations in water and acid content of plants; of the chemical effects induced in plant tissue by light and heat; and of the physiological functions of leaves in plant life.

One of the most interesting investigations under way during the year is that of Dr. Ellsworth Huntington, research associate of the department, on the secular variations of climate of the southwest desert area in recent geologic time. From this work it is believed that some of the salient fluctuations in climate during the past two or three thousand years may be clearly made out. Another noteworthy investigation of the year is that of the respiration of cacti, undertaken by Professor H. M. Richards in collaboration with the department. This has developed the remarkable fact of a definite diurnal periodicity in the acid content of the sap of the cacti under observation. The progress and status of many other instructive investigations are set forth at length under the twenty subdivisions of the director's report, to be found in full in the current year book. From this it appears that, in addition to the regular and associate members of the staff of the department, about an equal number of individual investigators have collaborated in the researches under way. Special attention may be here invited to the detailed account given in one of the subdivisions of this report by Professor Tower in reference to his further experiments on the evolution of chrysomelid beetles, the results of his early work in this line under the auspices of the institution having been issued as publication No. 48.

DEPARTMENT OF EXPERIMENTAL EVOLUTION

It is a well-known fact that important generalizations in science usually leave a multitude of details to be worked out. Indeed, advances often raise more questions than they settle. Such has been the wonderfully fruitful effect of the doctrine of evolution propounded by Darwin, Spencer, and Wallace a half century ago. It should not be surprising, therefore, that the program of the Department of Experimental Evolution presents a considerable variety of investigations related to the highly complex problem of heredity chosen by the director as the principal object of research. Thus the work of the year includes investigations of heredity in plants, insects, birds, animals, and man.

One of the most promising investigations of the year is that of the director in reference to the heredity of epileptics. Through his connection with the Eugenics Record Office, he has collaborated with Dr. David

F. Weeks, of the New Jersey State Village of Epileptics, and secured a large quantity of accurate statistical data bearing directly on this disorder. From these data it appears not improbable that important practical deductions may be presently, if not already, drawn. Another investigation continued during the year, which involves prime utilitarian application, is that of Dr. Shull on the effects of self-fertilization in maize, or Indian corn. His earlier conclusions, published in 1908, have been confirmed by the later studies. A striking result from the latter is that, other conditions being the same, the yield of cross-fertilized plants proved fifty per cent. greater than that of the self-fertilized plants. Observational and experimental work has been carried on also along many other lines. The total number of zoological individuals under study exceeded 2,000, while the range of plants observed included nearly 500 species and upwards of 40,000 individuals.

DEPARTMENT OF ECONOMICS AND SOCIOLOGY

The diversified work of this department has proceeded during the year in accordance with the plan approved by the executive committee in May, 1910, which contemplated completing the researches then under way as well as might prove practicable under the limitations of the balance of appropriations previously made to the department. A full statement of these appropriations, of the expenditures under them to date, and of the present available balance, will be found in the section of this report devoted to the proposed budget for the ensuing year.

As explained at length by the chairman of the department in his report, to be found in the current year book, progress in the work under way is necessarily slow, since the heads of the divisions of research and most of their collaborators are primarily engaged in other occupations. But in spite of this handicap, inherent in the organization, much work has been accomplished, and the chairman reports that several of the heads of divisions are now engaged on their final reports.

DEPARTMENT OF HISTORICAL RESEARCH

The eighth annual report of this department, and the sixth of the present director, is an instructive record of effective progress along all lines of work thus far undertaken to discover and to render available the sources of American history. Members of the department have been engaged during the year searching the archives of Great Britain, France, Spain, and Mexico, as well as those of the United States, for all accessible data, and these are being rapidly put in form for publication in convenient manuals. Three such works have been published by the institution during the past year, namely, "Guide to the Materials for American History in Roman and other Italian Archives"; "Inventory of Unpublished Material for American Religious History in Protestant Church Archives and other Repositories"; and "Calendar of Papers in Washington Archives relating to the Territories of the United States." The following are now in press: "Guide to the Manuscript Material relating to American History in the German State Archives" and "Guide to Materials for the History of the United States in the Principal Archives of Mexico."

It is worthy of remark that the results of this department's activities have received very general commendation from professional historians in Europe as well as in America. The ten manuals thus far issued are already much in demand in foreign countries, and they seem destined to become

as important in aggregate usefulness abroad as at home. It is hoped that the institution may be thus enabled to render adequate acknowledgment for numerous courtesies extended to the department by officials of governments, archives, libraries, and other establishments.

GEOPHYSICAL LABORATORY

The signal success already attained by this laboratory leaves no reason for doubt as to the practicability of continued advances toward solution of that large and difficult group of chemical and physical problems presented by the materials of the earth's crust. The current report of the director reviews twenty-six papers which have been issued by members of the staff of the laboratory during the year. Among these papers is a noteworthy contribution to general physics, in which the scale of precise thermometry is extended by 1250° C. This extension was an essential incident to the studies of mineral fusion, crystallization, etc., carried on in the laboratory, but it is of equal importance to other branches of physical research. Another noteworthy paper is a preliminary contribution to the long-standing question of the constitution of Portland cement. The complexity of this substance proves to be far greater than hitherto supposed; but its general characteristics have been determined and the resources of the laboratory are adequate to complete the remaining quantitative details of the investigation.

International appreciation of the work of the institution is now shown in many ways. The merits of the researches of the geophysical laboratory have been more promptly recognized, indeed, than its projectors anticipated. Thus nearly all of the preliminary papers issued by members of the staff of the laboratory have been published in German as well as in English, and arrangements have been made during the past year to have all such papers appear contemporaneously in both of these languages.

Of numerous investigations under way at the laboratory, attention may be called here to some preliminary studies of an active volcano, which indicate that the phenomena of vulcanism are within range of practicable determination and that progress in this direction is only a question of time and adequate effort.

DEPARTMENT OF MARINE BIOLOGY

In addition to the research work proper carried on by the director of this department during the year, much of his time and attention have been devoted to the construction of a new vessel and to the reconstruction of the laboratory at Dry Tortugas. Reference to this vessel, named the *Anton Dohrn,* has been made in a previous section of this report, and a description of her characteristics and equipment will be found in the current report of the director. It may suffice here, therefore, to state that this adjunct gives the department independent and adequate transportation facilities and greatly enlarged opportunities for marine research.

Mention was made in my report of a year ago of the probable damage done to the Tortugas laboratory by the destructive hurricane which swept the Florida Keys October 17, 1910. An inventory of the wreckage was made as soon as practicable, and it was found that an expenditure of $4,000 would be essential to renew the establishment in a safe and effective manner. Accordingly, an allotment of this amount from the insurance fund of the institution was made by the executive committee at its meeting of November 17, 1910, and the wrecked buildings have been replaced during the past summer by struc-

tures at once more secure and more commodious.

On account of lack of quarters the director has been able to afford facilities for research at the laboratory to only eight investigators. Nevertheless, the year has proved fruitful in important advances. One of these, attained by Mr. G. H. Drew, of Cambridge University, relates to the rôle of certain bacteria in depriving surface sea water of nitrogen and in precipitating the vast deposits of chalky mud (oolite) of the Florida-Bahama region; another, by Dr. T. W. Vaughan, records definite progress in his quantitative determinations of the growth of corals and coral reefs; while the director and his collaborators have published twenty-one papers, mostly included in volumes Nos. 132 and 133 of the publications of the institution.

DEPARTMENT OF MERIDIAN ASTROMETRY

As already explained in a preceding section of this report, the meridian determinations of stellar positions at the temporary observatory at San Luis, Argentina, were finished in January, 1911. This completion in an unexpectedly short time of the more formidable part of the undertaking of the department in the southern hemisphere leaves only the minor task in photometry of measuring the magnitudes (or brightness) of those stars for which this property has not been hitherto measured. This task, requiring only two observers and light equipment, will be subject to small expense.

In the meantime the deductions of stellar positions and motions are proceeding expeditiously in the computing section of the department at the Dudley Observatory; so that the final catalogue, giving precise positions of all stars up to the seventh magnitude inclusive, may be expected to appear in due time. As often happens in such extensive scientific investigations, many by-products are arising of hardly less importance than the primary ends in view. One of these, deduced from the director's preliminary Star Catalogue, published by the institution about two years ago, shows the mean velocities relative to the solar system of stars of different spectral types. The values derived from the "proper motions" of the catalogue are in striking agreement with those derived for the same stars by Professor W. W. Campbell from direct measurements of the motions of these stars in the line of sight. The remarkable result which is thus brought out from independent investigations is that the speed of a star through space increases with its age. Attention is here invited to the director's interesting summary of this by-product in his current report, the investigation in full having been published in the *Astronomical Journal*, April 3, 1911. It is of interest to note in this connection that the independent investigations of Campbell, referred to above, were also carried out by aid of grants made by the institution.

NUTRITION LABORATORY

Allusion has been made frequently in previous reports to a prime characteristic in the progress of all of the more highly developed sciences. This consists in the passage from the stage of observation and experiment to the stage of measurement and calculation, or in the transition from the stage of qualitative to that of quantitative knowledge. It is marked by the introduction of the meter, the balance, the thermometer, the telescope, the microscope, etc., and the definite methods of chemistry and physics. The development of the work of the nutrition laboratory affords a capital illustration of this characteristic mode of procedure, and therein we find also the best

justification for confidence in the enterprise.

The staff of the laboratory has been occupied during the year in the construction of new apparatus, in the improvement of apparatus already in use, in numerous researches on pathological and normal subjects, and in the preparation and publication of reports on results already attained. The year has shown also a remarkable increase of interest in the work of the establishment coming especially from members of the medical profession at home and abroad. Several of these have collaborated very effectively in the experiments under way, and the widely general approval of the objects and methods of the laboratory insures the heartiest cooperation from experts in the closely allied fields of physiological and pathological research.

The numerous investigations in progress and the publications issued during the year are reviewed in interesting detail in the director's report. Of the nine publications issued, one (No. 155 of the institution) gives the results of an important study of the variations of temperature in different parts of the human body. Of equal popular and technical interest also are the results, recorded in another paper, of experiments on men to determine the effects of breathing air rich in oxygen content.

THE SOLAR OBSERVATORY

By reason of the absence on leave of Professor Hale, the varied work of this observatory has been in general charge of Mr. Walter S. Adams, who, as acting director, has prepared the report of progress for the past fiscal year as well as that for the year 1909–1910. Quite fortunately the affairs of the observatory have proceeded without serious delay during Professor Hale's absence, and it is gratifying to announce that his health was so far restored as to permit him to return to his duties October 1, 1911.

Although the construction and equipment of the observatory are still incomplete, the members of the staff are making rapid progress with their programs of solar, stellar, and physical observation and of computation and deduction. Thus the attainment of tangible results proceeds along with the development and installation of equipment. Attention is invited to a list of such results, attained during the year, cited in interesting detail by Mr. Adams in his report, but too long for an abstract in this place. It need only be said of them here that they justify expectations and that they increase confidence in the capacity of the establishment to advance astrophysical science.

The observatory has now, nearly fully equipped and in use, four highly effective telescopes: the Snow, horizontal, 30-inch reflector; the two tower-telescope refractors; and the 60-inch reflector mounted equatorially. The 150-foot tower telescope, together with its auxiliary apparatus, constitutes the most important addition of the year in the way of equipment. Varied use of the 60-inch equatorial proves it to be alike effective in visual, photographic, and spectroscopic work. It is especially penetrating in its capacity to reveal the characteristics of globular star clusters and spiral nebulæ.

In view of the repeated failures of the contractors of St. Gobain, France, to cast a perfect disk for the 100-inch "Hooker telescope," it was determined to try the imperfect disk furnished by these contractors, but not accepted, four years ago. Accordingly an agreement was entered into with the makers to try shaping the disk, and to pay therefor in case it proves sufficiently stable after adequate trial. This work was begun early in the year, and good progress has already been made, although some delay

must result by reason of the illness of Professor Ritchey and his chief assistant in this delicate and laborious task. In the meantime the glass-founders of St. Gobian are unremitting in their efforts to secure a perfect disk.

It is with deep regret that the observatory and the institution are called upon to record the unexpected death, on May 24, 1911, of Mr. John Daggett Hooker, to whom the enterprise of the 100-inch telescope owes its inception. His intelligent interest in and appreciation of the work of the Mount a gift of $50,000 in 1906 for the purchase of a disk and for the shaping of it for a 100-inch reflecting telescope. Unfortunately the difficulties in the way of casting so large a disk of glass, together with his untimely death, have prevented him from realizing his desire to see this telescope in use. But if the enterprise succeeds, as now seems quite hopefully probable, the observatory and the institution will be glad to link the constancy of his faith in scientific investigation to the constancy of the stars by means of diligent applications of the "Hooker telescope" to astronomical research.

DEPARTMENT OF TERRESTRIAL MAGNETISM

The magnetic survey of the globe undertaken by this department is proceeding effectively on both land and sea. Observations of the magnetic elements of declination, dip and intensity have been made at numerous points on the continents of Asia, Africa, Australia, Europe, South America and on the Polynesian Islands; while the non-magnetic ship *Carnegie* has secured a large quantity of data of immediate practical utility to navigation and of still greater importance, doubtless, in their relations to the general problem of terrestrial physics.

At the end of the previous fiscal year the *Carnegie* was en route from the mouth of the Amazon to Rio de Janeiro. After visiting the ports of Rio de Janeiro, Montevideo, Buenos Aires and Cape Town, she arrived at Colombo, Ceylon, June 7, 1911. Having started on her present circumnavigation cruise June 20, 1910, her arrival at Colombo marked the end, approximately, of the first year out. During this year she traversed upwards of 23,000 nautical miles, measuring magnetic declinations at 252 different points, and dip and intensity at 172 different points at sea. In addition to this work, corresponding complete determinations were made on land at seven ports and intercomparisons of magnetic instruments were made at three ports.

Unexpectedly large errors have been found almost everywhere, except in the south Atlantic Ocean, in the best compass sailing charts now in use. This is especially the case in the Indian Ocean, for which some recently issued charts are in error as much as 4° to 6° in the "compass variations" assigned. To meet the pressing needs of mariners for more trustworthy charts, the data obtained by the *Carnegie* are promptly furnished to the hydrographic establishments of the world engaged in the publication of magnetic charts. It appears from the investigations of the department that the chief source of the errors in existing charts lies in a lack of knowledge of the secular variation of the magnetic elements. It is worthy of note, also, in this connection that observations of atmospheric electricity and atmospheric refraction have been carried on during this voyage of the *Carnegie*. The importance of precise navigation in recent times gives special interest to the outstanding uncertainties due to atmospheric refraction.

Expeditions for land determinations of magnetic data have been made to many

countries and to many islands. The most extended of these are that carried out by Mr. Stewart in traversing the length of the Amazon River and that by Mr. Sligh in Asia Minor, Turkey, Arabia, Greece, Tripoli, Tunis and Algeria. The director of the department, on his way to meet the *Carnegie* at Colombo, made observations at Tau Island, of the Samoan Group, on the day of the total solar eclipse, April 28, 1911; and also at six other island stations in the course of his voyage.

The office work of computation and compilation of results and of the construction and testing of instruments has proceeded simultaneously with the operations on land and sea. A complete collection of the data obtained since the establishment of the department, including those of the cruises of the *Galilee* and *Carnegie,* will be ready for publication by the end of the present calendar year. Three portable magnetometers have been completed and four others are under construction, while various improvements to instruments and apparatus in use have been made, along with all current repairs, in the construction and repair shop of the department.

INVESTIGATIONS OF RESEARCH ASSOCIATES

Between fifty and sixty research associates have carried on investigations under the auspices of the institution during the year, either by aid of grants made directly to them or for the purpose of publishing results of their investigations. Several of these associates have been connected with the departments of investigation. Many collaborators have also participated in the researches carried on under this head, and the fields of investigation are numerous and of very diverse kinds. An idea of the extent and variety of this work can be best gained by consulting the reports, in the current Year Book, of the individual investigators, by reference to the annual list of publications of the institution and the general bibliography of the year. As indicating the diversity of these investigations, attention may be called to two remarkable publications in widely different fields. One of these is a treatise on dynamic meteorology and hydrography, by Professor V. Bjerknes, of the University of Christiania, and marks a noteworthy advance in this difficult branch of mathematical physics. Part I. of this work has been issued and Part II. is now in press. It is interesting to note, also, that permission has been given to a foreign publishing house to bring out an edition of this work in the German language. The other work referred to is entitled "The Polynesian Wanderings," by Mr. William Churchill. It attempts to trace the migrations of the Polynesians in the Pacific Ocean by means of a critical examination of the philological contents of their language. Mention may also be made in this connection of progress in the publication of the Classics of International Law, one work of which—namely, that of Richard Zouche—having been completed.

CHARLES X. DALTON

THE passing of Charles X. Dalton removes a personality familiar not only to a large circle of scientists throughout the country but to many of Boston's leading business men, with whom he had a large acquaintance owing to his association with that eminent optician, the late Robert B. Tolles.

Born in Philadelphia in 1840, Mr. Dalton learned his trade as an expert mechanician from a German instrument-maker of that city. In his early days he worked in the factory of Joseph Zentmeyer, the well-known microscope manufacturer, and during the Civil War, served as an army nurse. At the close of the war, he entered the employ of Tolles, and later (1867) was associated with him in the Boston Optical Works.