The Journal of Physical Chemistry A

 VOLUME 102, NUMBER 47, NOVEMBER 19, 1998

Photograph by Yoram Lehmann

Raphael David Levine

Introduction and Biographic Sketch

This special issue of The Journal of Physical Chemistry A honors Raphael D. Levine, otherwise known as "Raphy", on the occasion of his reaching the traditional age of wisdom in Jewish tradition. Raphy was born in Alexandria, Egypt on March 29, 1938. His father Chaim was a civil engineer, who had been sent there to plan the new oil pipeline of the Iraqi Pipeline Corporation (IPC), ruler of the petroleum production and supplies in the Middle East at the time. Shortly after his birth, Raphy's family returned to Haifa, which was the headquarters city of IPC and the chief port of the British Mandate of Palestine. In this busy city full of British soldiers coming and going, Raphy began his education at the local real "Gymnasium". His first year went so well that he was allowed to skip the second grade, an accomplishment that was marked by his posting a sign on his door that read "Here lives R. D. Levine, the famous astronomer."

After the end of World War II, Raphy's father became the chief of public works for the northern region, then for all of the British Mandate. This took the family to Tel Aviv, where Raphy was enrolled in his parents' alma mater, the city's famous Gymnasium. At this point Levine's academic performance suffered serious deterioration. Indeed, the Gymnasium found his performance so wanting that they strongly suggested that he pursue his studies elsewhere. This kind invitation led to his attendance at an "ordinary elementary school" for the rest of his elementary education. There, along with all his other classmates, Raphy was given an examination at age 14 to determine his future academic path. The exam revealed an "aptitude for the light metal industry" and pointed Raphy toward a technical school. Fortunately, the school officials had

10.1021/jp982472u CCC: $15.00
Published on Web 11/19/1998

reckoned without the influence and determination of Raphy's mother Sonia. She managed instead to get him into Municipal School #1, an "elitist" high school "for gifted students", which boasts many other graduates besides Raphy who would be known to readers of The Journal of Physical Chemistry. With Sonia Levine's strong will behind him, Raphy managed two rather lackluster years at Municipal #1 until about age 16, when a new chemistry teacher arrived. This gentleman was a professional chemist, not a career teacher, and he awakened in Raphy the deep love of science for which he has become so well-known. As a result of his new fascination, Raphy built a laboratory at home and eventually graduated as a star pupil at Municipal #1.

The next step was Hebrew University for undergraduate studies in chemistry, with lots more mathematics and physics classes than required for the chemistry degree. At that time, the M.Sc. was the only undergraduate degree in chemistry given by the university. This required a master's thesis, which connected Raphy with Gabriel Stein, the father of the present day Israeli physical chemistry community. Stein put him to work in a laboratory (!), investigating the photochemistry of I^- ions in aqueous solution. Previous studies had shown that the yield of I_2 as a function of pH varied as $[H^+]^n$, with values of n ranging between 0.4 and 0.6. Raphy built an apparatus for his studies and obtained results that indicated an exponent within a narrow range about a value of 0.5. At that point, Stein directed him to go away and not come back until he had produced a theory for an exponent of exactly $^1/_2$. In due time this was accomplished, with a proposed mechanism involving photodetachment of an electron from I^-, which is first hydrated and is then scavenged by H^+ in a diffusion-controlled process. This was in 1959, when lots of people were looking for evidence of hydrated electrons, so the work made quite a splash.

Following the award of his M.Sc. in 1960, Raphy went into the Israeli Army for 2 years as a ranger in the First Armored Division. In 1962, having reached the rank of Staff Sergeant, Raphy was ready to resume his scientific career. He wanted to attend P.-O. Löwdin's summer school in Uppsala, but the Army was not enthusiastic. Finally, on the first day of the summer school, he was demobilized from the Army and even made the flight to Stockholm. In one month in Uppsala, he learned "everything he knows" about modern quantum mechanics and quantum chemistry.

Before going into the Army, Raphy had developed the ambition to "understand chemical reactions." After discussions with various theoreticians, he fastened on George Hall, then a Lecturer at Imperial College, as his guide in this quest. By the time Raphy was out of the Army, Hall had moved to the mathematics department at the University of Nottingham. Studying with Hall at Nottingham, Raphy completed a Ph.D. in mathematics in 2 years. His thesis topic was "The Theory of Chemical Reaction Rates".

On completion of his Ph.D. in 1964, Raphy went to Oxford as a Ramsay Memorial Fellow and a junior lecturer in St. Catherine's College and to work with Charles Coulson in the Mathematical Institute. In Raphy's second term at Oxford, Coulson suggested that he give a course on the work he was doing. Coulson sat in on this course and thought so highly of it that he suggested writing a book on the subject. The result was "Quantum Mechanics of Molecular Rate Processes", published by Oxford University Press in 1969, which came to be recognized as an early landmark in the field of reaction dynamics.

During his four years in England Raphy had the occasion to attend a number of scientific conferences. He soon discovered that theoretical chemists of the early 60's were not unanimous in their welcome to the new activities in dynamics. During his 1965 visit with Jeremy Musher at the (then) Rockefeller Institute he found more interest on this side of the Atlantic. Coulson offered to contact people he knew at the University of Wisconsin, and this resulted in Raphy's being offered an appointment as Visiting Assistant Professor of mathematics there. He taught mathematics courses for 2 years at Wisconsin (1966−1968) while developing friendships and collaborations with people in Joe Hirschfelder's Theoretical Chemistry Institute (TCI). It was in this period that Raphy's long collaboration with Richard Bernstein began. It bloomed only after the Wisconsin period, 1968−1974, during which time "surprisal analysis" was developed and their first book was written. Surprisal analysis has since become so integrated into the language of science that it is an IUPAC official term.

In 1968 Raphy returned to Israel and Hebrew University as Senior Lecturer in the department of Gabriel Stein. Shortly thereafter, Stein arranged the creation of a new professorship, the Professor of Theoretical Chemistry and Raphy was promoted to that post after only 1 year. During the 1973 "Yom Kippur War" Raphy corrected proofs of "Molecular Reaction Dynamics" on the banks of the Suez canal and thought it unlikely that he would soon return to doing science. Thus, it came as a surprise to him when he received the 1974 Israel Prize in Exact Sciences.

By mid-1974 Raphy was back into full-time science. As the body of his scientific work and the number of distinguished former students continued to grow, other honors and accomplishments flowed. With funding from the MINERVA foundation of the German Federal Republic, he established in 1981 the Fritz Haber Research Center for Molecular Dynamics, the first such center at Hebrew University. On the 60th anniversary of Hebrew University in 1985 he was appointed Max Born Professor of Natural Philosophy with support from the Volkswagen Foundation. In addition to the Israel Prize Raphy was awarded the Wolf Prize in Chemistry in 1988, jointly with Joshua Jortner. The Weizmann, Landau, Rothschild, and Max Planck prizes and the annual medal of the International Academy of Quantum Molecular Science soon followed. He was elected a member of the Israel Academy of Sciences and Humanities in 1991. He is a member of the International Academy of Quantum Molecular Science and a foreign member of the American Academy of Arts and Sciences. His other memberships and honors include Academia Europaea, the American Philosophical Society, and the Royal Danish Academy of Letters and Sciences. In the 1988−1989 academic year, he held an appointment as Miller Research Professor at the University of California at Berkeley. From 1989 to 1995 he was A. D. White Professor at Large at Cornell University. Since 1989 he has been Professor in Residence at the University of California at Los Angeles. In 1992 he was appointed an external scientific member of the Max Planck Society. He has honorary doctorates from the University of Liege and the Technical University of Munich.

Raphy's work has always been strongly driven by concepts. At an early stage in his association with Dick Bernstein, the two of them set out to write a book that would set the tone from a joint experimental−theoretical perspective for what was a brand new field of reaction dynamics. This effort first generated a number of TCI reports and ultimately led to their highly influential book "Molecular Reaction Dynamics" pub-

lished by Oxford University Press in 1974, with a revised version in 1989. This book soon became an essential classic in its field. Raphy's theoretical ideas often anticipate experiments that have not yet been done, though there are also many examples of trenchant analyses of existing data (e.g., as in the surprisal analysis). He can also, if the occasion presents itself, be a more formal "theorist's theorist", and some of the work that began as quite formal eventually reaches applications (e.g., algebraic methods).

Raphy's original scientific quest, to understand what really happens when a chemical reaction takes place, has continued to guide the main thrust of his efforts. In the broadest terms, his theme has been "the role of energy in chemical reactions" and related topics. His works range from fully quantum mechanical treatments to phenomenological generalizations. Topics that have been covered include resonances in reactive collisions, threshold laws, chemistry induced by cluster impact, dynamics of reactions in solution, stereochemistry, very high Rydberg states of large molecules, unimolecular reactions, the quantum theory of absolute rates, and nonequilibrium statistical mechanics. His work on the dynamical foundations of surprisal analysis generated methods for attacking "inversion problems" that have been widely applied in a number of fields as diverse as NASA's image resolution programs, advanced designs for human tomography, voice recognition, X-ray structure determination, radio astronomy, and even in economics. Work aimed at converting surprisal analysis into a predictive tool resulted in the elaboration of algebraic methods, which have also found widespread applications. In fact, there are many other fields where questions of energy and chemical change are relevant, such as aeronautical engineering (designing space vehicles that can survive re-entry into the earth's atmosphere), mechanical and chemical engineering (shock waves and detonations), or the design of high-power lasers. The work on algebraic methods influenced mathematicians to the extent that "Levine's problem" appears in titles and abstracts of papers on Lie groups. His large group of former graduate students have also carried his influence into many diverse areas.

Raphy's work includes over 500 scientific papers. He has authored or coauthored five books, and he has been an editor or coeditor of seven more books, all of which have played important roles in shaping the field of chemical reaction dynamics.

We look forward to many more years of interesting and stimulating science from Raphy Levine and to seeing the (suitably modified) banner waving over the field of chemical physics: "Here lives R. D. Levine, the famous astronomer."

Joshua Jortner

James L. Kinsey

William H. Miller