

Editorial

In memory of Julian Munson Sturtevant

Julian Sturtevant, Professor Emeritus of Chemistry and Molecular Biophysics and Biochemistry at Yale University, died on August 12, 2005. He was 97. He received his B.A. from Columbia University in 1927, his Ph.D. from Yale University in 1931, and immediately began his teaching career at Yale at the age of 23. A member of the Yale faculty until 1977, when he reached the then-mandatory retirement age of 68, he continued working in his lab for more than 20 years.

Julian Sturtevant was born in New Jersey on August 9, 1908 to Bessie and Edgar H. Sturtevant, who was professor of classics and linguistics at Columbia and Yale Universities. The Sturtevants come from a family with deep New England roots. An extensive genealogy,¹ compiled by his uncle, Alfred H. Sturtevant, II, indicates that Samuel Sturtevant came to Plymouth, Massachusetts around 1640, probably from England. A.H. Sturtevant thought that all those who use the same spelling of the surname are descended from Samuel. Another ancestor, Thomas Munson, was born in England around 1612 and lived in New Haven and Hartford.

Julian's immediate forebears and close relatives were academics of high standing; Julian's son, the late Bradford Sturtevant, carried this tradition on in the Graduate Aeronautical Laboratories at Caltech, specializing in fluid mechanics. Julian's great grandfather, Julian Monson² Sturtevant, was born in 1805 to a farm family that moved from Warren, Connecticut to the "Western Reserve" (Ohio) when he was entering his teens. In spite of the rigors of helping establish the family farm, young Julian managed to learn enough Greek and Latin to gain admission to Yale College, where he graduated in 1826. He continued at Yale, studying theology, and was ordained a minister in 1829. Following completion of his training, he returned to the Midwest and helped establish Illinois College. He and a group of supporters opened the institution in January of 1830. From 1831 to 1844, he was Professor of Mathematics and Natural Philosophy, and often gave instruction

in Latin and Greek. In 1844, he was elected President of the College, a post he retained for many years.

Two grandsons of Julian Monson, both sons of Alfred Henry Sturtevant, were distinguished professors. The elder, Edgar H. Sturtevant, Julian's father, taught Latin and Greek at Barnard College, and subsequently became professor of classics and linguistics at Columbia and Yale Universities. Edgar strongly influenced younger brother Alfred Henry Sturtevant, II, not only by setting a standard for scholarship, but also, with wife Bessie, taking him into their home and enabling him to study at Columbia University. Young Alfred brought a boyhood interest in genealogy and pedigree to New York, where Edgar encouraged him to do independent reading about genetics. Alfred caught on quickly, and saw how Mendel's principles could be used to explain the inheritance of coat colors in horses. Edgar encouraged him to write up his findings, and submit it to Thomas Hunt Morgan, Chair of Zoology at Columbia at that time. Young Sturtevant was welcomed into the Morgan laboratory as an undergraduate, and went on to do his Ph.D. research there, graduating in 1914. He remained at Columbia with Morgan until 1928, when he moved to Cal Tech and continued his outstanding career in genetics. Among his best known work is the method for mapping gene distances along a chromosome by measuring the rate of their loss of linkage in meiotic recombination.

Julian Munson Sturtevant did his undergraduate work at Columbia; it is tempting to speculate that the choice of Columbia was influenced by his father and his Uncle Alfred, but details on his early life are scarce and there are few if any living sources left. His own recollections [1] begin after he graduated with a Ph.D. in Chemistry from Yale in 1931. However, we do have one small artifact from the Columbia years: a copy of his sophomore year textbook of analytic geometry which he kept in his Yale office. (Thanks to Joanne Bentley for rescuing this volume.) In the back he lists the classes he "cut" for the Spring semester of 1925, along with his excuses. There are roughly 10 entries, for analytic geometry, Greek, and chemistry classes. On Feb. 17, 1925, he was absent because he "overslept" after the freshman dinner. Two days later he was again absent, because he overslept after the sophomore dinner.

Julian's Ph.D. thesis, done under the supervision of Prof. Arthur Hill, was a volume of 142 pages, short by today's

¹ This genealogy is available on the web at http://sturtevant.com/sturtevant/ahs_ancestry.

² Julian Munson Sturtevant's grandmother, Hulda Monson, or perhaps her parents, appear to have changed the spelling of the family name from Munson to Monson, a change that was reversed by Julian Munson's father Edgar, the grandson of Julian Monson. One can speculate that this reversal to the original was a consequence of the genealogical research done by Edgar's younger brother, the noted geneticist A.H. Sturtevant.

standards, but considerably longer than other Yale Chemistry theses of that period. The title, “The Synthesis of Certain Alkyl Naphthols” might lead one to classify him as a synthetic organic chemist, which he was certainly trained to be, but reading the thesis brings out the strong biological motivation for the work. The naphthols are antiseptics, whose use on human infections was much greater in the era before antibiotics. There was considerable interest in agents that improved on the performance of phenol, with reduced human toxicity. Julian synthesized a lot of them. The standard disinfectant assay method at the time was to calculate a ratio of the “disinfectant power” of the compound under test to the value for phenol, the so-called phenol ratio. A section from the introductory chapter in Julian’s thesis foreshadows the thorough disdain he developed for imprecise numbers and the lack of rigorous quantitative sense: “The phenol coefficient, together with such toxicity determinations as the “minimal lethal dose”, is the only laboratory test that has been developed as yet, and thus it must still be used. Nevertheless, it should be constantly borne in mind that the phenol coefficient is merely the roughest sort of an approximation, a fact which is likely to be forgotten when one sees the number of significant figures which are often included in the coefficients. In the tables which follow, the liberty has not been taken to reduce the number of significant figures appearing in the original articles. However, the limit of accuracy should usually be considered to be one significant figure, and there are many cases where the agreement between different observations does not really justify the retention of any significant figures.” I found no evidence that Julian ever stooped to measurement of phenol coefficients for the compounds he synthesized.

In keeping with the experience of many scientists, the first decade of independent work was formative for Julian’s career. (In the photo in Fig. 1, taken at the New Haven meeting of the

American Chemical Society between Christmas and New Years, 1931–1932, one can find an image of Julian at the beginning of his academic career.) Although trained originally in organic chemistry, he became by the late 1940s an early pioneer in biophysical chemistry, with particular emphasis on the application of thermochemistry to biological systems. As he describes in his “Recollection” [1], he first turned to theoretical efforts. In a 1933 paper [2] he addressed the problem of incorporating quantum mechanical effects into the calculation of the net dipole moment of rotating polar groups. Expressing the wave function in terms of Hermite polynomials turned out to allow evaluation of relatively simple integrals, with good agreement with experiment. However, he noted [1] that he needed mathematical help from the Yale physicist Henry Margenau. In a 1935 paper [3], he sought to determine by theoretical means whether deviations from the Brønsted formula for the dependence of the bimolecular reaction rate constant on ionic strength could be ascribed to asymmetry of the polar reacting partners. (The answer is that they could not.) The equations eventually boil down to integrals which turn out to be Hankel functions of the first kind. In this case, Julian acknowledged that he needed help from Lars Onsager in order to do the mathematics. (I had an eerily similar experience when I joined the Yale faculty 30 years later. After struggling with an integral related to kinetics for several days, I went to see Onsager, who looked at my integral for a few seconds, and said, “Oh, that will be a Hankel function of the second kind.”)

Chastened by his need for mathematical help, he decided that he “was not destined to be a theoretical chemist” [1], and turned his attention to experimental studies of organic reaction kinetics. His early efforts to measure kinetics by volume change were perturbed by the large amounts of heat produced, but he realized that a modification of the instrument would



Fig. 1. Section of a larger group photograph taken in front of Sterling Chemistry Laboratory on the occasion of the meeting of the American Chemical Society between Christmas and New Year 1931–1932. The young Julian Sturtevant is 4th from the left in the front row. Photo courtesy of J. Michael McBride.

enable him to measure the enthalpy change. In describing his first design of a calorimeter in 1937 [4], he noted that he considered two possible designs: one in which ΔH and reaction kinetics are determined from the temperature rise and its rate, along with a measurement of the heat capacity of a single adiabatic calorimeter. In a second design incorporating twin calorimeters, the electrical energy to keep the blank and experimental calorimeters at the same temperature could be used to determine the heat and reaction rate. Julian decided on the first design because the needed equipment was simpler [4]. The calorimeter was used not only to obtain ΔH values for the inversion of sucrose and decomposition of diacetone alcohol, but also the rate constants.

I found 12 J.M. Sturtevant papers from the 1930s, 4 theoretical, 1 describing his first calorimeter, 4 describing enthalpy change measurements, and 3 describing other kinds of apparatus, including a spindle for insulating wires, a phototube relay of increased sensitivity, and a thyatron-controlled thermostat. Most of the calorimetric work after the first paper was on heats of dilution, beginning with glycine, HCl and NaOH. In 1940 he reported on the heats of dilution of a wider set of amino acids. (References for these and most other papers I report can be found by using the Advanced Scholar Search under Google Scholar.) He had not, however, forgotten his organic chemical roots, since he published together with Robert Coghill a book (McGraw-Hill, 1936) entitled "Introduction to the preparation and identification of organic compounds".

The decade of the 1940s began with a new calorimeter [5] in 1941, which upgraded the 1937 version to allow rapid mixing of solutions. In addition there were 2 more papers reporting enthalpy measurements, 4 papers primarily chemical in nature, 2 describing other types of apparatus, and 1 on kinetics. One notes that the publications stopped in 1942 and resumed in 1947, as a consequence of the time he spent at MIT working on radar, for which his background in electronics was well suited. He later authored a book written together with Ernest Pollard on "Microwaves and Radar Electronics" [6]. He also filed a patent in 1946 [7]³ on an electrophoretic method to separate isotopes, including uranium. I suspect that this effort was part of the work on the Manhattan project that was underway at Yale in those years. However, as emphasized to me by Jerome Berson, Julian was a strong supporter of the Federation of American Scientists and a firm and life-long proponent of nuclear disarmament.

The decade of the 1950s also saw the introduction of a new calorimeter [8], the twin-calorimeter version that he had briefly described in 1937, but rejected in favor of the simpler version. The instrument was described in essence by Buzzell and Sturtevant [8] as follows: "In the twin calorimetric method as applied to exothermic chemical processes, the chemical energy liberated in one calorimeter is duplicated electrically in the other. In the case of an endothermic process, sufficient electrical energy is introduced into the calorimeter in which the process takes place to prevent any temperature change. If they are supported within an "adiabatic" shield, the differential method

of operation permits the uncertainty of any remaining calorimetric corrections to be reduced to a very low value." I counted 18 papers from that decade in which isothermal enthalpy measurements were reported using the new twin calorimeter. Julian also made significant contributions to reaction kinetics, particularly those catalyzed by enzymes, during this period. Always keen on collaborations, he worked with such noted kineticists as Gutfreund and Bruice, with the goal of elucidating reaction mechanisms.

The decade of the 1960s continued the effort using mixing calorimetry to measure reaction enthalpies, along with a continued effort in enzyme kinetics. (I was a beneficiary of the kinetic equipment in his laboratory when I came to Yale in 1964, and used his home-built stopped flow instrument to follow the kinetics of ligands reacting with DNA.) A new flow calorimeter, built by Beckman in collaboration with Sturtevant, was used to good effect for measuring heats of reaction. His laboratory also used a number of other physical methods, particularly optical techniques such as fluorescence, CD and ORD.

A major new development was signaled in 1967 by the description by Danforth et al. [9] of a new differential scanning calorimeter (DSC), a technique that dominated the laboratory for the remainder of Julian's career. In contrast to isothermal calorimetry, DSC measures excess heat required per degree to raise the temperature of a solution over that required for the buffer blank, thus giving a profile of the heat capacity of the dissolved material as a function of temperature. Integration of the excess heat capacity gives the enthalpy change for the reaction, for example a conformational change or denaturation of proteins and nucleic acids. Danforth et al. [9] report the capabilities of their instrument as follows: "An apparatus for the differential thermal analysis of small (1.7 ml) samples of solutions is described. A heat effect amounting to 50 cal l⁻¹ of solution taking place over a 30° temperature interval can be measured with a precision of 5%, and a change in heat capacity of the solution amounting to 2 cal deg⁻¹ l⁻¹ of solution can be measured with a precision of 15%". This instrument was the last in the line of "home built" Sturtevant calorimeters, as commercial DSC instruments began to become available, first from the Privalov group in Puschino, Russia, and finally from the U.S. company Microcal. These instruments steadily improved in sensitivity, sample requirements, ease of use, and computer control. John Brandts, the founder of Microcal, placed one of the company's instruments on indefinite loan in the Sturtevant laboratory in recognition of the leading role of the Sturtevant group. A remarkable feature of Julian's career is that in spite of the commercial availability of the new DSC instruments, scientists continued to flock to his laboratory for collaboration until he finally closed it, reflecting the expertise of his group in maintaining the equipment and interpreting experimental results. His last 8 papers on the Medline record, from 1996 to 1999, were done in collaboration with other groups, often from outside Yale.

The barest summary of Julian's scientific work is that he was a major player in most aspects of biochemical thermodynamics,

³ I am grateful to Jerome Berson for bringing this patent to my attention.

from the 1930s to the end of the millennium. His most cited paper is the single-author PNAS paper from 1977 [10] entitled "Heat capacity and entropy changes in processes involving proteins". In it he identified six possible sources for the large heat capacity and enthalpy changes observed for processes involving proteins, including hydrophobic effects, electrostatic charges, hydrogen bonds, conformational entropy, and intramolecular vibrations. He concluded that the conformational, hydrophobic, and vibrational effects are of greatest importance, and showed how his analysis could clarify previously confusing and apparently contradictory data.

Julian was widely recognized over his long career. As a foremost authority in biochemical calorimetry, he was elected to the National Academy of Sciences in 1973 and received numerous awards including Yale Graduate School Wilbur L. Cross Medal; Honorary D. Sc., Illinois College; doctor *honoris causa*, Universität Regensburg, Germany; Guggenheim Fellow and Fulbright Scholar, University of Cambridge, England; and Fulbright Scholar, Waite Institute, University of Adelaide, Australia. He was visiting professor at the University of California, San Diego, and the Batelle Research Center in Seattle, WA. Other professional awards include the Huffman Award by the U.S. Calorimetry Conference and the William Clyde DeVane Award given in recognition of teaching excellence by Yale College. His service to Yale included the Chairmanship of the chemistry department from 1959 to 1962.

None of these official honors, however, capture the vigor and grace of Julian and Elizabeth, his wife of 75 years. For many years, they were gracious and engaging hosts to Chemistry and other Department faculty and students in their lovely home on Long Island Sound. The special attention they paid to young Yale faculty was much appreciated. Jim Cross, then a young kineticist, recalls being invited to spend a day at their beach house when the famed kineticist Henry Eyring was a house guest with the Sturtevant. They were much admired for their vitality, in particular for their treks in the Himalayas after retirement age, documented for the Department in stunning color photographs. Julian and Elizabeth celebrated her 75th birthday by climbing to the base camp on Mt. Everest. As part of his training for these treks, Julian was fond of challenging much younger colleagues to climb the 12 flights of stairs to the

top of Kline tower for lunch, leaving most of us panting in his wake. Jerome Berson admits that he could on occasion beat Julian at squash, but he concedes that the age difference of 25 years had something to do with that. One way that Julian expressed his joy of living was ballroom dancing, for which he had, according to Harry Wasserman, a consuming passion second only to his love of chemistry. Of great pride to Julian was the occasion of his participation with his daughter Ann in a contest at Vassar College, where he was named "The Charleston King of Vassar."

Julian is much missed by all who knew him, at Yale and in the international scientific community. Individuals of his ability, integrity, hospitality, and grace are rare indeed.

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