

Twists and Turns in a (Mostly) Non-Academic Scientific Life

Unlike most of the distinguished people who have had Festschriften in this Journal, I have not spent my career in academia. Also, I cannot write of boyhood fascinations with science and experiments performed in the basement. Growing up in a modest neighborhood in Brooklyn, NY, during the 1940s and 1950s, my thoughts were largely of baseball. (My friends will ask, “What is different now?!”) I actually learned a lot about life from emotional involvement with the Brooklyn Dodgers in the Jackie Robinson era. I knew I would never be good enough to play, and after realizing that, although I idealized Red Barber, I really did not want to sit in a radio booth every day. I was in the fortunate position of going to school in the heyday of the New York City school system.

I have always been interested in politics and law, and I was sure that I would go in that direction when I encountered Jacob Feldman at Erasmus Hall High School in Brooklyn. He was a wonderful chemistry teacher who made the subject incredibly exciting, in part by performing experiments that OSHA, let alone the Board of Education, would have condemned. I can still visualize him saying “Stand back class!” while he climbed a table to ignite a magnesium strip in a tube of thermite!

I went to Cornell on the urging of my Mother, who liked the elitist ring of the Ivy League, although I had always thought of going to Brooklyn College. Among other things, I had no idea how we would pay for Cornell. Luckily I got a job working in the Catskill Mountain Resort area that made more than enough each summer to pay the tuition. (No way any student can do that these days!) Several years later I met my wife, Helen, at this same resort!

In my Freshman year at Cornell, two guys from my neighborhood were drafted out of college. In those days local Draft Boards had to meet quotas. Given the year 1952 and my lack of desire to go to Korea, I signed up with ROTC, which was mandatory for the first two years at Cornell anyway. I was commissioned when I graduated, but allowed to go on to Graduate School first.

I performed modestly well at Cornell, but it was in my senior year that I got interested in spectroscopy. Bob Hexter, then a young Assistant Professor at Cornell, advised me to go to Minnesota to work with Bryce Crawford, and I did. I learned an enormous amount about science and life from Bryce and am very appreciative. My thesis topic, however, shows in retrospect, some exquisite timing. I studied Raman intensities using mercury arcs, and this was completed in 1960. In the spring of 1961 I went to a meeting of the Optical Society and heard Charles Townes give a lecture on the coming uses of lasers!

I had decided that I had had enough of gas-phase spectroscopy and arranged a post-doc with Don Hornig at Princeton. I did get to Hornig’s lab for a few months, but despite his letter, in early 1961, suggesting that the American space program depended on my remaining at Princeton, the U.S. Army decided my time had arrived. It was an exciting two years on the global front. My time in the Army was slightly preceded by the Bay of Pigs, and included the building of the Berlin Wall, the

October Missile Crisis, and the beginning of the Military Assistance Group in Vietnam. Luckily for me, just as I was preparing for a mundane two years as an Ammunition Supply Officer, I was introduced to the Ballistic Research Laboratory at Aberdeen Proving Grounds in Maryland, where I had just finished four months of training. In my initial visit to BRL, I met Fred Kaufman, who spent about 15 years there before moving to the University of Pittsburgh. Fred, who remains one of the most wonderful people I have ever met, had a profound effect on my life and career. It was Fred who, having arranged for my assignment to BRL, interested me in chemical kinetics and who, together with his wife Klari, acted as chaperones when Helen, now my wife of 42 years, would visit from New York City.

I learned a lot working in Fred’s Lab with Frank DelGreco. Frank had built an apparatus for following OH decay in a flow tube by moving a spectrometer along the tube on rails. The light source was a microwave discharge lamp using water vapor. We studied $H + NO_2$, failing to have the time resolution to see the vibrationally excited OH. We moved on to $H + O_3$, where I think we were among the first to use silica gel in a trap to store ozone for later release in a flow of carrier gas. This reaction, which produces up to nine quanta of OH excitation, was interesting, but the most interesting result was when the lamp failed as it did from time to time, and we observed emission from OH! Frank and I got very excited and came to the lab the next day, Washington’s Birthday, which was a Federal Holiday, and worked all day to characterize what had to be electronic excitation induced by collisions of vibrationally excited OH. The next day, Fred came in with the latest *Journal of Chemical Physics* and tossed it to us. In the journal was an article by Herb Broida outlining the entire phenomenon!

After leaving the Army I thought I would like to spend time in the San Francisco Bay Area, so I asked Hal Johnston for a postdoctoral position. He was somewhat short of funds but suggested that I come anyway. I was too naïve to realize that Hal would find the funding, and by that time I was married and we were expecting a child, so I decided that Los Angeles would be OK too and wrote to Sid Benson at USC. Sid accepted my application and informed me that he was moving to Stanford Research Institute in Menlo Park, CA in the Bay Area! I had barely heard of Stanford Research Institute, but it seemed like a good opportunity to spend a year or two in California.

I came to what is now known as SRI in 1963. I have had the following titles and jobs at SRI: Postdoctoral Fellow, Physical Chemist, Sr. Physical Chemist, Department Director, Laboratory Director, Vice-President, Sr. Vice-President, and I am still associated with SRI in a modest way as a Sr. Staff Scientist. So instead of a year or two, I have spent 42 years in the San Francisco Bay Area. I spent the first 13 years at SRI working directly with Sid Benson. Nobody who is bothering to read this and knows me is unaware of the profound effect of Sid Benson on my career. It was a marvelous time. We were blessed with outstanding postdoctoral associates from all over the world. Most of these have remained lifelong friends. (Robin Walsh, who was one of the earliest, spent the summer of 2005 with me at

Stanford.) We were productive, because, although it was always difficult to have sufficient funding given our constant “soft money” status, the quid pro quo was that we spent 100% of our time on our research! We studied halogenation kinetics with an eye toward extracting the heats of formation of radicals. We were responsible for a good deal of the bond dissociation energy literature for quite a while. (Interestingly, our values depended on the assumption that $R + X_2 \rightarrow RX + X$ ($X = Br$ or I) reactions have zero activation energy. This has been questioned to the extent that these reactions are now thought to have negative temperature dependences. I still have not seen the potential energy calculation that explains this!) We also developed the use of Knudsen Cell techniques for kinetics in this time period.

From 1974 through 1981, I had an arrangement with the Stanford Chemistry Department whereby they paid 25% of my salary and I taught one quarter each of Freshman Chemistry and Physical Chemistry. I found the teaching to be great fun, and I think it widened my research horizons.

In 1975 I had the opportunity to spend most of the year in Lausanne, Switzerland, in Jürgen Troe’s Laboratory at EPFL. This was a fantastic year for me. I learned an enormous amount from Jürgen and his colleagues, and Helen and I, and our daughters, Rachel, Erica and Nadine, made lifelong friends with the Troe family and with Klaus Luther, Horst Hippler, and Martin Quack and their families. Also, I was happy that I got to spend time in the Troe group while they were still in Lausanne.

When I got back to California, I thought maybe I should find a job independent of Sid. Just as I was getting geared up, USC lured him back and I was able to stay at SRI. For the next few years we had a ball. John Barker and Steve Stein had joined a year or so earlier, and we were joined by Michel Rossi and Alan Baldwin as postdocs, both later becoming staff members, and Greg Smith who was my first hire to the staff. Don McMillen rejoined the group, and Keith King spent a sabbatical in that time frame. It was a very productive time. Don pulled together our *Annual Review* on bond dissociation energies that became a “best seller”. In addition, there were wonderful interactions with John Brauman at Stanford and many colleagues in other groups at SRI.

In 1977 the NASA/JPL Panel for evaluation of data to be used in atmospheric models was formed. I have been a member ever since, and it has given me the opportunity to interact with many impressive colleagues. I am afraid that if I tried to name them all I would inadvertently leave someone out, so I refer the reader to the output of this Panel. However, I would be remiss not to mention the friend and colleague who organized this issue, Chuck Kolb. Chuck and I have understood each other professionally and personally for a number of years. In part arising from our positions of responsibility in contract research organizations and in part just good personal chemistry.

In 1984 we joined the Chemical Kinetics department with the Molecular Physics Laboratory to form the Chemical Physics Laboratory. Although we lost John Barker to the University of Michigan in 1985, we had the notable addition to the group of Maggie Tolbert, first as a postdoc and then as a staff member. Maggie, along with Michel and with contributions from Ripu Malhotra, soon carried out experiments using a Knudsen Cell reactor that led to a paper in *Science* showing that $ClONO_2$ reacted with HCl on ice surfaces, which shared the Newcomb Cleveland Award with a similar paper by Mario Molina and co-workers.

I managed to spend my SRI fellowship (an annual award in which one or two staff members are given three months salary as a sabbatical) in Paris teaching and doing research in late 1984 and early 1985.

In 1988 I was asked to become director of the Chemistry Lab at SRI. Unfortunately, this entailed decoupling of the Kinetics group from the Molecular Physics Laboratory, although collaborations remained in place. This period was very interesting as I learned a good deal about what my colleagues were doing so that I could try to represent them both internally and externally. I traveled a good deal more than I had in the past, not as much to scientific meetings as to attempt to promote research at SRI in Washington, D.C., and often in Japan. In 1991 I was promoted to Vice President for the Physical Sciences Division. This meant even more learning and traveling. Throughout this period I managed to hang into my science work with help from many of the aforementioned colleagues and because I was clever enough to enlist Roberta Saxon as a Deputy Division Director.

At this point we rejoined the kinetics group with the Molecular Physics Laboratory. We did have some changes too. Michel Rossi went back to his native Switzerland to accept a position at EPFL, and Maggie Tolbert went back to her native Boulder, CO, as a Professor of Chemistry at the University of Colorado. We were joined by Leah Williams who took over from Maggie. By the time Leah left in 1998, we were joined by Laura Iraci, now at NASA Ames, who had been one of Maggie’s early students, so a “granddaughter” of sorts.

In 1995, I became Sr. Vice President for Sciences. This added the Life Sciences Division to my general responsibilities, although there was a Vice President for Life Sciences. After a while he left, and I tried to keep the overhead low by not replacing him. This worked for a while, but I really was not getting along with the new President of SRI, so we had a parting of the administrative ways at the end of 1997. I enjoyed my 10 years in administrative roles and was happy to meet many colleagues and to get to know their research.

At this stage it was time to get back to full-time research, which was aided by a summer in Lausanne working with Michel and his students. Originally I had planned to stay at SRI, but discussions with Tom Bowman and Ron Hanson led to an arrangement in which I would split my time between SRI and the Stanford Mechanical Engineering Department. After two years, I stopped the SRI part, although I still have an office and a position there, and have had a very happy time at Stanford.

As I write this my stay at Stanford is in its eighth year. I have had the opportunity to teach a chemical kinetics class a number of times and work closely with Tom Bowman, Ron Hanson, and several wonderful students. I think I have brought some deeper understanding of chemical reactivity to this group, and they have certainly brought deeper understanding of many issues in engineering science to me. I am particularly grateful for the way that the Thermosciences Group has welcomed me and treated me. I have also enjoyed a collaboration with Charles Musgrave in the Chemical Engineering Department and his wonderful students and with Mark Jacobson in Civil and Environmental Engineering. I have been able to continue my work in atmospheric chemistry due to generous support from Mike Kurylo’s program at NASA. I am also grateful to the GCEP (Global Climate and Energy Program) program at Stanford for support of an attempt, driven largely by my friend and colleague Michael Frenklach of The University of California Berkeley, to incorporate the use of cyberinfrastructure in

developing models involving chemical systems. We call this PrIMe (Process Informatics Model). We just got NSF support for this effort as part of a collaborative project with Berkeley, MIT, and Stanford, so I guess I'll be around for awhile!

So the fun goes on. Plenty to do and enjoy, a wonderful family, and my grandsons, currently 9 and 6 years old, are even

into baseball! I will try to indoctrinate my granddaughter, currently 10 days old, as soon as I can!

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