The University of Rochester's

Richard Heist

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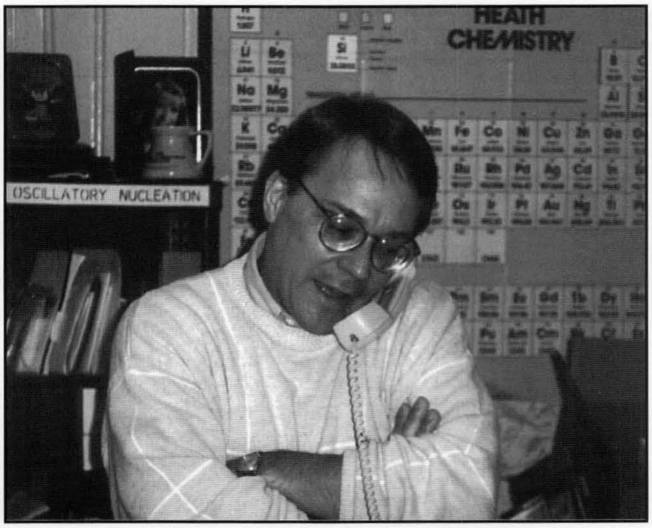

Richard Heist, Associate Professor of Chemical Engineering and Associate Dean for Graduate Studies at the University of Rochester, began his professorial career at the University of Rochester in 1974. His contributions to the education of countless undergraduates and graduate students through excellent teaching, innovative laboratory development, and meticulous, creative research collaborations with both graduate and undergraduates students are, and continue to be, of lasting significance to the department.

Dick grew up in the small town of Birdsboro, a close-knit community in southeastern Pennsylvania. The principal product of the area was steel, and Dick's father was the foreman of the electrical maintenance staff at the local steel mill. In retrospect, it should have been self-evident that Dick was destined to establish a career in experimental research involving chemistry. Dick, like many of us, recalls a childhood of curiosity and scientific exploration. But rather than be contented with disassembling anything mechanical or spending countless hours examining the natural world with magnifying glass or microscope, Dick's inquisitiveness and uninhibited enthusiasm for invention led to more active pursuits. He and a few close friends were in the habit of procuring substantial quantities of "energetic" chemicals, such as very fine grade (photograde) magnesium, potassium nitrate, and sulfur, for use in a wide variety of "chemistry-related activities" that Dick would dream up with the help of various chemistry texts that he found buried among the history and literature books that he enjoyed reading at the public library.

Legend has it that Dick's ingenious concoctions were used not only to produce colorful campfire displays during Boy Scout outings (he was very active in Scouts for about twenty years), but also for mischief of a more explosive kind. Needless to say, when these chemicals were constrained in empty CO_2 canisters and ignited, the energy stored in the chemicals became fully apparent. In hindsight, Dick admits that these activities were quite dangerous; fortunately, he and his friends escaped any serious consequences of their experimental investigations. I guess Dick knew what he was doing even back then—teaching his friends about chemistry, developing a creative style, learning by doing—a teaching philosophy that has stayed with him to this day. A generation of students at the University of Rochester can attest to his love of teaching, his propensity for experimentations, and his special attention to detail.

In high school, Dick continued his experimental exploration of chemistry in a more legitimate fashion. His science teachers gave him the run of the chemistry lab and encouraged him to present demonstrations to the class. At that time, he was very interested in organic chemistry and recalls the

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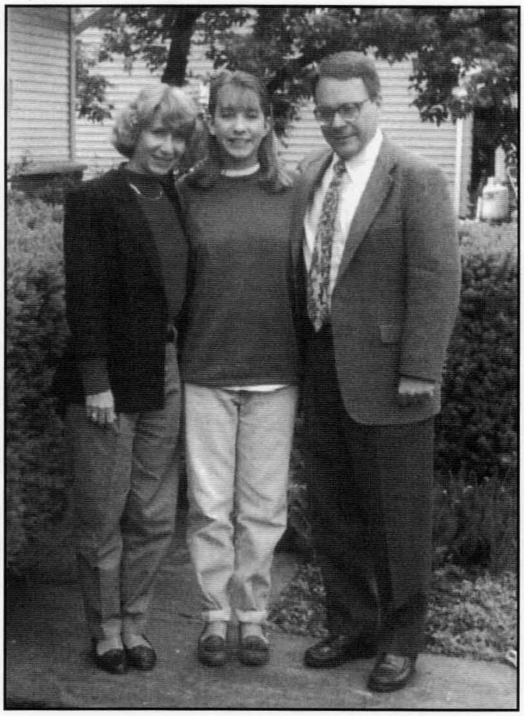
day he put half the class to sleep (literally!) by mixing acid with alcohol to produce ether. The ensuing evacuation of the school earned Dick a modest degree of notoriety.

Needless to say, his parents were relieved when Dick went off to Catawba College in North Carolina in 1963. There was even the possibility that he might study history—a subject in which he had developed a deep and abiding interest "due to the influence of a rather remarkable high school history teacher." But at Catawba, the freshman chemistry class was small, with about thirty students, and the chemistry professors quickly tapped into Dick's enthusiasm for experimental chemistry, giving him the run of their labs—the rest is history! He served as a teaching assistant for lower-level chemistry courses from his sophomore through his senior year and was one of three chemistry majors who graduated in 1967. Dick credits his seventh grade science teacher, as much as any other person in his life, for turning him on to science and ultimately determining his career pathway. But, obviously Dick also had a long-standing fascination with chemistry and what chemicals could do under carefully controlled circumstances, and he had a strong predisposition toward experimentation and improvisation for self-discovery.



The Heist family—Molly, Amy, and Dick.

Dick has many positive memories of his four years at Catawba, where he became a serious student, was president of the sophomore class, and made lasting friendships. By the time he reached his senior year, his initial plan to seek immediate employment had been altered by his love of science. As Dick puts it, "Chemistry and physics had become a terrific adventure; it was really neat and I just had to do more." His chemistry professors convinced him to apply to graduate school, and he chose Purdue.

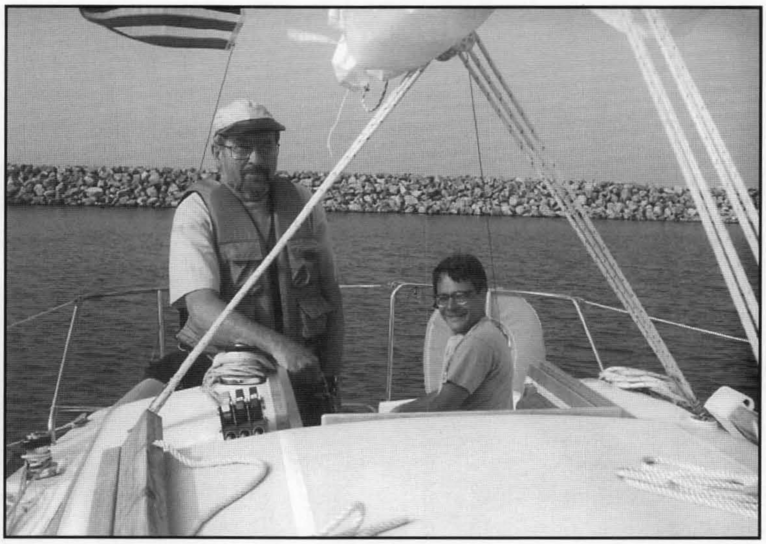
Dick recalls his four years at Purdue as being among the happiest days of his life. He had a research assistantship of $225/month, was single, and owned a car (which he admits he didn't use very much). His advisor was a young, enthusiastic fellow named Frank Fong (who received his PhD at Princeton), and Dick recalls with fondness the intellectual intensity of his advisor and his research group, "working 24 to 36 hours at a clip." Although he still liked organic chemistry when he entered Purdue, he was lured by physical chemistry's reputation of being "really tough." He also liked the mathematical rigor and the detailed nature of the subject.

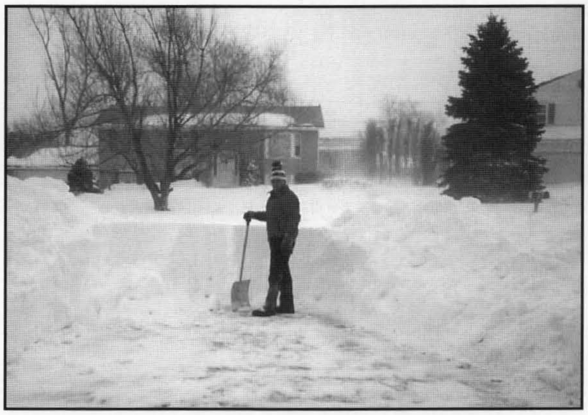
Purdue was quite a change from Catawba. The number of people in the chemistry department alone was nearly the same as the total number of people at Catawba College. The facilities at Purdue were first-rate, and Dick prospered under Fong's mentorship, doing research in solid-state physical chemistry and chemical physics, using spectroscopy to study alkali- and alkaline earth-halide crystals doped with rare earth ions and the resulting charge compensations that occur inside the crystal.

Prior to joining Purdue, Fong had worked at the North American Aviation Science Center in Thousand Oaks, California, where he was a colleague of the Director, Howard Reiss. Later, when Dick was in the final stages of his dissertation, Reiss, now Professor of Chemistry at UCLA, was looking for a first-rate experimentalist to fill a post-doctoral opening in his research group, and Fong recommended Dick for the position. Dick was by this time married to Molly, a hometown girl who had grown up only half a mile down the road from his parents. Although he and Molly were childhood friends, they had never dated until he returned to Birdsboro during the summer before his third year in gradu-

A study in contrasts: sailing, one of Dick's favorite and as-frequent-as-possible pastimes, shown here with good friend Howard Saltsburg . . .

and shoveling multiple feet of snow (where are your friends when you need them?), a less-than-favorite and all-too-frequent wintertime activity in Rochester.





ate school. They renewed their acquaintance at the community pool, started dating, and were married a year later, the summer before his fourth year. In August of 1971, Dick completed his PhD in physical chemistry, and he and Molly moved to Los Angeles, where he spent three intense, productive, and enjoyable years as a post-doc with Howard Reiss, learning about handball and nucleation phenomena, and exploring the potential of the diffusion cloud chamber as a detector for studying the kinetics of photochemical reactions such as the photo-oxidation of sulfur dioxide (the reaction of SO_2 with itself in the absence of oxygen to form SO_3).

In the fall of 1974, Dick joined the chemical engineering faculty at the University of Rochester. This outcome was initiated somewhat serendipitously by a visit to UCLA by Howard Saltsburg, one of Howard Reiss' first PhD students at Boston University in the early fifties. The U of R Chemical Engineering Department was in the market for an assistant professor in the general area of interfacial phenomena, and Dick was in the market for a faculty position. When Saltsburg met Heist, he seized the opportunity and convinced Dick to consider Rochester for his academic career, albeit in a chemical engineering department.

Upstate New York has provided many opportunities for community and family activities for Dick, Molly, and their daughter Amy, who will be a sophomore majoring in biology at Valparaiso University this year. Dick is an Elder in his church and enjoys the outdoors: canoeing, cross-country skiing in the winter, and spending every chance he gets sailing on his 27-foot Hunter sailboat in the summer, except for his customary one-week vacation on Lake George in the Adirondack State Park. Rumor has it that he "never gets lost," and if you can get him in a homespun mood, he might even tell you about how he is a descendant of Daniel Boone. He is still an avid handball player (almost unique at Rochester), managing to hustle up a match two or three times a week, and enjoys cooking homestyle Pennsylvania Dutch food.

INTEGRATION OF COMPUTERS INTO THE UNDERGRADUATE LABORATORY

Howard Saltsburg and Dick Heist share a common interest in interfacial science and a common philosophy regarding the value of "hands-on" educational experiences. Thus, it was inevitable that they would team up to make major contributions in undergraduate education through innovation in the undergraduate laboratories. In the mid-seventies, undergraduate laboratory experiments in most engineering curricula typically were tied inextricably to lecture courses and were designed to demonstrate the fundamental principles taught in class. Furthermore, instead of planning experimental strategies for investigating the scientific and technological issues embodied in the experiments, students spent countless hours on data collection, analysis, and regression, because the data were collected with analog instrumentation such as strip-chart recorders, pH meters, etc., or by manual means such as titrations. "Students were spending too much time trying to make things work, and too little time deciding what the data meant." Dick and Howard realized that if the students could be liberated from a lot of the busy work associated with data collection, then more time could be spent on the creative process of self-discovery in the laboratory.

It was in the '70s that the first affordable and easily programmable microcomputers (such as the Apple, Commodore PET, and the Radio Shack TRS-80) appeared in the marketplace, and a hobby subculture emerged that espoused the potential capabilities of these machines. Dick recalls giving a seminar at Westinghouse in the mid-seventies where a colleague described the new microprocessor technology as the greatest thing since "sliced bread." It perked his interest, and thus he and Howard began to read the pertinent hobby magazines like *BYTE* and the now-defunct *MICRO* to learn more. The breakthrough for the undergraduate laboratory came when an article appeared in *MICRO* that described how a microcomputer could be used to measure temperature with a thermistor coupled to a common 555 timer microchip. The microcomputer, with its internal clock, is used to measure the time between pulses of a 555 chip, the time period being determined by the resistance thermistor across two of its terminals. Howard and Dick immediately applied the concept to an unsteady-state heat transfer experiment, representing possibly the first use of a microcomputer for automatic data acquisition in an undergraduate laboratory environment.

Dick and Howard quickly realized that other experimental parameters, in addition to temperature, could be measured with resistance-based transducers. Beginning in 1978, they applied the generic concept of a 555 chip as a simple A/D converter for a PET computer to a whole host of undergraduate laboratory experiments. Soon after their first success in computer interfacing, the department hired Thor Olsen, a chemical engineer who had been working at the UR School of Medicine and Dentistry, to assist in the implementation of computers for data acquisition in the undergraduate laboratory. Thor gravitated to the computer programming and experimental design aspects of the project and, in addition, recognized that colorimeters based on LED/photocell systems also could easily be interfaced with the PET. Thus, shortly after he had joined the team, Thor had a continuous-flow stirred tank (CSTR) experiment up and running in which students could study the residence time distribution of dye pulses in a series of stirred tanks by monitoring the optical density of flow streams at various positions with the LED circuit multiplexed to the PET computer.

Using microcomputers for data acquisition and real-time analysis gave students more time to think about why they were doing the experiments in the first place. To capitalize on this still further, the faculty decided to make the undergraduate laboratory experiments discrete from the lecture courses. By bundling experiments into separate laboratory courses, students could be introduced to chemical engineering principles within the context of open-ended problems that combined the disciplines discretized in traditional lecture courses. Under the combined leadership of Dick, Howard, and Thor, the undergraduate laboratory courses have evolved into a set of experiences that teach students how to deal with real-world problems. Students decide on the aspects of the problem that need to be investigated, the experimental strategy and conditions, and the process of data analysis.

Interestingly, the microcomputer technology has migrated from the undergraduate labs to the graduate research labs at Rochester, an unusual path. Furthermore, the innovative use of microcomputers in the undergraduate laboratory has had an international impact through publications, presentations at ASEE conferences, and numerous visits from professors in the U.S. and Europe who have implemented these concepts in their home institutions. For several years, Dick, Howard, and Thor held successful summer workshops at Rochester and at ASEE conferences to educate professors on the simplicity and versatility of microcomputers as data acquisition tools in the undergraduate laboratory. Students at Rochester still get their first exposure to the use of microcomputers as a tool for data acquisition in the "air box" experiment, which is included in the *CACHE* anthology on computer applications in the undergraduate laboratory (1988).

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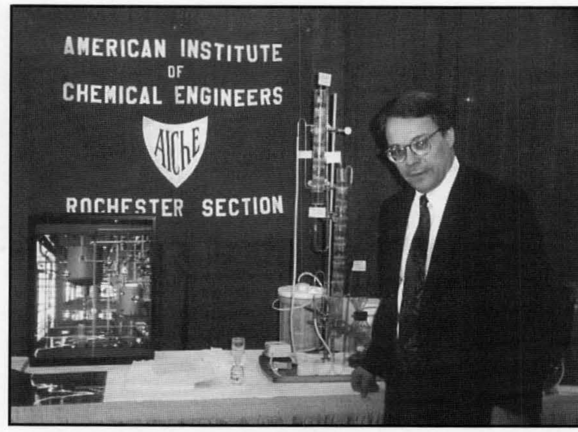
The box, invented in 1981 by Dick, Howard, and Thor, contains a thermistor, a heater, a fan, and "doors to the outside"; and students learn to use the microcomputer not only to measure the temperature inside the box but also to restore the temperature to a desired set point in an optimal fashion, after a sudden thermal disruption.

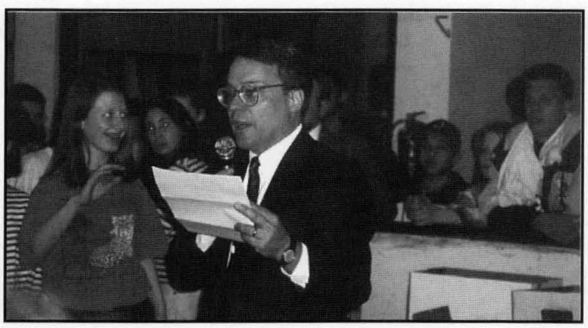
RESEARCH IN NUCLEATION OF SUPERSATURATED VAPORS

Dick and his research group are interested in nucleation and nucleation-related phenomena; that is, the physical process whereby one phase makes a spontaneous transition to another more stable phase. In nature, we see the process of nucleation in the formation of rain and snow and in the boiling of liquids; but these are examples of *heterogeneous* nucleation, which rely on "seed" particles to lower the activation energy by providing the initial surface area for growth of the new phase. By contrast, *homogeneous* nucleation occurs under somewhat more special conditions, in the complete absence of foreign surfaces or "seeds" to initiate the nucleation process.

In spite of the immense practical significance of nucleation and in spite of the fact that scientists and engineers have been studying it for decades, there is much we do not yet understand. For example, we know that if we shine light of certain wavelengths on certain supersaturated vapors, we



Scenes from the 1995 E^3 Fair (Engineering, Exploration, and Experimentation). As General Chairman, Dick led the team that organized the E^3 Fair and involved more than 300 participating middle school students and over 50 professional societies, industries, and colleges



can make the vapor nucleate. Even though this process has been investigated for a number of years and even though it occurs to a significant extent in our own atmosphere (*e.g.,* smog and gas-to-particulate conversion), we still do not really understand how it works. One of Dick's ongoing research efforts is to learn more about *photo-induced nucleation* and how it can be used for other scientific and engineering applications. In one such project, he is studying the photo-induced nucleation of organo-metallic vapors, such as nickel carbonyl, as a means of producing ultrafine metallic (nickel) particles. Because these particles are so small (as small as 10 nm) and are produced under such unusual conditions, they are expected to have novel chemical, physical, and electronic properties that may make them valuable commerically. Currently, Dick is examining the catalytic properties of these ultrafine nickel particles by forming them by photo-induced nucleation in the presence of various reactants and then examining the reaction products using gas chromatography and mass spectroscopy.

Phase transitions have long interested researchers in science and engineering. Unfortunately, theoretical descriptions of the underlying physical phenomena tend to be complex, and the length and time scales associated with the formation of the first fragments of the new phase (clusters of molecules) are such that detailed experimental information is difficult to obtain. One approach to the experimental problem is to investigate phase transitions in the critical region, since both the length and time scales increase as the critical point is approached. Dick and his students are probing the nature of intermolecular interactions in close proximity to the critical point, by studying nucleation phenomena in a diffusion cloud chamber designed to function at high pressures and temperatures. Dick says, "These types of measurements are normally quite difficult to make, but the results are of considerable scientific, engineering, and practical interest." For example, in modern technology, the process of chemical vapor deposition (CVD) is bound up with nucleation and growth processes.

While studying nucleation at elevated pressures and temperatures, Dick has also discovered that the presence of other, non-nucleating gases (background gases) can give rise to extraordinary behavior during nucleation. Nucleation researchers tend to ignore the presence of non-nucleating background gases in descriptions of nucleation phenomena and in the interpretation of results obtained from nucleation experiments. But the experiments of Dick's students show that the nucleation process can be profoundly affected by both the amount and kind of background gas present in the system. There is a clear connection to recent CVD observations where similar effects are observed.

PROFESSIONAL SERVICE

Dick joined the ASEE and the AIChE soon after he became a faculty member at Rochester. His interest in undergraduate education has been intense and constant over the years, and ASEE has provided an ideal forum for him to examine innovative ways to enhance undergraduate education. When Dick began the project of integrating microcomputers into the undergraduate laboratory, he (with Howard and Thor) presented several workshops on the topic at the ASEE Chemical Engineering Summer School. These initial activities inevitably led to active involvement in the DELOS division of the ASEE, an organization for which he served as Program Chair in 1993 and Division Chair in 1994. He is currently a Director of the Division. He is also a member of the AIChE and Instrument Divisions of the ASEE.

Locally, Dick has been active in the Rochester Section of the AIChE for many years and is currently the Section's Vice Chair. Thus, he organizes the monthly meetings of the Section and will succeed as Chair of the Section next year. In recent years, Dick has also played a leadership role in developing connections between the professional organization and the public schools, particularly at the middle-school level. He believes that the key to developing a technologically literate society is to interest the children in grades 6-8 in science, math, and technology. If we wait until the high-school years to expose students to the career opportunities in science and engineering, Dick feels it may be too late since by then students have already self-selected their career options through the courses they took in grades 7 through 10.

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Dick has been proactive in this effort by spearheading a program known as the E^3 Fair (Engineering, Exploration, and Experimentation), which is both a technology fair and a competition similar to the national "Odyssey of the Mind" contests, but with a specific focus on technological innovation. The E^3 Fair was created as part of the National Engineers Week celebration, the goal being "to focus the attention of students on the exciting world of engineering, science, and technology, as well as to motivate them to seek careers in these technical areas." It is now in its fourth year, and Dick is both the 1995 Chair of the E^3 Fair and the AIChE representative to the E^3 executive board.

At the E^3 Fair, middle-school students display projects that demonstrate engineering principles and have them evaluated by teams of judges who are practicing engineers or engineering students. Local industries, engineering societies, area schools and colleges present "hands-on" activities, demonstrations, and exhibits that illustrate various aspects of technology. As Dick says, "It is a great opportunity for industries and professional societies to show students what engineers do and why they do it." But the heart of the fair is the competition among teams of middle-school students to solve a particular engineering design problem. This year, the problem solving activity was to construct (using a LEGO kit of parts provided by the fair organizers) a stationary machine capable of lifting a basket of weights a given height in a given time. Student teams work for about six weeks on a solution to the problem, usually mentored by practicing professional engineers from the community. Students then bring their best solution to the fair along with a design journal that documents their problem solving process. Teams are judged not only on how well their device performs but also on their problem solving strategy as documented in their journal.

EXCELLENCE IN UNDERGRADUATE TEACHING

Dick has taught a variety of undergraduate and graduate courses at Rochester since he joined the faculty in 1974, including the introductory mass and energy balance course, reactor design, and, of course, the laboratory courses. But his forté in the undergraduate curriculum is thermodynamics. Every year, the students rank this course among the very best that they have taken at the University, and in both 1993 and 1994 they named Dick "Teacher of the Year." In addition, Dick teaches a graduate course in his research area, the kinetics of phase transitions, and team-teaches a course in molecular sciences with Eldred Chimowitz; both courses are very popular with the students. In an attempt to reduce attrition among freshmen who have expressed an interest in chemical engineering, the department last year instituted half-semester, elective courses for freshmen. These courses focus on contemporary issues that have a major chemical engineering component and are intended to teach students how chemical engineers formulate and solve real-world problems. This spring, Dick is teaching one of these courses. Titled "Atmospheric Pollution: An Engineering Perspective," it is packed with demonstrations and hands-on experiences, in typical Dick Heist fashion.

In summary, Dick Heist has played a leadership role in both his professional and community activities, and we look forward to many years of continuing contributions. ❒