John M. Prausnitz: Bridging Abstractions and Realities

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This Founders Tribute issue honors John Prausnitz as an exceptional intellectual leader, scholar, and educator and summarizes his impact on chemical engineering. John's early vision of connecting fundamental molecular theory to practical thermodynamic applications with Molecular Thermodynamics was an essential element in our profession's paradigm shift from empiricism to engineering science. John's writings and lectures have transformed our core knowledge and guided its utilization into areas well outside traditional engineering bounds. Further, he has vigorously advocated for technology to be considered in the context of all of life and as a human enterprise. Finally, John's personal interactions across generations and disciplines have inspired the personal and professional development of a vast community of students, coworkers, and colleagues. In countless ways, John Prausnitz has influenced the contemporary foundation and functioning of chemical engineering and of realms beyond. *AIChE J*, 61: 2675–2688, 2015
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Introduction

The Preface to the first edition[1] of Chemical Engineering Thermodynamics by B. F. Dodge (1942) addressed the question of "Why another book on thermodynamics; are there not more than enough on this subject now?" Dodge's answer was "The many important applications in the field of chemical engineering amply justify it." The contents included an extensive chapter on the "General Equations of Equilibrium" and the book ended with chapters on "Vaporization and Condensation Equilibria" and "Distillation". The Second Edition[2] of Chemical Process Principles Part II; Thermodynamics by Hougen, et al. (1947) noted the three stages of process design: "process, unit-operation, and plant-design problems." Thermodynamics was needed in the first stage and their book focused on "generalized methods for dealing with deviations from ideal behavior. . . . [for] the calculation of equilibrium compositions in both physical and chemical processes."

Both texts articulated essentially all of classical thermodynamic connections among conceptual pure component and mixture properties, including system energies and entropies, as well as component fugacities and activity coefficients, to the conditions of temperature, pressure, and composition. There were many graphs of property behavior over wide ranges of compositions and conditions, including azeotropes and criticals.

However, these important texts, as well as others of the middle of the 20th century, had limited influence on the design of industrial processes because the "generalized methods" were principally graphs or empirical equations that could only be solved with calculators. At the same time, improvements in technology had made it possible to obtain more data faster. Thus, for new chemical processes, it became common to make property and phase equilibrium measurements and then empirically correlate them. Thus, extensive plots of *K*-factors and relative volatilities were made for distillation design, since these variables showed less sensitivity to conditions.

Simultaneously, significant advances in fundamental and applied statistical and quantum mechanics provided models of intermolecular forces and connected them quantitatively to properties, especially gaseous virial coefficients, ideal gas transport properties, and component activities in liquids and solids. Much of the progress came via early computers that could both calculate results using less extreme approximations of the complex rigorous relations and could carry out primitive molecular simulations.

It was not common for chemical engineers to study such developments in chemistry and physics, but, like the others in these, the *AIChE Journal* Founders Tributes,[3,4] John Prausnitz (Figure 1) was one who did. His drive to read widely and to recognize how fundamentals could "enlighten the empiricism" of applied thermodynamics has been the basis of an incredibly prolific career focused on treating an amazing variety of systems. The adoption of his innovative models of local composition and group contributions for activity coefficients and of gas-phase nonideality into industrial practice and process simulators is unparalleled.

Prausnitz adopted the phrase "Molecular Thermodynamics" as the mantra to characterize his approach. It has come to signify the combination of molecular theory with strategic measurement and appropriate computation to uncover and describe patterns of property behavior in chemical systems. The first sentence of the Preface to the first edition of John's 1969 text

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Figure 1. John Prausnitz after 50 years at Berkeley.

Credit: Roy Kaltschmidt, Lawrence Berkeley National Laboratory. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

"Molecular Thermodynamics of Fluid-Phase Equilibria,"[5] says "the expression 'molecular thermodynamics' requires explanation" as it "seeks to overcome some of the limitations of both classical and statistical thermodynamics." The Preface to the 1986 second edition[6] starts with "Molecular thermodynamics is an engineering science … to provide quantitative estimates of equilibrium properties for mixtures as required for chemical process design." The Preface to the 1999 third edition[7] does not even contain the expression. This evolution—from obscurity to conventional—of what might be considered an oxymoron, is evidence of the impact John Prausnitz has had on the discipline of chemical engineering thermodynamics.

To achieve this dominance, John engaged his research coworkers and colleagues with theory, computation, and experiment. As detailed below, his books and articles range from the fundamentals of intermolecular forces and molecular simulation to applications such as distillation and adsorption. He was actively engaged in industrial lecturing and consulting. While his initial focus was on traditional chemical processing, John later turned to property needs in other areas, especially for materials, interfaces, and biological systems. Finally his manifold publications and presentations have been accompanied by much personal encouragement of others to significantly expand their horizons and seize the opportunities awaiting them in ever-widening technologies.

John Prausnitz has also shown commitment to learning, developing, and applying technology in the context of contemporary life. He has exhorted us to connect the abstractions of philosophy and humanism to the realities of education and environment. In particular, he has warned us about the impediments that "intellectual isolation" causes. "Interacting with people in other areas, including nonscientists, gives you a perspective that you do not have otherwise. It allows you to look at your scientific problem quite differently. You look at it not just from a narrow viewpoint of what your predecessor had done, but what other people are doing in other areas. There is much, much evidence in the history of science to show that a given area, a given discipline, always grows at the periphery. It is what goes on at the boundaries of that area that is important, not what is inside."[8]

Thus, John Prausnitz has envisioned and articulated bridges in all the dimensions that chemical engineers function. The theme of this article is taken from the title of a 1986 article[9] "Abstraction and Reality. Two Sources of Chemical Thermodynamics." This Retrospective endeavors to document his accomplishments and impact during a time of immense changes in chemical engineering. The following articles in this Tribute issue demonstrate how many others have embraced his messages and mission.

Background, Education, and Career

John Prausnitz' personal information and influences on his life through his education and early career have been summarized previously.[10–14] This section draws on these articles and updates some statistics about his activities.

John was born in Berlin on January 7, 1928. He came to the United States in 1937 and attended elementary and high schools in Forest Hills, NY. He was gifted in mathematics and physics and had "a good chemistry teacher in high school." Listening to WQRX radio in New York City, Prausnitz developed a life-long love of opera and classical music, especially Mendelssohn, Mozart, and Schubert.

Prausnitz started Cornell University in 1945. His 5-year major in chemical engineering was determined after "his mother's friends told him chemical engineers were well paid."[11] The discipline was also recognized to be an "opportunity to use science and do something useful with it. . . . We do not try to advance science as such; we try to understand it. . . . [after] I have this understanding now how can I put that to use?"[13] "The rich intellectual atmosphere of Cornell 'showed me the relationship between culture and technology.'"[14] John's wife, Susie, has written (e-mail communication August, 2014) "While at Cornell, John took advanced courses in German literature. He also took courses in the History of Science which made an indelible impression on him. The fact that he grew up knowing the German language gave him the opportunity to read German literature and poetry (which he loves to do), to understand the writings of important German philosophers, scientists, thinkers and to know what is being sung in the great operas of Wagner, Richard Strauss, etc." Much later,[8] John acknowledged,

> It was at Cornell forty years ago that I first learned those habits of thought that constitute the essential characteristic of good engineering: Science does not exist in a vacuum, and while scientific advances must often be attained in isolation, the engineer's calling is to put the pieces together, to synthesize, to interpolate, to construct whatever is needed to reach a desired, useful goal. No Cornell professor ever said so explicitly, but the Cornell atmosphere which determined my most formative years taught me implicitly that engineering in practice is a human activity.

Following his BS at Cornell, John earned an MSChE at the University of Rochester studying thermodynamics under Gouq-Jen Su. At both universities, he developed a strong interest in physical chemistry and chemical thermodynamics. In 1951, John began Ph.D. studies at Princeton University, joining the research group of Professor R. H. Wilhelm. Interestingly, his dissertation title was "Liquid-phase turbulent mixing properties" which was a study of "rapid mixing and chemical reaction in fixed-bed reactors." He spent two summers at the Brookhaven National Laboratory. John was an instructor of chemical engineering thermodynamics and of a course in chemical engineering for non-chemical-

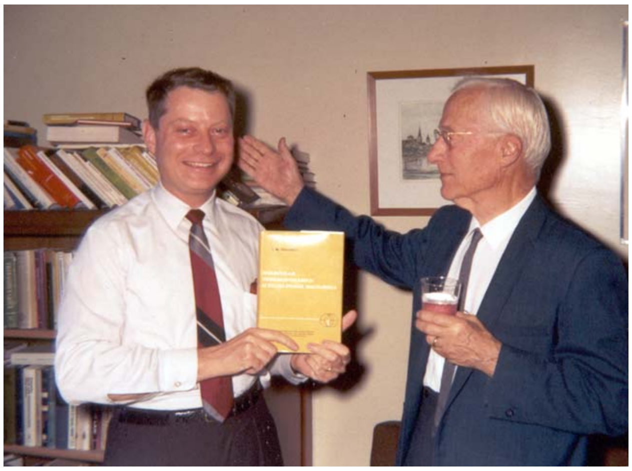

Figure 2. John Prausnitz and Joel Hildebrand celebrating publication of the first edition of "Molecular Thermodynamics of Fluid-Phase Equilibria."

Credit: College of Chemistry, UC Berkeley. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

engineering students, while also supervising several undergraduate theses. "He also was 'thrilled by magnificent choral music at the Princeton Chapel, inspired by sermons from numerous outstanding theologians including Reinhold Niebuhr and Paul Tillich', and engaged in philosophy seminars with Martin Buber."[10]

Though John received a teaching offer of $3500 from Princeton (the framed letter still hangs in his office), he moved in 1955 to the University of California, Berkeley, where chemical engineering was a division of the Chemistry Dept. Chemical Engineering had only six faculty and 15 graduate students. He was hired to specialize in chemical-reaction design and he did supervise three Ph.D. theses in that area, but ultimately chose thermodynamics. John has admitted that he "was attracted to Berkeley because of Joel Hildebrand. I had read his books as a graduate student at Princeton and I greatly admired his work. Also, Pitzer, Brewer, and the lovely Bay Area were magnets. . . . Hildebrand had worked with the thermodynamics of liquid mixtures. I took what I learned from his articles as well as those from Pitzer and Brewer and developed them for chemical engineering."[11] Figure 2 shows John Prausnitz and Joel Hildebrand celebrating publication of the first edition of "Molecular Thermodynamics of Fluid Phase Equilibria."

C.J. King, colleague and administrator at UC Berkeley, describes John's beginnings at Berkeley (e-mail communication August, 2014), "John brilliantly generated a sequence of projects that brought him, and the department, rapidly escalating attention. When I arrived in January of 1963, John already stood at the top." John's 30 publications between 1955 and 1961 were half transport and reaction and half thermodynamics. Interestingly, his first article was entitled "Isentropic Compression of Nonideal Gases"[15]; it appeared before his thesis publication.[16] The range of his interests was shown even in his early thermodynamics articles, covering intermolecular potential models, gas-phase nonideality, high pressure-phase equilibria, solvent selectivity, salt effects on vapor-liquid equilibria (VLE), and corresponding states. After 1961, the content was strictly physical properties and thermodynamics. The range and generality of his approach grew with publications addressing solids, transport properties, critical states, adsorption, and interfaces. Though most articles were theory or modeling, a significant number described new equipment and contained data.

Prausnitz earned tenure in 1960, spent the 1961–1962 year on sabbatical in Zurich during which he further evolved his vision, was given the AIChE Colburn Award in 1962 for "Excellence in Publications by a Young Member of the Institute," and advanced to full professor in 1963. For many years, he has been a Principal Investigator in the Chemical Sciences Division of the Lawrence Berkeley Laboratory. He was visiting professor at the University of Karlsruhe (1973), the Technical University of Berlin (1981), and the Institute for Advanced Study at Berlin (1985). He was also in residence at Oxford University and the University of Canterbury (New Zealand). John retired, "*de jur* but not *de facto*" and was named a Professor of the Graduate School of UC Berkeley in 2004.

According to Chemical Abstracts, John Prausnitz has been an author of over 780 cited works in 156 journals, along with 6 books, several in multiple editions.[5–7,17–23] A total of 97 articles have appeared in the *AIChE Journal*; the next highest is 75 in Fluid-Phase Equilibria. John's coauthors number 610; they include his own and other Ph.D. students, guest workers, and researchers at a distance from many different countries. Citations to his works have exceeded 16,000, including 47 articles with more than 85 citations. Of the five highest cited articles in the *AIChE Journal*, four have Prausnitz' name on them. Fluid-Phase Equilibria has the highest total of nearly 1900 citations, while the journal with the next most citations is the collection of Industrial and Engineering Chemistry journals with almost 900. John continues his commitment to the literature by being Editor of the Annual Review of Chemical and Biomolecular Engineering, now in its fifth volume.

John's significant awards are listed in Table 1. Most prominent are the National Medal of Science; Election to the National Academy of Sciences, National Academy of Engineering, and American Academy of Arts and Sciences; multiple Society-wide awards from the American Institute of Chemical Engineers, American Chemical Society, American Society for Engineering Education, and the International Union of Pure and Applied Chemistry; and four honorary doctorates. He was included in AIChE's list of 100 Modern-Era Chemical Engineers.[11] He has also delivered 31 named lectures at universities and given numerous plenary and keynote lectures at international meetings.

John Prausnitz has also contributed significant literature on education. He has addressed both undergraduate and graduate studies, though the focus of most of his personal interactions has been on Ph.D. students. At last count,[14] there were 81 Ph.D. students and 49 M.S. students. In addition, 35 postdoctorals have spent time in the laboratory along with countless visiting scholars. The size of John's "academic family"—the coterie of his students and their successive generations of Ph.D. graduates—seems to be uncertain, but it now must be several hundred since the number was over 300 in 1988. Figure 3 shows John Prausnitz with the Colburn Award (1962).

Molecular Thermodynamics

Beginnings

Although the first articles of "Molecular Thermodynamics" appeared in 1922,[24–26] and there was a text with that title in

Table 1. Awards Received by John Prausnitz, 1962–2013

Award	Organization	Year
Colburn Award	AIChE	1962
Walker Award	AIChE	1967
Elected Member	National Academy of Sciences	1973
Chemical Engineering Award	ASEE	1975
Murphree Award	ACS	1979
Elected Member	National Academy of Engineering	1979
Honorary Doctor of Engineering	University of L'Aquila, Italy	1983
Carl-von-Linde Memorial Gold Medal	German Society of Refrigeration and Air-Conditioning	1987
Elected Member	American Academy of Arts and Sciences	1988
Honorary Doctor of Engineering	Technical University of Berlin	1989
Solvay Prize	IUPAC	1990
Corcoran Best Paper Award	ASEE ChE Division	1990, 1999
Katz Award	Gas Processors Association	1992
Institute Lecturer	AIChE	1994
Petroleum Research Award	ACS	1995
Honorary Doctor of Science	Princeton University	1995
Arthur K. Doolittle Award	ACS	1997
Rossini Award	IUPAC	2002
Honorary Doctor of Engineering	University of Padua, Italy	2004
National Medal of Science	United States	2005
One of "100 Chemical Engineers of the Modern Era"	AIChE	2008
Lifetime Achievement Award in Pedagogical Scholarship	ASEE ChE Division	2012
Emeriti of the Year Award	UC Berkeley Emeriti Association	2013

1965,[27] these were by chemists. Chemical Abstracts reports that the phrase was also in the 1965 Ph.D. Dissertations of C.A. Eckert and A.L. Myers at U.C. Berkeley with John Prausnitz as their advisor.[28,29] Thus, John can be identified as the "Father of molecular thermodynamics in chemical engineering."

By that time, John was teaching the concepts and content of molecular thermodynamics in his graduate course. John's unique vision was not so much to connect rigorous molecular theory to macroscopic properties and phenomena as it was to develop more reliable and generalized quantitative models than were then available for process engineering. This was explained in some detail in an early article in the *Journal of Engineering Education*.[30] "...whereas classical thermodynamics lies behind, molecular thermodynamics lies ahead as a challenge whose conquest can extend the boundaries of the chemical engineer's domain". The applicability of thermodynamics would not be "... due to advances in classical thermodynamic principles or formalism, but...primarily to advances in molecular physics and to new procedures for relating macroscopic thermodynamic functions to molecular properties. ...By drawing on statistical mechanics and on molecular physics, molecular thermodynamics is concerned not only with the relation between various thermodynamic functions, but also in their quantitative prediction."

Figure 3. John Prausnitz with AIChE Colburn Award, 1962.

Further, describing the goal of a thermodynamics course, "the aim...must not be to provide merely the formal analysis; ...it should also provide...the concepts and techniques to carry such analysis to a quantitative stage under such conditions (which usually prevail) where not all the required experimental data are available. It is in the translation of the purely thermodynamic equation into a physically useful result that molecular concepts...play an increasingly important role."[30]

Much later, this theme was extended in an article that included many original illustrations, about the evolution and nature of chemical thermodynamics, including molecular thermodynamics.[8]

> Chemical thermodynamics is a large subject with an extensive literature. . . .[This is] a brief survey of chemical thermodynamics to a broad audience of scientists and others whose experience may be remote from chemistry. . . . how equilibrium thermodynamics and chemistry intersect and how equilibrium thermodynamics provides intellectual tools the help solve some practical problems. . . . There can be no doubt that thermodynamics is truly useful in science and in engineering. But thermodynamics is also more than that because it can provide for many practitioners of science and engineering a methodology for answering, in part, a deeply-felt need to understand the world around us.

For traditional chemical systems and processes

During the 1960s and 1970s, John Prausnitz' group extended the molecular thermodynamics concept to an enormous number of systems with a proliferation of publications. The content included very fundamental topics, such as the work by Sherwood on third virial coefficients[31] and nonadditivity of pair intermolecular potentials,[32] but most articles and books were aimed toward practical applications and industrial users.

Evidence that the combination of theory and application would be the goal for John's work arose from the summer position he held in 1956 at Chevron Research in Richmond, CA. J.D. "Bob" Seader (e-mail communication, August, 2014) describes John's role in developing the transformative Chao-Seader correlation for estimating vapor-liquid equilibria in the oil and gas industries.[33] Into the 1950s, "K-values for hydrocarbon and light gas mixtures for flash, absorption, stripping, and distillation calculations in the petroleum industry were estimated using nomographs and charts, taking into account the effect of small deviations because of composition through convergence pressure. . . . Prausnitz suggested . . . [to] extend regular solution theory to light gases . . .[so] they back-calculated solubility parameters from gas-solubility data." John was the lead author on an article published on this new method in 1960.[34]

Seader continues, "The use of digital computers in process design was now becoming a major goal of most companies. They were being used to make flash calculations and a few companies including Cal Research were digitizing the Lewis-Matheson and Thiele-Geddes methods for tray-by-tray distillation calculations." Chao developed an empirical equation for the required pure component reference fugacity to accompany the vapor and liquid nonideality models. Comparisons of the method with "a compilation of 2696 data points for paraffins, olefins, aromatics, napthenes, cycloparaffins, and light gases" yielded an average deviation of 8.7%. "On that basis, we presented the correlation at an AIChE meeting and submitted the article for publication in the *AIChE Journal*. It was immediately rejected by the editor, Harding Bliss, without review. I wrote Bliss a letter citing 13 reasons why he should reconsider and have it reviewed. The correlation was already in wide use in the petroleum industry. He did and it was accepted and published in 1961.[33]. . . Prausnitz deserves all the credit for the success of the method. He was the innovator; we simply implemented it."

Another early demonstration of the value of molecular thermodynamics concerned the consistency of *K*-factors from VLE data for propane with hydrogen and methane.[35] The liquid phase was essentially pure propane and the vapor nonideality could be fully described by the second virial equation of state, so the modeling was straightforward. However, that particular set of isothermal VLE data could only be correlated with erroneous and pressure-dependent second virial coefficients-which could not be correct. Thus the data were inconsistent, a very controversial conclusion. The relevance of the situation was that another attempt to model the system[36] was judged as flawed because of discrepancies with these data. The analysis was buried at the end of a theoretical article about the Kihara intermolecular potential model.[37]

Two more indications of John Prausnitz' acumen for seizing opportunities to apply molecular concepts with suitable approximations and make them accessible for traditional applications are (1) there local composition models for correlating activity coefficients in mixtures of complex substances, and (2) a group contribution method for predicting activity coefficients in the absence of data.

By the early 1960s, the capability of available correlations for activity coefficients in chemical systems beyond "normal fluids" was limited.[38,39] It often took several parameters to describe binaries, demanding considerable amounts of data. There was some uncertainty about treating higher-order systems despite their industrial importance. Ternary systems usually required an additional parameter for greater accuracy. John became aware of the Ph.D. work of Grant Wilson on the concept of "local composition" around molecules and a new mathematical form for the excess Gibbs energy to correlate activity coefficients.[40] It had only two binary parameters and needed no additional parameters for higher-order solutions. Bob Orye was directed to explore and develop this model for applications. This would be the linchpin of the monograph[17] "Computer Calculations for Multicomponent Vapor-Liquid Equilibria" that also engaged Charles Eckert and John O'Connell. Prausnitz organized the work shrewdly. All of the students were experienced in computer programming, so they were assigned different sections (Orye did activity coefficient models, O'Connell did vapor nonideality and supercritical substance models, and Eckert did the remaining thermodynamic property models and oversaw the computer programs). The text included all of the thermodynamic and modeling relations; tabulations of necessary properties and parameters for 41 pure components and 49 binaries with only subcritical components and 12 systems with a supercritical component; plus complete FORTRAN II listings. It had been pretested by properties workers at Fluor with whom John had been consulting. After publication, the work proved very popular and reliable. Soon after that, John and another graduate student, Ping Chueh, published a similar monograph focused on normal fluids, "Computer Calculations for High-Pressure Vapor-Liquid Equilibria."[18] Also, the local composition concept was extended to polymer solutions using a local segment composition.[41]

The Wilson model had on one fundamental flaw; it could not treat liquid-liquid systems because the equation could not give thermodynamic instability of a single phase. Also, though it contained a temperature dependence that could yield excess enthalpies, they were not quantitatively reliable. John guided Henri Renon to use a more complete molecular theory to establish the Nonrandom, Two-Liquid Theory [NRTL].[42] While it contained three parameters per binary, rules for estimating one of them were provided. It has been used much more than the Wilson model; Scopus now gives 2362 citations to the original article. Seader also notes (e-mail communication, August, 2014), "In industrial use, the NRTL equation is by far the most widely used equation for estimating liquid-liquid equilibria when binary-interaction parameters are available from experimental data."

However, not being satisfied with the NRTL model because it did not allow for the effects of different molecular sizes and shapes of substances, Prausnitz guided Denis Abrams to develop the Universal Quasi-Chemical [UNIQUAC] equation.[43] This model has been cited 1874 times. Experience has shown that local composition models are dramatically better than older methods, but the differences in quality of regression among the Wilson, NRTL, and UNIQUAC are usually small, with the best one depending upon the system of interest.

Another of John Prausnitz' most notable properties contributions is the UNIQUAC Functional-group Activity Coefficient [UNIFAC] group contribution method. Group contribution methods for pure component properties[44] and for infinite dilution activity coefficients[45] had been developed in the 1950s. The origins and extensions to mixtures are summarized very well by Deal and Derr.[46] An innovation by Grant Wilson was the "Solution Of Groups" concept for excess properties, where it was not molecules, but small collections of atoms making up the substances, that possessed solution properties. The excess properties of molecular solutions were then obtained from the excess properties of the solution of groups, first graphically,[47] then analytically as the Analytical Solution of Groups method (ASOG).[48] Prausnitz recognized that for this major advance to be fully accessible, it would have to be developed in an academic institution. This was accomplished when Aa. Fredenslund of Denmark spent time at Berkeley in the Prausnitz lab. The first publication was in 1975[49] with 18 solution groups; this article has been cited 1080 times. Fredenslund took home the idea and organized an enormous data analysis to obtain group parameters and computerized the calculations for chemical systems. The major publication was a monograph,[50] and there were direct applications to distillation design.[51,52] Prausnitz also directed a successful application of the method to polymer solutions.[53] The method has been expanded to activity coefficients, enthalpies, and solubilities for 99 chemical groups[54] and 17 groups for ionic liquids,[55] though there are still many parameters for binary group interactions that have not been determined. Overall, Scopus lists 2411 citations for UNIFAC. Its use has far superseded that of the original ASOG for predicting activity coefficients. Note that John Prausnitz was the instigator of a breakthrough methodology, but generously allowed others to complete the development.

During the period from 1962 to 1985, John's laboratory produced 308 journal articles and 8 books. The subjects ranged from the fundamentally rigorous to the fully applied. Some examples include statistical mechanical partition functions to obtain equations of state,[56–61] intermolecular force models[62,63] and molecular simulation,[64,65] acid-gas absorption,[66,67] complex mixtures,[68–71] and distillation.[51,52,72–74] In other directions, there were 17 articles on adsorption (one of which[75] has been cited 959 times) and seven on weak electrolytes, including one[76] cited 316 times.

The opportunities and expectations he saw were described in his keynote address to the 7th Triennial International Conference on Fluid Properties and Phase Equilibria for Chemical Process Design.[77]

> To realize the large potential utility of molecular thermodynamics, both classical and modern, researchers must not only exhibit more willingness to reduce their work to practice but also to exhibit multidimensionality, i.e., to relate molecular thermodynamics to other chemical engineering disciplines such as mass and heat transfer, nucleation and chemical kinetics. While the future success of molecular thermodynamics will be enhanced by progress in its own narrow domain, the promising possibilities of applied molecular thermodynamics depend crucially on its integration within the wider domain of chemical technology.

The total number of subjects treated by John Prausnitz is too great to articulate in a summary such as this, but it is clear that he touched all of the areas of thermodynamic properties and phase equilibria of traditional interest in his time.

For nontraditional systems and processes

Typically, John Prausnitz was not satisfied with dominating research into the immense range of traditional systems and processes, when he could see other opportunities for applying his acumen and approaches. Harvey Blanch of UC Berkeley, with whom John has published 106 articles, describes his view when they started together (e-mail communication August 2014).

> My impression from the mid-80s was that John thought there weren't any really challenging problems in the world of "traditional" thermodynamics left (analogous to low Reynolds number fluid mechanics, which was only revived by microfluidics and DNA separations). The phase equilibria and properties prediction area, where he had really made really major contributions was pretty well covered, and he thought the next big challenge was going to be in the biological area. We discussed possible areas that thermodynamics could play a role - not the usual "biological thermodynamics" (free energy changes for biological reactions, open systems, etc.)-but rather with a focus on bioprocessing. Could thermodynamics help with biological separations or in the drug delivery area? Could coarse grained molecular thermodynamics approaches yield insights into protein disease states (aggregation, etc.)? John has always seemed very focused on applied areas rather than the esoterica of thermodynamics and I think this has been his major contribution in the biological area. John applied molecular thermodynamics to a range of biological areas that had no real theoretical underpinnings at that stage. Some examples are aqueous two-phase systems for protein separations, protein aggregation, protein separations by salting out (and in), hydrogel swelling by salts, hydrogel swelling/collapse in response to pH, temperature for drug delivery. We started looking at proteins using very simple models - proteins as colloids, and then moved to coarse grained and more detailed models to describe their interactions. This work spawned a real interest in biological systems and many chemical engineers started to work on these areas. I think John gave the area a real credibility! When John and I started to work together, he took the undergraduate course in biochemical engineering and one in biology. And asked some pretty good questions in both courses.

John has described what called him to the bio area.[13]

> Bio is king now, you see the letters B-I-O all over the place, and so what I did there is certainly nothing unusual. There are two major factors, I think, that pushed it. First of all, I found it very challenging to ask if molecular thermodynamics could tell us something that would be of use in the biological area. So far, that has been very limited. But, I found that a great challenge. Then beyond that, there are practical things. If you want to get good graduate students to work with you, you have to have something that is exciting, that they at least think is exciting.
>
> So, my usual topics about oil refinery and polyethylene and stuff like that, that was not exciting, that was considered old stuff. But, if, instead of saying, "Would you like to do thermodynamics?" The answer would usually be no. If I can say, "Would you like to work in biothermodynamics?" Oh that was fine, you see? So, it was student pressure and then the usual one that dictates so much of what we do in research, is financial pressure. If you want to get funds from the various sponsor agencies in Washington, you have to have a topic that is popular and that is considered relevant to today. So, that was another force that pushed me in that direction.

Finally, we started adding bio-type people in our department. We now have, I think, four professors out of twenty who are bio orientated. They are professors of bioengineering you might say. So associating with them was also an influence.

John has applied the usual range of tools from experiment, theory, and modeling—complemented by molecular simulation. His most recent work has been with Clay Radke on properties of the cornea and materials that might be used for contact lenses, and with Alex Bell on biofuel production.

The Introduction to "Thermodynamics of structured fluids. Hard science for soft materials"[78] summarizes John's perspective on his current work.

> Since the pioneering work of Gibbs about 125 years ago, chemical thermodynamics has generated a vast literature, dozens of textbooks, and thousands of articles in many languages. The overwhelming majority of these publications is concerned with experimental or theoretical studies of relatively simple substances such as hydrocarbons, petrochemicals, salts, metals, and so on; historically, much less attention has been given to the thermodynamic properties of complex materials like gels, biomacromolecules, micelles, colloids, block copolymers, and similar substances that are often called soft materials.
>
> While such materials abound in nature and technology, application of chemical thermodynamics to soft materials has been delayed because of experimental difficulties and because, until recently, there were few theoretical models available for describing assemblies of complicated molecules. To utilize these evolving theoretical models, we require statistical mechanics. About 50 years ago, the status of statistical mechanics was well summarized by a Nobel laureate, physicist Eugene Wigner:
>
> > With thermodynamics, we can calculate many things—roughly.
> > With kinetic theory, we can calculate a few things—approximately.
> > With statistical mechanics, we can calculate (almost) nothing—exactly
>
> That was two generations ago. Now, thanks to much progress in theoretical physical chemistry and to the ever-rising power of computers, Wigner's pessimistic comment is no longer valid. Statistical mechanics is now not only applicable to a wide variety of relatively simple substances but, in addition, we can clearly discern a new era where statistical mechanics can be used to describe the properties of those complex soft materials found in nature or synthesized by clever experimental scientists for high technology. [My] examples . . . are chosen to indicate some areas of current research and to encourage young chemical thermodynamicists to give attention to new problems, toward contributing to the development of the emerging science of soft materials. In choosing these examples, not from my own work, but from the work of others that I admire, I resemble the rooster who showed an ostrich egg to the hen and said, "I am not complaining. I only want to show you what's possible."

Other encouragements to become engaged in engineering biothermodynamics are in overview articles of this work[79–86] and contributed chapters in "Biothermodynamics," edited by Von Stockar.[87] Others have taken up the same call.[88–90] Once again, John Prausnitz has stimulated study and action in an area in which he recognized opportunity and personally pioneered.

All the while, John Prausnitz did not really give up doing research on properties and phase equilibria of traditional and nonbiosystems. Of his over 400 articles from 1988 to 2015, precisely one-half were advances in areas he had treated before, such as equations of state and polymer solutions, as well as addressing new challenges like vapor-liquid and liquid-liquid critical regions, continuous mixtures, asphaltenes, polyelectrolytes, and ionic liquids. John continues to find treasures in Nature's richness and mysteries.

Technology in Context

John Prausnitz has always infused his work with a humanist element, though it has come much more to the forefront in recent years. This undoubtedly arises from his love of music and art, his drive to interact with others outside of his discipline, and his great sensitivity to his intellectual and physical environments. Further, those of us privileged to have spent time with John in person have experienced another dimension of his contributions: exceptionally positive impacts on an enormous number of lives. This section describes his amazing breath of thought and how he has personally touched many individuals. Because a summary of expressions of his and others is unlikely to fully capture the feelings, much less improve upon them, extended quotations are frequently used here.

Pedagogy

Throughout his career, John has urged his students and colleagues to adopt a broader view of their enterprise and embrace all branches of scholarship. An example of John's concern for insufficient breadth in engineering and insularity of disciplines was published in 1989.[6] Using the literary scholars' term of Hermeneutics, John said, "to achieve significant understanding, we cannot isolate an object or subject; we must study it in its extensions in space and time, because the significance of something lies not primarily in itself but in its relation to other things. It is this insight that should guide engineering education." Referring to the theme of his talk, "Prometheus brought fire to Earth so that it might benefit humankind. If engineering is briefly defined as applying science for the benefit of people, it follows that engineering must be concerned with the human consequences of science." Chemical engineering is not only relevant, but also "when taught with generosity, chemical engineering can serve as an integrating factor for understanding our living world as described in newspapers, television, and history books. . . . I am pleading for a multidimensional view of our subject, for presenting science with a human face."

This message has become more strongly articulated in recent years. John has explored how scientists and engineers could connect to humanists by explaining that they share much in common. Among other presentations, he described his view in a presentation at the UC Berkeley Center for the Study of Higher Education,[91] summarizing a seminar he had just given at the Berlin Academy of Sciences.

> When talking to colleagues in the Humanities and Social Sciences, one of my most difficult tasks is to persuade them that those who practice science and engineering are not confined to cold logic and bloodless experiments but that instead, science and engineering is a human enterprise, subject to all the paradoxes, inconsistencies and aesthetic judgments that characterize the human condition. When scientists and engineers are at

their best, they suffer the same frustrations, self-doubt, and delights common to artists or novelists or literary critics, or to anyone who creates to extend knowledge and awareness. Like all other members of a university, scientists and engineers strive to make a better world; in participating in this common activity, they necessarily operate within the borders set by our common human nature. I stress this common activity and this common purpose because ultimately, it is this commonality that provides the only sound basis for overcoming the alienation, this Sprachlosigkeit, that under another name, is known as the silence between the cultures.

The need for going beyond technical considerations was also fully articulated in two plenary lectures: the 2001 Danckwerts Lecture[92] and the keynote address to the 2007 11th Triennial International Conference on Properties and Phase Equilibria for Product and Process Design (PPEPPD).[93] Both had wonderful artistic images and photos. PPEPPD was held on Crete, so John suitably referred to Greek mythology to illustrate the need to work in multiple dimensions.

He also has said,[14] "Chemical engineering needs to be reinvented if it is to remain relevant. Because our task is to serve society, our attitudes and our activities need to adjust to what a changing society expects and demands, even if these expectations and demands go beyond our traditional views of chemical engineering. We must learn to communicate more effectively with those who know very little about science."

One of John's delights is to talk about his student, Bryan Rogers, who earned an M.A. in art with a specialty in fluid kinetic sculpture, while obtaining his chemical engineering Ph.D. Bryan held several academic appointments in Art, including Dean of the School of Art & Design at the University of Michigan. True to the Prausnitz model, Rogers' work explored "conceptual intersections of art, science and technology, often manifested in complex, interactive installations of kinetic objects."[94]

John received the 2012 ASEE Chemical Engineering Division's Lifetime Achievement Award in Pedagogical Scholarship. The nomination cited 70 articles related to chemical engineering education. In addition to molecular thermodynamics, the subjects included creativity,[95,96] versatility,[97,98] and humanities and engineering.[8] In the last, he says, "The humanities and engineering must have some common elements because, lest we forget, engineering is concerned with the use of science for meeting human needs. I would like to explore those common elements and to discuss their implications for engineering education and also for sharpening the increasingly fuzzy distinction between academic scientists and academic engineers."

When interviewed about his current efforts to extend undergraduate education beyond the scientific and technical into the human dimension,[13] he says, "In today's world, we need to know more than just science, we should understand its place in the world, know more about ethics and sociology, about how science and engineering interface with culture." It is not feasible for "our students take more courses in other areas, or have special courses, like 'culture for engineers'." Culture and engineering in separate courses does not integrate the materials, so students do not make the connection. "For effective broad education, we need to integrate 'culture' into the chemistry and chemical engineering courses directly. . . . teaching our students, maybe ten minutes, twice a week, saying something about how chemistry and engineering relate to the rest of the world would be helpful. I have started to work with the Berkeley Center for the Study of Higher Education." The Leonardo Project on "Humanities and Social Relevance for Chemistry and Chemical Engineering Students" is "to prepare reports or examples or case studies, where there was or is a significant interaction between engineering and culture, that engineering professors can use in their own regular lectures. . . . Regrettably, it is very difficult to obtain financial support for such activities."

John acknowledges the limited extent this happens in practice by others.[13]

Whenever I mention these things, people do not disagree with me. They say, 'yes it would be good if we did that. If we revise our curriculum accordingly,' and so on. They all say that. The problem is they never give it enough priority. Everybody is busy and it has gotten much worse in recent years, especially with these budget crises. So, everybody says, 'Oh yes, yes, yes, we should do that. What you say there, John Prausnitz, it is very sensible. It's fine, but excuse me, I have to go to a meeting now.' It is not that anybody opposes it. It is not resistance. It is just that there is always something else that has to be done.

When asked what he tells students, he responds with,[13]

. . . if they are well rounded, if they know something other than their own area, then they can make a good case to what they are doing. In other words, they can explain to the public, 'Look I am doing such and such and the reason is because it will do such and such for society. I think that is a big help. It sort of relates what you do to what other people do. And it helps you to get support and helps you convince, perhaps the directors of your company, to allow you to do what you want to do. . . . [Further], I think you would just be a happier person. You can talk to people from all walks of life and relate to them and they can relate to you. You can have a more interesting dinner conversation with your wife. You can use your God-given good brains in a much broader way and I think it is very satisfying to do that.

It is apparent that John feels very deeply about these issues. Further, he displays his own breadth and versatility by liberally infusing his articles and lectures with illustrations from art, poetry, history, and other literary sources. Hopefully, these appeals will receive the widespread respect and application that his technical work has enjoyed.

Personal

While one might expect that a person with such tremendous technical impact and elevated view of scholarly work might be above interactions that would be genuinely personal and supportive of individuals. In fact, it is this side of John Prausnitz that may be the most remarkable. As has been said,[10]

He is one of the rare individuals of great capability and depth who is also generous with his attention and time. In addition to the wonderful hospitality he provides to all who visit him in Berkeley for shorter or longer periods, he is constantly uplifting in his manner and interactions, makes time for the many 'molecular thermo groupies' who seek him out at many

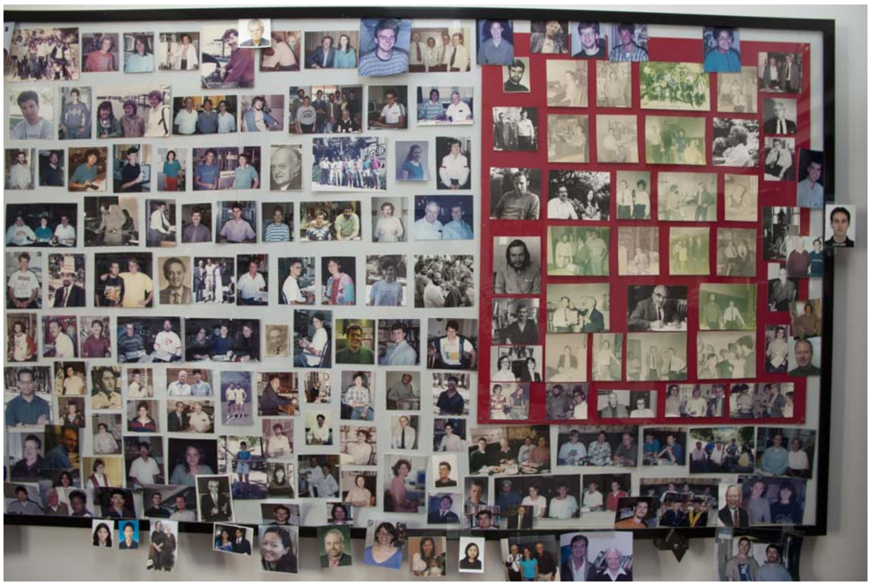

Figure 4. Board in John Prausnitz' office with pictures of students, colleagues, and events over many years.

Credit: Michael Barnes, College of Chemistry, UC Berkeley. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

> meetings and lectures, and faithfully responds to the vast number correspondences that arrive to ask questions about his work and solicit his wise counsel on personal and professional matters. . . . he empowered his colleagues and co-workers to grow and achieve. Thus, everyone benefited from exposure to John's standards of scholarship, learned from his insights and questions, understood his appreciation of all things human, and reflected upon the aspiration to 'reach higher than we can grasp.'

Figure 4 shows the board where John keeps pictures of former students, colleagues, and events.

John has been the subject of a number of tributes over the years.[10,12,99,100] Included here are only a few of the many extant comments about the professional and personal differences John has made in lives of those around him, with the selection focusing on those not published previously.

Depending upon one's stage of life, place in profession, and personal need, John has fulfilled one or more of the roles of teacher/mentor, consultant, and colleague.

Teacher/mentor

It has been said about John that, "As a research advisor, John has been the perfect combination of counselor, coach, teacher, and banker. He structured his lab's environment to possess an elevated ambience, outstanding graduate students, diverse and able visitors, plenty of equipment, an overload of ideas, and a constant urging to do more and better."[12] Also, "Our job as educators is to build on students' abilities and build up their confidence."[10]

To exemplify John's impact on his students, here are a few quotes:

> John's quote of Browning, 'Man's reach should exceed his grasp', is always a special comfort. Thus, he not only provides the inspiration for the reach, but he sensibly guides us to a grasp that is possible and appropriate.[10]

> It was very interesting for me, as your first graduate student (in 1955), to witness you launching yourself into thermodynamics research after your Ph.D. studies on turbulent mixing in packed beds. This provided a real inspiration for me with regard to learning new fields, and seeking to make contributions in areas new to me. . . . I particularly appreciated your excellent teaching, your strong interest in my research, even though it was in your 'old' field, and the freedom you allowed me to make my own mistakes and learn from them. (Elton Cairns, Lawrence Berkeley Laboratory, CA September 19, 1988)[99]

> How can I thank John Prausnitz for all that he has done? Let me count the ways. . . . for the sage advice and support he has given to generations of young investigators; . . . countless recommendations that have launched careers; . . . research contributions; . . . dedication to teaching and demonstrating that it is possible to be both an excellent teacher and a scholar; most of all, I thank him for showing me what I should aspire to be. (David Allen, University of California Los Angeles, September 29, 1988)[99]

> First, you taught me to conceptualize nature as simply as possible. . . . [to question] assumptions. . . . Second, . . . the importance of oral and written communication. (WR Parrish, Phillips Petroleum Co., Bartlesville, OK, September 1988)[99]

> I have received all the benefits that apprenticeship with a distinguished master can give. I have not only received his teaching, friendship, and permanent advice in academic and mundane matters, but I have also benefitted from his protective shadow in all these years. Many pages can be written on [his] achievements. . . . While . . . necessary and valuable, . . . they are totally insufficient to describe him. . . .[He] is much more than a collection of scientific papers, . . . books, much more than the advisor of many, many graduate students. . . . [I]magine . . . the combination of both the productivity and the human sides . . . [to get] a portrait of John Prausnitz and . . . why all his coworkers feel for him not only respect but also admiration. (Juan Vera, McGill University, Montreal, September 1988)[99]

Consultant

John Prausnitz is proud of his record of industrial consulting and enjoys the interactions that occur in company settings. Among the many corporations he has provided information and advice, his relationships with Air Products in Allentown, PA, and Fluor in California were especially lasting.

Some quotes from John's contacts illustrate his success in the practical environment both professionally and personally. From Air Products:

> The success with applying thermodynamic theory to our large-scale helium recovery processes led to a continuing consulting agreement with Professor Prausnitz, which has existed for more than 25 years and has enabled Air Products to be a leader in gas processing. . . . His contributions toward developing thermodynamic correlations based on theoretical approaches have been so useful, that several years ago Air Products dismantled its thermodynamics laboratories. The technical staff of the Company had developed sufficient confidence in its accurate thermophysical and thermodynamic predictions, based on many years of verification in industrial plants. During the many years that we worked together, I found John to be an outstanding consultant to industry and an admirable personal friend." (Jack Geist, GeistTec, Allentown, PA, April, 25, 1988)[99]

> Air Products has been involved in a wide range of technologies that have pushed molecular thermodynamic modeling to the limit. John has always been able to contribute to our efforts in these areas. He can very rapidly pick out the essential elements of a problem. For example, one could picture John leafing through pages of complex equations and quickly asking, "How will you obtain the value for that parameter and why doesn't it depend on density?" He helps to keep the feet of our recently hired graduates on the ground! . . . Our enduring relationship is built upon more than professional respect. John shows interest in us as persons and always inquires about his past associates at Air Products. In spite of his obviously busy schedule, he is a gracious host at Berkeley and promptly returns all telephone calls - but he never hesitates to give his honest evaluation of our technical proposals! His sense of humor is both dry and spontaneous.' (TW Copeman, HC Klotz, PM Mathias, EJ Miller, Air Products, Allentown, PA, September, 1988)[99]

> One has to be in awe of his boundless energy for understanding both theory and practice in so many different areas, and then bridging the gap between the two. (EJ Miller, Air Products, e-mail communication, August, 2014)

From Fluor:

> Many times you were able to steer us correctly and we always admired your willingness to accept the restrictions of industry where a more theoretical approach that you knew so well might be more elegant. Not only did we realize we had met a great engineer and scientist, but we also realized we were dealing with a real human being. Your humor made our proceedings more enjoyable. . . . you could always explain things in terms that even I could understand. (K. Walker, retired, Medford OR, September 23, 1988)[99]

> [T]his has been a 'mutual-assistance' relationship - you showed us and taught us and then told us again, while we brought your attention to process engineering problems that needed solving, both 'now' and later. Your work and your guidance, insight, instructions, and long-suffering with a 'motley crew' enabled us to perform highly varied process designs for a host of successful, even beneficial, chemical process plants world-wide whose costs probably well exceed $25 Billion. (F.T. Selleck, retired, Irvine, CA, September, 1988)[99]

Colleagues

There are so many individuals in our profession around the globe that have been positively impacted by John Prausnitz, it would be impossible to collect here all of their expressions of admiration and gratitude, much less the multitude of stories about how interactions with him, directly or indirectly, changed their lives for good. Many have been published,[10,12,100] so here is a selection from the unpublished 60th birthday tributes[99] and other personal communications.

> John selected a field of research (molecular thermodynamics) that was in its infancy but was ripe to take off. It was also well positioned to take advantage of the location of chemical engineering within the College of Chemistry at Berkeley. . . . John was very interested in the newer and younger faculty, individually. He was a frequent source of mentoring to me. With John being on the more fundamental, phase-equilibrium side of separations and me more of the process-oriented side, John set in motion the concept that he would encourage his PhD students to take qualifying-exam propositions and side projects with me. This worked very well educationally, and I managed to reciprocate by encouraging students similarly. . . . John also participated often and thoughtfully in the various discussions of what the department should try to be as it grew, i. e., the development of the academic plan. He has had much to do with the design of the department. He is also a deep thinker on pedagogical methods, the Leonardo project being an example of that. (CJ King, University of California, Berkeley, CA, August, 2014)

> I remember one series of conversations [during my sabbatical at UC Berkeley] concerning the thermodynamic basis for multicomponent diffusion and mass transfer. We read and discussed several papers, which enlightened me to many aspects of this deep subject that were previously unknown to me. In the intervening decades I have published on this topic, used it in graduate courses and doctoral qualifying exams, and taught some aspects of it to my colleagues. John is surely unaware of the depth of his impact on me from that year. (MF Doherty, University of California, Santa Barbara, CA, Letter to support nomination for ASEE Lifetime Achievement Award, December 2011)

> One of John's traits that I have greatly admired is the interest in and encouragement he has shown to many young people getting started in their careers. Moreover, this help has not been limited to his own students or colleagues. I can well remember the assistance and advice he gave to me on several occasions soon after I arrived from Britain, a period when I was struggling to understand how one plays the game in a new country. (KE Gubbins, Cornell University Ithaca, NY, October, 1988)[99]

> I believe that first of all, he teaches me how to be a good man, in virtually all dimensions. Like what I heard from others many times, he can benefit virtually anyone who is working with him, no matter whether or not the person is interested in doing research. His generosity is unmatched by anyone I know of; he always helps others in a sincere and truly humane way. No doubt that he is a true scholar, and exemplifies himself to live a scholarly life. (Jianzhong Wu, University of California, Riverside, CA, August, 2014)

> Those who have had the experience of close colleagueship with John also know him as a true friend. John's unfailing generous interest in the progress of his students and associates

is a truly remarkable characteristic. (RA Heidemann, University Calgary, Alberta, September, 1988)[99]

In getting to know him personally stimulated my interest in the exciting field of phase-equilibrium thermodynamics and my desire to collaborate with him. After staying nearly two years in Berkeley, I started my own research group at the University of Heidelberg naturally in the field of equilibrium thermodynamics and John ever since has strongly sustained my work. . . .Throughout the years we got to know one another so well, that we usually agree easily on how to approach and to solve scientific and nonscientific problems, but if we don't, open, honest and sometimes tough discussions are taking place. (RN Lichtenthaler, Heidelberg, DE, September, 1988)[99]

. . . you were kind enough on a couple of occasions to lend me your insight into problems that I was examining in the early part of my own career. You took the time to write me about the interpretation of some solid solubility behavior in our laboratory (at Notre Dame) and about the correlation of density of highly supercritical dense fluids. By themselves, these insights may not have seemed that profound, but they started me thinking in patterns, based on molecular concepts, that have served me well in many later problems with which I have been involved. (KD Luks, University of Tulsa, OK, October, 1988)[99]

One of my fondest memories from my early career was your invitation to visit the Berkeley campus and present a lecture. . . you convince[d] . . . Shell and Chevron to invite me for lectures in order to finance my trip. I recall how impressed I was that you would expend so much effort on someone like myself. I also recall that I had suggested a rather theoretical presentation on intermolecular potential functions and their relation to macroscopic properties, while you were obviously thinking that I would be talking on a modified Chao-Seader correlation. In your response letter, you gently steered me toward a more practical talk and mentioned Otto Redlich's admonition that a good talk "uses at most one equation and no more than six symbols"! (RL Robinson, Oklahoma State University, Stillwater, OK, September, 1988)[99]

I have been neither a student nor a collaborator of Professor Prausnitz, and personal contacts took place in the course of scientific conferences only. I have always perceived him as an excellent lecturer, and his willingness to participate in discussions is particularly impressive. The stimulation and inspiration he thereby provides for the scientific and engineering community can hardly be overrated. (E. Wilhelm, University of Wien, Austria, September, 1988)[99]

During my early years of teaching, I could always count on words of encouragement from John. In many ways he was my model as I developed my own professional style. Whether John is giving a technical paper, or a classroom lecture on phase equilibrium, or an address to a general technical/nontechnical audience (very difficult do to, but he does it best), or even discoursing on Wagner and Verdi, John is well worth one's complete attention. These capabilities, together with his leadership and interest in education and teaching issues, make John Prausnitz an outstanding faculty member, a pioneering researcher, and a valued friend. (MC Williams, University of California, Berkeley, CA, September, 1988)[99]

Final Thoughts

This exposition about John Prausnitz has been able to give only a glimpse of him and his significance as a founder of modern chemical engineering. To finish, a few additional commentaries about him as researcher, educator, and person are given.

In the first published tribute to Prausnitz in 1998, Charles Eckert wrote,[100]

Why then has John's impact been so profound? He is certainly not an experimentalist - his Ph.D. advisor at Princeton, Dick Wilhelm, spoke with some mirth of his experimental efforts. Although John absorbs theory like a sponge, he is not a theoretician. Above all, any personal contact with a computer is absolute anathema. However, his superlative talent has always been his astonishing effectiveness in finding the right problems, the right methods, and the right people to implement them - and in his ability to motivate them to make it happen. From a dark room on the top floor of Gilman Hall, John Prausnitz has seen the future and made it happen.

Figure 5 shows the office referred to by Eckert.

Figure 5. John Prausnitz in his Gilman Hall office. Note the picture board on the right.

Credit: Michael Barnes, College of Chemistry, UC Berkeley. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

In an interview, John said[13]

> I just cannot conceive of living in such a way that I would only do chemical engineering. I always tell my students there is more to life than chemical engineering. Now go out and do something else. And as you know, that is a problem because time is limited and the students work hard and they have lots things to do to satisfy their academic requirements. But, what I am talking about does not really take any extra time. I want students, when they have dinner to stop meeting with other chemical engineers and talk to people who are in law school, or literature school, or what do I know, something else. They have dinner anyway. They have lunch. They certainly, on weekends, have outings, I do not know what they do, they go to dances or whatever. They should do that with people who are not like themselves!

In discussing his proudest achievement, John gave insight about what gives him satisfaction.[13]

> My proudest achievement is students. I have enjoyed, very much, working with students, influencing them. I hope that the influence that I have had on them has been beneficial. I think it has in most cases. The greatest reward that someone like me gets is the success of the students. There is not any one thing in my scientific career that I can point to that is more satisfying than any other; I mean, they all are satisfying. But, the contact with young people and the opportunity to influence them beneficially, that has been a major reward for me.

In addition to his humanistic and cultural interests awakened in college, John says,[13] "All my life, I have loved classical music, especially chamber music and opera. But in recent years, I have learned to appreciate popular music thanks to my daughter Stephanie's fiddle in a five-member band (The Stairwell Sisters) and thanks to my wonderful wife Susie of nearly 55 years strumming the ukulele." He is also justifiably proud of his son, Mark, who is Regents' Professor, Love Family Professor in Chemical & Biomolecular Engineering, and Director of the Center for Drug Design, Development, and Delivery at Georgia Institute of Technology.

Mark reports that even now, John "continues to nurture students, undergraduates as well as graduate students and post docs. It's a win-win situation. He has received a great number of touching letters from former students thanking him for insisting on good writing, to stick to the point- and to know where the hyphen belongs! These days, he spends his mornings at home reading, both technical and nontechnical materials, and then spends the afternoon in his office in Gilman Hall. He maintains research collaborations, meets with students and colleagues, keeps up with correspondence and develops ideas for new projects."

Last, John has apparently begun reflecting on his life by including in some lectures the following story that also embodies his sense of humor:

Some years ago, one of my colleagues at Princeton pointed out that in a professor's career there are five stages:

Stage 1: Who is Prausnitz?

Stage 2: Let's give Prausnitz a chance!

Stage 3: Prausnitz has arrived. He is one of us!

Stage 4: Where can we find another Prausnitz? and, inevitably,

Stage 5: Who is Prausnitz?

It is clear that Stages 1–4 have occurred with gusto. However, it will take a very long time, if ever, for Stage 5 to happen!

Acknowledgments

The author is grateful for the insightful responses of those who responded to requests for information and perspective, especially Susie and Mark Prausnitz, plus Kristin Stangl, Michael Barnes, and several faculty of Chemical and Biomolecular Engineering at UC Berkeley—all who had to keep this tribute issue a secret from John.

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