Gallery is established as a bureau of the Smithsonian Institution, but is directed by a separate Board of Trustees. The earlier art interests of the Institution are included in the National Collection of Fine Arts and the Freer Gallery of Art. The latter, presented and endowed by Charles L. Freer, is devoted chiefly to the Oriental field, and through its highly valuable archeological materials will figure more and more importantly in strictly scientific studies.

From one building, a small staff, and a single publication, the Institution has grown in a century until it now occupies five buildings on the Mall and numerous structures at the National Zoological Park, while it issues 14 series of publications, each devoted to a particular sphere.

The main influence of the Institution has centered in its scientific staff, its series of publications, and its collections. The first comprise the heart of the organization, which continues through the younger members who come, as older ones drop out, to carry forward the living Institution in its policies for the advancement of science. The publications of the Institution constitute one record of its accomplishment in the fields of scientific culture. The collections are the base for much research and investigation and in addition are a scientific and cultural archive that the Institution guards on behalf of our Nation.

The various phases of the Institution's scientific work are passed in factual review in papers that follow, the whole comprising an outline of the major activities as they have developed and operated during its first 100 years. From this foundation the Smithsonian Institution looks forward in 1946 toward the second century of its work.

Astrophysical Contributions of the Smithsonian Institution

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ASTROPHYSICS AND THE SMITHSONIAN Institution were born about the same time. Joseph Fraunhofer, to be sure, had discovered many absorption lines in the sun's spectrum in 1814–15, but G. R. Kirchhoff and R. Bunsen's key to the interpretation of these did not come until about 1860. Photography was used to observe the shorter-wave solar spectrum by Rutherford, Mascart, Draper, and others during the first quarter century of the Smithsonian. But it was not until H. A. Rowland constructed his gratings, and photographed through the range of ultraviolet and visible about 1890, that anything like an adequate observation of the solar spectrum was made. Even Rowland perforce neglected the far-reaching region of the infrared, first mapped in detail at the Smithsonian and not available to photography until recent time. Of the numbers, distances, diameters, masses, temperatures, and detailed composition of the stars very little was known until the present century came, with its great telescopes and their exact driving mechanism, improved photography, knowledge of the structure of the atom, and far-reaching theoretical advances in physics.

As to our own habitation, the earth, it was not until many years after the establishment of the Smithsonian Institution that extensive observations of the weather were undertaken by governments. Weather studies have been a major feature in Smithsonian researches from its beginning. The Institution has also contributed its part to our present knowledge of the sun and stars.

Smithsonian promotion of astrophysics has been of two kinds. Much research has been done by members of its own staff. In addition, many choice researches by able men have been financed in part or whole, or published, with Smithsonian funds. In this brief survey it will not be possible to mention all these grants-in-aid, but their importance may be indicated by a few examples.

As we now believe, the sun's energy depends on a catalytic transformation of hydrogen into helium, whereby a certain amount of mass is lost. Our knowledge of this loss depends on the exact determination of the relative atomic weights of hydrogen and oxygen by E. W. Morley, with the aid of a superlatively fine balance supplied to him by the Institution. His research was published in 1903 in *Smithsonian Contributions to Knowledge* (Vol. 29). In the same volume is the report of A. A. Michelson's epoch-making research, "On the application of interference methods to spectroscopy," promoted by Smithsonian grants. There appears also a report by V. Schumann, "On the absorption and emission of air and its ingredients for light of wave lengths from 250 to 100 $\mu\mu$." This work, supported by Smithsonian grants, opened up a new region of the spectrum, called for some time "the Schumann region." Crowning this extraordinary volume is the paper of Lord Rayleigh and Sir William Ramsay, "Argon, a new constituent of the atmosphere," for which the Institution awarded them the Hodgkins grand prize of $10,000.

The *Contributions* of 1907 (Vol. 34) contains a reprint of Draper's classic, "On the construction of a silvered glass telescope," published in 1864 (Vol. 14). With it is published G. W. Ritchey's even more valuable article, "On the modern reflecting telescope and the making and testing of optical mirrors."

In this partial reference to valuable contributions to astrophysics on the part of outsiders who have received the Institution's aid I can go no farther than merely to cite the following references to *Smithsonian Miscellaneous Collections*:

A. Ångström: ''A study of the radiation of the atmosphere,'' 1915–16, Vol. 65, No. 3.

H. H. Clayton: Many papers on the sun's influence on weather—1917–18, Vol. 68, No. 3; 1919–20, Vol. 71, No. 3; 1924–26, Vol. 77, No. 6; 1926–27, Vol. 78, No. 4; 1933–34, Vol. 82, No. 15; 1933–34, Vol. 89, No. 15; 1939, Vol. 98, No. 2; 1940, Vol. 99, No. 5; 1946, Vol. 104, No. 19.

R. H. Goddard: ''A method of reaching extreme altitudes,'' 1919–20, Vol. 71, No. 2; and ''Liquid propellant rocket development,'' 1936, Vol. 95, No. 3.

Clayton edited and extensively aided the preparation of "World weather records," 1927, Vol. 79, and 1934, Vol. 90. A third volume is now in press, bringing this invaluable source material up to the epoch of 1940.

It was the Institution's belief that Goddard's classic researches would open the way to determining the constitution of the upper atmosphere and enable the obtaining of photographic spectra of the extreme ultraviolet regions for the sun and the brighter stars. In view of the recent great development of rockets, this hope seems likely to be realized.

I turn now to researches by the Institution through members of its staff. As the sun is the fountain of life, maintainer of temperature, ultimate source of power from coal, oil, and water, and the fundamental cause of climates and weather on the earth, besides being the most available subject for stellar research, it is natural that the Institution's astrophysical investigations should center on the sun in these various relationships.

The first secretary, Joseph Henry, actively promoted weather studies throughout his life. He was particularly concerned with collecting long-range data on the climates and weather of stations in every region, as a basis for sound meteorological advance. He also recognized immediately the usefulness of the then new telegraph to promote forecasts of day-to-day changes in weather. He persuaded the regents of the Institution to sanction the use of a considerable part of its revenue to obtain weather reports from a great network of voluntary observers. Instruments were prepared, directions for observation given, telegraph companies employed, and for about 20 years the Smithsonian was, indeed, the national weather bureau. Cleveland Abbe wrote in 1871:

> However frequently the idea may have been suggested of utilizing . . . the electric telegraph, it is to Professor Henry and his assistants in the Smithsonian Institution that the credit is due of having first actually realized this suggestion. . . . The Smithsonian Institution *first in the world organized* a comprehensive system of telegraphic meteorology.

When the Institution turned over its great system of meteorological reports to the Signal Corps in 1870, Secretary Henry summed it up as follows:

> The Smithsonian meteorological system was commenced in 1849, and has continued in operation until the present time. . . . It has done good service to the cause of meteorology: 1, in inaugurating the system which has been in operation upward of twenty years; 2, in the introduction of improved instruments after discussion and experiments; 3, in preparing and publishing at its expense an extensive series of meteorological tables; 4, in reducing and discussing the meteorological material which could be obtained from all the records from the first settlement of the country till within a few years; 5, in being the first to show the practicability of telegraphic weather signals; 6, in publishing records and discussions made at its own expense, of the Arctic expeditions of Kane, Hayes, and McClintock; 7, in discussing and publishing a number of series of special records embracing periods of from twenty to fifty years in different sections of the United States, of great interest in determining secular changes of climate; 8, in the publication of a series of memoirs on various meteorological phenomena, embracing observations and discussions of storms, tornados, meteors, auroras, etc.; 9, in a diffusion of a knowledge of meteorology through its extensive unpublished correspondence and its printed circulars.

The third secretary, Langley, long an ardent observer of solar phenomena, created the Astrophysical Observatory as a branch of the Institution about 1890. Its first contribution was the bolographic scanning of the infrared solar spectrum to map the lines and bands of absorption there, beyond the reach of Rowland's photography. These lines and bands are caused by the gases of the sun's and earth's atmospheres. In doing this, the hairlike bolometer, which had been an untamed instrument, became easier to use than a mercury thermometer, though capable of measuring temperature differences of less than a millionth of a degree. The research, published about 1900 as Vol. 1 of *Annals of the Astrophysical Observatory,* showed the distribution of intensities in the solar spectrum from 0.76 to 5.3 microns of wave length. It disclosed 740 lines and bands of absorption in this region and indicated their relative intensities. It included a precise determination of the dispersion of rock salt and of fluorite, materials much used for infrared spectroscopy.

In 1928 C. G. Abbot and H. B. Freeman, at the request of H. D. Babcock, repeated this bolometric search for absorption lines in the infrared solar spectrum. They had the advantages of Mount Wilson cloudlessness, long bolometric experience, greater sensitivity of apparatus, and wider spectral dispersion. They reported on over 1,200 lines and bands of absorption within the wave length range 0.76–1.82 microns. Babcock assures me that, so far as photography yet extends in this region, he finds practically every indentation in their bolographic curves meaningful, and the research indeed enables confirmations of theoretical conclusions regarding regularities of atomic and molecular spectra.

In 1902, under Langley's direction, C. G. Abbot and F. E. Fowle began researches on the transmission of the earth's atmosphere for different wave lengths, the intensities in the solar spectrum at the earth's surface and outside the atmosphere, and the problem: Is the sun a variable star, and, if so, what effects do its variations cause in weather? At that time the textbook values given for the solar constant of radiation (average heat equivalent per unit area of solar radiation at mean solar distance) ranged from 1.76 to 4.0 calories per centimeter square per minute. The only fairly accurate instrument for measuring total solar radiation was the Ångström electrical compensation pyrheliometer, then subject to errors of several per cent, since corrected.

The research has gone on until the present time. Its principal results are as follows:

(1) The solar constant of radiation lies certainly within 1 per cent of 1.94 calories per centimeter square per minute. Spectrobolometric determinations of it were checked by sounding balloon observations at an altitude of 15 miles. (2) The sun, as a variable star, is subject to changes of output, never as yet observed to exceed 5 per cent and generally less than 1 per cent. (3) The sun's variations may be classed in two types: (a) day-to-day changes, usually running between high and low in three to five days, repeating at the average rate of four rising, four falling, per month, and found to be associated with the 27-day rotation of the sun and with the waxing and waning of prevalence of faculae and flocculi; (b) long-interval solar radiation changes of periodic nature, such that 16 such cyclic changes go on simultaneously, with periods ranging from 7 to 273 months, all being nearly integral submultiples of 273 months, or two sunspot cycles. (4) Both day-to-day and long periodic solar changes are major factors in the control of weather. (5) The atmospheric transmission for radiation has been measured at over 40 wave lengths between 0.34 and 2.3 microns at many stations ranging from sea level to 14,500 feet altitude, at all seasons of the year, and in a great variety of atmospheric conditions. (6) The amount of radiation scattered by sky and clouds has been measured under similarly wide diversity of conditions. (7) The distribution of radiation over the sun's disk, a matter of much interest in the theory of the stars, was determined for many wave lengths. Indications were found of its slight variability associated with changes of the solar constant. (8) The temperature of the sun was estimated in three ways, twice from the form of distribution curve of radiation in the spectrum and again by the value of the solar constant. The average result is about 6,000° Absolute Centigrade. (9) The energy spectrum curve of solar radiation was determined between wave lengths 0.34 and 2.35 microns. (10) The change of form of the energy spectrum curve attending solar variation was determined and found to be rapidly increasing toward short wave lengths for increasing values of the solar constant. (11) Solar energy was harnessed for power, distilling, and cooking. An efficiency of power production exceeding 20 per cent is obtained. (12) F. E. Fowle made a classic study of the transmission of long-wave radiation through long columns of air containing known loads of water vapor and carbon dioxide. (13) Fowle also determined ozone in the atmosphere and computed with high accuracy the number of molecules per cubic centimeter of air from measures of atmospheric transmission. His long editorship of the Smithsonian Physical Tables was highly valuable. (14) L. B. Aldrich, in cooperation with the Signal Corps, made the classic measurement of the reflecting power, or albedo, of an infinitely extending cloud surface. He found it to be 78 per cent. (15) Radiometric determinations were made with the 100-inch telescope at Mount Wilson, California, of the distribution of radiation in the spectra of 20 bright stars and planets. (16) Standard instruments for measuring sun and sky radiation were devised, used, and furnished abroad to fix the scale of measurement of solar radiation in heat units. Foreign measures are usually expressed as on "the Smithsonian scale."

These are the principal items, but they by no means exhaust the results described in Vols. 1–6 of *Annals of the Astrophysical Observatory* and in the many papers of members of the staff, published for the most part in *Smithsonian Miscellaneous Collections* and the *Astrophysical Journal.*

Many expeditions have been made. Total solar eclipses were observed in 1900, 1901, 1908, 1918, and 1919. Bolometric measures of the brightness of the corona and pyranometric measures of the brightness of the sky were the most interesting results of these observations, although they also included photography.

Objections having been raised by some as to the soundness of our measures of atmospheric transmission, simultaneous measures of the solar constant of radiation were made in 1910 at Mount Wilson, California (5,700 feet) and at Mount Whitney, California (14,500 feet). Again in 1911 and 1912 solar constant measures were made simultaneously at Mount Wilson and at Bassour, Algeria. Since 1918, simultaneous measures have been made on thousands of days by stations in the Northern and Southern Hemispheres. No differences above the small experimental errors have ever been found between the solar constant results obtained under these diverse conditions of atmospheric transmission. In all, as many as 12 different stations have been occupied by us for solar constant work. These have been located in North and South America, Africa, and Asia and range from sea level to 14,500 feet in elevation. Several of them have been continuously occupied in desert regions for 20 years or more.

During World War I C. G. Abbot and L. B. Aldrich were active in the improvement of searchlights. The Corps of Engineers report on that activity even gave the leading place to our efforts. In World War II studies were made of the relations of radiation to clothing and on a filter to exclude visible light and infrared rays while admitting the ultraviolet. Both researches were successful.

Since the end of the war the Observatory, now under the direction of L. B. Aldrich, has been amassing great quantities of data for the Army on the intensity of sun and sky radiation at the earth's surface at all times of the day and year.

For many years the writer had been keenly interested to know which of the sun's rays were most effective in supporting plant growth, through the assimilation of carbon dioxide from the air. About 1930 the Division of Radiation and Organisms was established under grants from the Research Corporation of New York. W. H. Hoover did there a fine piece of research which fixed the relative efficiencies of different wave lengths to promote photosynthesis in wheat. He used with close agreement three different sources of radiation: the Mazda lamp, the carbon arc, and sunlight. The curve of wave length and photosynthesis showed two maxima in the blue and the red, respectively, where chlorophyll has absorption bands. Rays of wave lengths less than 4,000 A. or more than 7,500 A. appear to be totally ineffective in photosynthesis. Many other interesting researches which relate to different aspects of radiation and plant growth have been carried on in the Division. Most of these have been published in *Smithsonian Miscellaneous Collections*.[1]

Congress has supported the Astrophysical Observatory financially in part and has authorized the inclusion in it of the Division of Radiation and Organisms. A considerable part of the financial support has, however, come from private sources, including the Hodgkins Fund and the Arthur Fund of the Smithsonian endowment and gifts from John A. Roebling aggregating over $500,000 during the past 26 years. Mr. Roebling is well versed in science and ardently interested in the problems of the dependence of climate and weather on solar radiation. He makes no blanket appropriations but discusses with great acumen each individual project. Without his aid and wise suggestions we should have come far short of our present accomplishment.

[1] See papers by Johnston, McAlister, Weintraub, Meier, and others.

One Hundred Years of Smithsonian Anthropology

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FROM ITS VERY INCEPTION the Smithsonian Institution has been a leading participant in the field of anthropology, particularly in the study of the New World aborigines. Throughout the 100 years of its history, this phase of its operations has been one of its better-known and more generally popular activities. However, the word anthropology does not appear in the heading summarizing such work until the Annual Report for 1877. Previously, and reflecting American concept in general, most of the branches at present incorporated under Anthropology were grouped under Ethnology. In the rare cases where the word was used it was, for the most part, in the restricted sense of the study of physical man. The change was brought about by influences spreading from Europe, where, during the 1860's under the stimulus of the appearance of Darwin's *Origin of species* and the determination of the geologic antiquity of man, the subject had a rapid growth. Many societies and museums devoted to the "whole science of man" were organized, and there was an accompanying, although somewhat delayed (because of wartime conditions in the United States), increase of interest in the American field. It was two decades or more, however, before thinking in the Institution and the country at large changed from ethnology, archeology, and Indian linguistics to the more comprehensive anthropology.

In line with Joseph Henry's policy of not recruiting men for original research and supporting them and their work entirely from the funds of the establishment, it was many years before an anthropological staff was organized. When such steps were taken, the necessary funds were furnished by the Government.