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OF

SAMUEL PIERPONT LANGLEY

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CHARLES D. WALCOTT

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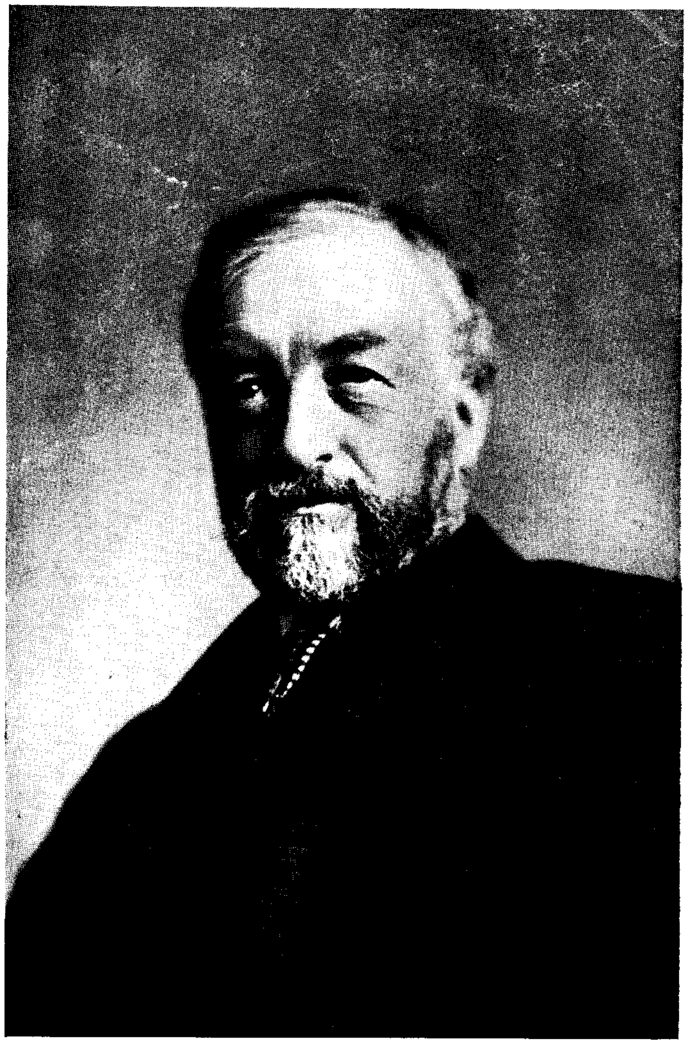

S. P. Langley.

NATIONAL ACADEMY OF SCIENCES.

Of the biographical memoirs which are to be included in Volume VII, the following have been issued:

SAMUEL PIERPONT LANGLEY.[a]

Samuel Pierpont Langley, Doctor of Science and of Civil Law, was born at Roxbury (now part of Boston), Massachusetts, on August 22, 1834, and died at Aiken, South Carolina, on February 27, 1906. Mr. Langley won eminence by his achievements as an astronomer, especially by his astrophysical observations and discoveries, and he became known to the world at large through his eighteen years of administrative service as Secretary of the Smithsonian Institution. His fame will also become increasingly greater as the new science of aviation—or aerodromics, as he termed it—is further and further developed, for to Langley belongs the honor of being the first to demonstrate to the world the practicability of mechanical flight with machines heavier than the air, sustained and propelled by their own power.

Mr. Langley's boyhood and his young manhood, until the age of twenty-three, were spent in Roxbury and Boston. He was educated in private schools, in the Boston Latin School, and in the Boston High School, from which he was graduated in 1851. Led by an early taste for mathematics, he chose the profession of civil engineering and architecture, and in 1857 went West, where for seven years he successfully practiced his profession, chiefly in Chicago and St. Louis.

In 1864, in company with his brother, John Williams Langley, he visited Europe and traveled for about a year, taking a keen interest in the work of the scientific institutions, the astronomical observatories, and the great art galleries of the Old World. The knowledge then acquired led, upon his return to Boston in 1865, to his appointment as assistant at the Harvard College Observatory, and in 1866 he became assistant professor of mathematics in the United States Naval Academy at Annapolis, chiefly for the purpose of reorganizing its small observatory. His reputation as a skillful astronomer was thus

[a] The draft of this memoir was prepared by Mr. A. Howard Clark, of the Smithsonian Institution.

early established, and at the close of a year's service at Annapolis he was invited to fill the post of director of the Allegheny Observatory and professor of astronomy and physics in the Western University of Pennsylvania, where he remained for twenty years.

One of the most important achievements accomplished by Professor Langley while at Allegheny was the introduction of a system of standard time distribution to various cities and railroads, a work which he himself thus described about the year 1885, when time signals were being sent from Allegheny over 4,713 miles of railroad:

> A mention of the observatory's work would be incomplete without some account of its system of time distribution introduced by the present director in 1869. Previous to that date, time had been sent in occasional instances from American observatories for public use, but in a temporary or casual manner.
>
> The Allegheny system, inaugurated that year, is believed to be the parent of the present ones used in this country in that it was, so far as is known, the first regular and systematic system of time distribution to railroads and cities adopting it as an official standard. * * * For the benefit of any future writer of the history of the subject, it may be stated that in 1870 the Allegheny Observatory had already in extended operation the system of time distribution above described; that about 1873 the director at Cambridge Observatory, after conference with the writer, introduced substantially the same provisions for connecting Harvard College Observatory with the New England roads; and that about the same time the Washington Observatory, which had previously sent signals in a limited and desultory manner, commenced to do so in emulation of the new system.

It was at the Allegheny Observatory, aided largely by the income derived from the standard time service, that Professor Langley began the series of researches which have so greatly added to our knowledge of the sun.

As an astronomer, his work was devoted chiefly to original investigations relating to the physical nature and functions of the celestial bodies, rather than to measurements of time, distance, and position. As an observer at the eye end of an equatorial he was inferior to none, and his visual studies of the minute structure of the sun's surface have become classical. His beautiful drawing of the great sun spot of December, 1873, has not yet been surpassed in accuracy of detail, notwithstanding the great improvements since made in instruments of observation.

In 1869, 1870, 1878, and 1900 he observed the total eclipse of the sun, and his account of the eclipse of 1878 from Pikes Peak is particularly notable.

Mr. Langley's distinction as a visual observer, however, was far exceeded by his valuable contributions to the study of solar radiation. In these studies, which he began as early as 1870, he employed the thermopile, but he became more and more dissatisfied with this instrument, on account of its slowness of response and the inadequacy of its sensitiveness to the measurements which he desired to make. His experiments with this instrument on the solar spectrum convinced him that something as much superior to the thermopile of those days as that was to the thermometer would be required before any satisfactory progress in this direction would be possible. From 1878 to 1880 he was engaged in various attempts to devise a more perfect instrument for measuring radiation, and he succeeded at length in the invention of the bolometer, an instrument now in world-wide use. With this instrument, essentially an electrical thermometer on the Wheatstone's bridge principle, changes of temperature of less than the hundred-thousandth of a degree Centigrade are measured; and, by special installation, differences in temperature amounting to one-billionth of a degree may be detected.

The investigations by Mr. Langley in radiation may be grouped under five heads: (*a*) The distribution of radiation over the sun's surface and in sun spots; (*b*) the solar energy spectrum and its extension toward the infra red; (*c*) the lunar energy spectrum and the temperature of the moon; (*d*) spectra of terrestrial sources and determination of hitherto unmeasured wave lengths; and (*e*) the absorption by the earth's atmosphere of the radiation of the sun, and the determination of the solar constant of radiation. In the first of these investigations he found that at 98 per cent of the radius from the center of the sun's disk, along both the polar and equatorial diameters, the radiation fell off one-half. Sun spots were found to affect the total radiation of the sun not more than one-tenth of one per cent. In the investigation of the solar energy spectrum toward the infra red, Mr. Langley discovered evidences of solar radiation extending beyond all previously known wave lengths. The temperature of the sun-lit moon he found to be a little above 0° Centigrade. His most interesting researches in terrestrial sources of radiation related to the light of the Cuban firefly, *Pyrophorus noctilucus,* which he compared with that of the electric arc and other sources of illumination. He proved the immense relative economy of Nature's source of light.

The last of the series of researches to be mentioned was the determination of (*a*) the absorptive power of the earth's atmosphere for solar radiation, and (*b*) the solar constant of radiation. In his preliminary study of this important subject he found that all previous estimates of atmospheric absorption were too low, and that all parts of the spectrum must be studied separately and in detail in order to determine from the solar radiation reaching the earth's surface the total amount of radiation which reached the outer limits of our atmosphere. He became so convinced of the great practical importance of this work to mankind in its relation to climate and life on the earth that in 1881, while at the Allegheny Observatory, he enlisted the aid of wealthy friends and of the United States Government to send an expedition to Mount Whitney, California, where exceptional opportunity would be afforded for the necessary observations.

In the introduction of the Mount Whitney report Mr. Langley says:

> If the observation of the amount of heat the sun sends the earth is among the most important and difficult in astronomical physics, it may be termed the fundamental problem of meteorology, nearly all whose phenomena would become predictable if we knew both the original quantity and kind of this heat; how it affects the constituents of the atmosphere on its passage earthward; how much of it reaches the soil; how, through the aid of the atmosphere, it maintains the surface temperature of this planet; and how, in diminished quantity and altered kind, it is finally returned to outer space.

In 1892 Mr. Langley introduced a continuous automatic photographic registering device to record the indications of the bolometer, and thus made it possible to map in a few minutes the whole energy spectrum of the sun in a manner adapted to bring out details which it had been impossible to detect during years of work. He was enabled by this powerful instrument to carefully map the infra-red energy spectrum of the sun from wave-length 0.76 micron to wave-length 5.3 microns, revealing about 700 absorption lines and bands in this invisible region. These and subsidiary investigations were made public in the first volume of the Annals of the Smithsonian Astrophysical Observatory, published in 1900. He then directed his researches toward the solution of that fundamental question as to whether the emission of radiation by the sun is substantially constant in amount, or sufficiently variable to produce marked and predictable effects on the climate of the earth. This investigation had not, at the time of Mr. Langley's death, been completed, but it had proceeded so far as to indicate a very strong probability that the solar radiation outside the earth's atmosphere varies notably and frequently, in such a manner as to profoundly influence the temperature of the earth.

The inventiveness of mind displayed by Mr. Langley in all his work was remarkable. Among many devices which he originated are means for determining times of transit without personal equation; means for observing sudden phenomena, by substituting the observation of a place for a time; the bolometer and its automatic registering devices; and means for producing improved seeing by stirring the column of air traversed by a beam of light. He also re-invented, without knowledge of its earlier use, the principle of the coelostat, and employed that instrument about 1880 at Allegheny.

Mr. Langley often stated that even as a boy he was interested in watching the motions of hawks and buzzards, and he wondered by what mysterious power birds so much heavier than the air could maintain themselves in space and could move about at will without apparent movements of their wings. His dormant interest in the subject was aroused to action when, in 1886, he listened to a paper communicated to the American Association for the Advancement of Science. It seemed to him that prevailing theories as to how birds fly were not based on sound facts, and he resolved, as a fundamental problem, to ascertain by scientific observation and experiment what mechanical power was required to sustain a weight in air and make it move at a given speed. It was at Allegheny Observatory, in 1887, that he was enabled to begin a series of observations in aerodynamics which extended over three years, and were aided in part by the Bache fund of the National Academy of Sciences. The results of this work were published by the Smithsonian Institution in 1891 under the title of "Experiments in Aerodynamics," and at once attracted the attention of physicists in America and Europe. The experiments were made upon plane surfaces and related to the long-disputed questions of air resistances and reactions. They established a more reliable coefficient for rectangular pressures than that of Smeaton; believing the frictional drag to be negligible, he proved that air pressures were normal to the surface; he disproved the "Newtonian law" that the normal pressure varies as the square of the angle of incidence on inclined planes; and showed that the Duchemin formula proposed in 1836 is approximately correct, and that the position of the center of pressure varies with the angle of inclination and follows approximately Joessel's law. He corroborated the work of Wenham who proved, in his celebrated paper of 1866,[a] that oblong planes are more efficient when presented with their longest dimension at right angles to the line of motion; and that planes may be superposed without loss of power if spaced at distances properly proportioned to the speed. The conclusion was also reached, usually known as "Langley's law," that "if in such aerial motion, there be given a plane of fixed size and weight, inclined at such an angle, and moved forward at such a speed, that it shall be sustained in horizontal flight, then the more rapid the motion is, the *less* will be the power required to support and advance it."

As a result of his observations, Mr. Langley announced in 1891 that it was possible to construct machines which would give such a velocity to inclined surfaces that bodies indefinitely heavier than the air could be sustained upon it and moved through it with great velocity. It was stated in particular that

[a] First Ann. Rept. Aeronaut. Soc. Great Britain for 1866, pp. 28 and 36.

a plane surface in the form of a parallelogram of 76.2 cm. by 12.2 cm. (30 by 4.8 inches), weighing 500 grams (1.1 pounds), could be driven through the air with a velocity of 20 meters (65.6 feet) per second in absolutely horizontal flight, with an expenditure of 1/200 horsepower; or, in other terms, that 1 horsepower would propel and sustain in horizontal flight, at such a velocity (that is, about 45 miles an hour), a little over 200 pounds weight of such surface, where the specific gravity of the plane was a matter of secondary importance, the support being derived from the elasticity and inertia of the air through which the body is made to run.

In 1893 he published his paper on "The Internal Work of the Wind," in which he showed that the irregularities of the wind were much greater than had been supposed. He concluded that these irregularities might be a source of power and might to a considerable degree account for the ability of certain birds to soar with outstretched, unflapping wings. This paper, like the one on aerodynamics, attracted much attention and was published in both England and France. The term "internal work" was here applied to pulsations of sensible magnitude always existing in the wind and having extraordinary possible mechanical importance. Mr. Langley[a] asserted his belief that as "a ship is able to go against a head-wind by the force of that wind, owing to the fact that it is partly immersed in the water, which reacts on the keel, * * * it is not impossible that a heavy and inert body, *wholly* immersed in the air, can be made to do this." He further said that he believed that the future aerodrome would utilize not only the particular pulsation of the wind described in the memoir, but also the ascending, lateral, and whirling motions of the wind.

Having become convinced that mechanical flight was scientifically feasible, Mr. Langley then began the construction of several model flying machines. Experimenting first with numerous small rubber-driven models of various designs, he built, from 1891 to 1895, four model aerodromes, one of them driven by carbonic acid gas and three by steam-engines. On

[a] The internal work of the wind. Smithsonian Contributions to Knowledge, vol. 27, 1893, p. 6.

May 6, 1896, his faith and perseverance were rewarded by the successful flight of his aerodrome No. 5 for a distance of 3,000 feet. The total flying weight of this machine was 26 pounds and the total area of support was 68 square feet. It was of the general type now classed as monoplanes, though with two pairs of wings, one set forward and the other in the rear of the two propellers. Never in the history of the world previous to that experiment had any such mechanism, however actuated, sustained itself in the air for more than a few seconds. Mr. Langley was thus the first to produce successful flights, of convincing lengths, of models with an artificial motor, and thus paved the way for others who have achieved success with man-carrying flying machines.

In 1898 Mr. Langley, assisted by the United States Government, began the construction of a man-carrying aerodrome for purposes of further experimentation. When completed, in 1903, this machine weighed, with the aeronaut, 830 pounds, and its sustaining surface was 1,040 square feet. The gasoline motor of 52-brake horsepower, weighed, with cooling water, carburetter, battery, etc., somewhat less than five pounds to the horsepower. Defects in the launching apparatus resulted in such serious injuries to the machine that further experiments were suspended in December, 1903. "The machine," said Mr. Langley, "never had a chance to fly at all, but the failure occurred in the launching ways." It is interesting to note, however, that experiments with the Langley type of aerodrome did not actually cease in December, 1903, when Mr. Langley made his last trial, but as recently as August 6, 1907, a French aviator made a flight of nearly 500 feet with an aerodrome of essentially the same design.

The words of Professor Langley after the close of his experiments in 1896 were prophetic of what is now so rapidly coming to pass. He said:

> I have brought to a close the portion of the work which seemed to be specially mine—the demonstration of the practicability of mechanical flight—and for the next stage, which is the commercial and practical development of the idea, it is probable that the world may look to others. The world, indeed, will be supine if it do not realize that a new possibility has come to it, and that the great universal highway overhead is now soon to be opened.

On January 12, 1887, Mr. Langley was appointed assistant secretary of the Smithsonian Institution. On August 19th of that year Professor Baird died and on November 18th the board of regents elected Mr. Langley to succeed him as secretary, and for eighteen years he evidenced his ability as an administrative officer in a marked degree. To his efforts is due the foundation of the National Zoological Park at Washington "for the instruction and recreation of the people." To him, also, is due the establishment of the Astrophysical Observatory of the Smithsonian Institution, and it was during his administration that was begun the spacious new structure for the National Museum. During his administration, the permanent fund of the Institution was largely increased through the munificent gift of Thomas G. Hodgkins, part of the income of which, under the terms of the gift, has been devoted to the study of the earth's atmosphere in relation to the welfare of man.

Secretary Langley was a worthy successor to Secretaries Henry and Baird. All three were honored members of the National Academy of Sciences. Each won fame in his special field of study. Henry, the physicist, by his scientific researches in electricity, made discoveries which have been utilized in its application to the transmission of messages, to transportation, and to the generation of power for industrial work. He also inaugurated the system of daily meteorological observations, out of which grew the Weather Bureau; and, as head of the Lighthouse Board, he revolutionized the methods of lighthouse operation and signaling. Baird, the biologist, bent his energies to increase man's knowledge of animal life, and established the United States Commission of Fish and Fisheries, later known as the United States Bureau of Fisheries. Langley, the astronomer, will be long remembered by the world for his discoveries in astrophysics and in the science of aviation. Each of these men advanced the general activities and the prestige of the Smithsonian Institution, whose business affairs they administered.

Mr. Langley's published works, covering a wide range of topics, include nearly two hundred titles (several of them in French and German) and date from 1869, when he reported on his solar-eclipse observations at Oakland, Kentucky, to 1905, when he contributed to the Astrophysical Journal an article "On the comparative luminosity and total radiation of the solar corona."

In addition to his researches in astrophysics and aeronautics, and his duties as secretary of the Smithsonian Institution, Mr. Langley was studiously devoted to general literature; was an exceptional French scholar, thoroughly familiar with the language, both spoken and written, and was particularly interested in the history of the French Revolution. His presidential address in 1888 before the American Association for the Advancement of Science evidenced his broad philosophic mind. In this address, discussing radiant energy, he said:

> We have, perhaps, seen that the history of progress in this department of science is little else than a chapter in that larger history of human error which is still to be written. * * * Shall we say that the knowledge of truth is not advancing? * * * It *is* advancing, and never so fast as today; but the steps of its advance are set on past errors.

Mr. Langley's ability as a scientific writer to express technical matter in words to be understood by all was well evinced by his book on "The New Astronomy," based on a course of lectures delivered before the Lowell Institute in Boston. The new astronomy relates to the physics of the heavenly bodies, their constitution, and not to their mere existence and position and other problems of the old astronomy. In the preface to this book he says:

> I have written these pages, not for the professional reader, but with the hope of reaching a part of that educated public on whose support he is so often dependent for the means of extending the boundaries of knowledge.
>
> It is not generally understood that among us not only the support of the Government, but with scarcely an exception every new private benefaction, is devoted to "the old astronomy," which is relatively munificently endowed already; while that which I have here called "the new," so fruitful in results of interest and importance, struggles almost unaided.
>
> We are all glad to know that Urania, who was in the beginning but a poor Chaldean shepherdess, has long since become well to do, and dwells now in state. It is far less known than it should be that she has a younger sister now among us, bearing every mark of her celes-

tial birth, but all unendowed and portionless. It is for the reader's interest in the latter that this book is a plea.

The studies of metaphysicians and psychologists attracted his attention and he made a close study of the mysteries of psychical research. He had a passion for investigating the most abstruse, perplexing, and remote subjects of thought. These were to him in the nature of pastime and seemed to quicken his energy for his scientific work.

The achievements of Professor Langley were recognized by many universities and learned institutions. He received the degree of doctor of civil law from Oxford, doctor of science from Cambridge, and, among numerous others, the degree of doctor of laws from the universities of Harvard, Princeton, Michigan, and Wisconsin. He was awarded the Henry Draper Medal by the National Academy of Sciences, the Rumford Medal by the Royal Society of London, and the Rumford Medal by the American Academy of Arts and Sciences, as well as the Janssen Medal by the Institute of France, and the medal of the Astronomical Society of France. He was a foreign member of the Royal Society of London, a correspondent of the Institute of France, fellow of the Royal Astronomical Society of London, member of the Royal Institution of London, member of the Academia dei Lincei of Rome, of the National Academy of Sciences, and of many other well-known learned bodies.

Mr. Langley, although a member of very many scientific and other societies, was not a regular attendant at meetings and avoided holding office; perhaps the only exceptions were the presidency of the American Association for the Advancement of Science, the vice-presidency of the American Philosophical Society, and membership in the council of the National Academy of Sciences.

Mr. Langley's ancestors for more than two centuries were almost without exception of New England nativity and included many of the leading men of the seventeenth and eighteenth centuries. Without doubt it was through some of these forefathers that he inherited an indomitable perseverance, which obstacles and repeated failures could never daunt, and likewise an originality of mind and breadth of view which were the principal characteristics of the man, leading him to eminent success in every endeavor.

In concluding a touching tribute to the memory of Professor Langley, Dr. Andrew D. White said of him:

> Self-seeker he never was. His labor, his thought, his efforts in every field, had as their one object the establishment of truth as truth. For he had high aspirations and a deep faith—aspirations toward the best that humanity can receive, and faith in the truth that makes mankind free.

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[a] Prepared from Mr. Langley's personal set of his writings and other sources, under the supervision of Mr. Paul Brockett, Assistant Librarian of the Smithsonian Institution, and published in the Smithsonian Miscellaneous Collections, vol. 49, 1907, pp. 35–49.

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