Rich Noble

. . . of the University of Colorado Boulder

John L. Falconer
University of Colorado Boulder

Rich was born in Newark, N.J., on Oct. 14, 1946, to Richard and Elaine Noble, and he is the oldest of seven children (six boys, one girl). His father worked as a bookkeeper for Monsanto Chemical Co. in Kearney, N.J., and his parents moved the family to Sayreville, N.J., when Rich was 12 years old. He attended Sayreville War Memorial High School where he graduated as the top male in his class (12th out of approximately 250 students—the top 11 were females). He was elected senior class president and chosen as the boy most likely to succeed. He enjoyed sports, and after running track his freshman year, he played baseball the remaining three years. His love of baseball would carry over to college and his adult life.

Rich biking in the Colorado mountains.

His parents instilled the idea of hard work and the value of money at an early age. When he wanted to go to a movie or school dance, the first question his mom asked was "Do you have the money to go?" Thus, he had his first newspaper delivery route at the age of 13 and continued to deliver papers through high school. He also helped to deliver milk on a truck route every other morning, getting up at 3 a.m. and finishing in time to go to school.

His father interested Rich in engineering since he worked with many engineers at Monsanto and saw the value of this career. His high school advisor also encouraged him since he was good at math and science. He taught his first class in high school chemistry. The teacher got a migraine headache, and Rich volunteered to teach that class. It actually worked, and he got a better reception from the class than most substitutes.

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UNDERGRADUATE SCHOOL

Rich attended Stevens Institute of Technology where he received a B.E. degree in engineering with honors in 1968. The curriculum at that time primarily focused on mechanical engineering courses with additional courses in civil, electrical, and chemical engineering. The positive side of this curriculum was the exposure to a wide range of engineering; this has proved helpful at times throughout his career. The negative side of this approach was that he took fewer chemical engineering courses than students at institutions with a distinct chemical engineering program. As a result, when Rich started graduate school he was not as prepared as his fellow classmates. Stevens changed their curricula a few years after he graduated and now offers traditional engineering curricula in several disciplines.

He started to develop his ability for and enjoyment of teaching as an undergraduate student. He taught what were called "poop" sessions so other students could prepare for exams. In general, he would explain the course material and work out the solutions to previous exam questions; 10-30 students attended these sessions.

He played baseball all four years at Stevens, which had a Division III sports program with no athletic scholarships. Rich played outfield and had a batting average over .300 when he graduated. To attend Stevens, Rich received scholarships and loans since his parents could not afford the tuition and housing costs. He appreciated the many people he never met who paid taxes and donated funds that were invested in him. This showed him the value of giving back, and it had a significant influence on Rich later in life.

Rich in 1976 when he started his first academic position at the University of Wyoming.

He worked summers to make money for the following school year. He worked as a laborer in a chemical plant for two summers, and the summer after his junior year he worked as a project engineer in another chemical plant.

He was a member of the Pi Lambda Phi fraternity, and he lived in the fraternity house except for one semester due to an unexpected problem and an unusual solution: He lived on a boat for one semester because the fraternity house had a heating failure between the Fall and Spring semesters. Stevens purchased a large boat normally used for tourist cruises and docked it on the Hudson river next to campus. Stevens used the boat as a dormitory for several years.

One of Rich's fraternity brothers was Jim Schwarz, who later would become a chemical engineering professor at Syracuse University. Jim and Rich were also teammates on the Stevens baseball team.

AFTER UNDERGRADUATE SCHOOL

Because Rich had a high GPA at Stevens, he was permitted to take four courses for graduate credit as an extra load in his last two years as an undergraduate. Upon graduation with his B.E. degree from Stevens, he worked for two years as a process engineer for National Starch and Chemical Co. in Plainfield, N.J. He continued to take graduate courses in the evening, and took six courses in two semesters while working full time, and received an M.E. degree in 1969.

In the summer of 1969, Rich attended the first Woodstock concert with one of his brothers and another friend; both his brother and friend had been in the Army and just returned from Vietnam. They all decided that it would be fun to go to a concert for the weekend, but did not realize until they were a few miles from the site that several hundred thousand people had the same idea, and Woodstock became the most-celebrated music concert in history. It rained during much of the weekend, but the two Army veterans had dealt with lousy weather and taught Rich how to roll up in a poncho and survive. He still has his tickets from the concert.

Rich's two years in industry were a useful experience, but Rich decided he did not want to work in industry for his career. He realized that he enjoyed teaching and started to explore options. Seeing an ad in *The New York Times*, he applied for and got a position as a high school science (physics and chemistry) teacher at a boarding school in England for one year. During school breaks and the following summer he traveled around England and continental Europe. The students at the boarding school were not very motivated, however, and this teaching experience showed him that he wanted to teach more-motivated students, so Rich decided that he needed to get a Ph.D. degree and teach at a university.

GRADUATE SCHOOL

Rich applied for Ph.D. programs while teaching in England. He was accepted at UC Davis and headed to California after returning from England in 1972. He talked with Alan Jackman soon after arriving at Davis and quickly decided that he wanted to pursue a Ph.D. under Jackman's direction because of a mutual interest in environmental problems. This collaboration started his interest in running since he would run with Alan at noontime. This was a way to both get some exercise and talk with his advisor. Also, Rich started biking in Davis, which was set up well for bicycle commuting, and that interest in biking continues today.

His graduate research focused on developing a heat-transfer computer model to analyze the effect of different thermal loads on a river. The objective was to be able to estimate the change in a river temperature due to discharges from electrical power plants. In order to develop the model and obtain experimental data, he had to find a river in California with no dams or power plants so he could determine the natural thermal variations. Only two rivers met these criteria, and only one was long enough to provide a reasonable basis. Thus, the Mattole river basin became his laboratory, and Rich spent two summers there collecting weather, stream flow, and temperature information. He used that information to validate his model, which consisted of three large boxes of computer cards. In those days, a fixed amount of computer time was allocated to a user on a main frame computer. He became very good friends with everyone working at the computer center since he was there almost every day trying to get additional computer time to run and debug his program. For one month Rich tried to get this program to run correctly without success before he finally figured out one evening that he had offset all of his matrix indices by one number. He was at the computer center first thing the next morning, and the model finally worked correctly; Rich learned an important lesson about motivation and problem solving.

Rich and Susan at their wedding.

One of the most important pieces of equipment for his thesis research was a 1959 Ford station wagon that he used to travel throughout this rural river basin. He installed two weather stations and several temperature monitoring units throughout the basin, and he had to check them on a regular basis. Keeping the car in good operating condition in the middle of a remote river basin was a challenge. He spent a lot of time keeping his research "equipment" working properly—another problem solving experience!

FIRST ACADEMIC POSITION

Rich accepted his first academic position at the University of Wyoming in 1976. As stated earlier, Rich entered the academic world so he could teach, but initial idealism met reality when his first courses did not go well. However, he attended the 1977 ASEE Summer School for Chemical Engineering faculty at the Snowmass ski resort near Aspen, Colorado, and implementing ideas from the presentations and from advice he received at the meeting really helped; he received the College teaching award (voted by the students) at the University of Wyoming a few years later. This was the first of 17 teaching awards (11 voted by students), including the ASEE Chemical Engineering Chemstations Lectureship Award in 2011 and the National Society of Professional Engineers/Professional Engineers in Higher Education/Sustaining University Program Engineering Education Excellence Award in 2013. While at the University of Wyoming, he also received the ASEE Zone IV Campus Activity Coordinator Award in 1980 and the ASEE Dow Outstanding Young Faculty Award for the Rocky Mountain Section in 1981.

At the 1977 Summer School, Rich first met John Falconer. This led to a lifelong friendship, first as running partners and later as research collaborators. He met other faculty who also became lifelong friends, including Phil Wankat and Jim Stice. Rich credits Jim with being a great help in improving his teaching skills. One technique that Jim provided was a method to get student feedback during the semester by finding student volunteers who periodically collect feedback, good and bad, from the class. Rich would then meet with the volunteers and get the anonymous feedback and discuss what could be done to correct any problems. At the next class, Rich would spend time describing the feedback and explain what would be done to improve things. Jim warned Rich that he needed to be prepared for negative comments and be able to address them. This technique was extremely helpful since it allowed the class to improve as the semester progressed. Once students realized that Rich took their comments seriously, they responded well throughout the semester.

The luckiest day of his life was Nov. 28, 1977, when he took a flight from Denver to Spokane to give seminars at Washington State University and the University of Idaho. He struck up a conversation with a woman in the seat next to him. One thing led to another and two years later he and Susan Richardson were married. They celebrated their 38th wedding anniversary in December 2017. Rich and Susan actually published a paper together based on their common interest in problem solving. Susan is a Ph.D. psychologist, and the article focused on the role of anxiety in problem solving.

NATIONAL LABORATORY EXPERIENCE

While at Wyoming, Rich decided that he wanted additional research experience, so he accepted a position at the National

Bureau of Standards (then called NBS, now known as the National Institute of Standards and Technology) in Boulder in 1981. They were starting a program that focused on membrane science and technology, and this was the start of Rich's career in membrane research. He wanted to continue teaching, so he also became an adjunct faculty member in the Chemical Engineering Department at the University of Colorado Boulder, where he both taught classes and advised graduate students. One student he advised was a co-worker, Doug Way, who became Rich's first Ph.D. student as they collaborated on membrane research at NBS. Doug has had a very successful academic career at the Colorado School of Mines.

UNIVERSITY OF COLORADO BOULDER (CU)

In 1987, Professor Bill Krantz approached Rich about becoming a full-time faculty member at CU in order to work with him to start an NSF Industry/University Cooperative research center in membranes. Rich had to recruit industrial sponsors and convince faculty to participate. The Center, now called the Membrane Science, Engineering and Technology (MAST) Center has been very successful; it has been in continuous operation since 1990, and Rich served as the center director for many years. It currently has sites at the University of Arkansas and New Jersey Institute of Technology, and efforts are underway to include Penn State University. The center has funded more than 110 research projects with more than 60 participating faculty and produced 31 M.S. and 46 Ph.D. degrees. Center research provided proof-of-concept results that lead to almost $34 million of additional "spin-off" funding. The center was recently awarded an additional five years of NSF funding and so will continue to be an excellent example of industry-university collaborative research. Besides Bill Krantz, Rich became good friends with Alan Greenberg in the Mechanical Engineering Department because of Alan's key leadership role in the MAST Center for many years.

Rich has been very fortunate to collaborate with excellent colleagues and friends over the years. He has advised or co-advised 29 Ph.D. students and 23 postdoctoral researchers, and 25 of them have gone on to academic careers (Table 1). He has also advised numerous undergraduates, and 24 are co-authors on 35 of his research publications. He currently has more than 340 publications, 80 patents and patent applications, 22,500 citations, and an h-index of 87 in Google Scholar. He has received 15 awards for his research, including three national awards (ACS National Award in Separation Science and Technology, AIChE Separations Division Clarence G. Gerhold Award, AIChE Institute Excellence in Industrial Gas Technology Award) and two international awards (Chair d'Excellence Pierre de Fermat, Paul Sabatier University, Toulouse, France, and the IChemE Innovator of the Year). Rich co-authored one of the early textbooks on environmental separations (*Principles of Chemical Separations with Environmental Applications*, Cambridge University Press, 2004) with Pat Terry (University of Wisconsin, Green Bay) and co-edited a comprehensive membrane handbook (*Membrane Separations Technology: Principles and Applications*, Elsevier, 1995) with Alex Stern (Syracuse University).

His first research collaboration started unexpectedly. Bev Louie was his first M.S. student, and she was investigating a chemical complexing agent for use in a facilitated transport membrane. She convinced Carl Koval in the Chemistry Department to get involved in the project. This started a long-term collaboration and friendship with Carl, who is an electrochemist. After working on facilitated transport membranes, they worked together on the use of electrical or light energy to aid in selective separation processes. The energy is normally used to change the binding affinity of the complexing agent, but it can also be used to drive the process. As a result, they developed an electrochemical pump with no moving parts that produced a pressure in excess of 20 atm. This technology has applications for lab-on-a-chip, microspectroscopy, and

TABLE 1
Ph.D. students and Postdoctoral Researchers with Academic Positions

Manuel Arruebo	University of Zaragoza, Spain
Jason Bara	University of Alabama
Trevor Carlisle	Oregon State University
Moises Carreon	Colorado School of Mines
Joaquin Coronas	University of Zaragoza, Spain
Matt Cowan	University of Canterbury, NZ
Steven Drew	Carleton College
Hans Funke	University of Colorado Boulder
Tracy Gardner	Colorado School of Mines
Bill Jacoby	University of Missouri
Halil Kalipcilar	Middle East Technical University, Turkey
Yuki Kohno	Tokyo University of Agriculture and Technology
Teri Longin	University of Redlands
Alex Lopez	University of Mississippi
Mya Norman	University of Arkansas
Cigdem Oral	Istanbul Technical University, Turkey
John Pellegrino	University of Colorado Boulder
Paul Scovazzo	University of Mississippi
Takayuki Suzuki	Tokyo Denki University
Pat Terry	University of Wisconsin, Green Bay
Begum Tokay	University of Nottingham, UK
Doug Way	Colorado School of Mines
Stephanie Wettstein	Montana State University
Takeo Yamaguchi	Tokyo Institute of Technology
Miao Yu	Rensselaer Polytechnic Institute

Right, Rich and Susan in front of the Coliseum in Rome in 1986.

Below, Rich and Susan at Mount St. Michel in France, more recently.

other micro-scale devices, and has been licensed for use as a controllable metering pump.

As stated earlier, Rich met John Falconer initially in 1977. They became friends and running buddies for many years. John's background and expertise in heterogeneous catalysis did not overlap with Rich's research. However, eventually catalytic membrane reactors started to be discussed in both the membrane and catalysis communities. John and Rich saw this as an opportunity and obtained funding to study methane partial oxidation using this concept. During this project, they realized membranes were needed with much smaller pores than were available at that time, and that led them to pursue research on zeolite membranes. Their research group has synthesized several types of zeolite membranes on the interior of microporous alumina and stainless steel tubes. Various characterization methods were developed in collaboration with Professor Hans Funke. Highly selective separations for carbon dioxide/methane, organic isomer vapors, and organic/water liquids were obtained with zeolite membranes prepared in their laboratory.

Professor Doug Gin came to CU in 2001 with a joint appointment in the Chemistry Department and Chemical Engineering Department. Doug is an organic chemist with expertise in polymers and liquid crystals, and he was interested in preparing membranes using liquid crystals. At the same time, Rich became interested in ionic liquids. Rich had worked on liquid membranes and saw their limitations; a critical issue was liquid volatility. Ionic liquids have extremely low vapor pressures so they seemed like ideal materials for membrane applications. However, using ionic liquids as membranes did not eliminate

Rich and Susan attending a happy get-together with his side of the family.

the second limitation, which is liquid displacement from the support pores due to a pressure difference across the membrane. Doug and Rich teamed up to synthesize ionic-liquid polymer membranes for selective gas separations. Due to the charged nature of the ionic liquid polymer, ionic liquids can be incorporated into the polymer to make a composite material with excellent properties for a variety of applications. Their research expanded to study these materials as barriers against chemical warfare agents and membrane separators for batteries and electrochemical pumps. Based on Doug Gin's expertise, they conducted research using liquid crystals for membranes by forming self-assembled structures with uniform pores on the order of 1 nm. The resulting membranes perform better than conventional nanofiltration membranes based on size differences and as well as reverse osmosis membranes to reject charged species due to Donnan exclusion. These membranes can treat produced waters from "fracking" wells and also be used as separators in flow batteries.

SERVICE

Rich has provided service to AIChE, ACS, ASEE and other professional groups. He played a major role in the founding of the AIChE Separations Division and later served as a program director and chair of that division. Rich also served the same roles for the ACS Separation Science and Technology sub-division. For ASEE, he served in several roles for the Rocky Mountain Section as well as the Educational Research and Methods Division. He was a member of the organizing committee that formed the North American Membrane Society and later served as program chair for two technical meetings. He also was the chair for two Gordon Research Conferences: Separation and Purification, and Membranes: Materials and Processes. However, he is most proud of his community service. He has always felt that it is important for those who have benefited from society to give back. In 1988, he volunteered with a non-profit agency in Boulder called Voices for Children. This agency trains volunteers that work with juveniles who are in the legal system due to abuse and/or neglect. These volunteers work with lawyers, social workers, foster parents, and others, acting as an adult advocate for the child. Rich worked as a volunteer for several years for different children, including some difficult cases. He then participated on the Board of Directors for the agency, including a term as president. He has received four service awards, including the AIChE Institute Service to Society Award, primarily for his community service activities. This award has only been given 18 times in the last 30 years.

SABBATICAL EXPERIENCES

Rich has been fortunate to have taken sabbaticals and lived in Europe several times. While working at NBS in 1986, he spent six months in Rome working at an Italian national laboratory. He worked on various membrane applications including an artificial pancreas. He spent two sabbaticals at the European Membrane Institute in Montpellier, France, focusing on inorganic membranes. Anne Julbe was his primary collaborator, and they still maintain this connection; Rich has served on several Ph.D. student committees where Anne is the advisor, and these students have performed some of their research with Rich at CU.

For his latest sabbatical, he spent six months at the Paul Sabatier University in Toulouse, France. He received a Chair d'Excellence position from the regional government, and these funds allowed Rich to continue the collaboration afterwards. Three Ph.D. students from that university have done a portion of their research at CU. Pierre Aimar is his primary collaborator and friend, but he also works with Jean-Christophe Remigy and Jean-Francois Lahitte.

Rich has often stated that he has three objectives when living in a foreign country; learn the language (he speaks French), gain some professional experience, and visit the country to learn about the culture and the people. He and his wife have been fortunate to be able to obtain these experiences, and he continues his collaborations with his French colleagues. Susan also enjoys living in France and has become an excellent French speaker. Everyone comments that she has a much better accent than Rich.

Rich and John at the end of the Bolder Boulder 10-K race, above.

Rich and Susan after Rich finished riding Ride the Rockies, which is a weeklong bike ride in the Colorado mountains, right.

BIKING

Rich has a passion for bicycle riding. It started in graduate school at Davis as a means to commute and became a part of his life when he moved to Boulder. He commutes a few miles each way to the university most of the year by bike, and he has participated in many one-day and multi-day rides in Colorado. The one-day rides are 50-100 miles in length and the weeklong rides are usually 420-450 miles in total length. This includes daily climbs with 5,000 to 7,000 ft. of elevation gain. He likes to tell the story of one cyclist that he met on Ride The Rockies, a weeklong ride through the Colorado mountains. He had just turned 50 and thought that was a "big deal." He was halfway up a 10-mile-long climb when he stopped at a rest area and said hello to a cyclist who asked Rich his age. When Rich told him, his response was "You're just a kid. I am 75." Rich's response was "I hope that I can ride a bike when I am 75." He is getting there (now 71). He has ridden his bike many times in France and has done many of the climbs used in the Tour de France, although at a somewhat slower pace than the professionals.

SUMMARY

Rich made an excellent choice to become an academic, and he continues to enjoy this profession, particularly all the people he has befriended. Indeed, Rich officially retired from his full-time position as the Alfred T. and Betty E. Look Professor as of July 1, 2017, but he continues to direct research and co-advise graduate students and postdocs. It will be a while before he rides off into the sunset on his bike. ❐