A quest for fun

Dick Zare's career spans several scientific disciplines, motivated by a lively sense of curiosity and a love of adventure and entertainment.

"When I finished graduate school, I wasn't even sure I could make a living," says Richard (Dick) Zare of Stanford University. "But I knew I wanted to try, so I thought to myself, 'If I could, in my whole life, make just one entry into the Chemical Rubber handbook, that would be success.'" Well, Zare has achieved more than just an entry in the *CRC Handbook of Chemistry and Physics* (also known as the Chemical Rubber Company handbook). He's made it into Wikipedia.

Zare's CV is jammed with awards, honors, fellowships, honorary degrees, chair positions, and publications. His research on laser chemistry and chemical reactions at the molecular level put him on the map early in his career—he was inducted into the National Academy of Sciences in his mid-thirties. His lab's development of laser-induced fluorescence as a method for studying reaction dynamics has made a significant impact in analytical chemistry. Throughout his career, Zare and legions of his lab members have covered a wide-ranging array of problems in physical chemistry and chemical analysis.

They have even analyzed a 4.5-billion-year-old Martian meteorite that was discovered in Antarctica (*Science* **1996**, *273*, 924–930). In that meteorite, the investigators discovered polycyclic aromatic hydrocarbons concentrated around the rims of carbonate globules in the rock. The observation, along with others, led them to speculate that the meteorite carried possible evidence of fossilized remains of primitive Martian life forms. But Zare says he never claimed to have definitive proof for life on Mars, and the interpretation of the data remains controversial.

In doing all those varied research projects, "fun" has been Zare's modus operandi. "I'm totally opportunistic. I'm driven by a lot of curiosity, the sense of exploring things, adventure," he says. "It has to be fun."

COURTESY OF DICK ZARE

Zare's wife, Susan, took this photo of him in 2003 when they visited Toulouse University (France) so that Zare could receive an honorary doctorate. Zare struck the pose with the statue because "I could not resist the opportunity."

Jonathan Sweedler, who was a postdoc in Zare's group from 1988 to 1991 and is now at the University of Illinois Urbana–Champaign, recounts a recent time he invited Zare to give a seminar at the university. "He came into my office with another one of our assistant professors in tow and spent the whole time talking about science experiments he was working on, like pulling an egg with holes in it out of liquid nitrogen and watching it spin around. It was a blast for an hour. All we did was science demonstrations. When they left, my office was completely destroyed. But it was fun. That's Dick—whether it's doing an eighth-grade science experiment or something that deserves to be a Ph.D. topic, he's excited about science, and he's never lost that."

Others who studied with Zare confirm Sweedler's account. "His interests are so broad that he will embrace almost any project you can imagine," says Aaron Wheeler at the University of Toronto. Wheeler completed his Ph.D. thesis under Zare in 2003. "I've carried that attitude with me from his lab. It's a real gift."

The University of Michigan's David Lubman, who did his Ph.D. under Zare in the 1970s, credits Zare with teaching him the art of scientific wanderlust. "I have switched fields throughout the years. One thing Dick taught me is you have to be flexible. You have to look at the world and see what's realistic. You have to do what will work, [will] gain attention, is fundable, and will have impact," says Lubman. "Dick's been very flexible and able to change his opinions when needed and moved through the

fields. He once sat me down and gave me a lecture on being flexible because I still wanted to build chemical lasers!"

On mentoring

Zare credits his Ph.D. thesis adviser, Dudley Herschbach at Harvard University, for his no-boundaries attitude toward science. Herschbach has such a wide range of research interests that, Zare says, "Dudley is considered by some of the experimentalists to be a theorist and by some of the theorists to be an experimentalist!"

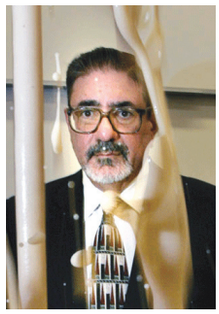
Former graduate students and postdocs remember the Zare lab of 30–40 members as a lively, congenial environment with Zare's imprint all over it. "One thing I appreciated very much was [that] he created a really nice atmosphere," says Daniel Chiu, who was a graduate student in the lab in the 1990s and is now at the University of Washington. "I don't know to what extent other big labs are able to develop a 'lab family' culture."

When Zare is in his office, he has an open-door policy. "He makes you feel important, and he cares about what you do," says Chiu. "If he was in the middle of something and I knocked on his door, he just stopped what he was doing and focused on me."

Lubman had a similar experience. "I remember one day an experiment just wasn't working. I went outside and sat under a tree," he says. "Dick saw me sitting there, dog-faced, and came out and started to try to get the enthusiasm going, saying, 'Dave, we've all gone through these moments.' He was very encouraging. There are always up and down times in grad school, but Dick was very good at keeping that enthusiasm going."

Science is an approximation

Today, Zare has a range of interests that would exhaust an investigator half his 60-odd years: high-throughput TOFMS to analyze both positive and negative ions in one instrument; ways to culture cells on PDMS for single-cell analysis; whether fullerenes reported on meteorites truly exist or are artifacts of analysis; and a way for cavity ring-down spectroscopy to work on large organic molecules. And this is just a sprinkling of examples.



COURTESY OF DICK ZARE

In 2006, Zare demonstrated during a lecture at Massey University (New Zealand) what happens when rock salt is added to a 2 L bottle of Coca-Cola.

Zare sees chemical analysis as a gating step to the progress that will be made in understanding living systems and developing new types of medicine. "I think people don't give [chemical analysis] the type of credit it deserves," he states.

But Zare is quick to point out that the nature of analysis is forever changing, so researchers shouldn't get hung up on a technique. "I'm right now very excited about mass spectrometry, still excited about lasers, all types of [analytical techniques], but to me, they're tools. They're not ends in themselves," he says. "We [in my group] are very much involved in inventing tools, and in that sense, I feel very much like a frustrated instrument maker. But it's a means to an end. . . . With new tools and measurement techniques, you can make advances in all types of fundamental problems."

Lubman adds, "Dick always encouraged us to question science because with whatever science we come up with today, it is only an approximation. With new technologies and methods, the measurements may yield different results."

Aflatoxins and analytical chemistry

The story of how Zare got into analytical chemistry illustrates his philosophy. "I was giving a talk at an ACS national meeting. A man by the name of Dr. Larry Seitz, who has since retired but was at the Manhattan Agricultural Test Station in Kansas, wandered into the wrong talk," recollects Zare. "There I was, talking about how sensitive a technique I pioneered called laser-induced fluorescence was for looking at reaction products, and I went on and on about how great it was. This fellow asked me, 'Can you detect aflatoxins?'"

Zare didn't know what aflatoxins were but confidently told Seitz, "If you can put it in the gas phase and it fluoresces, I can detect it." Zare's response didn't make any sense to Seitz because aflatoxins decompose in the gas phase. But he began corresponding with Zare after the meeting to impress upon him how important it was to detect aflatoxins.

"He started sending me papers about turkey X disease and all the poultry that died from aflatoxins, how there was a lot of moldy cereal of various sorts, and how it was a national threat," says Zare. "I read all this, and it started making me withdraw from peanut butter," which can also be contaminated with aflatoxins.

But the problem intrigued him. Zare recognized that aflatoxins wouldn't survive in the gas phase but realized that he could use fluorescence detection. "This led right away to the idea of trying laser-induced fluorescence detection of analytes that are separated in chromatography," he says. The result was one of the first papers published on the subpicogram fluorescence detection of analytes separated by HPLC (*Science* **1977**, *196*, 1439–1441).

Bubbles and beer

In the same vein, Zare's curiosity led him to Guinness beer. He wanted to know why bubbles grow in size and accelerate in a glass of beer. Initially, he thought it was a matter of pressure. But the bubbles readily double in size, and their volume goes up by a factor of 8. The pressure at the bottom of a beer glass is not 8× that at the top, so pressure can't be the explanation.

"It turns out to be a nucleation process where the supersaturated CO_2 in solution goes into the bubble and expands it," Zare says. "That launched me into the world of bubbles, which is fun. Then somebody wrote to me, 'Is it true that the bubbles in Guinness beer go down the side of the glass?' At first, I didn't believe it."

Zare's success is in stark contrast to his childhood. He nearly failed kindergarten. Zare says, "The only requirement for kindergarten was **you should be able to tie your shoelaces. I refused to** learn to do this because I had found if you waited long enough, other **people would tie them for you."**

Zare, along with a postdoc, Andy Alexander, began to do some experiments ("Yes, we drank too much Guinness," confirms Zare). With a high-speed camera, they could show that as a result of circulation of the liquid, more bubbles rose more rapidly in the center of the beer glass than on the sides. Because the liquid circulation is more rapid than the rising of the bubbles in Guinness beer, the bubbles appear to the observer to go down even though they are still rising. Now Zare is an expert on bubbles and has even appeared on National Public Radio's *Talk of the Nation* to discuss champagne bubbles.

Failing shoelaces and "See Spot Run"

Zare's professional success is in stark contrast to the stories he has told about his childhood. "I'm a person who nearly failed kindergarten in Cleveland, Ohio," he says. "The only requirement for kindergarten was you should be able to tie your shoelaces. I refused to learn to do this because I had found if you waited long enough, other people would tie them for you."

Almost failing kindergarten led to Zare actually failing reading in first grade. "I found they were doing the same story about 'See Spot Run', and I listened to it a couple of times," he says. "I have a strong memory, so if they called on me, I could continue the story anywhere. That's when they discovered I wasn't learning to read." The transgression soon landed him in the school psychologist's office.

Thumbing his nose at rules and boundaries has been a consistent factor in Zare's life. He describes himself as an "avid but poor" chess player. When his chessboard was confiscated in a seventh-grade study hall, he says, "I defied them and played a kind of chess with a friend without a chessboard called blindfold chess." The moves in the game are communicated by special notation. He adds, "Again, I have a strong memory, so I could play several games at once."

Today, despite the first-grade failure to read, Zare knows several languages. German is his second language, partially thanks to his admiration of a Professor Wolfgang Demtröder, who wrote extensively about laser spectroscopy. Zare first picked up German in college, where he discovered how an instructor with a misguided sense of humor could mar a class.

The German word "sehr" means very and sounds much like "Zare". "Unfortunately, the teacher thought it was terribly hilarious to call on me," recounts Zare. "He would call on me, and I would say something. He would either say 'sehr gut', which means literally 'very good,' or he'd say 'sehr schlecht', which means 'very bad' or 'Zare bad'. He thought this was very funny, and the first time, it was funny. But around the fifth or sixth time, it wasn't funny at all."

He also knows French and Latin. "I'm one of those people old enough that I had to take something like 3 or 4 years of Latin in school," he says. "What saved me from Greek was that the Greek teacher died, ending the program at my school."

Zare's philosophy

Given that Zare's interests are so broad, from single-cell analysis to bubbles, from meteorites to new instrumentation, one might be tempted to think that Zare doesn't have a sense of where to go next. But it isn't so. "It's very important to make plans. If you don't make plans, you're lost," he says.

But he is very careful not to become wedded to the plans because "life is a much more stochastic process than you might think. The important thing is to make a plan and then have the flexibility to change your plan when something else happens." ◥

—Rajendrani Mukhopadhyay