Visions of the Future

A Day in the Life of a Scientist

Earlier this year *Science* asked readers to imagine what life would be like in the year 2050. In Part III of a 4-part series we present the third installment of these fictional essays.

Technology Transfer

by RUTH KOHEN

I was trying to fit the PCR machine into a box, sweating, cursing, and wrestling with its bulky size as John emerged from behind his lab bench to bear silent witness to my efforts.

With a final shove, 65 pounds of multichannel thermocycler settled among DNA analysis chips, reaction tubes, and pipette tips.

Of course, I was officially entitled to the PCR machine, having rescued it from the junk pile and having dutifully filled out all 28 pieces of paperwork including the "Statement of Transfer of Laboratory Equipment Outdated More Than 25 Years into Private Possession, Form 2085," but that was about all that should make the university legal department happy about my efforts.

John had no idea that my thermocycler and I were bound for Hanoi, but ignorance would not save him from serving hamburgers for the rest of his life if he was seen lending a hand in my escape from the USA to the deregulated hills of Vietnam. He would be accused of assisting in International Transfer of Technology to Avoid National Regulatory Guidelines and summarily dismissed, never mind the outcome of any ensuing legal proceedings. University administrators were terrified of appearing forgiving of scientific misconduct lest they lose the air of uncompromising ethical rigor and the federal funding that went with it.

John was a decent guy, and I would never forgive myself if anything happened to him, despite his nasty habit of getting into my bootleg Bliss candy. Bliss candy was good for you. It contained all essential vitamins and minerals, had the calorie count of lettuce, and came in 38 different flavors of chocolate. The International Moratorium on Bioengineered Food outlawed its sale in Europe and North America and provided U.S. scientists with a strong incentive to attend international meetings.

Even the detractors of biological science vouched for its taste. "Not everything is Bliss," Greenpeace's posters had read as the mammoth trees and strangler vines reduced the capital of Brazil to jungle in spite of all efforts to contain them. Replanting the rain forest with recombinant vegetation had been a bit more successful than anticipated. I hid the half-eaten box of Bliss in John's –250°C desktop freezer as a farewell gift and looked around for more stuff to pack. John returned to his desk and frowned at his palmtop computer.

"How come it's my turn again to do our Accountability in Science Weekly Progress Report?"

"Because I am leaving and you actually believe in the merits of progress reports?" I offered.

"Oh, right." John looked at me like the sheriff who has been accidentally locked into a jail cell overnight with the cattle thief. "People should just pay their taxes and not worry about whether anybody uses their money to start World War III or permanently unhinge the global ecosystem. No need to monitor whether scientists behave ethically and responsibly, let's just give our trust blindly to anyone wearing a lab coat?"

"Not exactly," I hedged. "But there is such a thing as too much caution. With this many restrictions, regulations, and safety concerns, the American West would never have been settled."

Bad rhetoric move, I realized. John was gathering steam now. "And maybe, if our forbears had been more circumspect and worried about ethics, Native American culture would still be as vibrant today as it was back then. And slavery would not have happened. No 300-year legacy of heartbreak, racism, and poverty!"

I shook my head. "We are always smarter afterwards, John."

"Exactly!" He slapped his palm on the table. "But we could learn from our mistakes every once in a while, couldn't we? About how it really pays to think about what you are doing before rushing headlong into the next disaster. Over the past 100 years, science has become so much more powerful that the price of failure has gone way up. There may not be much of an 'afterwards' any more, after a really big mistake. Or there may be a really big heartache after a small mistake because somebody in a laboratory somewhere has just not been careful enough."

This was an old argument, and not just between John and me.

Most North American citizens would agree with John, and so, in the big questions of our time, the American public had come down firmly on the side of caution. It did not help that, in proportion to science's ever-expanding power, its particulars had become increasingly difficult to understand and that the average high school science courses were woefully inadequate to convey a solid foundation of knowledge from which anyone could make informed policy decisions.

While science had made people's lives increasingly comfortable and secure (motor vehicles had become accident-free after a series of software improvements pioneered by the Honda Auto Works), these same people had become less and less tolerant of hazards of any kind. Nowhere were the fears greater and the laws therefore more restrictive than in the area of biomedical science. The Federal Ban on Cloning, Replication, and Unauthorized Manipulation of Genetic Material was signed into law in 2036, shortly after the extended Human Genome Project, including functional analysis of all human genes, was officially declared a success. The ban had been heavily sponsored by the Religious Right who argued convincingly that if humans and all other living beings were the result of divine creation, we had no right to introduce changes into their genetic blueprints. Manipulating bacteria or transfecting isolated cells was theoretically still allowed, but required so much in the way of paperwork, permits, and approvals that it had become de facto restricted to a handful of intramural laboratories at the National Institutes of Health.

ILLUSTRATION BY ADAM MCCAULEY

I stuffed a few pages from my last futile grant application as padding around the PCR machine. Nowadays, the average grant proposal took a year to prepare and three more to get reviewed. All experiments and assays needed to be preapproved by the department head in conjunction with the Legal Advisory Committee to assure compliance with federal, state, and local regulatory guidelines. And biomedical science in the United States had slowed to a glacial crawl.

Now I was officially bound for a sabbatical at the University of Oregon. Unofficially, I was leaving the country. I decided to give John's and my perennial argument one last try. "You cannot avoid mistakes," I said. "No matter what the price of errors is, the only way anybody has ever been able to avoid mistakes is by doing precisely nothing or the same old thing over and over again. That's the fundamental flaw in our system. The less room for errors you allow in research, the less research actually happens. That is a direct proportional relation and the main reason why our work has not been going anywhere in a hurry." At the risk of sounding corny, I plunged ahead. "I really do believe that science is humanity's final frontier. I do want to know what is behind the next hill, just how life is put together from genetic blueprints and how they can be made do our bidding."

Before John could diagnose me with a God complex, Barbara from the lab across the hall stuck her head through the door. "Anybody care for lunch?" She was wearing her standard attire of a "Remember Kenya" T-shirt to announce to the world and sundry that she was a good and responsible scientist, not a cowboy like me. In Kenya, a new species of supposedly drought-resistant crops had been introduced in 2033. The crops were drought-resistant all right, but for some reason their nutritional yield was much lower when grown in the wild as opposed to the laboratory. Not only that, the plants secreted alkaloids into the ground, poisoning the earth they grew on and providing biologists the world over with the reputation of incompetent Dr. Frankensteins.

Environmental cleanup took about a decade. The relationship between Barbara and me was beyond repair, since I once, during a glazed-doughnut-induced sugar high, made the mistake of suggesting that the Kenya project had been a good concept. She glowered at me. "Where are you going?"

"Israel," I volunteered. Israel had become a land of employment opportunities for the adventuresome biologist, provided you did not mind working, eating, and sleeping in an airtight underground military complex and were not easily frightened by weekly threats of annihilation through germ warfare issued courtesy of Syria and Iraq. If you bought groceries in Tel Aviv, you had to present your vaccination card and get your monthly updated inoculations against anthrax 5.0, airborne AIDS, and whatever other terrors the region's rogue biolabs might be dreaming up at that moment. Israel's national defense program brooked no exceptions, so if you did not get your vaccinations, you did not get to take home your groceries either. Security at the Weizmann Biomedical Complex was rumored to make the Pentagon look like Disney World, which is probably why I had not passed my preemployment background check.

"Oregon." John hastily corrected my destination and hustled Barbara off to lunch before we could go on insulting each other. I had given up on the sandwich bar about six months before, when I found out that hunting for abandoned equipment was more exciting than the cafeteria chicken. The federally mandated security lockout of biological research facilities from 4:30 p.m. to 8:00 a.m. prevented adventurers like me from unsupervised nocturnal activities, but the noon hour was relatively quiet.

About 20 years ago, when the research use of radioactive materials had still been allowed, an unfortunate graduate student had spilled ^{3}H on a robo-petter and then tracked the contamination to an ultra-minicentrifuge. Regulations required that the contaminated equipment be stored in the laboratory for ten half-lives, even if the original spill had barely exceeded the background of naturally oc-

curring radioactivity. That meant that nobody was going to miss these particular items for the next century.

Better yet, they neatly fit side by side into my backpack. I still had to get past the metal detector in the building entrance, but that was where the thermocycler came in. I pushed the cart out into the hallway, past the rows of smiley-faced "Customer Service First" posters and to the bank of elevators. Waving a cheerful hello, I trundled up to the security monitor and brandished my permit. I flung my backpack on the box and pushed the cart between the metal detector plates. As expected, the thermocycler produced a big spike-and-ruffles pattern on the monitor, which effectively concealed the smaller wave profiles generated by the items in my backpack. I mailed off the equipment in a box of "miscellaneous household items" on my way to the airport.

Unfortunately, I was just one of many hopefuls eager to make it in the Far East. Scientists working in the laboratories of Tokyo and Kyoto University were raking in the Nobel prizes, but my chances for a Japanese work permit were about the same as winning the Washington State lottery jackpot. I could not even get a tourist visa. Not that I could have expected any pay even if I could have landed a job in Japan.

On Saturday evening, the red-light district of Tokyo was clogged with American postdoc taxi drivers chauffeuring around visiting businessmen from wealthy nations such as China, Taiwan, and India. The tax on revenues from enzymatic anti-aging creams patented to New Delhi Pharmaceuticals alone had been enough to pay for Calcutta's brand-new subway system. I had been very lucky to be offered laboratory space in a remodeled warehouse in Hanoi as part of a biomedical start-up venture, even if employment was conditional on my supplying my own equipment. At least there was an all-you-can-eat, calorie-free lunch bar in the building, so no matter what mankind's future looked like, I would be slim getting there.

The author is the grandmother of the story's protagonist. In 1988, she immigrated as a freshly minted physician from Germany into the United States. Now in Seattle, she became a psychiatrist and is now working in molecular biology research at the University of Washington and the Seattle division of the Veterans Affairs Puget Sound Health Care System. Her ambitions in life are to get a bigger cubicle and to find the cure for depression and bipolar disorder. R. Kohen, Veterans Affairs Puget Sound Health Care System, GRECC (182B), Seattle, WA 98108, USA. E-mail: ruko@u.washington.edu

This essay is a work of fiction. Names, characters, places, and incidents either are the product of the author's imagination or are used fictitiously. Any resemblance to actual persons, living or dead, events, or locales is entirely coincidental.

DATE: January 25, 2050

TO: Erin Bernstein-Wu, Ph.D., D.V.M.
EXPERT JUROR
Area of Technical Expertise:
AGRO-ENGINEERING

FROM: Morgan Freemont
Executive Director
EXPERT JUROR ADVOCACY

SUBJECT: **Appointment as Expert Juror**

by MARY ANN KRUG

Your application has been reviewed, your background check has been completed, and your credentials have been scored and verified. We are pleased to offer you an appointment as EXPERT JUROR in the area of AGRO-ENGINEERING.

Your appointment is created and funded through the provisions of the Prescott-Elliot legislation of 2046. Prescott-Elliot dictates that jurors be given access to technical experts when a preponderance of evidence presented in a criminal or civil trial is highly technical in content.

During the early development of commercial organ technology, $MHCII^-$ organs were cultured using classic techniques. Although this worked well in cases where the need for transplants was predictable, it did not work well in emergency circumstances. Additionally, sustaining organs in culture was labor-intensive, extremely expensive, and ultimately finite.