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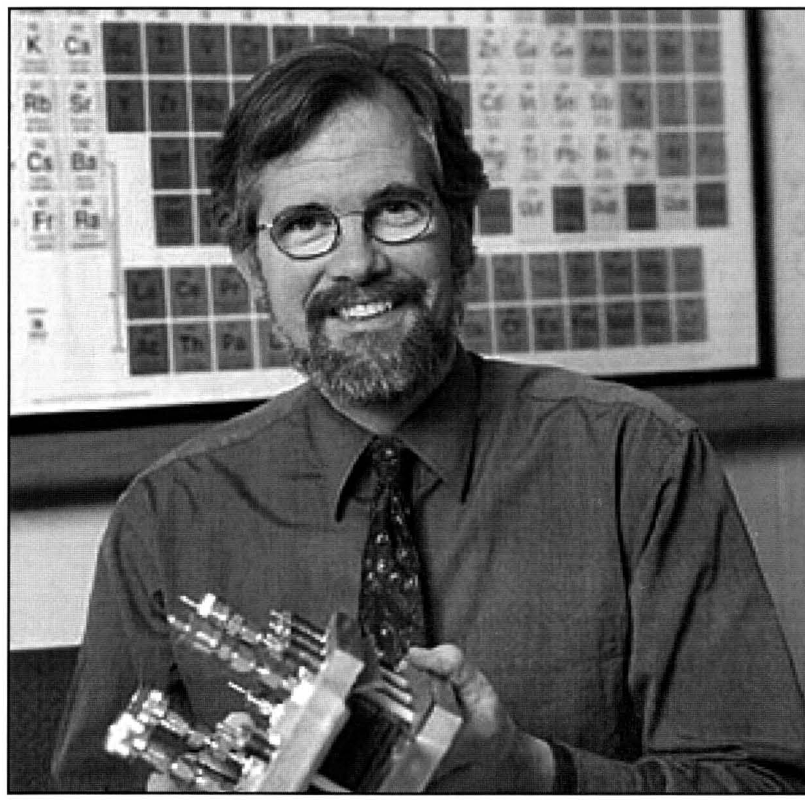


Eric is one of the few people I know who watches the Indianapolis 500 race. That's a legacy from growing up in Indiana.

He was born in Montana, but soon afterward his parents moved the family to the Midwest, living in Michigan, Wisconsin, and Indiana. It's typical of Eric that he retained his affection for that down-home pastime even as he embraced the intellectual challenges of studying the sciences and pursuing a professorial career. Eric has always been one to run his own race.

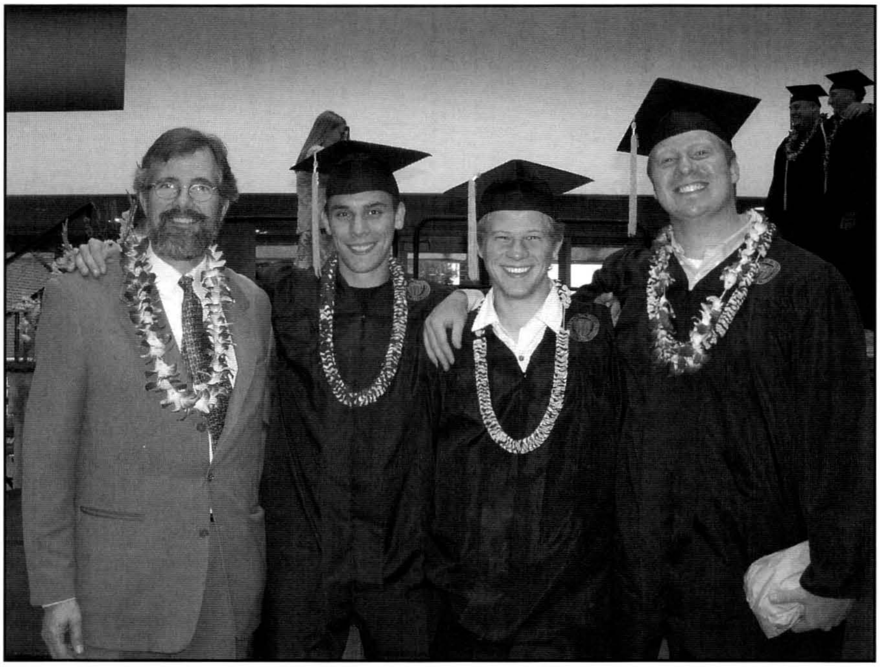
Since he was living in Milwaukee as a high-school senior, attending the University of Wisconsin, Milwaukee, was a natural choice. After one year, and upon the advice of Charles G. Hill, he transferred to the Madison campus, where he excelled. In preparing for graduate school, Eric was fortunate to receive good advice from the Wisconsin professors. Ed Lightfoot reviewed faculty at a number of schools and Hill, for whom Eric was doing an undergraduate research project, cautioned about getting involved in surface science as it was a lot of ultrahigh vacuum physics. It *was* good advice, but Eric had other plans.

Eric's research began at Stanford, where he worked with Bob Madix on surface reactions in ultrahigh vacuum on platinum and silver. He found the physics was fun. Following his Ph.D. (1984) he went to Berlin with an Alexander von Humboldt Fellowship in the Fritz-Haber-Institut der Max-Planck-Gesellschaft, and it was in Berlin that he met Monika, who was born and raised in East Germany. They wed in 1985, which was also the year Eric came to the University of Washington, where he is now chair of the Department of Chemical Engineering.

Eric is committed to involving students in innovative projects in both design and research, and he brings considerable enthusiasm, humor, and a fundamental understanding to all his interactions with the students.

TEACHING AND RESEARCH

With Eric, teaching and research are inseparable. Learning by teaching has served him well. He reports that, in his first year teaching the process design course, he learned to put



Eric and three very happy grads let loose with some leis following commencement ceremonies on campus.

into perspective what he did at the molecular level, helping him as an educator *and* researcher. Likewise, teaching his first course in graduate thermodynamics challenged him to make the homework problems relevant—and he suddenly saw how he could bring electrical engineering and chemical engineering to the course. Furthermore, he says, he had one of those eureka moments: "I could do this."

Thus spawned his work on high electric fields, which ran for 10 years and provided important data no one else had: A field ion microscope was used to study field-induced surface chemistry at very high electric fields (100 MV/cm); adsorption and reaction of water on sharp (10-100 nm) field emitter tips elucidated the basic ionization of water to hydronium ions and hydroxide ions induced by the electric field and the structure of water at the interface. This information is useful for rational catalyst design for fuel cells, understanding ice chemistry in oceanic and atmospheric environments (ozone hole chemistry), and development of ultra-capacitors for high-energy/high-power electrical devices.

As he began his research at the University of Washington, Eric branched out into electrochemical problems as well, providing the underlying support for his later work on fuel cells. While in Berlin, he had learned how to apply electrochemical concepts to surface reactions on metal electrodes immersed in liquids. He then built equipment that enabled comparison of electrochemical and gas-solid surface phenomena under nearly identical conditions. This helped elucidate the importance of potential in reactions at the fluid-solid interface. The electrode surfaces could be analyzed using thermal desorption, low-energy electron diffraction, Auger and X-ray photoelectron spectroscopy, and secondary ion mass spectrometry.

For his work, Eric was chosen as an NSF Presidential Young Investigator. Since his work was mostly done under high vacuum, he joined the American Vacuum Society (AVS) and, over time, became a director, trustee, and chair of the Investment Advisory Committee. In his work with investments, he taught the other scientists the concept of net present value, which—fittingly for Eric—he had learned by teaching the undergraduate design course. He is currently a fellow of the AVS.

FUEL CELL LOCOMOTIVE

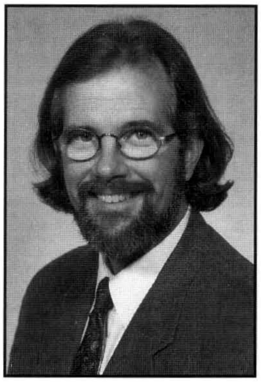
One day Eric and a professor from Aeronautics and Astronautics (Reiner Decher) came to see me in the chair's office. They proposed making a fuel-cell driven locomotive, amusement park size.

Eric's interest was in the fuel cell, and Reiner's passion was with trains. They explained that combining the efficiency of a train for transporting goods with the efficiency of a fuel cell would make an ideal system. As we talked, the image of having a small train circle Frosh Pond during Engineering Open House came to mind as a great crowd pleaser. Except . . . the thought of inexperienced undergraduates handling hydrogen in a venue with thousands of middle school kids was a scary one, to say the least.

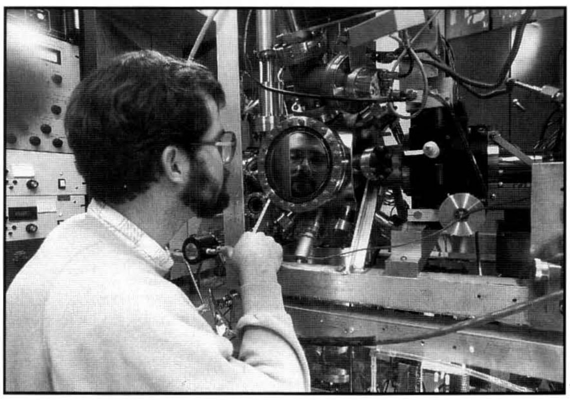
But Eric was undeterred, and had other ideas as well. Thus through his determination and vision was born one of the country's best centers for fuel cell education, now encompassing several professors and several courses—undergraduate and graduate, one of which is delivered as televised distance learning.

The goal of the Fuel Cell Locomotive Project (which began in 1996) was to produce a fuel cell system, fully contained, that could provide 10 kW of power at 100 V to a proton exchange membrane system. The fuel cell would be the prime mover for an 18-inch-gauge locomotive (one-third size) that would pull two passenger coaches.

Eric's plan to demonstrate the train setup at an Engineering Open House got the green light, and it became a combined project involving students and faculty from many dis-



Hey, long hair was in then, left. Eric and Monika on their wedding day in 1985, right. Eric's lab is a true reflection of his determination, below.



ciplines and two universities: the fuel cell chemistry interested chemical engineers; the special materials interested materials science students; the manufacturability interested mechanical engineers; and the applications interface interested electrical engineers. Through an NSF program, students at Penn State were also involved (in the 1997-98 school year). The students worked in groups, which required the development of communication skills and experience with teamwork. It marked probably the first time these students had been exposed to peer evaluation. It was also the first time most chemical engineering students came in close contact with students in other disciplines, at least at a high, working level. A key driving force that made the project fun was that it required the "hands-on" design of a complex system.

The chemical engineering and materials science students learned how to make and optimize a single cell, and then the chemical engineering students joined the mechanical engineering students to make a "stack," or several single cells connected in electrical series. This task required designing the flow field plates and seals, and dealing with the ever-present safety concerns. Along the way students built several versions of fuel cell test stands, ranging from small to large scale.

Eric's role as project leader was to integrate all these disciplines and coordinate with faculty in other departments. It involved a degree of risk since the outcome wasn't certain at the beginning, but Eric kept a global view and ensured that students learned something at each stage. While the mechanical engineers were way ahead in building the rolling stock for the train, the chemical engineers were learning that it is hard to build a fuel cell. The fuel cells worked, but they didn't provide enough power. Eric had the foresight to have students each quarter build on what was learned the previous quarter and improve it. In that way, progress was consistent and the students had a feeling of success in achieving their team goals.

As to my imagined fears at the outset, it turns out there was only one explosion (no injuries). And for good measure, the students were led through subsequent safety procedures to see that there was never another.

On top of his success in bringing the idea to fruition, Eric also learned how to guide such a project and avoid the end-of-quarter rush, which is very important to those schools still on a 10-week quarter system. In evaluating the experience, Eric says, "Students are over-confident and under-experienced." He notes the biggest problems were communication (as in the real world) and time management (as in the real world), but he was surprised at what they could do. The course is definitely good preparation for work after school!

By 1999, under Eric's steady steering, the little train project had gone from "I think I can, I think I can," to "I know I can, I know I can."

FUEL CELL COURSES

The classroom program began to blossom when Eric asked to teach his new fuel cell course on TV. I had been encouraging faculty to present more of their specialty courses on TV so that they could be taken by engineers who couldn't come to campus. When Eric committed to giving it a try, we had to rearrange the teaching schedule, with some faculty doubling up to cover his previously assigned load, but we managed and the course was a great success. Engineers in fuel cell

As evidence of Eric's inner drive, he insists on maintaining his regimen of bicycling to work even in one of the rainiest months in Seattle's history. It takes more than a few raindrops and puddles to steer these wheels off course.

companies on both coasts took the course on TV, and approximately 160 University of Washington students and 85 distance-learning students have taken the course since 1998. It also has been offered as a professional short course at three national meetings of the Electrochemical Society.

With all this experience to bank on, Eric was able to partner with colleague Dan Schwartz and get funding from the Dreyfus Foundation to integrate fuel cells into the chemical engineering curriculum. They put a fuel cell in the unit operations laboratory and created new courses. Eric had already partnered with Chevron, Apple Computer, and Boeing to provide a high-vacuum device for the undergraduate unit operations laboratory, where the students investigated Knudsen flow in conditions pertinent to the electronics industry. But Eric isn't satisfied with having students make things without also understanding them.

Two classes were developed, one a course for juniors in science and engineering (and for fuel cell professionals) and the second a more rigorous course for seniors. As with all his courses, Eric makes good use of PowerPoint slides that are colorful and appeal to students for later viewing. They also make it possible for Eric's graduate students to teach the class as a distance-learning course (as part of a Huckabay Teaching Fellowship).

Students frequently take the courses because of their desire to contribute to improving society. They often report that after the course, they appreciate how hard it is to make a fuel cell system work, and they also are perceptive in seeing the potential of fuel cells and recognizing that the public doesn't understand where the hydrogen is coming from. Since Eric attends conferences during the quarter, he comes back with real-life examples of fuel cells that demonstrate to the students that these are current topics and not just classroom lessons. As one student put it, "They are cool, very modern."

Lessons learned in the Fuel Cell Locomotive Project are applied in the fuel cell courses, too: design projects involve working with professors and other students, and developing a fuel cell system that incorporates constraints of size and functionality for real-life situations. As the courses proceed from year to year, the projects change to reflect what was learned previously. Since Eric is also now chair of the department, he shares the teaching load with Professors Dan Schwartz and Stuart Adler. The fuel cell curriculum has grown to include three faculty members and several courses. At the undergraduate level are Introduction to Fuel Cells, Fuel Cell Engineering, and Solid Oxide Fuel Cells. Courses at the graduate level are oriented to the scientific questions raised by fuel cells and other reactions on surfaces: Thin Film Science, Engineering, and Technology; Reactions at Solid Surfaces; and Electrons at Surfaces.

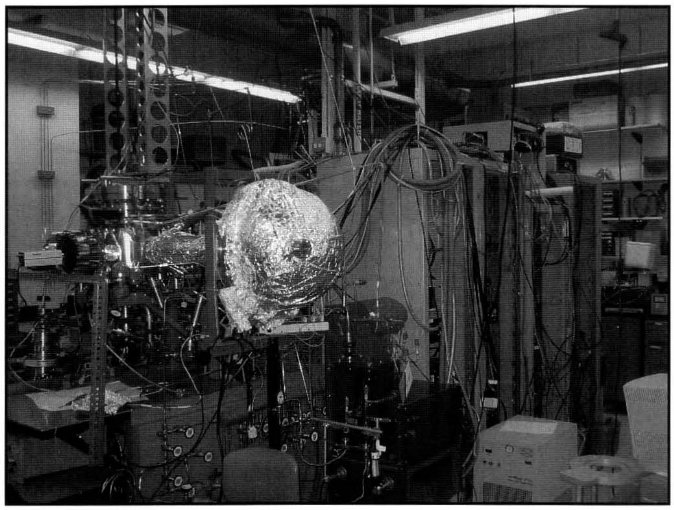
For Eric, the education program is a big part of his driving force. He says, "If we can't work with students, I don't see why we're here."

As a result of their experience in fuel cell projects, designs, and courses, many of our graduates have gone to work for fuel cell companies. Some were apprehensive about interviewing with such companies, saying, "But our fuel cell didn't work very well." In the course of their interviews, they found out that the companies' fuel cells didn't always work well either—and were hired!

REACHING OUT TO GRADUATE STUDENTS

Befitting his individualist nature, when graduate students start to work in Eric's lab, the first assignment he gives them is to watch the film *Dr. Strangelove*. It's his habit to advise his students on books to read, music to listen to, and movies to see.

After broadening the students' outlook on research, it's time to get down to work. New students quickly learn Eric's mantra for reading a technical paper is to read from left to right, stop at the end of each line, then see that you understand it before going on to the next one. He has new students read three to four papers, discuss them, and write a research proposal. This exercise sharpens their critical thinking skills and illustrates that the generation of new knowledge requires thought and hard work.



A look inside Eric's lab.

Students then begin working on a problem in his lab, possibly using the high-vacuum surface science equipment. As the work nears the point of publication, a draft is submitted, but it comes back covered in red ink. The laboratory holds a copy of Fowler's *Modern English Usage*, and students are expected to use it. Papers from Eric's laboratory don't have author lists as long as the abstract; you are expected to do the work yourself. As you might expect, some of his graduate students are getting a chemistry degree, and he teaches those students chemical engineering principles, too; he thinks everyone should know them! Eric believes in thorough preparation. His students are prepared for the future by writing and rewriting papers, and by presenting the work at conferences, always with a fundamental look at the problem. As you'd expect, Eric's Ph.D. students work predominately in companies dealing with fuel cells, electrochemistry, and surface science (see Table 1).

LAUNCHING A LAB

Sometimes a researcher will look around for a problem that can be solved with techniques and instruments he/she has available. Not Eric. He sees a problem and thinks how best to solve it, then proceeds. It was in this fashion that he built up his laboratory equipment to be the extensive lab that it is today (see Table 2). The philosophy does require creativity, though, since it often means learning a new area that one hasn't formally studied. Thus, the effects of high electric fields, ceramics (and solid oxide fuel cells), and linear density functional theory were things he learned in response to particular problems.

One example of this philosophy in action is how Eric's group was able to resolve a scientific argument. The background involves a focus of current research: namely, to determine the reaction mechanisms that occur at surfaces. A major application is direct methanol fuel cells (DMFC) for portable power and low-power applications. Teasing out the mechanism for the oxidation of methanol on platinum and platinum plus ruthenium requires careful work, often under high vacuum. Yet, the understanding is essential if DMFCs are to become widespread. Beginning with the Langmuir-Hinshelwood surface reactions, mechanisms are proposed and then experiments designed to determine the rate-controlling steps. Some researchers felt the reaction followed a parallel path, while others insisted it was a serial path. By elucidating four different controlling rates of reaction, Eric's group was able to determine that the previous findings in favor of the series path were the result of reaction conditions and catalyst modifiers (*e.g.*, ruthenium). Both sets of reactions are necessary, but local conditions determine which ones apply in any given situation.

Since fuel cells operate at temperatures above room temperature, Eric conducts studies at higher temperatures, too. More recently, work on solid-oxide-supported platinum catalysts supports the goal of fuel cells that run on diesel or other hydrocarbon fuels without having to reform the fuel to produce hydrogen. Copper-ceria electrocatalysts minimize carbon formation, thus avoiding the problems of nickel-based electrocatalysts. Solid oxide fuel cells have strong potential for use in transportation, defense, and industrial and residential applications.

The fundamentals of surface science have widespread application in other fields, too. The power of fundamentals was brought home to me one day when I was reading a paper about how polymers slip while being extruded, but the phenomena seemed to depend upon the type of surface. I asked Eric about that, and described some of the surfaces mentioned briefly in the paper. He proceeded to line them up for me, explaining which ones would allow slip at the lowest pressure drop, etc. Impressed, I called the author (at an industrial laboratory); the paper had not been completely forthcoming, but the author confirmed that the sequence Eric provided was exactly what was found in the laboratory.

ERIC AS CHAIR

Eric was appointed acting chair of chemical engineering in 1999 and soon became the permanent chair. One of the highlights of his chairmanship has been the preparation and execution of the department's Centennial, a celebration of the beginning of the department in 1904. It involved hundreds of people to organize, and Eric seems to have tapped into his student experience as an actor and techie to pull off the pageantry to the last detail. With Eric in the driver's seat, the event was carefully crafted to show off the department to alumni, the university, and ourselves. He reports he had the usual "opening night" jitters, but all the planning made for a memorable event. In the end, even his planning for contingencies got tested, as a thunderstorm erupted just as we were about to leave the luncheon to walk to the laboratories.

Eric enjoys hearing stories from retired alumni and values their friendships. In turn, alumni have been very generous to the department, and Eric loves the stories they tell about chemical engineering in the "early days." Chuck Matthaei (of Roman Meal Bread) has shown great interest in education and recently endowed a professorship. Neil Duffie (of Willamette Industries) knows what is important and challenges Eric to think strategically; Neil has been a longtime supporter of graduate fellowships.

PERSONAL CHARACTERISTICS

I have always valued Eric's creative side. If there is an idea to explore "outside the box," Eric is one of the people I want in the group. In addition to his comprehensive knowledge, his willingness to forge his own path means he has a knack of looking at problems in different, sometimes quirky, ways, and this spawns new ideas.

Eric is not all fuel cells and surface reactions, though. Well-known for his love of Gary Larson's *Far Side* cartoons, he has an endearing sense of humor that can defuse tense situations. His love of music is also well known: He and his wife Monika attend the opening night of Seattle Opera every year. Eric even drew upon his theatrical side at the departmental holiday party in December 2005, when he serenaded the attendees by singing "O Tannenbaum."

Further evidence of his well-developed nonscientific side is his practiced penmanship: Eric's mother was artistic, and Eric learned calligraphy—so well, in fact, that his wife requires a card done in the elegant writing style for birthdays and special events. The artistic streak carries over to Monika, as well, who has achieved "teacher" status in Ikebana flower arranging. She quickly learned the Japanese art and has even displayed her accomplishments at a Seattle show along with a Japanese master and his entourage.

The Stuves also enjoy traveling, and one benefit of Eric's fuel cell research has been an increase in opportunities to do so. A repeat destination is Bangkok, Thailand, as part of an exchange program Eric participates in with Dow Chemical and the Chemical Technology Department of Chulalongkorn University. During their last visit, they encountered a situation we all hope to avoid. As the plane took off from Bangkok, a bird flew into an engine and the pilot aborted the takeoff. In the process, a wheel caught fire, and the plane was evacuated at the end of the runway. While the plane was quickly emptying, Eric was concerned about his wife and son Kurt, who were also onboard. As if sliding down the chute weren't enough excitement, it took some time for the family to reunite. Then, more problems appeared. Since everyone had left their carry-on baggage on the plane, no one had their passport. Thus, they could not enter Thailand again while waiting for another plane the next day! Eventually, sanity occurred among the authorities, and the passengers were taken to a nearby hotel to spend the night. The next day the plane took off without incident, and Eric and his family returned to Seattle safe and sound, and none the worse for wear. Leave it to Eric to take such an unplanned "pit stop" in stride.

CONCLUSION

With his commitment to keeping students on the right track and his fundamental approach to problems, you might say Eric is the kind of chemical engineering educator who helps set the pace for our profession. Not bad for an Indy fan. ❐

TABLE 1
Stuve's Ph.D. Graduates

Naushad Kizhakevariam - Varian in Portland
Rod Borup - Los Alamos National Laboratories
David Sauer - Intel
Thomas Jarvi - UTC Fuel Cells
Timothy Pinkerton - Intel
Dawn Scovell - Intel
Suresh Sriramulu - Tiax Consulting (formerly Arthur D. Little)
Seng-Woon (David) Lim - UW Chemistry Dept.
Thomas H. Madden - United Technologies Research Center
Chris Rothfuss - U.S. Department of State
Nallakkan Arvindan - Symyx Corp.

TABLE 2
Equipment in Stuve's Laboratory

Differential Electrochemical Mass Spectrometer
Ultra-high vacuum (UHV) analysis chamber (4)
Potential step chronoamerometry
Linear and nonlinear electrochemical impedance spectroscopy (EIS and NLEIS)
Field Ionization/Emission Microscopy (FIM/FEM)
X-ray photoelectron spectroscopy (XPS or ESCA)
Low energy electron diffraction (LEED)
Thermal desorption spectroscopy (TDS)
Time-of-flight mass spectrometer (TOF-MS)
Auger electron spectroscopy (AES)
Contact potential difference (CPD)
Electron stimulated desorption ion angular distribution (ESDIAD)