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BIOGRAPHICAL PROFILE

Kristin Shrader-Frechette: Confronting environmental injustice

Kristin Shrader-Frechette, photo taken 4-8-23

1 | EARLY RISK LESSONS, LOVE OF MATH, AND UNEQUAL RISK BURDENS

Few have had as many interesting and challenging early life experiences as Kristin Shrader-Frechette. She reflects from her childhood:

> Until I was about 9, when anyone asked what I wanted to be when I grew up, my response was always: "a flyer in the circus." Risk was part of our family life in Fern Creek, Kentucky, partly because of several-times-weekly travel to Louisville's Turnverein, the multi-story German gymnastics club where we took classes, went to practice, and appeared in Turner's April circus. Mom and Dad were a husband-and-wife gymnastics team. Two brothers were tumblers. I did trapeze and Spanish-web flying.
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> Dad, a near-sighted, thick-glasses, largely-self-taught mechanical engineer, gave me an early, but double-edged, love of mathematics, problem-solving, thus risk. His quiet, unstoppable curiosity was infectious, yet he also repeatedly said he'd never seen a woman who was "really good" at math.

Kristin says that just as her dad taught her to love mathematics, her mother first showed her how heavier risk burdens impact vulnerable communities:

> Childhood Sundays often meant family drives to Danville, Kentucky to visit Mom's two mothers: Lona, her White biological mother, hospitalized with severe encephalitis since Mom was three, and Catherine Jackman, her Black day-to-day mother. These visits introduced me to (what we now call) environmental injustice: White Danville had paved streets and indoor plumbing. As late as 1960, Black Danville (then called "Colored Town") had only unpaved dirt streets, backyard pumps, outhouses, and no running water.
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> Grandma Catherine, one of the first Black graduates of Danville's Centre College, was the most trusted employee in Grandpa's shop. When his wife's sickness forced Grandpa to bring his toddler daughter to work, Catherine cared for her, often taking Mom home with her, as Grandpa struggled to manage his business and visit his invalid wife. Soon Mom was living with Catherine and her bricklayer-husband John. She remained close to her Dad but grew up as Colored Town's only white resident.
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> Mom later became the first white member of the Kentucky NAACP. She was critical of both segregated schools and the much heavier chemical pollution in the largely Black Rubbertown or West Louisville. She and Dad also took all of us children with them in civil-rights marches, pulling my younger siblings in our red-metal Flyer wagon.
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> The Preface to my *Environmental Justice* tells how my parents' civil-rights work inspired my own environmental-justice (EJ) research (Shrader-Frechette, 2002). Until Mom was diagnosed with bone cancer, she taught high-school English in Louisville's poorest Black slum. Her death at age 45 was devastating.

In Louisville, Kristin attended an all-girls' high school. She says that because her all-female teachers were strong and brilliant, most with graduate degrees, she was in awe of them:

> My favorite, Mary Aquinas Connaughton, was a stooped-over, osteoporotic math teacher. She had a habit of bending her head, peering over her rimless glasses, and explaining precisely why a theorem was 'beautiful.' She loaned me math books over the summer.

A college math major, Kristin also studied physics with a Podolsky student (of Einstein-Podolsky-Rosen). She planned to teach high-school math for a year, then start a math doctorate. However, a philosophy professor made her an "accidental philosopher" by nominating her for a Woodrow Wilson National Fellowship—about which she learned only at the final-interview stage. She won the fellowship but had to use it to earn only a philosophy, not a mathematics, PhD:

> That's why I studied philosophy of mathematics/science, not mathematics. A Harvard PhD and former Bell-Labs researcher directed my PhD dissertation, on Shannon-Weaver information-theoretic modeling. Math was also part of the attraction of my abstract-algebraist boyfriend, now 49-year husband.

2 | KENTUCKY ENVIRONMENTAL-JUSTICE ISSUES

Eager to help raise her younger brothers and sisters after her mother's death, Kristin joined the University of Louisville faculty just as city public schools began 1975 integration. She said university faculty members organized, lining public-school, front-entrance walks:

> We hoped the food and rocks, thrown at incoming Black children, would hit us first. One of Mom's heroes, Pete Seeger, came to cheer us on, and integration seemed swift and largely peaceful.

> However, risk studies in three other Kentucky communities taught me that achieving justice there would be more difficult. Nuclear-waste-site-fenceline farmers in eastern Kentucky, Appalachian coal miners, and residents of mostly Black Rubbertown/West Louisville, showed me statistics are 'people with the tears wiped away,' as occupational-physician Irving Selikoff said.

> Small family farmers, with land abutting Kentucky's Maxey Flats nuclear-waste facility, were members of the first EJ community. They came to the university and asked for help, but they taught me more, especially about radiation risks. The nuclear dump was burying enriched uranium, plutonium-239, and other transuranics in 15-foot-deep, unlined, earthen trenches. The farmers claimed site managers were pumping radioactive-trench leachate downhill, onto their farms, killing their cows. The farmers may have been correct: A decade later, in 1986, Maxey Flats was named a US CERCLA site.

Hiking/scrambling in eastern-Kentucky mountains introduced me to a second EJ community: coal miners. I saw careless strip-mining, no required reclamation, denuded mountains, and muddied streams filled with coal sediment. Reading Whitesburg, Kentucky's *Mountain Eagle*, I learned 'big coal' routinely violated mine-safety rules, caused deadly methane explosions, intimidated miners, and threatened non-coal-controlled Appalachian newspapers like the *Eagle*.

After arsonists mysteriously fire-bombed *Eagle* offices in late 1974, a crime later traced to big coal, another UL-faculty member and I organized a bluegrass-benefit concert to buy a new printing press and get the *Eagle* back in business. Our concert poster had a muscular, lifted-up, coal-miner's arm, his open hand releasing an eagle. Its caption was the *Eagle's* bannerhead: 'It still screams.'

Students from a third EJ community, West Louisville/Rubbertown brought me into their neighborhoods, home to most city chemical plants, thus most city Blacks (including boxer Muhammad Ali and police-victim Breonna Taylor). They told me about their dirty air, lung and liver problems, and brought my husband and me to their jazz clubs. I also learned Rubbertown's BF Goodrich plant had just experienced three worker deaths from the same rare liver cancers. Yet in 1974 the company denied that its vinyl chloride was the culprit and claimed the deaths were the 'first time' it had any indication of vinyl chloride's 'potential danger' (Markowitz & Rosner, 2004).

This 1974 denial was critical to my later work for three reasons. *First*, it was my earliest exposure to scientific misrepresentation. Internal Goodrich documents show that beginning in the 1950s, members of the Manufacturing Chemists' Association, including Goodrich, made a 'secrecy agreement' to withhold their vinyl-chloride-research results. Yet Goodrich's 1959 internal confidential documents showed both vinyl-chloride associations with liver pathology and Dow's warning, that it was 'quite confident' then-allowed exposure

levels produced 'rather appreciable [worker] injury' (Sass et al., 2005; Moyers & Moyers, 2001).

Second, the 1974 misrepresentation was my initial introduction to the intractability of EJ problems: Half a century after the first three vinyl-chloride deaths, 2021 *Harvard Medical Review* authors were still reaffirming dire, US EPA air-toxics warnings about West Louisville (APCD, 2023; ALA 2022, 2023; Guilderbloom et al., 2021).

The Harvard analysis criticized Rubbertown/West Louisville chemical and coal-fired plants for having created 'one of the nation's unhealthiest, and most polluted, cities;' second-worst for air toxins among US mid-size cities; 'worse than…Detroit…and Louisiana's cancer alley'—so that West Louisville residents die 10–13 years prematurely and face up to four-times-higher rates of 'asthma, COPD, heart disease, and liver disease,' than other Louisvillians. This pollution has not improved, claimed the 2021 analysis, because of 'lobbying and million-dollar donations' from offending industries—who also orchestrated 'the sudden closure of environmental-justice programs at the University of Louisville' and their replacement with an industry-funded university center that issues 'numerous…false claims that levels of pollution in Louisville are improving.' Thus, west Louisville pollution, health harm, and misrepresentation continue today (Guilderbloom et al., 2021).

Third, as a new PhD, breathing the foul West Louisville air and seeing residents' (especially children's) health problems, drove me to try to help in the only way I knew how: to investigate whether any misused math/science/quantitative risk assessment (QRA) was used to try somehow to justify Rubbertown suffering and environmental injustice. Rubbertown is where I first discovered that most EJ-community harm is associated with some subset of QRA methodological flaws, subtle practices causing false-negative biases, practices that I eventually labeled 'special-interest science' (Shrader-Frechette, 2007).

Besides what Kristin learned from nuclear-waste-site-fenceline farmers, Appalachian miners, and Rubbertown Blacks, two other events (appointment to a US EPA coal-versus-nuclear study committee—and local plans to build a commercial reactor) led her to apply for three successive, US NSF-funded, risk-related post-docs, respectively, in economics, hydrogeology, and biological sciences.

3 | MATHEMATICS, QUANTITATIVE RISK ASSESSMENT, AND NUCLEAR POWER

Kristin says her first NSF-funded, or economics, post-doc helped her better understand coal-versus-nuclear economic risks:

> The economics post-doc taught me about risk-cost-benefit analysis (RCBAs), discount rates, values of statistical life, Arrow, Kneese, and also Roger Cooke. Cooke criticized MIT's classic 1975 nuclear-risk assessment and showed its subjective probabilities contradicted frequency data. When he checked reactor-accident numbers against MIT predictions for seven core-melt-initiating events, all seven frequency rates were outside MIT's 90%-confidence bands.

Roger Cooke reflects:

> Philosophers of the peripatetic school see science and philosophy as coterminal. When I migrated from philosophy to Safety Science in 1980, I was asked to represent the TU Delft Safety Science in the "Broad Social Discussion" over nuclear energy. I think it was Kristin's "Technology, Public Policy, and the Price-Anderson Act," Research in Philosophy and Technology 3 (1980) that prompted me to phone her for background and advice. Her help was invaluable and we've stayed in contact ever since. She midwifed my book *Experts in Uncertainty* and encouraged me at many points in my own peripatetic career. Not to say we always agreed; we co-authored all of one paper. Philosophers have their own code. It's not about agreement, it's about subjecting beliefs to merciless rational critique.

Kristin's second NSF-funded, or hydrogeology, post-doc led her to USGS-repository documents and earth-scientist/historian-of-science Naomi Oreskes, one of the world's leading climate experts. More than any other scientist, Oreskes also has shown that deliberate, corporate-funded climate and risk disinformation blocks public acceptance of science, especially climate science (Kenner, 2014; Oreskes, 2022, 2023; Oreskes & Conway, 2011). In coauthored *Science* pieces, Naomi and Kristin critiqued misused hydrogeological models and QRA transparency problems (Oreskes et al., 1994; Shrader-Frechette & Oreskes, 2011).

The third NSF-funded, or biology, post-doc introduced Kristin to population and medical biology, as well as

epidemiology; the landmark *Crisis in the Workplace*, by MIT chemist/attorney Nicholas Ashford; and the OSHA work of fellow-Kentuckian and toxicologist Eula Bingham.

Colleague Nick Ashford comments:

> During my 50 years at MIT, Kristin Shrader-Frechette's scholarship in the area of risk is the one whose commentary I would first go to for clarity and insight. She is clearly among the most relevant and precise risk scientists in the field. I also assign her work in my classes on environmental law, policy, and economics.

4 | SCUBA-DIVING EVIDENCE FOR NUCLEAR-REPOSITORY RISKS

During Kristin's Florida post-doc, University of Nevada, Las Vegas biologist Jim Deacon, a desert-fish expert, invited her to lecture in Nevada on the proposed Yucca Mountain nuclear-waste repository (Shrader-Frechette, 1993, 1996). Surprisingly, Kristin's trip-associated scuba dive, to help count desert fish, provided new information about Yucca Mountain repository risks, which she had been assessing for several years:

> Jim's invitation was an offer I couldn't refuse; he promised I could join two divers on the twice-annual population count of the Devil's Hole Pupfish, the endangered, iridescent-blue minnow (US FWS, 2011). I was excited; only species-count divers are allowed in Devil's Hole. After glacial ice retreated 10,000 years ago, Earth's rarest fish became isolated in this 500-feet-deep, travertine-walled, geothermal spring/cave near Yucca Mountain.
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> Getting into the hole was tricky; we put our tanks on our backs, regulators around our necks, fins and masks on our wrists; then grabbed rock toe-holds and hand-holds to climb down the two-story, almost-vertical, cylindrical-rock surface above the hole. Just above the water, we dropped in, back first. The 90-degree water meant we needed no weights and could descend by exhaling.
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> Surprisingly, my between-dives hikes unearthed Yucca Mountain risks: multiple nearby, groundwater-fed, desert springs. Yet repository proponents claimed the area would be 'dry for millennia'. Jim said that even Asian or South American earthquakes caused Devil's Hole water to churn, disappear, then rush back.

Kristin Shrader-Frechette: Kristin, at left, helping with the species count at Devil's Hole, near the proposed Yucca Mountain Nuclear Waste Repository. On between-dives hikes, Kristin was surprised to discover several groundwater-fed desert springs—evidence against the dominant QRA claim that Yucca Mountain would be "dry for millennia."

5 | QUANTITATIVE RISK ASSESSMENT AND RISK-COST-BENEFIT ANALYSIS

Kristin strongly defends economics, quantitative risk assessment (QRA), and risk-cost-benefit analysis (RCBA) but has frequently criticized their misuse:

> Apart from a *Science* piece on hydrogeological modeling (Oreskes et al., 1994), my 'Defense of Risk-Cost-Benefit Analysis' is my most-reprinted article, e.g., (Shrader-Frechette, 1998). For me, QRA/RCBA *methods* always deserve support because when they're employed well, they can help clarify complex risk problems. However, often these methods are misused (Shrader-Frechette, 1984, 1985, 1993). Many of my heroes, magnificent scholars like Adam Finkel, Sheila Jasanoff, David Michaels, Paul Slovic, and Lauren Zeise, have uncovered these misuses and oversimplifications. *Reductionistic misuses of QRA/RCBA* occurred mainly in the early days when assessors often reduced risk-acceptability to probability of fatality, then attacked the public's supposed 'irrational' rejection of allegedly low-probability risks like nuclear power or fracking (Shrader-Frechette, 1993).

Nonrigorous misuses of QRA/RCBA occur when modelers don't follow technical guidance. For instance, they fail to conduct sensitivity and uncertainty analyses, then present their anecdotal narratives/guestimates as science (Shrader-Frechette, 1984, 1993).

Financially-conflicted misuses of QRA/RCBA arise when assessors slant scientific methods toward special interests. For instance, they may defend less-protective, workplace-toxin standards by misusing Adam Smith's compensating wage differential, so as to claim that Smith shows higher wages compensate higher-risk jobs. Yet Smith postulated no crude risk-to-wages proportion. Instead, he warned: *if* people are 'free both to choose…[their] occupation' and 'to change it,' *then* 'the advantages and disadvantages of…different employments' tend toward equitable compensation (Shrader-Frechette, 1984).

However, poor, uneducated, low-skilled workers rarely meet Smith's if…then conditions; if not, high-risk employment can also be low-wage exploitation, e.g., (Shrader-Frechette, 2007). For instance, the US has used pesticides for nearly a century, yet two-thirds of US agricultural workers probably cannot give free informed consent to their pesticide risks, mainly because workers don't know these risks. Why not? Only California and Washington routinely monitor and report worker-pesticide exposures.

Frequently, *financially conflicted QRAs* threaten health because of false-negative (low risk) biases. These include using small-sample, low-power, or nonrepresentative sampling; incomplete studies; too-short tests; no environmental-justice analyses; contraindicated tests/methods/controls; subjective point estimates instead of risk ranges/distributions; no long-term, non-cancer, developmental, or morbidity studies; and statistical-significance tests of nonrandom samples, e.g., (Shrader-Frechette, 2008).

6 | SOLAR, WIND, AND WATER: CHEAPER THAN NUCLEAR

In 1967, the US Atomic Energy Commission predicted that by the year 2000, the United States would have 1000 nuclear power plants (IAEA, 2004). Instead, US reactors peaked at 104. What happened? Nuclear proponents say atomic energy is needed to fight climate change. However, Kristin argues that nuclear power is uneconomical, unneeded, and unsafe. A market proponent, she explains how *market data show commercial reactors are uneconomical*:

Asset-management-leader Lazard calculates that unsubsidized wind and solar-photovoltaic are now 4 and 3 times cheaper/megawatt-hour, respectively, than unsubsidized nuclear. Even after receiving 16-times-more subsidies, nuclear is still far more expensive than solar/wind. Since 2011 wind has been the cheapest source of new US utility-scale generating capacity, and since 2015 solar-photovoltaic has been the second-cheapest source (Bilicic & Scroggins, 2023).

Investors agree. Since 2012, most new US-electric-generating capacity has been renewables, including 84% in 2021. Between now and 2050, government predicts nuclear, coal, and natural gas will decrease massively, while wind and solar-photovoltaic will increase, so that renewables easily supply 80–90% of US electricity (US EIA, 2023; Geocaris, 2022).

US industry likewise agrees with Lazard. When the military began promoting Cold-War commercial reactors and their fuel cycles, in order to support its nuclear-weapons efforts, government asked US corporations to begin nuclear-generated electricity. All refused, dismissed reactors as uneconomical and warned of accident-caused bankruptcies (Shrader-Frechette, 1980, 2011).

However, government persuaded industry to change its mind, in exchange for three main taxpayer subsidies: below-cost, reactor-construction loans/loan guarantees; federal responsibility for commercial-nuclear waste (which alone avoids nuclear-electricity-cost increases of 600%); and protection from roughly 99.96% of accident liability. Thus by law, US nuclear plants must purchase market coverage for only about 0.04% of their accident liability (Shrader-Frechette, 1980, 2011).

Kristin also clarifies how market-actuarial data illustrate that nuclear energy is unsafe:

If one prorates costs of current-market, nuclear-liability insurance, needed to cover Chernobyl-level, $1.6-trillion accidents, the market price is an uneconomical *$2.3 billion* per nuclear plant/year, 12 times above total subsidized-reactor-electricity costs per plant, and yet Chernobyl was not a worst-case accident. These market-insurance rates presuppose a core-melt frequency 2400% greater than US Department of Energy (DOE) QRAs—which use subjective probabilities, not relative frequencies (Shrader-Frechette, 1980, 2011).

> Interestingly, current frequency data likewise suggest a higher core-melt likelihood, 2200% greater than DOE's QRAs predict. Five core melts have occurred in the US, three in reactors on the grid (in Harrisburg, Los Angeles, and Detroit), and two in DOE reactors supplying local electricity—in Idaho Falls and Arco, Idaho (Shrader-Frechette, 1980, 2011).

Kristin expressed skepticism about US DOE's 2022 claims, that US core melts, like Harrisburg (Three Mile Island), caused "no injuries, deaths or direct health effects," only "small" radiation releases (USONS, 2022):

> At least during and after the Los Angeles and Harrisburg core melts, radiation monitors went off-scale; for weeks, operators intentionally vented reactor-core gases into the environment, neither of which argues for 'small' radiation releases. Moreover, the consensus/National Academies' position is that any non-zero radiation dose is risky. That's likely why independent, university, case-control studies in France, Germany, Scotland, the US, etc, indicate reactor-associated increases in infant-fetal mortality, child leukemia, lymphoma, or brain cancers, despite no accidents, only allowed releases (Shrader-Frechette, 2011).
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> DOE's denial (of Three Mile Island health effects) also addresses only acute, not latent/later, exposure-induced, fatalities. As a result, it confuses no-adequate-testing with no-harm. Though no US core melts received full epidemiological testing, scientists from ATSDR, Cal-EPA, UCLA, Michigan, North Carolina, and other universities have published refereed, retrospective-cohort analyses alleging increases in fatalities, low-birthweight infants, infant-mortality, cancer (especially radiosensitive cancers), after the Los Angeles and Harrisburg core melts, e.g., (Kaltofen et al., 2021; Shrader-Frechette, 2011; Wing & Hirsch, 2006).
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> Even worse, problems stemming from US accidents like the 70-years-ago, Los Angeles core melt are ongoing for at least three reasons: *First*, despite the smaller reactor size, it released hundreds of times more radiation than Harrisburg did. *Second*, although US EPA mandated Los Angeles cleanup for 23 different radionuclides, blown miles away from the reactor, no cleanup has occurred—only continuing legal wrangling between government and the responsible parties. *Third*, within a 9-mile-offsite radius that is home to 500,000 Angelinos, 2021 tests showed radionuclides were still several orders of magnitude above background/allowed levels (Kaltofen et al., 2021).

Kristin also explains why nuclear energy is not needed to address climate change:

> Using expensive nuclear power diverts financial resources from cheaper, faster greenhouse abatement. Many consensus-position publications, including from the Academies and Stanford engineers, show that wind, water, and solar together can supply all US electricity, at/below current costs, without load loss—provided that smarter, faster grids integrate and distribute time-dependent loads with these least-cost-available renewables. Of course, the US grid and transmission lines need updates, but this remains true, regardless of the energy mix, e.g., (Geocaris, 2022; Jacobson et al., 2015, 2017; US EIA, 2023).

Emphasizing EJ to summarize her nuclear-related arguments, Kristin asks:

> If nuclear power is safe, why do investors (but not citizens) need liability protection? If it's economical, why must taxpayers subsidize 75–90% of nuclear costs, thus privatizing profits but socializing risks? Why do credit raters downgrade utilities with reactors (Shrader-Frechette, 1980, 2011)?
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> If atomic energy promotes environmental justice, why did the US District Court say commercial-nuclear policies violate due-process and equal-protection rights and discourage utility safety? Why did the court say these policies impose nuclear costs 'on an arbitrarily chosen segment of society, those injured by nuclear catastrophe' (Shrader-Frechette, 1980, 2011)?
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> I think *Forbes* has it right: 'The failure of the US nuclear-power program ranks as the largest managerial disaster in business history, a disaster on a monumental scale….Only the blind, or the biased, can now think that the money has been well spent' (Cook, 1985).

7 | ENVIRONMENTAL JUSTICE AT THE CORE

Kristin explains how she and scores of other pro-bono scholars, including sociologist Bob Bullard, worked with two Black communities to achieve the first major US environmental-justice victory:

> Just before Christmas 1994, while making a gingerbread house with our younger child, I

> received a phone call from Louisiana. Two impoverished, 97-percent-Black settlements in northern Louisiana wanted urgent scientific and environmental-justice analyses from me. Why? The US Nuclear Regulatory Commission had just issued a draft environmental-impact report (EIR), with only a four-week deadline for comments. A multinational corporation wanted to build a uranium-enrichment facility in their community.
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> Stealing time between family celebrations, my best Florida graduate student and I discovered the Louisiana EIR had no QRA and no RCBA, only unsubstantiated, deterministic risk and cost guestimates. It also attempted to defend an outdated, dirtier, 50-percent-costlier enrichment method than DOE uses; and it allowed massive, million-year-half-life, radioactive-waste piles to remain onsite in perpetuity.
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> We sent our comments to NRC, then organized our analyses into two different articles that we published in two different refereed journals. With other pro-bono scientists, we waited three years for NRC's decision. Bob Bullard and I were together on an environmental-justice panel in Australia when I received the news: NRC issued its first-ever license denial, partly because of "environmental racism." This was the first major US environmental-justice victory (Shrader-Frechette, 2011).

Shortly after coming to Notre Dame in 1998, Kristin recruited ND science faculty and students, then organized them into the Center for Environmental Justice and Children's Health. Its mandate? To respond to 10–15 annual EJ-community requests for pro-bono, university scientific help. Notre Dame also provided two free-tuition seats each year in Kristin's biological-sciences-credit, EJ course, both for southside-Chicago, EJ-community residents:

> That course, by far, has always been both the grad and undergrad favorite. It requires each student to choose her own project; respond with comments, by deadline, to a specific government-draft EIR, QRA, RCBA, or rule-making; and to work with the affected EJ community to do so.
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> Always the course has been a win-win-win. *EJ communities benefitted* from student comments that typically helped make environment-related projects more equitable, safe, and scientifically defensible. *Students benefitted* from doing science, not just learning it, and from intense, weekly, group interactions/criticisms that improved their projects. If they later worked with Center faculty, half of the class often achieved project-related journal publications. Most important, *democratic citizenship benefitted*; these projects 'vaccinated' students for lifelong, pro-bono scientific-EJ work—not just doing volunteer work that ignored their scientific skills.

Regarding Kristin's mentoring, Inmaculada de Melo-Martín, PhD, Professor of Medical Ethics, Weill Cornell Medicine, Cornell University, added:

> Kristin Shrader-Frechette's philosophical activity is an extraordinary example of scholarly work that offers not only rigor in argumentation but that contributes to making a difference in the world and nurturing democratic societies. The passion she exhibits in her scholarship is also reflected in her dedication to mentoring. Kristin's welcoming embrace when I came to study with her as a foreign graduate student was crucial to my decision to stay in the USA. As a mentor, Kristin was meticulous in her scholarly advice, prompt in returning drafts and comments, committed to the success of my career, and dedicated to my personal wellbeing. She has continued to be a professional and personal role model, always ready to help me when needed, always caring, always insightful. I wish all graduate students were lucky enough to have a mentor as fantastic as she has been to me.

8 | FOR YOUNG RISK ASSESSORS

Kristin's advice for young scholars:

> To young people—who want both to succeed professionally and to make a difference in the world, because of their QRA work—I suggest building a two-track *curriculum vitae*. The first, or theoretical, track is for prestigious research grants/top-journal publications/etc, that guarantee your professional pedigree. The second, or practical, track is for publications/pro-bono efforts that typically are less prestigious and easier to accomplish. Yet they more often address the needs of underserved communities, people who otherwise might have no assistance (Shrader-Frechette, 2012, 2007).
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> Often I think you'll find that your practical-track work enables you to do better QRA theoretical analyses. Practical work can improve the HOW of QRA in at least two ways. *First*, practical work can provide a new source of insights for reconceptualizing old theoretical problems and thus generating additional discoveries about

them. Recall the way that Pasteur's practical work, trying to help brewers and vintners stop their spoilage, gave him unique insights that lead to his revolutionary theoretical discovery, the germ theory of disease.

Second, practical-track work can generate a motivational WHY for the analytical HOW of QRA. My personal WHY is like that of pro-bono Innocence Project attorneys, working to overturn flawed legal analyses that condemn innocent inmates to death row. I try to discover misused math, science, or QRA methods that condemn innocent people, especially children, to disproportionate pollution, disease, and death.

Along with an esoteric love of math/science puzzles, this practical work keeps me still-jumping-out-of-bed-early each day. If you, too, can find a similar WHY that inspires you, I think your professional HOW will become almost effortless. It will become your passion, not just your job.

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