George C. Pimentel (1922–1989): A Retrospective Personal and Pictorial Tribute a Decade after His Death

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Abstract: Ever since receiving the 1993 ACS Pimentel Award in Chemical Education (Figure 1), I have been interested in the life and achievements of the Fresno-born, larger-than-life figure after whom the award was named. The year 1999 provides an especially appropriate occasion to recall Pimentel's personal and professional career, for it is the tenth anniversary not only of his death but also of National Chemistry Week, the expanded form of National Chemistry Day, the popular American Chemical Society outreach program that he originated.

Early Youth

George Claude Pimentel (Figure 2), the younger son of Emile J. Pimentel, a farmer and later construction worker, was born on May 2, 1922 on the Pimentel family ranch (Route K, Box 309A) in Rolinda, a small community of about fifty inhabitants that is now part of the city of Fresno, California [1–9]. Despite his Portuguese surname, all four of his grandparents were French emigrants from a village in Alsace-Lorraine. After his maternal grandfather, Georges Videau, unable to find work in the United States, returned to France and disappeared, his maternal grandmother, Elizabeth, married José Pimentel, a farmer and rancher, who adopted her two children, Emile (George's father) and Ondine (Figure 3).

George's mother, Lorraine (from Alsace-Lorraine; she had a twin sister named Alsace!) Alice Pimentel (née Laval), was a member of one of Fresno's most prominent early families, which is still active in local business and cultural affairs (George's second cousin, Claude C. Laval III is currently President of the Claude Laval Corporation, a manufacturer of filtration separators). Her brother, from whom young George received his name, was Claude "Pop" Laval, the famous photographer who took more than 100,000 photographs of California between Stockton and Bakersfield, starting in this century's first decade [2]. His work, exhibited at the 1915 Pan Pacific Exposition in San Francisco, attracted the nation's attention to Fresno, and he continued to record the character and growth of Fresno and the San Joaquin Valley until his death in 1966. Pop's grandson, the late Jerome D. Laval, assembled many of his pictures in the three-volume set, *As "Pop" Saw It* (Graphic Technology Co.: Fresno, 1975, 1976, 1985), and a 1996 pictorial historical calendar, *Valley Times Remembered*, was produced from photographs in Pop's collection by Bonnie Simonian of Simonian Farms, a rural Fresno produce market visited several times by President Bill Clinton and his entourage on their trips to Fresno.

When George was about a year old, the family moved to Los Angeles because of the post-World War I depression, but although he grew up in Los Angeles, the family always maintained a close tie with the Pimentel family farm, which they visited every summer. George and his older brother Joe (Figures 4–6) frequently visited the Laval family house at 656 Van Ness Avenue, where their mother, a court reporter in the Fresno County District Attorney's Office, had lived. Decades later, on one of his trips to Fresno, George saw that the Christmas tree that he had helped to plant in the front yard was higher than the house itself and was pushing up the house's foundations.

Although their father's schooling had ended in grade school and their mother had left high school to attend business school, both parents encouraged George and Joe to get a good education "so you won't have to work with your hands the way I do" [3], as George later recalled his father's words. But Emile also encouraged his young sons, who did everything together, to tinker with tools and improvise instruments, a talent that later became a hallmark of George's career in chemistry. He loved home construction projects, and he passed on his skills and enthusiasm in both carpentry and chemistry to his stepson, Vincent.

High School Years

Pimentel's short stature, exaggerated in high school because he skipped two grades, earned him the nickname "Peewee:" "I was very gung ho about sports, and it had to do, I guess, with having to prove myself, being so little" [4]. Growing up in a working-class neighborhood, the Pimentel brothers were selected to attend school programs for brighter children but gained acceptance among their peers through their athletic skills.

Their parents separated, and their mother took a night-shift job to support them. George never forgot his humble origins and credited his upbringing for his strong self-reliance.

Although in high school George enjoyed debating and found the humanities courses interesting, he developed a specific interest in science, primarily because he found the mathematics, physics, and chemistry courses the most challenging of the courses that he took. Because the country was still in the throes of the Great Depression, as a high school senior (Figure 7) he decided upon a career in chemistry after a job counselor visiting his school told him that there were no jobs at all in math and physics.

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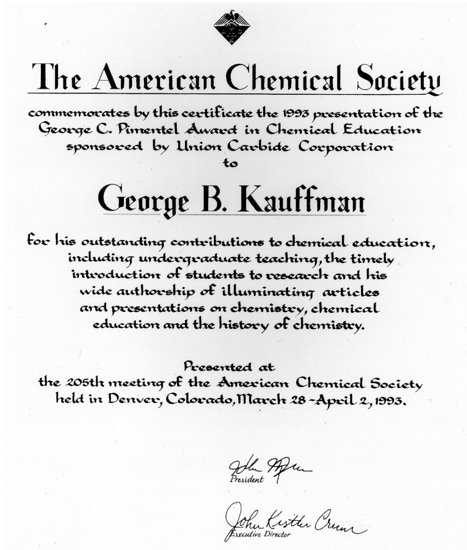


The American Chemical Society

commemorates by this certificate the 1993 presentation of the George C. Pimentel Award in Chemical Education sponsored by Union Carbide Corporation to

George B. Kauffman

for his outstanding contributions to chemical education, including undergraduate teaching, the timely introduction of students to research and his wide authorship of illuminating articles and presentations on chemistry, chemical education and the history of chemistry.

Presented at the 205th meeting of the American Chemical Society held in Denver, Colorado, March 28 - April 2, 1993.

President

Executive Director

Figure 1. Certificate for the 1993 ACS Pimentel Award in Chemical Education (courtesy, Dr. George B. Kauffman).

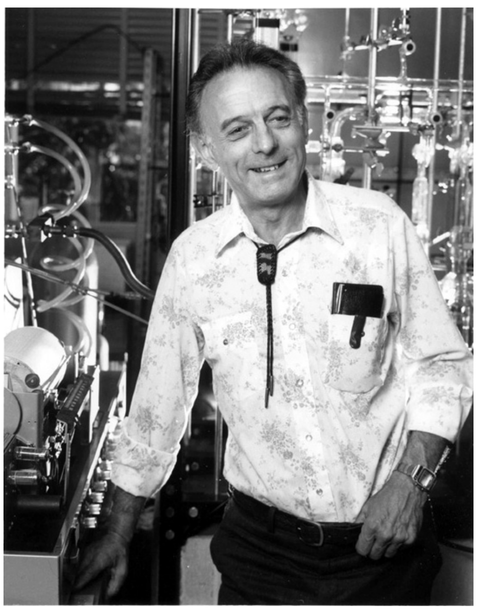


Figure 2. George Pimentel's favorite portrait of the 1980s, taken in his lab at UC Berkeley (courtesy Lawrence Berkeley National Laboratory)**.**

Figure 3. Stepgrandfather José Pimentel, George, brother Joe, and grandmother Elizabeth Pimentel (courtesy, Jeanne Pimentel).

Figure 4. Never bothered by sibling rivalry, George worshipped his tall, handsome, talented older brother Joe, whom he credited with inspiring him throughout his life, shown sitting on a wagon, about 1925 (courtesy, Jeanne Pimentel).

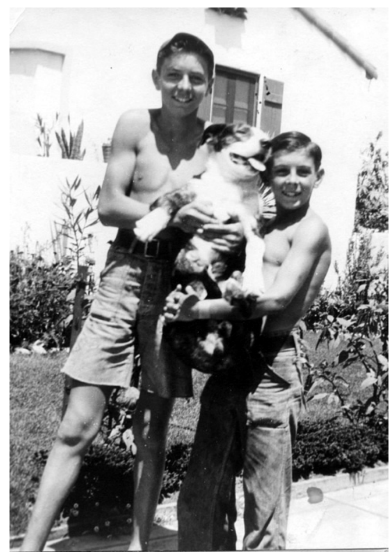


Figure 5. Joe and George Pimentel with dog, Tippy, about 1934 (courtesy, Jeanne Pimentel).

Figure 6. Brothers Joe, an aeronautical engineer and later rancher (left), and George Pimentel (right), about 1987 (courtesy, Jeanne Pimentel).

Undergraduate University Years

In 1939 Pimentel enrolled in the tuition-free University of California, Los Angeles (UCLA) as a chemical engineering major. He chose this program rather than chemistry "because it had to do with the construction business which my dad was in and sort of a fulfillment of his dreams" [3]. Although he lived only six miles from the California Institute of Technology compared to the 20 miles to UCLA, he could not afford the Caltech tuition so he lived at home where he had free room and board and commuted daily all the way to the other side of the city. He grew six inches in height and played intramural football, baseball, and basketball. During his first two years at the university he took whatever jobs were available—picking apricots, running a zoo stand selling hot dogs and hamburgers in Griffith Park, and working one summer for an uncle who was a construction engineer. With his earnings during the first summer he bought a car and charged his fellow student commuters to pay for gasoline.

In order to include some courses in the humanities Pimentel took many units above what he needed for graduation. Beginning with his junior year at UCLA he carried out undergraduate research on quantitative analysis with Professor W. R. Crowell and began work as a teaching assistant under Professor J. B. Ramsey in courses in physical chemistry and thermodynamics. According to Pimentel, Ramsey, called "Justify Briefly" Ramsey by students because of his use of the phrase on his test questions [3], had the greatest influence of any undergraduate teacher on his career:

> His emphasis always was placed on critical thinking. His whole approach was, "I don't want you merely to hear me and believe me or to parrot back things I have said. What I'm interested in is that you think about the ideas I talk about" [4].

In 1942, during his senior year, Pimentel married Betty Ann Jeffrey, who talked him out of his original plan of joining the Air Force immediately after his graduation (His brother Joe was in the U.S. Air Force, and George felt guilty about not doing anything active in the war effort). A discussion with his father also helped him to make up his mind; the elder Pimentel told him, "You know, you picture this aviation business as a romantic, exciting thing, and you don't think about the fact that if you go up and shoot down another plane, you killed a human being" [3]. The couple had three daughters—Anne Christine, now known as Chris and twins Janice Amy and Tess Loren (Figure 8). After they divorced Pimentel married Jeanne Duval Robinson (Figure 9), who had a son, Vincent, and daughter, Tansy, from a previous marriage. He was a devoted family man, and throughout his life he enjoyed as much time with them as his busy schedule would permit (Figures 10–13).

War Work

Pimentel received his A.B. *summa cum laude* in February, 1943 and was offered several jobs but chose the lowest-paying one. He was recruited by Saul Winstein and Glenn T. Seaborg to work at the University of California Berkeley on the Manhattan Project, which, he was told, involved important war work. While awaiting his security clearance, Pimentel worked at UCB for three months learning new laboratory techniques with no idea whatsoever as to what he was doing. Because his brother was risking his life in the service, George salved his conscience and earned extra money by moonlighting on the graveyard shift as a boilermaker's assistant in the Moore Drydock Company in the Oakland shipyard. After receiving his clearance, he learned from project head Professor Wendell M. Latimer that the radiochemical analyses that he had been carrying out were on neptunium and plutonium (elements 93 and 94) for use in making the first nuclear bomb. His first publication was a patent [10] for separating plutonium from the fission products of uranium.

Lieutenant j.g. Pimentel

However, in the course of the next nine months of soul searching, "it became more and more clear that we were trying to invent a new and better way of killing people" [3], so Pimentel decided that he did not want to work on a weapon of such widespread destruction. In 1944 he joined the U.S. Navy to fight for his country in a more conventional manner and spent ten months learning electronics and training to be a submarine officer for five months each at Princeton University and the Massachusetts

Institute of Technology, where he realized the enormous potential of modern physics. He managed to go to sea for three months aboard an old submarine acting as a target for anti-submarine warfare off Key West.

Pimentel graduated first in his class at the submarine school, but the war ended just after he arrived at Pearl Harbor. While awaiting demobilization, he asked the Navy Department for a job utilizing his Manhattan Project experience. Now a lieutenant junior grade (Figure 14), he was assigned to the Office of Research and Inventions (later the Office of Naval Research) in Washington, DC as a nuclear physicist and became a member of a team that traveled around the country investigating promising research projects. He also used the knowledge gained by attending the McMahon Committee Congressional hearings to encourage the Navy to take more control of postwar utilization of nuclear energy. He devised a plan to perform remote sensing during the Bikini nuclear bomb trials, which he had been invited to observe, but in 1946 he chose to return to Berkeley to pursue graduate work and fundamental research in chemistry.

Career at University of California Berkeley

Pimentel's early interest in mathematics and physics led him to study quantum mechanics. He chose as his research director Kenneth S. Pitzer, a pioneer in the application of quantum mechanics to chemical bonding and spectroscopy, especially infrared spectroscopy, around which Pimentel's later research revolved. Receiving his Ph.D. in 1949, he spent his entire academic career at Berkeley, rising through the ranks as Instructor (1949–51), Assistant Professor (1951–55), Associate Professor (1955–59), and Professor (1959–89) (Figure 15). He also served as Chairman of the Chemistry Department (1966–68). Professor Joel H. Hildebrand [11], who had a great interest in undergraduate teaching, influenced Pimentel to devote considerable time and effort to this area.

During Pimentel's four-decade career his research on hydrogen bonding, infrared spectroscopy, molecular structure, free radicals, and chemical lasers, carried out with 71 doctoral students, 39 postdoctoral fellows, and 19 other students, produced more than 220 scientific publications and 11 books

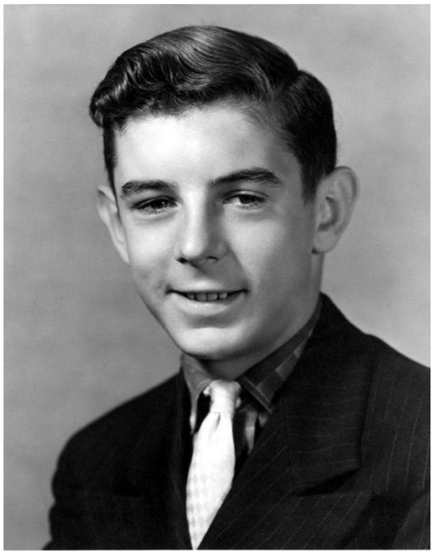


Figure 7. George Pimentel graduated at age 16 from Franklin High School in Los Angeles, where he was student body president—but very shy with girls, 1938 (courtesy, Jeanne Pimentel).

Figure 8. George Pimentel with first wife betty and daughters Janice (left), Chris, the eldest (center), and Tess, janice's twin (right), 1956 (courtesy, Jeanne Pimentel).

Figure 9. George and Jeanne Pimentel at the presentation of the ACS Peter Debye Award in Physical Chemistry, 1983. George hated black-tie events because he felt that they were elitist; he usually wore a bolo tie or no tie at all (courtesy, Jeanne Pimentel).

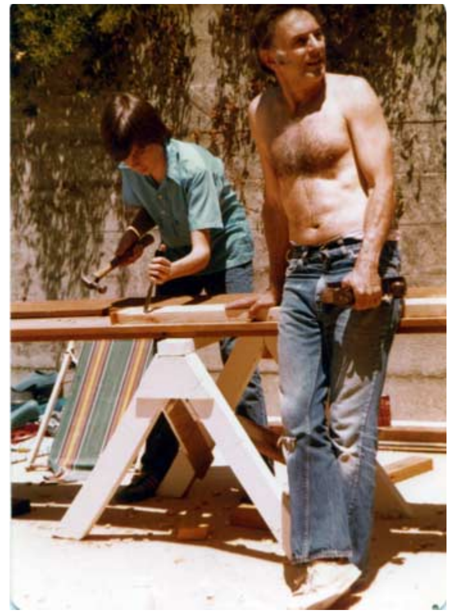


Figure 10. George Pimentel working on a construction project in his backyard with stepson Vincent (courtesy, Jeanne Pimentel).

Figure 11. George Pimentel with eldest granddaughter, Amy Jones, about 1977 (courtesy, Jeanne Pimentel).

Figure 12. George Pimentel with mother, Lorraine, and dog, Lew, about 1978 (courtesy, Jeanne Pimentel).

as well as videos [12] and films [13]. The earliest book [14] on which he was a coauthor—along with with his *Doktorvater* Kenneth S. Pitzer, was selected in 1979 by the Institute for Scientific Information (ISI) as a "Citation Classic" [14]—"one of the most frequently cited works in its field." The volume summarized in tabular form the results of a quarter-century of experimental and theoretical work, including the appraisal of the work of others, on the physical and thermodynamic properties of hydrocarbons and related compounds.

Considering the hydrogen bond as "one of the most important bonds in biological systems of any, including the carbon-carbon bond" [3], during the 1950s Pimentel employed infrared spectroscopy, "one of the important techniques that chemists were not using then...to learn about molecular structure" [3], to study the hydrogen bond. Together with Aubrey L. McClellan, he wrote a "landmark book [16] in the sense that we tried to include everything that was in the literature at the time and finally had to put a cut-off date on the literature because it was growing exponentially and we couldn't keep up with it" [3]. Like the book mentioned above, in 1982 it was also selected by ISI as a "Citation Classic" [17], having been cited in more than 3340 publications since 1961. Containing a comprehensive bibliography of 2241 references, it reviewed the implications of the hydrogen bond for physical, thermodynamic, spectroscopic, solution, dielectric, and kinetic behaviors, and it tabulated crystalline and biological structures strongly influenced by hydrogen bonding. At the time of its completion Pimentel and McClellan "predicted that the growth of the subject would never again permit a complete survey by a limited set of authors in a single volume" [17]. Their prediction proved accurate, for the next comprehensive review [18] required three volumes, and its 29 chapters were written by teams involving 36 authors.

Matrix Isolation Technique

Pimentel was interested in "molecules that were not on the chemical shelf, free radicals and other transient species, and that consequently fell into the area of the unknown—both concerning what molecular structures one would encounter and concerning the applicability of existing ideas of chemical bonding" [4]. Spectroscopic techniques available during the 1950s were useful for elucidating molecular structures and chemical bonding, but unfortunately they were not applicable to these extremely reactive molecules which play a central role in chemical reactions. Therefore Pimentel and his students developed and exploited the so-called "matrix isolation technique" to

> try to trap these transient species of very short lifetime—micro-second lifetime—in solid inert gas at cryogenic temperatures. If we could trap them, then they'd have an environment that was totally inert and we could do leisurely spectroscopic study. That was the early fifties, and there was no experience in the field—no cell design or anything—so we had to do everything from scratch, but I was used to working with cryogenic liquids like liquid helium and liquid hydrogen so that didn't bother me a bit. We proceeded to develop techniques and equipment.... That was a nice test of stubborness because it took us about six years before we had our first real success [3].

A solid matrix of a frozen, unreactive inert gas, such as argon, cooled to the temperature of liquid hydrogen (20 K or -253° C) prevented a free radical imbedded inside it, "like the dinosaur in the ice" [3], from reacting with other free radicals, which could not have been otherwise detected [19]. In Pimentel's words,

> It's at such a low temperature [that] chemistry stopped, and you have all the time you want to study it. You study its characteristic absorptions, and that's the valuable part of the infrared spectrum as far as a chemist is concerned—that every molecule has characteristic vibrational motions, and [these] are manifested in characteristic frequencies that act like a fingerprint, and you can identify the species that's there by its fingerprint and decide things about its molecular structure [3].

In 1960 Pimentel and his group used the new method to investigate the HCO radical and to measure spectra of hydrogen-bonded species, which are ubiquitous in the chemical substances found in living systems [20]. They later studied inert gas compounds and many other theoretically and practically significant species [21]. They also applied Pimentel's technique, which greatly expanded the fundamental knowledge of molecules, to studies of reactions relevant to solar energy storage [22]. It was widely used for various investigations extending far beyond what Pimentel originally intended, and it is now employed routinely in chemical laboratories.

Rapid-Scan IRS

Pimentel was also extremely interested in measuring spectra of free radicals in the gaseous phase, a goal that was impractical unless the spectra could be recorded within microseconds (millionths of a second). In the early 1960s, together with graduate student Kenneth C. Herr, Pimentel recognized the great potential of germanium semiconductors as infrared detectors, and he began to build a rapid-scan infrared spectrometer (IRS) around a semiconductor detector. With their new spectrometer they opened a new chapter in microsecond infrared absorption spectroscopy by recording spectra in 100 microseconds—about two to three orders of magnitude faster than had been previously attained [23]. In 1965 Pimentel reported the infrared spectrum of gaseous CF_2, the first such spectrum of a gas-phase free radical [24]. He soon reported the spectra of other free radicals such as CF_3 and CH_3 [25].

Chemical Lasers

Development of the rapid-scan IRS led to two other important scientific contributions of Pimentel's—chemical lasers and the investigation of the Martian environment. He explained the development of his best-known achievement—the chemical laser [5]—as follows:

> The chemical laser idea was a natural follow-on thought to lasers in general, and physicists were coming up with quite a variety of lasers in which the light is taken out in the form of laser light. That's a form of energy, and you never get any free lunch, so somehow you have to put energy in. All of the lasers that were being developed by the physicists...were either initiated by putting in light of ordinary type...so, light in, light out for energy in, energy out—or electrical, as for instance in a fluorescent tube.... The idea of drawing energy from a system by use of chemical reactions is a very familiar one. It's like

Figure 13. A four-generation family gathering, 1984. Mother, Lorraine (second from left) and George (extreme right) with dog Blondi (courtesy, Jeanne Pimentel).

Figure 14. Lieutenant j.g. George Pimentel graduated first in his class from submarine school, 1945 (courtesy, Jeanne Pimentel).

Figure 15. Young George Pimentel, about 1963 (courtesy, Jeanne Pimentel).

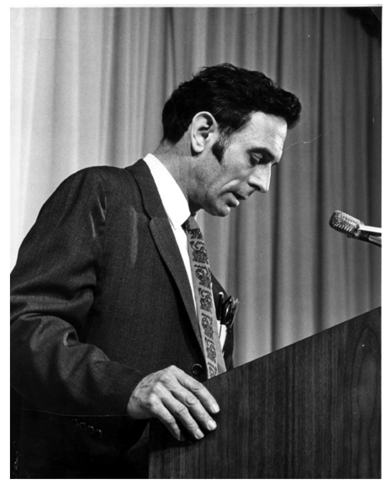


Figure 16. George Pimentel speaking at a press conference after the mariner 6/7 flyby of mars, 1969. He and Ken Herr were confident that they had detected methane and ammonia on mars, a claim that was not confirmed (courtesy, NASA/JPL/CALTECH).

Figure 17. George Pimentel in his flight suit for a test session in a jet plane, 1967. He applied for the scientist-astronaut program but was not selected because of a slight eye defect. He preferred to devote himself to teaching and research rather to be on the ground crew. (courtesy, Jeanne Pimentel).

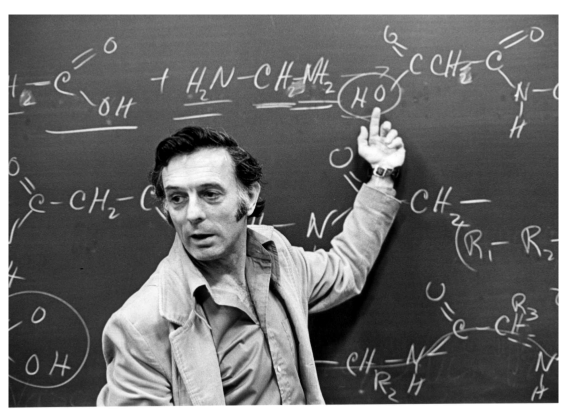


Figure 18. George Pimentel teaching at the University of California Berkeley, in what is now Pimentel Hall, during the 1970s. Photograph by Dennis Galloway (courtesy, UCB College of Chemistry).

comparing an electric car with an normal automobile. In an electric car you have electrical energy that is converted into mechanical energy. In an automobile you take a chemical reaction, and from the heat released and the chemical reaction you're able to convert it into mechanical energy. So, the question was whether one could find chemical reactions that allow you to tap the energy in the form of light and consequently develop a laser system from that with no electric cord associated with it.... This was a natural thought, and all of the big labs in the laser field were working on it.... All the big names were in this.... What we did was make a shot at it by a technique that was just off the beaten track and that people felt didn't have much chance. That was to look for chemical lasing—chemically pumped lasing—in the infrared region. Of course, we were geared up to do infrared spectroscopy. Also, we were geared up to do it on a short time scale so we did an experiment nobody else was doing, and after about maybe nine months to a year of very frustrating failures, we finally recognized that we were getting lasing action and that was the birth of the chemical laser. We went on from that and discovered about the first twenty or so chemical lasers—all in the infrared [3].

Pimentel's rapid-scan IRS allowed him to work on a very short time scale rather than looking for a continuous flowing system that was highly luminescent. In 1964 Pimentel and graduate student Jerome ("Jerry") V. V. Kasper reported an atomic iodine photodissociation laser, the so-called "iodine atom laser"—the first chemical laser [26], and in the next year they reported a laser based on the hydrogen-chlorine explosion—the second chemical laser [27]. Together with his German postdoctoral student Karl Kompa, Pimentel discovered the hydrogen-fluorine laser—the third chemical laser [28]. The iodine laser has been studied as a possible means for initiating nuclear fusion, and the hydrogen-fluorine laser was studied in connnection with the Reagan Administration's Strategic Defense Initative (SDI, popularly known as "Star Wars"). With doctoral student Mario J. Molina, who later went on to win the 1995 Nobel Prize in Chemistry for his work with F. Sherwood Rowland for their work on the effect of chlorofluorocarbons on the stratospheric ozone layer [29], Pimentel developed techniques that made possible the development of illumination lasers and recombination lasers [30].

NASA and the Mariner Spacecraft

Pimentel's rapid-scan IRS also provided the most definitive analytical tool for remote determination of the composition of the atmosphere and surface of Mars—the search for life on the red planet. While he had been in the U.S. Navy at the Office of Naval Research, Pimentel's immediate supervisor was a chemist with experience in very early infrared spectroscopy, Urner Liddel, who, like Pimentel himself, had been "relabeled" a nuclear physicist by the Navy. In the 1960s, while examining Pimentel's rapid-scan IRS in his laboratory in Berkeley, Liddel, who was then working for the National Aeronautics and Space Administration (NASA), suggested, "Look, if you can take an infrared spectrum in a millionth of a second, you ought to be able to tell us how to take an infrared spectrum of the atmosphere of Mars" [3].

During a plane trip from Washington, DC to Berkeley, Pimentel decided to spend the time trying to figure out how to accomplish this task:

I came up with a rather novel infrared spectrometer of a type that was not yet in use—not discovered—in which instead of using a dispersive element like a prism or a grating, we attempted to use an interference filter that was, as I used to call it, wedged, so that as you move this interference filter in front of the detector, it changed the range of the infrared light that struck the detector. This simplified the spectrometer very, very much, making it compatible with the idea that there would be only 25 pounds associated with the whole infrared spectrometer taking infrared spectra under conditions no one had ever taken in a laboratory with no such restrictions whatsoever [3].

Thus, working under a NASA grant, Pimentel and Herr developed a spectrometer based on an interference filter, which flew aboard the Mariner 6 and 7 spacecraft in 1969 [31] and revealed, among other things, the unlikelihood of life on Mars [32] (Figure 16). It was one of the few U.S. instruments in space that was built by the scientists who designed it.

Pimentel described the instrumentation that he and Herr designed and the results of the mission:

Of course, we were following the suggestion of Urner Liddel—making use of this extremely sensitive germanium detector which was not in common use, but we had to couple with that some rather—well, certainly novel and unprecedented techniques for space exploration—which [were] to carry along the capability of cooling this detector to essentially liquid helium temperatures, which had never been done before. We did this with the high-pressure gas system that turned out to work just fine, but which the Jet Propulsion Lab was dreadfully afraid would blow up on the way and wreck the whole spacecraft. In any event the experiment turned out to work beautifully. The spectrometer had about a 10-inch F1 lens to look at the planet—it was a flyby. It went 10 seconds through the infrared looking at the light emitted from the surface of the planet, which was tantamount to using as a heat source in a spectrometer a piece of ice, because that was the surface temperature.

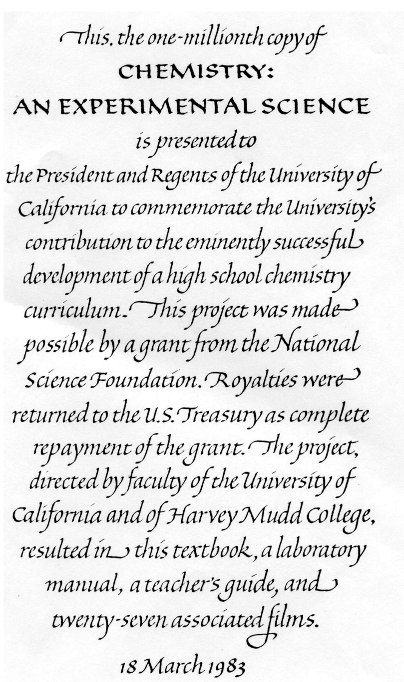
The experiment was able to give us a very good reading on what was in the atmosphere of Mars and what was not in the atmosphere of Mars. We saw the icecap was solid CO_2. We saw high clouds that might be likened to our cirrus clouds, which are ice clouds except they were dry ice [CO_2] clouds, and then we put upper limits on lots of things that might have been there like SO_2 from volcanoes and methane from life and so on. We were able to put upper limits on these, which then showed that it's a very inert planet [3].

Scientist-Astronaut

Pimentel was convinced that science should play a greater role in the space program. This conviction as well as his adventurous spirit and belief that "scientist-astronauts, not 'hot-shot Charlies,' would provide the most benefit to posterity" [9] led him to apply in 1967 for the Scientist-Astronaut program (Figure 17). Although he was overage, he excelled in the rigorous trials, and in 1968 the U.S. National Academy of Sciences ranked him first among the more than one thousand candidates who had applied, but he was not selected to fly because of a slight flaw in one retina. He declined to participate passively in the program but retained his interest in the space program, for from 1967 to 1970 he served as a member of the Lunar and Planetary Missions

Figure 19. George Pimentel's small office ("the dungeon") in the sub-basement of Hildebrand Hall always looked chaotic with papers piled high everywhere, but he could (almost) always find what he wanted (courtesy, Jeanne Pimentel).

Figure 20. George Pimentel loved parties. A typical graduate student party in his home in Kensington, California home, 1983 Jeanne (second row, left) and George (second row, third from left) (courtesy, Jeanne Pimentel).



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contribution to the eminently successful
development of a high school chemistry
curriculum. This project was made
possible by a grant from the National
Science Foundation. Royalties were
returned to the U.S. Treasury as complete
repayment of the grant. The project,
directed by faculty of the University of
California and of Harvey Mudd College,
resulted in this textbook, a laboratory
manual, a teacher's guide, and
twenty-seven associated films.
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Figure 21. One-millionth copy of "Chemistry: An Experimental Science," March 18, 1983 (courtesy, Jeanne Pimentel).

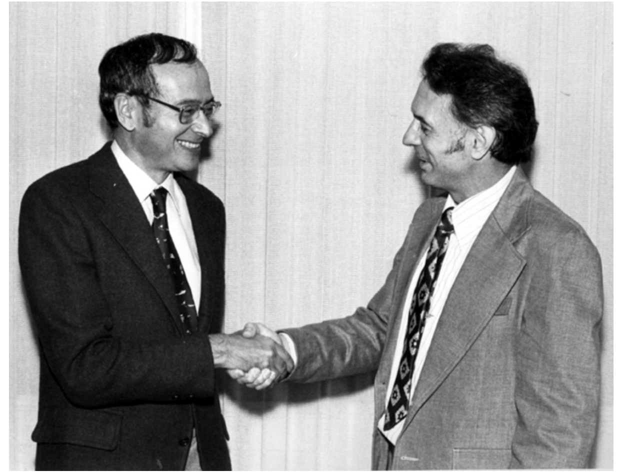


Figure 22. Frank Press, President Jimmy Carter's science advisor (left), and george pimentel (right) at Pimentel's swearing-in ceremony as NSF's deputy director, 1977 (courtesy, National Science Foundation).

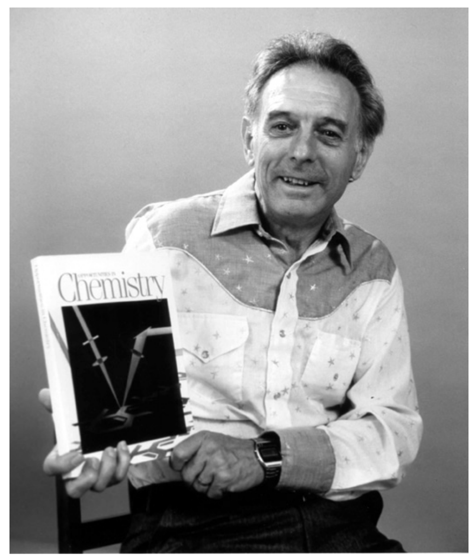


Figure 23. George Pimentel and the "Pimentel Report," which was commisioned by the National Academy of Sciences and later revised for high school students and the general public, 1986. Photograph by Andrée Abecassis (courtesy, Jeanne Pimentel).

Figure 24. Janice A. Coonrod and her father George Pimentel, coauthors cf the revised "Pimentel Report," 1987 (courtesy, Jeanne Pimentel).

board, "a group of so-called experts across all the disciplines that NASA put together to advise them on optimizing the science that came from the lunar landings" [3]. As his widow Jeanne later pointed out, "He did get to go to Mars, vicariously, when the infrared spectrometer designed in his lab was part of the payload of Mariner 6 and 7" [9].

Chemical Education and Research Mentoring

Pimentel summarized his *modus operandi* of mentoring his students as follows:

> Most of my papers that have been published have had two coauthors—myself and a graduate student or a postdoctoral student…. It's very highly personalized but definitely collaborative—I think the best possible kind of a beginning for a science career for a young person…. It optimizes the opportunity to nurture the creativity of the young person while benefiting from the experience and, hopefully, wisdom of the research director. I want to contrast that with the modern trend, which is to very large groups, where oftentimes there will be five to ten coauthors on a paper, and each individual has a tiny role in it, and nobody has complete responsibility for the experiment. That goes with very expensive equipment as one finds in big science. But, in our case, I was in a situation in which I could ask the student, "What do you think we should do next?" and, if it wasn't too far out, say, "Well, why don't you try it?" and let the student make mistakes and find his own way [3].

Pimentel's contributions to chemical education and science policy were as notable as those that he made to scientific research. He was an enthusiastic, talented, and award-winning teacher (Figures 18–20), and his best teaching efforts were not confined to his graduate research students but extended to the freshmen often scorned by "prima donna" researchers. Many of his thousands of former students have paid tribute to his teaching ability and human qualities. A typical example is this letter that I received from Leni V. Reeves, M.D., a Fresno physician:

> I was very touched by your article in the [Fresno] Bee about Dr. Pimentel [2], as well as saddened by reading of his death, [of] which I had not previously heard. [He] was the first professor I had when I entered UC, Berkeley in 1973 as a naive student from Delano [a small California Central Valley farming community], and he was the best teacher I encountered there. His inspired teaching and clearly written text lent a glamour to introductory level inorganic chemistry…. After the Final of the 3rd quarter, a number of us asked him to autograph our texts. In mine he wrote "You really ought to come in and see me this summer or next year." When I did, he invited me and my husband to a party at his house, where he danced the latest dances (remember the Bump?). Well, I have tucked the article with its photo into the front of *Understanding Chemistry* next to the signature George C. Pimentel. It would seem only right that someone so brilliant, vivid, kind, and creative should live forever.

Pimentel's general willingness to autograph his textbook and his profound influence on the high school teachers to whom he frequently lectured are corroborated by a letter dated September 21, 1992 from Peter Judson of the Science Department of the Ramona Convent Secondary School:

> Mrs. Pimentel, your husband autographed a book that I treasure…. *Opportunities in Chemistry*. In it he wrote "To Peter: Chemistry is fun…. Pass it on." Ever since, I have always tried to keep those words as bedrock to my teaching.

CHEM Study Program

The USSR's successful but completely unexpected launching of Sputnik, the first artificial space satellite, on October 4, 1957 caused frenzied attempts to improve science education in the United States so as not to fall further behind the Soviet Union in the race for space. Pimentel recalled the parlous state of secondary school science education at the time:

> I had been teaching freshman chem so I had a very great interest in the chemistry preparation of the students coming into the class. I felt very, very discouraged about the high school education they were getting. It was literally no better, no more improved, no more modern than the high school chemistry course I had had decades earlier [3].

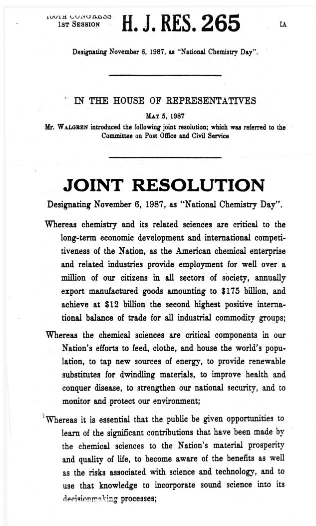
The CHEM (Chemical Education Material) Study Program was organized to develop curricular materials to update high school science education. J. Arthur Campbell, Professor of Chemistry at Harvey Mudd College in Claremont, California, the Director of the program, Nobel laureate and UC Berkeley Chancellor Glenn T. Seaborg, and Kenneth S. Pitzer, Dean of the UC Berkeley College of Chemistry, convinced Pimentel that he was the ideal person to edit the proposed CHEM Study textbook. Pimentel accepted under the following three conditions:

> I would be relieved from teaching for a year so that I would have the time free to work on the book without interfering or interrupting my graduate research career and activities. I still had a big graduate group, and I wanted to keep that going…. The second one was that I...would be relieved of...faculty committee work. The most important one was that I wanted to have a clear understanding that if I was the editor of this book with twenty coauthors that I would have the last word on the inevitable disputes [3].

Work on the book proceeded on a breakneck schedule:

> We selected the coauthors, who were ten of the leading lower division chemistry teachers at the top universities and ten of the best high school teachers we could get from the point of view of contributing as authors. We brought them together for six weeks down at Harvey Mudd College…and we all lived in residence there in a dormitory and worked very, very intensively for...fourteen hours a day.... At this time, of course, we were continually trying to rationalize different points of view. Everyone of these college people had, generally speaking, more age and as much experience as I had and felt, "I could do this job myself. What do we need Pimentel for?" So, there was a lot of diplomacy involved, but Art [Campbell] was a great help in this.... I ended up with draft chapters of the entire book…, had a commitment that we'd have a book in the hands of forty classroom teachers in the beginning of the fall [1960] semester. So I brought it back [to Berkeley] and worked alone with one of the high school teachers up here for the next six weeks trying to bring it into a unified coherent textbook.... We got a third of the textbook ready for the beginning of the semester, and the other two-thirds came along at the appropriate time. We didn't miss a deadline, and no classroom was ever without a textbook. It was a real *tour de force*. Then, for the next two years we ran teacher institutes in which we tried to show teachers

Figure 25. George Pimentel, official portrait on his election as American Chemical Society President, 1986. Photograph by Greg Tease (courtesy, American Chemical Society).



100TH CONGRESS
1ST SESSION
H. J. RES. 265
IA

Designating November 6, 1987, as "National Chemistry Day".

IN THE HOUSE OF REPRESENTATIVES

MAY 5, 1987

Mr. WALGREN introduced the following joint resolution; which was referred to the Committee on Post Office and Civil Service

JOINT RESOLUTION

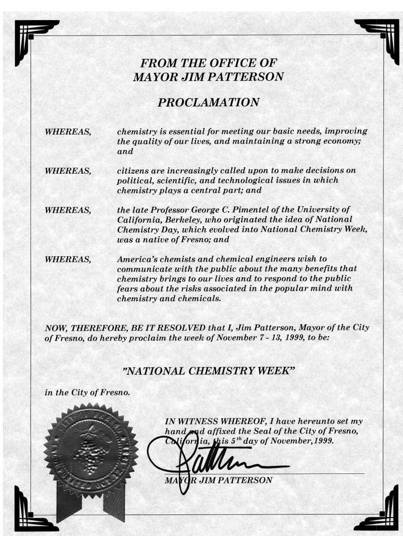
Designating November 6, 1987, as "National Chemistry Day".

Whereas chemistry and its related sciences are critical to the long-term economic development and international competitiveness of the Nation, as the American chemical enterprise and related industries provide employment for well over a million of our citizens in all sectors of society, annually export manufactured goods amounting to $175 billion, and achieve at $12 billion the second highest positive international balance of trade for all industrial commodity groups;

Whereas the chemical sciences are critical components in our Nation's efforts to feed, clothe, and house the world's population, to tap new sources of energy, to provide renewable substitutes for dwindling materials, to improve health and conquer disease, to strengthen our national security, and to monitor and protect our environment;

Whereas it is essential that the public be given opportunities to learn of the significant contributions that have been made by the chemical sciences to the Nation's material prosperity and quality of life, to become aware of the benefits as well as the risks associated with science and technology, and to use that knowledge to incorporate sound science into its decisionmaking processes;

Figure 26. Joint congressional resolution (H. J. Res. 265) designating November 6, 1987 As "National Chemistry Day" (courtesy, Jeanne Pimentel).



FROM THE OFFICE OF
MAYOR JIM PATTERSON

PROCLAMATION

WHEREAS, chemistry is essential for meeting our basic needs, improving the quality of our lives, and maintaining a strong economy; and

WHEREAS, citizens are increasingly called upon to make decisions on political, scientific, and technological issues in which chemistry plays a central part; and

WHEREAS, the late Professor George C. Pimentel of the University of California, Berkeley, who originated the idea of National Chemistry Day, which evolved into National Chemistry Week, was a native of Fresno; and

WHEREAS, America's chemists and chemical engineers wish to communicate with the public about the many benefits that chemistry brings to our lives and to respond to the public fears about the risks associated in the popular mind with chemistry and chemicals.

NOW, THEREFORE, BE IT RESOLVED that I, Jim Patterson, Mayor of the City of Fresno, do hereby proclaim the week of November 7 - 13, 1999, to be:

"NATIONAL CHEMISTRY WEEK"

in the City of Fresno.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the Seal of the City of Fresno, California, this 5th day of November, 1999.

MAYOR JIM PATTERSON

Figure 27. Mayor Jim Patterson's proclamation of November 7-13, 1999 as "Chemistry Week" in the city of Fresno (courtesy, Dr. George B. Kauffman).

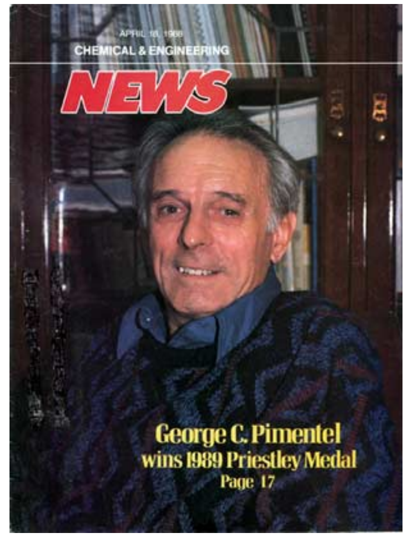


Figure 28. George C. Pimentel wins 1989 Priestley Medal. Cover of *Chemical & Engineering News* **April 18, 1988**, *66* (16)**.** Photograph by Ernest Ccarpenter (courtesy, American Chemical Society).

Figure 29. Portrait of George Pimentel (right) receiving the national medal of science from President Ronald W. Reagan, not his favorite president (left), in the white house, 1985. (courtesy, the Reagan Library).

Figure 30. Pimentel with his former NSF boss at Pimentel's National Medal of Science ceremony, 1985. From left to right, Richard C. Atkinson (chancellor of UC San Diego), wife, Jeanne, and George Pimentel (previous NSF deputy director) (courtesy, National Science Foundation).

> what we had in mind, they teaching at the same time using the materials, and used that as the basis for two successive revisions in the next two years [1961, 1962].
>
> I enlisted [Aubrey McClellan, my coauthor on the hydrogen bond book [16]] to be the editor of the teacher's guide so the two of us would meet once a week with these teachers and find out what had happened during the last week.... This was an exciting time for them and for many of them just a memorable experience. I have had people come back...as recently as this last year [1989] but continually over the decades...telling me that that was the most exciting thing that ever had happened to them in their teaching career [3].

Chemistry: An Experimental Science [33], the product of all this activity on the part of so many educators, revolutionized the teaching and study of chemistry in U.S. secondary schools. The 1963 hardcover edition sold more than one million copies (Figure 21) with all royalties going to the U.S. Treasury, and it was translated into 14 languages. The project included a series of 27 films, some of which are still used in classrooms in the 1990s.

NSF: The Washington Years

Pimentel was strongly committed to science and public service. He spent three years serving on the National Academy of Sciences panel on atmospheric chemistry leading to the 1976 report on halocarbons in the ozone layer as well as on the NAS Committee on Science and Public Policy. He related the inception of his service with the National Science Foundation:

> Some of my poly-sci colleagues [at Berkeley during the 1970s] decided to run a cross-disciplinary seminar on science policy—how it's made and how it should be made. They got engineers and me, as a chemist, and we'd have biweekly meetings...in which we'd talk about the various kinds of science policy decisions the country and the world was faced with and the mechanisms by which they were addressed.
>
> About that time I became so concerned that there were so few scientists involved in Washington, DC and making these policy decisions that I began to make it a flag that I was carrying that more scientists had to go to Washington, and as a result of these activities...my name was known in Washington, and I felt if I didn't take the job, I'd have to put up or shut up, and I couldn't see myself shutting up so I decided to take the job...as Deputy Director of the National Science Foundation [3].

Pimentel accepted the presidential appointment from President Jimmy Carter and served three years (from July, 1977 to June, 1980) under Director Richard C. Atkinson (Figure 22). Here in Washington he confronted numerous science policy issues, implemented a wide range of innovations in the management of science, and encouraged NSF staff to be risk-takers in their support of science. He had previously refused a position under President Richard M. Nixon, and he left the position when Ronald W. Reagan was elected not because of their political party (Pimentel was a liberal Democrat or Independent) but because he was opposed to their policies. He resisted pressures to distribute NSF funds uniformly by geography across the country instead of on the basis of merit. He defended the agency against challenges to the peer review system, which "was always accused of being an 'Old Boys' Club' but nevertheless...was the best way we had to find out what were the projects that deserved the support" [3]. He helped defend the NSF budget during the last two years of the Carter administration, when the budget crisis became severe. And he also received an unexpected education in the ways of politics:

> When I went to Washington I had no idea that it would be a political job in any sense of the word. I figured that it was just a matter of going there as a good scientist helping to make the maximum use of resources to further fundamental research. Well, it turned out that that was one important role, but equally important was this business of convincing Congress and, of course, the President's Science Advisor [Frank Press], that we were doing a good job, and so I testified a lot in front of Congress and spent a lot of time in the staff advisor's office doing things that might have intimidated me to the point that I wouldn't have taken the job if I'd realized that I'd spend so much time in political activity [3].

Return to Berkeley

On returning to Berkeley from Washington Pimentel became Director of the Laboratory of Chemical Biodynamics (a division of the Lawrence Berkeley Laboratory), founded by Nobel laureate Melvin Calvin [34] as one of the earliest interdisciplinary laboratories in the country. While maintaining Calvin's emphasis on cross-disciplinary research, Pimentel, during his tenure in this post (July 1, 1980-June 30, 1988), introduced new themes and new directions. One of these "was to broaden the traditional meaning of photosynthesis from what Melvin [Calvin] had made it mean, which was natural photosynthesis, to...what I call photoconversion for the storage of solar energy, including natural photosynthesis but also including artificial systems that would do the job perhaps more efficiently" [3]. Another of his aims was to "move our biological side toward bioengineering." In his own research he made use of his previous expertise in flash photolysis as a result of his rapid-scan IRS and matrix isolation work to devote himself to the study of electronically excited molecules in order to learn how their chemistry is unique and different from that of normal molecules.

The Pimentel Report

Two years after returning to Berkeley Pimentel became involved with a project at the National Research Council

> to see if we couldn't find some way, some mechanism, by which the public and Congress could be awakened to the importance in a positive sense of chemistry in modern industrial societies. The question was raised as to whether we should have a report...that surveyed what chemistry is all about in the modern world in a way that would persuade people that it's much more important to them than is merely indicated by saying...'Look at all the chemicals in the environment that are being disputed—that are killing us all [3].

Pimentel, with his expertise from the CHEM Study Program and "all full of fire about this issue of chemistry not being well treated, as a result of my experience in Washington at NSF" [3], was a natural choice for Editor of the proposed book. An advisory committee of 25 other eminent scientists selected under the auspices of the National Research Council to be "broadly representative of the major subdisciplines of chemistry, of geographical areas, and of the full range of academic, industrial, and governmental research...then called upon more than 350 chemical researchers to suggest topics and prepare commisioned papers on research at chemistry's frontiers" [35]. From these essays Pimentel and his committee "tried to generate a book that you could lift...and that had language level and coherence so that it could be read by science policy people in Washington" [3].

After three years of work, the book, *Opportunities in Chemistry*, which argued strongly that chemistry is the central science providing fundamental concepts required to deal with many of society's needs, was completed in October, 1985 [35, 36]. Popularly known as the "Pimentel Report," it was widely acclaimed in the United States and abroad (Figure 23). According to Pimentel,

> It came at a time when the national deficit was a matter of prime concern, and budgets were being cut all over the place, and I feel confident that the appearance of the report helped avert cuts that would have come into chemistry otherwise [3].

Opportunities in Chemistry: Today and Tomorrow

Because the "Pimentel Report" was directed at a specialized audience—Congress and the science policy experts in Washington, Pimentel decided to revise this comprehensive survey of modern chemistry so that it would appeal to a much wider readership and asked his daughter, Janice A. Coonrod of UC Berkeley's Lawrence Hall of Science and a high school teacher, collaborate with him (Figure 24). Their primary goal was "to make the volume valuable to a different audience by reorganizing the content, adjusting the technical vocabulary, and adding explanatory material and supplementary reading suggestions" [35].

Opportunities in Chemistry: Today and Tomorrow [37], a shorter, less technical, and more profusely illustrated new version of the original report [38], required a year to compose and appeared in 1987. It was sometimes referred to humorously as "Pimentel Jr." This resource book included sections on risk assessment and careers in chemistry and was written for advanced placement high school students, college nonscience majors, and their teachers. It has been translated into seven languages. The National Research Council distributed 8000 copies directly to high school teachers, and the American Chemical Society made more than 4000 copies available on request to local ACS sections to distribute in connection with another Pimentel creation, National Chemistry Day.

National Chemistry Day

In 1986 Pimentel served as President of the American Chemical Society [39] (Figure 25):

> A programme of popularisation and image enhancement for chemistry—was a feature of Pimentel's ACS presidency.... He feels that it is not in the public's interest to have a panicky attitude towards chemistry and technological advance in general, and he believes passionately that chemistry can and should be made accessible to the layman so that decisions about, say hazardous substances, can be made in a more rational way in a democracy. He ran for the ACS presidency on this platform… [6].

Consequently, among Pimentel's various initiatives during his presidency was

> to originate the concept of National Chemistry Day...to be celebrated across the country by all of the local sections, of which there are 130 [now 187].... The idea was to try to reach out to as many people as possible to tell them about chemistry, what it's all about, how important it is in their lives in a positive sense, and to provide an opportunity for the chemical industry to reach out toward the public and let them know that the chemical industry cares an awful lot about safety, toxic materials, and the welfare of the public in a bigger sense than just selling more products [3].

By the following year, together with 1987 ACS President Mary L. Good, Pimentel spearheaded the drive for this idea through the ACS, and on May 5, 1987 Congressman Doug Walgren (D-Pennsylvania) of the Committee on Science, Space, and Technology introduced House Joint Resolution 265 to designate Friday, November 6, 1987 as National Chemistry Day (NCD) (Figure 26). The resolution was passed, and the rest, as they say, is history [40]. The NCD Office in Washington, DC, headed by Randall (Randy) Wedin, coordinated the activities throughout the country by sending planning kits to 171 of the 182 local sections as well as to 500 ACS Student Affiliate chapters. The event was a resounding success, and in 1989 Pimentel's brainchild was was expanded to a full week.

Since then, National Chemistry Week (NCW) is celebrated the first complete week in November throughout the United States and Puerto Rico, and other countries have instituted similar outreach programs to enhance the public's awareness of the contributions that chemistry makes to society and our everyday lives as well as to combat the increasing epidemic of chemophobia that characterizes our time. NCW events reaching millions have included chemical demonstrations, hands-on activities, games, contests, lectures, open houses, classroom visits, workshops, exhibits, radio and TV broadcasts, billboard displays, and all manner of positive messages about chemistry. Throughout the nation resolutions have been passed by local officials proclaiming Chemistry Week in their communities (Figure 27), and numerous articles appear annually on the local, state, and national level [2]. In 1998 the International Chemistry Celebration (IChC) carried out NCW goals globally for the entire year, beginning in November.

Because of its integral role in almost every aspect of our daily lives, chemistry has been called "The Central Science," a title that Professor H. Harry Szmant and I chose for our book [41], which we designed to introduce general readers and high school students, their teachers, counselors, librarians, and parents to chemistry's contributions. The ACS purchased one thousand copies of our book for distribution, especially in connection with NCW, in order to further Pimentel's goal of improving the image of chemistry.

Honors and Awards

In 1989, six weeks before his premature death, Pimentel received the Priestley Medal, the American Chemical Society's highest award [42, 43] (Figure 28). His other ACS awards include the California Section Award (1957), the Award in Petroleum Chemistry (now the George A. Olah Award in Hydrocarbon or Petroleum Chemistry) (1959), the

Figure 31. At the time of the campus revolts of the 1960s George Pimentel was considered a conservative at Berkeley but a radical elsewhere. He happily wore love beads and bandanas given to him by his daughters. Photograph by Dennis Galloway (courtesy, Jeanne Pimentel).

Figure 32. George Pimentel participated in ceremonies at UCB as a sign of his belief in the university as an institution. Convocation in Greek Theater, 1988 (courtesy, Jeanne Pimentel).

Figure 33. George Pimentel playing his first game of softball after cancer surgery, 1989. The game was between rival research groups (courtesy, Jeanne Pimentel).

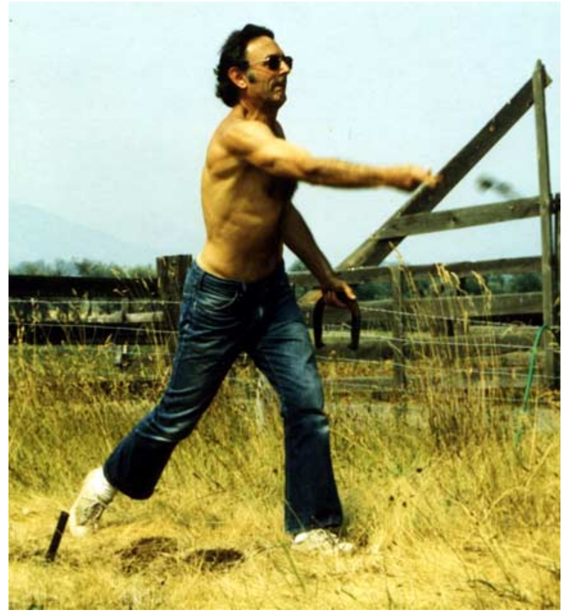


Figure 34. George Pimentel playing horseshoes on his brother joe's ranch, 1970s (courtesy, Jeanne Pimentel).

Figure 35. George Pimentel (left) receives the Wolf Prize in Chemistry in the Israeli Knesset, 1983. He used the prize money to buy a cement mixer to use in his favorite home hobby. (courtesy, Wolf Foundation).

Figure 36. The New Lobby Display in Pimentel Hall on the University of California Berkeley campus. Panels picture Harvey White, the physics professor who designed the lecture hall as well as all professors who have won the campus's Distinguished Teaching Award or the Donald Sterling Noyce Award for Excellence in Undergraduate Teaching, 1999. Photograph by Greg Butera (Courtesy UCB College of Chemistry).

Puget Sound Section Linus Pauling Award (1982), North Alabama Section Madison L. Marshall Award (1983), and the Peter Debye Award in Physical Chemistry (1983) (Figure 9).

Pimentel's other honors include a Guggenheim Fellowship (1955), Dickinson College Priestley Memorial Award (1972), Spectroscopy Society of Pittsburgh Award (1974), Alexander von Humboldt Senior Scientist Award (1974), E. K. Plyler Prize in Molecular Spectroscopy (1979), Ellis R. Lippincott Medal (1980); NSF Distinguished Service Gold Medal (1980); Wolf Prize in Chemistry (1983); William Proctor Prize (1985); National Medal of Science, the government's highest scientific honor (1985) (Figures 29 and 30); Robert A. Welch Award in Chemistry (1986) [12]; Challenges in Chemistry Award (1986); Maurice F. Hasler Award (1987); American Institute of Chemists' Members and Fellows Lecture Award (1987) [44]; American Institute of Chemists Gold Medal (1988); and the Alpha Chi Sigma Hall of Fame Award (1990).

In 1958 Pimentel received the Campus Teaching Award at the University of California Berkeley on the basis of student evaluations. His other teaching awards include the Manufacturing Chemists Association Award for Excellence in College Chemistry Teaching in 1971 and the Donald Noyce Prize for Excellence in Undergraduate Teaching in 1989. The ACS Award in Chemical Education, which he received posthumously in 1990 (his daughter Janice Coonrod accepted for him), now honors his name in appreciation of his multifaceted contributions to chemical education.

Pimentel was elected a member of the National Academy of Sciences (1966) and the American Philosophical Society (1985) as well as a Fellow of the American Academy of Arts and Sciences (1968) and an honorary member of Great Britain's Royal Society of Chemistry (1987) and Royal Institution (1989). He was selected to participate in the 1973–1974 U.S.-Japan Eminent Scientist Exchange Program. He held honorary doctorates from the University of Arizona (1986), the Colorado School of Mines (1987), and the University of Rochester (1988). Although he greatly valued the respect and admiration of his peers, "he cared less for the honors heaped upon him than for the opportunities it gave him to reach more people and teach them about science—and to enjoy new adventures" [9].

The Personal Pimentel

George Pimentel was a person of tremendous loyalty, vigor, intensity, commitment, generosity, and drive to succeed. His widow Jeanne described him as "poet and performer, as well as researcher and educator, athlete and family man, public servant and adventurous romantic... a passionate player in everything he attempted" [9]. He possessed a contagious enthusiasm for life itself, and one of his favorite exclamations was, "Ain't life grand?" [9]. An informal man (Figure 31) who eschewed pomp and ceremony, he was known in Washington for his "California" attire, complete with bolo tie and cowboy boots. As Master of Ceremonies at an NSF Christmas party, he performed a comic routine as a cowboy with calculators on hip and thigh instead of pistols. The sole exception to his informality was his appearance in cap and gown as he marched in the faculty procession at UC, Berkeley's graduations—to demonstrate his respect for tradition and his esteem for the university to which he dedicated his professional life [9] (Figure 32).

Pimentel actively opposed the Vietnam War before it became fashionable to do so, and he occasionally joined his graduate students in distributing anti-war leaflets. When I wrote a National Chemistry Week article about him for our local newspaper [2], Russell Minick, the Editor with whom I was dealing, told me how he vividly remembered Pimentel's participation in a massive anti-war rally in UC, Berkeley's Greek Theater following the invasion of Cambodia and the Kent State University shootings even though more than two decades had elapsed since he was a Berkeley student.

By Berkeley's radical standards Pimentel was considered a conservative. At the rally mentioned above he disagreed courageously with most of the speakers who were inciting the students to attack the university, which they considered to represent the establishment. He favored the more patient and law-abiding approach of impeaching the President of the United States! [9]. At the time of the Free Speech Movement he wrote to UCB's campus newspaper,

> If we are to maintain the University as a haven for the pursuit of truth and knowledge, we must subscribe to higher standards of conduct than those that society finds minimal to its daily existence.... Such a stance is essential to our primary purpose here at Berkeley, to ponder together on man's place in his environment [45].

Pimentel was extremely active in sports, especially squash and softball, which he played with students and colleagues all his life. His agility made up for his small stature (Figures 33 and 34). When he was awarded Israel's prestigious Wolf Prize in Chemistry (1983), in the formal photographs of the presentation ceremony the remains of a black eye that he received in a softball game the previous week are still visible (Figure 35). He hit a home run only a few months after a major cancer operation, and he faced an early death with relative serenity and gratitude for a full and exciting life. He died in his Kensington, California home at the age of 67 [46–51]. "He went to the ball park every day/ And he let them know he came to play" was his chosen epitaph [9].

The Pimentel Philosophy

George's many achievements, despite his underprivileged youth, provided him with the joyful satisfaction of succeeding against odds—a satisfaction that he wanted others to enjoy. Always in sports and often in life he rooted for the underdog [9].

In his commencement address at UC Berkeley he advised graduating students how best to succeed:

> My formula consists of three elements: Work hard—be smart—and be lucky. Now I realize that it isn't easy to plan to be lucky, so you have to take that element as it comes. My own experience is that it isn't so easy, either, to plan to be smart. But the third element you can do something about. You can find something you think is worth doing, and then you can give it your best effort. I guarantee that it will work for you as well as it has for me. I find that whatever rewards came to me from working hard, I treasured above all other things. And while I was working hard at things I liked to do, every now and then I would inadvertently do something smart, enhancing still more the

Figure 37. Jeanne Pimentel (left) with astronomer Carl Sagan at the dedication of the Pimentel Lecture Hall at the University of California Berkeley, October 22, 1994. Photograph by Rudy Baum (courtesy, American Chemical Society).

pleasure of the outcome. And finally, inevitably, every now and then, something lucky is bound to happen [9].

The Pimentel Legacy

George Pimentel was a dedicated research chemist, educator, and public servant whose seminal contributions to chemical education at all levels from middle school through graduate school and whose articulate advocacy of basic research, scientific literacy, and improvement of chemistry's image rivaled his scientific discoveries, the most prominent of which were his discovery of chemical lasers and their use to explore chemical dynamics and his development of the spectroscopy of transient molecules in inert matrices. He was the coauthor of eleven books, five of which are textbooks and three of which concern areas of his research. But his influence still continues beyond his premature death.

I have already discussed George's establishment of National Chemistry Day, which, as National Chemistry Week, annually carries his message of the vital and indispensable importance of chemistry to both scientists and the public alike. His works are still cited and used daily in scientific and educational circles.

In December, 1996 Laurel Kirkland, a scientist at NASA's Lunar and Planetary Institute (LPI), Houston, TX, began a campaign to contact persons who had worked with Pimentel and Kenneth Herr in order to retrieve and calibrate the original data from the Mars Mariner 6/7 1969 flyby. She and Jeanne Pimentel hosted a reunion of the Pimentel IRS group on December 7, 1997 at the UC Berkeley Space Sciences Laboratory, and the project has so far resulted in several scientific papers and presentations by Kirkland and various coauthors using the data from three decades ago [52]. Kirkland has written an extensive article on the history of this remarkable project, and is ensuring that the enriched data are safely archived for future use.

In this Mariner 6/7 "renaissance" Mars Mariner flew again! Kirkland described Pimentel's lasting educational influence in these words:

> What George did still affects "second generation" students.... students who never met or knew him. So, for example, it isn't just that George taught Ken [Herr], but that Ken has passed along things to me that George taught him. Surely, that's a sign of an unusually good teacher. Also, for the people involved in IRS, probably the most lasting part was what they learned. You've seen how successful most members of the group have been. Tom Foster told me that he still applies lessons about how to work that he learned then, and that's probably true for many of the people involved. That's a kind of education that can't come from a textbook, but ultimately proved at least as important as the technical end, if not more so [53].

In 1994 the UCB Physical Sciences Lecture Hall where Pimentel taught chemistry to so many students for so many years was renamed George C. Pimentel Hall in his honor (Figure 36). At the dedication ceremony on October 22, 1994 the late Cornell University astronomer and science popularizer Carl Sagan, who, like Pimentel, was interested in the exploration of space, presented the first George C. Pimentel Lecture, "Organic Chemistry in the Outer Solar System: Clues to the Origin of Life" (Figure 37).

Perhaps the most touching and insightful tribute to George Pimentel's legacy was given by his daughter and coauthor Janice A. Coonrod at the dedication:

> Each of us has a great deal of power to effect change. Like a pebble dropped into a pond—the ripples spread out until the entire surface of the water is affected. My father somehow understood this. He touched things with love, with energy, with creativity, and with joy [9].

Acknowledgment. I gratefully acknowledge the assistance of Jeanne Pimentel, George's widow, for valuable source materials and illustrations and Aubrey L. McClellan, George's colleague and coauthor, for providing information used in the preparation of this article. I am also indebted to CSUF's Randy Vaughn-Dotta, Academic Innovation Center, and Kelly Lee O'Boylan, Information Technology Services for technical assistance.

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