Eunice Foote's Pioneering Research On CO_2 And Climate Warming*

Raymond P. Sorenson[1]

Search and Discovery Article #70092 (2011)
Posted January 31, 2011

*Manuscript received and accepted January 11, 2011

[1]Independent, Tulsa, OK (sorensonrk@sbcglobal.net)

Abstract

According to conventional wisdom John Tyndall was the first to measure the variation in absorption of radiant energy by atmospheric gases and the first to predict the impact on climate of small changes in atmospheric gas composition. Overlooked by modern researchers is the work of Eunice Foote, who, three years prior to the start of Tyndall's laboratory research, conducted similar experiments on absorption of radiant energy by atmospheric gases, such as CO_2 and water vapor. The presentation of her report at a major scientific convention in 1856 was accompanied by speculation that even modest increases in the concentration of CO_2 could result in significant atmospheric warming.

Introduction

In recent years the increase in the concentration of atmospheric CO_2 due to human activity and its potential effect on global climate have become a focus of scientific research and a major international topic of political controversy. CO_2 in the atmosphere very efficiently absorbs radiant energy, and increases in the concentration of that gas over time as a result of the burning of fossil fuels and other human activity is projected to cause global climate warming.

Credit for the first recognition of these concepts is routinely given to John Tyndall, who published a series of papers on this and related topics beginning in 1859 (Fleming, 1998).

Unrecognized by modern researchers is a study by Eunice Foote that was presented at the 1856 AAAS annual meeting in Albany, New York, three years prior to Tyndall's first report. Her research was similar to that of Tyndall and resulted in similar conclusions, but it was not formally published. It is known today only from a journalistic summary published in an annual review of world-wide scientific achievements. The text of that review article is reproduced here to make it more readily available and to give proper credit to Eunice Foote for her innovative research.

John Tyndall's Groundbreaking Research

John Tyndall began his experiments on the absorption of radiant energy by gases and reported his initial results to the Royal Society of London in 1859. He announced that "Different gases are thus shown to intercept radiant heat in different degrees," although in that first paper he did not provide quantitative results or specify which gases were the subject of investigation. In an effort to claim priority for his research, Tyndall included the following comment: "With the exception of the celebrated memoir of M. Pouillet on Solar Radiation through the atmosphere, nothing, so far as I am aware, has been published on the transmission of radiant heat through gaseous bodies. We know nothing of the effect even of air upon heat radiated from terrestrial sources." He also stated that: "With regard to the action of other gases upon heat, we are not, so far as I am aware, possessed of a single experiment" (Tyndall, 1859; Wells, 1860, p. 174-175).

In 1861, Tyndall provided quantitative analyses indicating that CO_2, water vapor, and hydrocarbon gases, such as methane, were extremely efficient absorbers of radiant energy, as compared with the oxygen and nitrogen that make up the bulk of the atmosphere. He also speculated that changes in the concentration of those gases could have an impact on climate. (Tyndall, 1861). The numerous publications by Tyndall on heat and other topics related to climate change have been covered in depth by Fleming (1998).

Eunice Foote's Forgotten Work

At the 10th annual meeting of the American Association for the Advancement of Science (AAAS) in Albany in 1856, Joseph Henry of the Smithsonian Institution read a paper on behalf of author Mrs. Eunice Foote. The following summary of Mrs. Foote's paper was reported by David A. Wells in the 1857 volume of his *Annual of Scientific Discovery ... for 1856*:

"Prof. Henry then read a paper by Mrs. Eunice Foote, prefacing it with a few words, to the effect that science was of no country and of no sex. The sphere of woman embraces not only the beautiful and the useful, but the true. Mrs. Foote had determined, first, that the action of the rays increases with the density of the air. She has taken two glass cylinders of the same size, containing thermometers. Into one the air was condensed, and from the other air was exhausted. When they were of the same temperature the cylinders were placed side by side in the sun, and the thermometers in the condensed air rose more than twenty degrees higher than those in the rarified air. This effect of rarefaction must contribute to produce the feebleness of heating power in the sun's rays on the summits of lofty mountains. Secondly, the effect of the sun's rays is greater in moist than in dry air. In one cylinder the air was saturated with moisture, in the other dried with chloride of lime; both were placed in the sun, and a difference of about twelve degrees was observed. This high temperature of sunshine in moist air is frequently noticed; for instance, in the intervals between summer showers. The isothermal lines on the earth's surface are doubtless affected by the moisture of the air giving power to the sun, as well as by the temperature of the ocean yielding the moisture. Thirdly, a high effect of the sun's rays is produced in carbonic acid gas. One receiver being filled with carbonic acid, the other with common air, the temperature of the gas in the sun was raised twenty degrees above that of the air. The receiver containing the gas became very sensibly hotter than the other, and was much longer in cooling. An atmosphere of that gas would give to our earth a much higher temperature; and if there once was, as some suppose, a larger proportion of that gas in the air, an increased temperature must have accompanied it, both from the nature of the gas and the increased density of the atmosphere. Mrs. Foote had also tried the heating effect of the sun's rays on hydrogen and oxygen, and found the former to be less, the latter more, susceptible to the heating action of sunlight" (Wells, 1857, p. 159-160).

Unfortunately, Eunice Foote did not publish a paper on her findings in the AAAS Proceedings volume for the 1856 meeting (AAAS, 1857), and there is no mention of either Eunice Foote or of Professor Henry's oral presentation in that volume. Judging by the opening comments from Joseph Henry as reported by Wells, it is not obvious that a woman scientist in that time period would have been given an opportunity to present her own work or publish a paper. Nevertheless, her laboratory results showing enhanced absorption of radiation by CO_2 are in the published record via the report by Wells (1857), two years before Tyndall started his laboratory work in 1859. It is not certain from the language used whether the potential for atmospheric warming due to rising CO_2 levels was part of Edna Foote's presentation or whether it was speculation by Wells using journalistic license, but either way that concept was also clearly stated and in print as of 1857.

Eunice Newton Foote

The affiliation of Mrs. Foote was not mentioned by Wells (1857), but it is likely that she was Eunice Newton Foote, the wife of Elisha Foote (Wikipedia, 2010) of Seneca Falls, New York. Evidence of other scientific work by Eunice Foote has not been found, but she is known to have served on the editorial committee for the 1848 Seneca Falls Convention, an early and influential meeting of the women's rights movement (Wikipedia, 2011).

Elisha Foote (1809-1883) was a judge, inventor, and mathematician who later (1868-1869) served as commissioner of the U. S. Patent Office. Elisha Foote was listed in the 1856 AAAS Proceedings volume as a new member elected at the Albany meeting (AAAS, 1857, p. xlvi). "Judge Foot" also presented a paper at the 1856 AAAS meeting, on the heating power of the sun's rays, as reported by Wells (1857, p. 159). It stands to reason that the separately presented papers from Eunice Foote and Elisha Foote could have been the result of a collaborative research effort.

Elisha and Eunice Foote were the parents of Mary Foote Henderson (1846-1931), the wife of John B. Henderson, who served as U. S. Senator from Missouri (1862-69), and who introduced the 13th amendment to the U. S. Constitution that abolished slavery. Mary Foote Henderson later became a leader in the real estate development of Washington, D. C., in particular the Meridian Hill area (Wikipedia, 2011).

David Wells and *The Annual of Scientific Discovery*

The Annual of Scientific Discovery, published in Boston by Gould and Lincoln, was a serial book-length review of scientific progress in the year preceding publication. It attempted to cover the full breadth of scientific endeavor from all of the scientific journals of North America and Europe, as well as reports presented at scientific conferences and important patents. From the time of its first volume in 1850 through 1865, the editor was David A. Wells. In these volumes can be found not only coverage of Eunice Foote's forgotten research (Wells, 1857, p. 159-160), but also John Tyndall's well-known work from 1859 (Wells, 1860, p. 174-175), as well as other research on related topics.

David Ames Wells (1828-1898) graduated in 1851 from Harvard University's Lawrence Scientific School, after starting his career in 1848 with the Springfield (Massachusetts) Republican newspaper. His background as a journalist and his access to the Harvard library clearly were factors in his becoming the first editor for *The Annual of Scientific Discovery*, and his scientific and writing skills were in evidence as he published introductory textbooks on chemistry, geology, natural philosophy, and general science in the late 1850s and early 1860s.

David Wells also wrote widely distributed papers related to economics, sufficiently impressing President Abraham Lincoln that he was appointed chairman of the U. S. Treasury Department's newly formed Revenue Commission in 1865, an assignment that caused him to turn over *The Annual of Scientific Discovery* to a new editor. For the rest of his career, Wells focused on government and business, and he is best known today for his innovative work in economics in the late 19th century (Anonymous, 1899; Wikipedia, 2011).

Conclusion

In the course of scientific discovery, it can be difficult to assess claims of priority, particularly if research results are not placed in the public domain through formal publication. This is commonplace for presentations at scientific conventions, where often only a title or perhaps an abstract is preserved for posterity. In the case of Eunice Foote's pioneering research on absorption of radiant energy by greenhouse gases, such as CO_2, and the implication that compositional changes in the atmosphere could impact climate changes, it was only through the journalism of David Wells that the originality of her work has been documented. Despite the absence of a formal publication, it is clear that Eunice Foote deserves credit for being an innovator on the topic of CO_2 and its potential impact on global climate warming

References Cited

AAAS, 1857, Proceedings of the American Association for the Advancement of Science. Tenth Meeting, held at Albany, New York, August, 1856. Joseph Lovering, Cambridge, 258 p.

Anonymous, 1899, David Ames Wells: The Journal of Political Economy, v. 7, University of Chicago Press, p. 93-95.

Fleming, James Rodger, 1998, Historical Perspectives on Climate Change: Oxford University Press, New York, 194 p.

Tyndall, John, 1859, Note on the transmission of heat through gaseous bodies: Proceedings Royal Society of London, v. 10, p. 37-39.

Tyndall, John, 1861, On the absorption and radiation of heat by gases and vapours, and on the physical connexion of radiation, absorption and conduction: Philosophical Transactions of the Royal Society of London, v. 151, part I, p. 1-36.

Wells, David A., ed., 1857, Annual of scientific discovery: or, year-book of facts in science and art, for 1857, exhibiting the most important discoveries and improvements in mechanics, useful arts, natural philosophy, chemistry, astronomy, meteorology, zoology, botany, mineralogy, geology, geography, antiquities, etc., together with a list of recent scientific publications; a classified list of patents; obituaries of eminent scientific men; notes on the progress of science during the year 1856, etc.: Gould and Lincoln, Boston, 406 p.

Wells, David A., ed., 1860, Annual of scientific discovery: or, year-book of facts in science and art, for 1860, exhibiting the most important discoveries and improvements in mechanics, useful arts, natural philosophy, chemistry, astronomy, geology, zoology, botany, mineralogy, meteorology, geography, antiquities, etc., together with notes on the progress of science during the year 1859; a list of recent scientific publications; obituaries of eminent scientific men; etc.: Gould and Lincoln, Boston, 430 p.

Websites

Wikipedia, 2011, “David Ames Wells”: Web accessed, January 9, 2011, http://en.wikipedia.org/wiki/David_Ames_Wells.

Wikipedia, 2010, “Elisha Foote”: Web accessed, December 31, 2010, http://en.wikipedia.org/wiki/Elisha_Foote.

Wikipedia, 2011, “John Tyndall”: Web accessed, January 3, 2011, http://en.wikipedia.org/wiki/John_Tyndall.

Wikipedia, 2011, “Mary Foote Henderson”: Web accessed, January 9, 2011, http://en.wikipedia.org/wiki/Mary_Foote_Henderson.

Wikipedia, 2011, “Seneca Falls Convention”: Web accessed, January 9, 2011, http://en.wikipedia.org/wiki/Seneca_Falls_Convention.