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CARL SHIPP MARVEL

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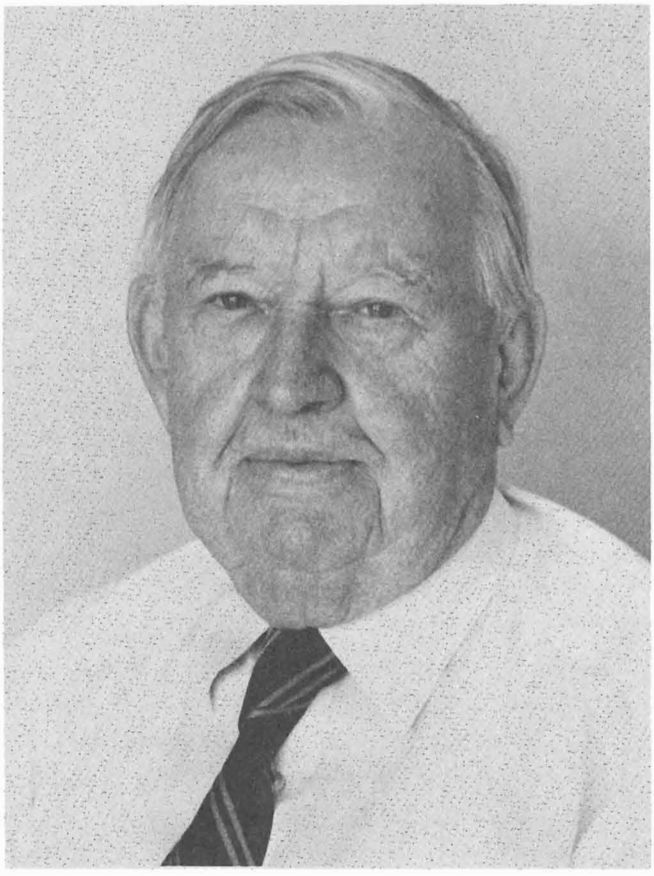
A Biographical Memoir by

NELSON J. LEONARD

Biographical Memoir



Carl S. Marvel

CARL SHIPP MARVEL

September 11, 1894–January 4, 1988

BY NELSON J. LEONARD

CARL S. MARVEL had a spectacular career of seventy-two years in organic chemistry. It was during the same period that the chemical industry in the United States experienced its greatest growth. The two careers were synergistic. From 1920 to 1961, Dr. Marvel was on the staff of the University of Illinois in Urbana, and from the date of his first retirement through 1987 he was a faculty member at the University of Arizona. He consulted for nearly sixty years for the DuPont Experimental Station. He was a dominant figure in American organic chemistry and has been recognized as the "father" of synthetic polymer chemistry. The impact of his teaching, research, and consultation was matched by his important contributions to government, foundations, and the professional community. It was at the personal level, however, that his influence was most pervasive, reaching beyond the 176 Ph.D. students and 150 postdoctoral students whom he trained to thousands of chemists, friends, colleagues, and acquaintances with whom he shared common interests or goals. His personality was so memorable that his influence will continue to affect and guide the lives of all those with whom he came in contact.

Carl Marvel was born on a farm three miles south of Waynesville, Illinois, during the forenoon of September 11,

1894. His father, John Thomas Marvel, who was a farmer from a farm family, was of Norman, English, and Irish ancestry. The Marvel family migrated from Normandy to Cambridgeshire, England, in 1091 and eventually to Sussex County, Virginia (later Maryland), during the period 1630–1707. John Marvel had a limited grade school education with a very short period at the preparatory school of Illinois Wesleyan University. Carl's mother, Mary Lucy Wasson, who was also from a farm family, had grade school and high school training. She qualified for college, but her father disapproved of college training for women, so she taught country school until her marriage. She was of Danish, Scotch-Irish descent. The Wasson family is supposed to have moved from Denmark to Scotland during the Danish invasion and colonization period.

Carl grew up on the Illinois farm with three sisters and did the usual farm work during vacation periods. He did not, however, drop out of school to help on the farm during the spring and fall work seasons, which was contrary to the usual custom of the community. His father believed Carl's schooling came first. Carl was interested in flowers, birds, animals—in short, in all of nature. He spent much time hunting on winter weekends after he was six or seven years old. He also ran trap lines for muskrat, mink, and skunk to earn spending money. He related that after he had skinned one skunk the others were sold without preliminary treatment. He attended the West Hull District School in Barnett Township, Dewitt County, Illinois, through the eighth grade, which he completed in 1907. He remembered with special gratitude three teachers at that school, Mary Keys, Grace Barr, and Ida Jeffrey, who stressed proper study habits for their pupils and who insisted that only the best work possible was acceptable.

He was the last graduate of Waynesville Academy, which

he attended from 1907 to 1911, when it was turned into a township high school. The school was four miles from the Marvel home, and Carl either drove or rode a horse back and forth every day. He singled out Professor W. H. Smith, a retired minister, as being a superb teacher of English, mathematics, history, Latin, Greek, and German (!), who also suggested books to read covering physics, zoology, and botany when he learned that Carl was ambitious enough to go to college. Carl learned to classify and identify the flowers of central Illinois and to know them thoroughly. He considered that this self-instruction method did much to improve his self-reliance.

At Illinois Wesleyan University, which he attended during 1911–15, receiving A.B. and M.S. degrees in 1915, he was introduced to chemistry as a freshman. An uncle, who had been a high school teacher, advised his nephew to take this subject if he expected to be a farmer, since the next generation of farmers would require scientific knowledge to get the most out of their work. During most summers while Carl was attending high school and college, he worked as a farmhand, but during one summer he was an auto mechanic and a driving teacher for another uncle who sold cars in Lincoln, Illinois. At Illinois Wesleyan, he took as much biology as possible under Professor F. E. Wood. Mr. Wood found, in botany class, that Carl was familiar with the flowers of the region and asked that he choose another family to study. The result was a semester spent in identifying the mosses of central Illinois and in the assembly of a collection of fifty to sixty specimens.

One of Carl's first successful scientific experiments was carried out during the summer vacation between his junior and senior years in college. His father was skeptical of the importance of bees in the fertilization of red clover blossoms. For his benefit, Carl selected a healthy red clover

plant in the farm yard and carefully covered half of it with a fine screen shelter. The other half was allowed to grow exposed. He was pleased to be able to show his father a good crop of clover seed in the heads that grew outside the screen and the absence of seed in the sheltered heads. This experiment convinced his father that scientific study might be useful to a prospective farmer and persuaded him that perhaps Carl might even profit from graduate study when the opportunity developed in due course.

It was the excellent teaching and personal attention received from Professor Alfred W. Homberger at Illinois Wesleyan that was directly responsible for Carl's decision to specialize in chemistry. During his final year at Illinois Wesleyan, Carl was a teaching assistant and did a thesis problem with Professor Homberger that resulted in his first publication. The same professor succeeded in obtaining for his prize student a $250 scholarship in chemistry at the Graduate College of the University of Illinois to enable him to study further. Carl's graduate education started in 1915 with an overload of course work, including four lab courses, in order to "catch up." When he was not studying, he worked late at night in the laboratory. As a result, he slept as late as possible but still got to the breakfast table before the dining room door closed at 7:30 a.m. His student colleagues decided that was the only time he ever hurried, and they nicknamed him "Speed." A nickname was appropriate to his friendly spirit, but it causes us to smile in retrospect because it was really an accurate moniker indicative of his chemical thinking, his human insight, his fishing and bird-watching prowess, the way in which he took care of his correspondence, and the alacrity with which he helped a student or colleague who had a chemistry or personal problem.

As a chemistry graduate student, Speed Marvel delighted in the synthesis of organic compounds and earned an early

and lasting reputation for his ability to classify and identify volatile organic compounds by odor alone. When he entered graduate school, Germany was the center of chemical manufacture and research, but the start of the war in Europe had interrupted the supply of chemicals to the United States. The shortage, which included research chemicals, led Professor Clarence Derick to organize a group of graduate students at Illinois to work during the summer of 1916 making chemicals to fill the needs of the departmental research programs. An A.M. degree was awarded to Speed in 1916. When the size of the Organic Chemical Manufactures group was increased by Roger Adams, who had arrived from Harvard to be head of the Department of Chemistry, Marvel joined the group in the summer of 1917 and stayed with it for two years. He went back to full-time graduate work in 1919, received a DuPont fellowship for his final year of graduate study, and in 1920 received his Ph.D. in chemistry under the direction of Professor William Albert Noyes with a thesis entitled "A Study of the Possible Asymmetry of Aliphatic Diazo Compounds," which was published in the same year in the *Journal of the American Chemical Society.* That study represented an initiation of his interest in organic stereochemistry.

He also received great stimulation from three teachers, Roger Adams, Oliver Kamm, and H. B. Lewis. Adams hired Marvel as an instructor in chemistry at the University of Illinois in 1920, a rank he held during 1920–22, followed by associate, 1922–25; assistant professor, 1925–27; associate professor, 1927–30; professor of organic chemistry, 1930–53; and research professor of organic chemistry, 1953–61. In his early teaching days, Wallace H. Carothers and John R. Johnson were also instructors at the University of Illinois. Marvel, Carothers, and Johnson, along with several graduate students, including Paul Salzberg and M. M.

Brubaker, organized a special seminar in organic chemistry that met weekly in Marvel's home to discuss controversial questions in organic chemistry. They called the seminar "Chemistry 398," since they were not quite at the "400" (graduate course) level of organic chemistry at the time.

Marvel gained wide-ranging experience in synthesis by submitting and checking preparations for *Organic Syntheses.* This publication, the first annual volume of which appeared in 1921, is a collection of preparations of organic compounds for which checked directions are provided in detail. Collective Volume I of *Organic Syntheses,* which contained the preparations that appeared in the first nine volumes, was published in 1932 and was reprinted in 1941. Nearly 20 percent of the 264 preps in that volume were either submitted by Marvel or checked by him, which represented a most energetic and devoted contribution to synthetic organic chemistry.

Marvel's early published papers reflected both his love of synthesis and the need of the chemical community for pure organic compounds—for example, the amino acids that were to form the basis of Professor William C. Rose's classical research on human nutritional requirements, in particular the essential amino acids. Marvel prepared dialkylmercury compounds and investigated their reactions, synthesized hexasubstituted ethanes and studied their dissociation, synthesized polyines and dienynes and determined their modes of rearrangement or cyclization, and made and studied the reactions of alkyllithium and Grignard reagents, quaternary phosphonium, and ammonium compounds. In addition, he perfected the synthesis of organic chemical reagents needed in the early years for characterization, identification, and analysis. His seminal research on intermolecular hydrogen bonding performed prior to infrared capability was based on solubilities and heats of mixing.

Trained as an organic chemist, Professor Marvel's interest in polymer chemistry emerged from studies of organic reactions. His approach to polymer chemistry was characterized by the same skills in synthesis, structure determination, and technique improvisation that marked his early contributions to organic chemistry. To him, polymers represented a logical extension of his research on simple organic molecules, and he thought of their synthesis, analysis, and characterization in a similar vein. Guided by this philosophy, he made major fundamental contributions to the polymer field.

In 1933 he determined that γ-halopropyldimethylamines yielded open-chain polymeric products and subsequently found that, by contrast, the diethyl, di-*n*-propyl, and di-*n*-butyl analogs yielded monomeric cyclic ammonium salts. He introduced high dilution to produce the dimethylammonium four-membered ring compound and delineated the conditions under which it converted to polymer.

His extended studies of olefin/sulfur dioxide polymers provided key chemical methodology for all subsequent investigations of addition polymerization. In 1934, Marvel and his students, following earlier reports of Solonia (1899), Matthews and Elder (1914), and Seyer and King (1933), and contemporaneously with Staudinger, found that a polymeric sulfone was produced by the reaction of sulfur dioxide and an olefin, cyclohexene, in the presence of a peroxide catalyst. Determinations of elemental analysis, average molecular weight, end-group analysis, and the products of alkaline fusion established the principal structural features of the high-molecular-weight polymer. Reaction of sulfur dioxide with monosubstituted olefins and acetylenes and with mixtures of olefins established the generality of the addition polymerization. Polypropylenesulfone was found to have a head-to-head, tail-to-tail orientation, while the

polymer from vinyl chloride and sulfur dioxide was found to have a head-to-tail array of two units of olefin to one of SO_2. In an exploration of various initiators of olefin/SO_2 polymerization, Marvel demonstrated that identical structures were obtained from catalysis with peroxide, ultraviolet light, and amine oxides.

Marvel's success in elaborating the structures resulting from olefin/SO_2 polymerization led him, starting in 1938, to investigate the structures of other vinyl polymers, particularly homopolymers from monosubstituted olefins. He used the reactions of the carbonyl group in the polymers of methyl vinyl ketone and isopropenyl methyl ketone and of the hydroxyl group in polyvinyl alcohol to establish that these were head-to-tail polymers. He showed similarly that the copolymer of vinyl chloride/vinyl acetate had a head-to-tail structure. He supplemented end-group analysis with the finding that the kinetics of addition polymerization could be followed through the use of a vinyl monomer containing an optically active group. It should be noted that Marvel was among the first to recognize the significance of stereoregular polymers, which he endeavored to prepare by the principle of asymmetric induction using optically active initiators and monomers.

Marvel began to receive recognition for his innovations in research. He gave the Foster Lecture at the University of Buffalo, Buffalo, New York, in 1937. He was elected to membership in the National Academy of Sciences in 1938 and served, during 1944–47, as chairman of the Section on Chemistry. He gave the Julius Stieglitz Memorial Lecture before the Chicago Section of the American Chemical Society in 1943 and received the Nichols Medal of the New York Section of the American Chemical Society in 1944.

With the onset of the second World War, Marvel became involved in U.S. Government service. In September 1940

he became associated with Section C-2, Synthetic Problems, of Division B of the National Defense Research Committee, performing various tasks until the reorganization of the NDRC in September 1942, when he served as chairman of Section B-3, Synthetic, Analytical, and Inorganic Problems, until a further reorganization of the section as Division 9 took place in December 1942. Then, at the request of the Office of the Rubber Director, he joined the Rubber Reserve Corporation program on synthetic rubber synthesis. The U.S. government launched a major program to alleviate the critical shortage of natural rubber, without which tires for automobiles, trucks, military vehicles, and aircraft could not be made. Speed Marvel organized a research group at the University of Illinois, with the aid of his colleagues in organic, physical, and analytical chemistry, that concentrated on the synthesis and polymerization of 2-substituted butadienes and styrene. He also helped coordinate work on the project that involved other universities, including MIT, Chicago, Minnesota, Cornell, and Case, and industrial laboratories, including Bell Laboratories, ESSO Research, DuPont, and Union Carbide. Within one year's time, this effort brought forth adequate formulation, additives, modifiers, and processes for synthetic rubber and thereby provided successful resolution, not broadly recognized, of a potentially catastrophic situation. There was, however, recognition for Dr. Marvel's role with the award of the President's Certificate of Merit for Civilians in World War II.

When hostilities ceased, Marvel went on a technical intelligence mission to Germany to learn of innovations that their rubber industry had made in butadiene-styrene copolymers. Their rapid polymerization technique, known as redox-polymerization, was adapted to low-temperature polymerization in the United States, thereby improving the

synthetic product to the point where it became a most useful general-purpose rubber. Marvel's laboratory at the University of Illinois went on to prepare, in large number, unusual butadiene copolymers with vinylsulfonic acid derivatives, anthracene and other polynuclear hydrocarbons, aconitic esters, substituted styrenes, and methyl acrylate, the latter for lithium aluminum hydride reduction to a diene/allyl alcohol copolymer.

Another major contribution to the synthetic rubber program stemmed from Marvel's extensive studies of reactions of thiols with olefins. He was the first to demonstrate the preparation of high-molecular-weight polymers by adapting the reaction to bifunctional thiols and bifunctional olefins, with the goal of imparting rubbery character to the polymers. He extended the work further to include polythiol esters, polymercaptals, and polymercaptols. The advent of coordination catalysis provided opportunities for new kinds of polymers that Marvel was quick to perceive. He made polymers of the terpenes pinene, myrcene, and alloocimene and of linear compounds containing 1,6-diene functionality that resulted in ring-containing polymers.

About 1955 the Materials Laboratory of Wright Patterson Air Force Base approached Professor Marvel, asking him to study organic polymeric materials that would withstand high temperature without loss of strength. His association with the U.S. Air Force's high-temperature polymer research program as its principal contributor, which began toward the end of his first career at the University of Illinois, continued throughout his entire second career at the University of Arizona. His basic research on condensation polymers with aromatic and heteroaromatic recurring units led to a series of products with progressively better and better properties and finally to polybenzimidazole (PBI). This was commercialized due to its exceptional resistance to fire and

retention of strength at high temperature. Fibers of this polymer are used to make reentry parachutes, the suits of astronauts and fire fighters, and for upholstery and other similar uses for aerospace application. Fibers and films fabricated from two-strand or ladder polymers were recognized as providing significant improvement over the usual linear type of polymer, combining properties of lightness and high tensile strength. The U.S. Air Force Materials Laboratory honored Marvel with its Distinguished Service Award (1966) and the Air Force Systems Command, with its Award for Outstanding Achievement (1966).

While Speed Marvel always felt, and frequently reminded his colleagues, that the essential product of academic research was the students, he also taught that the best graduate training was to be achieved, along with possible national prestige, by work on essential problems. He believed there was no such thing as a dead end to a worthwhile research problem—delays and detours and retracing of steps, indeed, but no dead end.

In an early University of Illinois tradition, a new instructor gained his first experience in directing research by working with senior undergraduates. When Marvel took up his duties as a teacher at Illinois in 1920, he had six seniors in research. In the first class that Marvel taught in organic qualitative analysis there were several impressive students, including Wallace Carothers, who later invented nylon at DuPont; Samuel McElvain, who became a professor of organic chemistry at the University of Wisconsin; and George Graves, who played an important role in the plutonium plant at Hanford, Washington, during World War II. Dozens of Marvel's students went on to outstanding careers, including those who directed research in major chemical industries such as Paul L. Salzberg, Glenn A. Nesty, Donald S. Frederick, William J. Sparks, Thomas W. Mastin, Robert

R. Chambers, Max T. Goebel, John R. Elliott, John W. Copenhaver, Charles L. Levesque, James H. Sample, Charles W. Hinman, and Lester E. Coleman, Jr. Among Marvel's students and postdoctorates who made their reputations in university positions were Vincent Du Vigneaud (Nobel laureate), Henry E. Baumgarten, William J. Bailey, Alfred T. Blomquist, Robert B. Carlin, Herbert E. Carter, Frans DeSchryver, Delos F. DeTar, Arjeh B. Galun, Chester M. Himel, Evan Horning, Michael M. Martin, Charles G. Overberger, Norman Rabjohn, and John K. Stille. Volume 8, issue number 8, of *The Journal of Polymer Science* (1970) was devoted to contributions from former students and research associates as a tribute to Dr. Marvel.

Speed Marvel was a founder of the High Polymer Forum that became the Division of Polymer Chemistry of the American Chemical Society, of which he was chairman in 1950–51. During his long membership in the ACS, begun in 1915, he held just about every elective office possible, up to and including the presidency in 1945. He held that office longer than any other ACS president in history because he stepped into the position when the previous president died in office. In 1980 Marvel received an award for forty years of service as an ACS Council Member. The ACS gave him the Priestley Medal (1956), the Witco Award in Polymer Chemistry (1964), and the Borden Award in Chemical Plastics and Coatings (1973). The New York Section of the ACS awarded him the Nichols Medal (1944, mentioned earlier); the Chicago Section, the Willard Gibbs Medal (1950); and the North Alabama Section, the Madison Marshall Award (1966); and he delivered the Edgar Fahs Smith Memorial Lecture before the Philadelphia Section (1948). The Division of Polymer Chemistry of the ACS gave him both its Divisional Award (1978) and its Educational Award (1984). The all-purpose meeting room of the ACS building in Wash-

ington, D.C., is designated "Marvel Hall" to indicate the esteem with which the ACS held Speed Marvel and the society's gratitude for the leadership he provided in raising the funds that made the building possible. Other societies joined in honoring Dr. Marvel: membership in the American Philosophical Society (1945); fellowship in the American Academy of Arts and Sciences (1960); the Society of Plastic Engineers International Award (1964); the American Section of the Society of Chemical Industry Perkin Medal (1965); the American Institute of Chemists Gold Medal (1955) and the Chemical Pioneer Award (1967); the Alpha Chi Sigma John R. Kuebler Award (1970); the University of Illinois Alumni Association Alumni Achievement Award (1976); the University of Arizona Foundation Creative Science Award (1978); and an American-Swiss Foundation Lectureship, Switzerland (1951).

During his long career Marvel gave unselfishly of his time on a variety of committees and editorial boards (*Organic Syntheses, Journal of Organic Chemistry, Journal of the American Chemical Society, Proceedings of the National Academy of Sciences,* and *Journal of Polymer Science*), as he did also for his two universities. The University of Arizona holds biennial Marvel Symposia, and the University of Illinois has annual Marvel Lectures. Both Arizona and Illinois award Marvel scholarships. In 1984 the University of Arizona renamed the chemistry laboratory building where he worked the Carl S. Marvel Laboratories of Chemistry. At the Memorial Tribute to Carl Shipp Marvel at the University of Arizona in 1988, Dr. Richard E. Heckert, chairman of the Board of Directors and chief executive officer, E. I. DuPont de Nemours and Company, announced that DuPont had commissioned the internationally acclaimed sculptor, Charles Parks, to create bronze busts of Speed Marvel. One now resides in Marvel

Hall of the American Chemical Society, one at the University of Arizona, and another at the University of Illinois.

In the spring of 1928 Speed was invited to become a consultant to the DuPont Experimental Station. His selection was due to the kindness of Roger Adams. DuPont originally wanted Adams as a consultant, to travel to Wilmington, Delaware, every month, but so much travel was not agreeable to Adams. He suggested that DuPont hire two Illinois chemists so that they could alternate visits, and he named Marvel as his consulting cohort. There followed a long and fruitful association, during which it is estimated that Speed gave some 19,000 individual consultations. He was adept at building confidence and in guiding the industrial scientists to make their own discoveries. One of his consulting abilities was to direct the attention of DuPont scientists to appropriate publications and reports by other DuPont scientists and to encourage and facilitate contact between people working in different parts of the company. Beyond the coordinating function, Speed also provided specific help with particular problems. For example, one practical and important contribution was the suggestion of amide solvents for polyacrylonitrile, which led to the process for the acrylic fiber orlon. He was also a valuable guide in the development of DuPont's heat-resistant polymers. One of Speed's most fruitful "assists" was his encouragement of Wallace Carothers, newly arrived at DuPont in 1928, in his plan to study polyesterification and polyamidation. Speed was able to offer Carothers one kilogram of adipic acid (price, $30), made in "summer preps" at the University of Illinois. This was the first sizeable quantity of a crucial intermediate that was to play an epic role in Carothers's discovery and DuPont's development of nylon.

There are so many facets to Speed Marvel's life, and so many attendant accomplishments, that it is difficult to record

all of them. His government service, during and after World War II, also included chairmanship of the National Research Council's Panel on Synthesis of Antimalarial Drugs and membership on the Board for the Coordination of Malarial Studies, 1944–46; membership on the National Advisory Health Council, 1945–47; and membership on the National Science Foundation Advisory Panel for Chemistry, 1952–54. His contributions to various research foundations were capped by sixteen years, 1971–87, on the Scientific Advisory Board of the Robert A. Welch Foundation, the mission of which is to foster and encourage the growth of the chemical sciences, primarily through operating grants to faculty for research at universities and colleges in Texas. During these years, Marvel helped in the selection of the most worthwhile basic research grants and in evaluation of their progress and continuing quality. He also played an important role, according to Dr. Norman Hackerman, chairman of the Advisory Board, in decisions as to departmental grants, scholarships, fellowships, establishment of Welch chairs, visiting lectureships, and summer science training programs, as well as presiding over two of the annual Welch conferences on chemical research.

Marvel also presided over fishing expeditions to Canada, in which he had well-photographed success, and ornithological expeditions during which he succeeded in spotting and identifying practically all of the 630 species of birds in the United States and a good sampling of the bird life wherever else he traveled. He kept a "life list," an "American list," and a "foreign list" of birds he had seen, and he was very proud of his one publication, among over 500 papers and fifty-five patents, on ornithology. Speed occasionally organized poker games with his colleagues at Illinois and DuPont, an enterprise in which he claimed, as befits a professional, only modest success; however, he did not enjoy

gambling for high stakes. He was a true connoisseur of wines and, during one period of his life, cigars. In short, he excelled at so many things that a person would have been ill advised to try to surpass him in areas nurtured by his experience and knowledge.

Over and above all of these pleasurable enterprises was the fun of doing chemistry, which Speed Marvel mentioned again and again. He had infectious enthusiasm for the making of new molecules. While he was willing to recognize other viewpoints, he held the opinion that anyone not engaged in synthesis was not making his living in the most positive manner. Another source of joy for Speed was in being able to do something for someone—usually immediately and by telephone! He had great influence and liked to use it to help people and projects. The warm friendliness of his approach made him most effective in this role. A one-man employment and reemployment agency, he sought out alumni at national ACS meetings, quickly recognized all former Illinois students, and helped them in every way possible. He was always in a hurry yet always had time for people; always busy, but never gave the impression that he was being imposed upon when asked for advice. His wife, Alberta Hughes, whom he married in 1933, created a relaxed home atmosphere for him. She was motherly, practical, and unsentimental, with a wry sense of humor and a generous balance of other interests. Speed was candid and critical but also considerate and indulgent with his children, John Thomas (Jack) and Mary Catherine (Mollie), and as they developed, so did his appreciation, pleasure, and pride in them. They provided special filial devotion and physical support for him during his final dependent years. Speed's extended family comprised the thousands of chemists with whom he came in contact, whether at Illinois, Arizona, DuPont, or in professional circles through-

out the country. The chemical community showed its appreciation for his research, teaching, and personal contributions with numerous recognitions in addition to those mentioned earlier and in honorary degrees from Illinois Wesleyan University; the University of Illinois; the University of Louvain, Belgium; and the Polytechnic Institute of New York.

In remembering Speed we may well recall a few of his favorite sayings, but some may become entwined with the aphorisms of Mark Twain, another man who crossed the Mississippi River. "Anyone is a fool to go into academic work. All good chemistry is done in industry. If chemistry isn't fun, it shouldn't be done. Insurance is useless due to inflation with the Democratic (or Republican) Party in power. It is wicked to gamble and lose. Membership in a scientific honor society is like a pair of pants—you don't get any credit for it but you would look funny without it." His advice to a department head (Herbert E. Carter) included the following messages: "Keep committees to a minimum. They seldom create new ideas and are too often swayed by the most aggressive talker. Never take a vote until you know you have a good majority on your side. Never ask the Provost for less than you need, but always supply documentation. Don't ask for funds to do something—start doing something, even at a sacrifice, and ask for funds to continue and expand a promising activity. Know your faculty and keep track especially of the young chemists." Speed could drink the hottest coffee and consume the largest amount of popcorn. He was fond of guiding his colleagues through the Greek alphabet and of interjecting Latin quotations. He teased us with statements of the wonderful chemistry they were doing at DuPont that he wished he could tell us about. In answer to our random complaints, he had lived through a bigger snowstorm, had had a worse

graduate student (who improved dramatically) and a worse secretary (who responded to training), and always felt old (while doing the work of at least three young people). In remembrance of Speed Marvel we smile for someone we really cared for and who cared for all of us.

Carl Shipp Marvel loved people and loved chemistry. He contributed to basic methods for the synthesis of organic compounds and taught us that polymers could be treated as extensions of simple organic molecules. He made major fundamental contributions to the polymer field with innovative methodology in synthesis, analysis, and characterization. His ideas and his research led to substantial practical results; for example, the production in the United States of synthetic rubber, amide solvents for polyacrylonitrile, and polymers with exceptional resistance to fire and retention of strength at high temperature for aerospace applications. He was highly successful in teaching and in research guidance and training. He was the mainstay of organic chemistry first at the University of Illinois and then at the University of Arizona. Marvel was a valued and venerable consultant for the DuPont Company, and he was a magnet for chemists and for the profession of chemistry during almost three-quarters of a century.

I AM INDEBTED TO the other speakers at the Memorial Tribute to Carl Shipp Marvel at the University of Arizona in 1988 for information provided on that occasion. I have drawn heavily on Marvel's autobiographical material either published by him or available from the files of the National Academy of Sciences. I have also provided my own reading of this scientist and events of his life during the period (forty-six years) it was my privilege to be his colleague and friend.

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