

Shaking Up Science

Two journal editors take a hard look at honesty in science and question the ethos of their profession

FERRIC FANG AND ARTURO CASADEVALL ARE AN UNLIKELY DUO.

They live a continent apart and barely speak on the phone. ("There were a couple of times that I failed to immediately recognize his voice," Fang admits.) Fang grew up in Los Angeles, the son of a doctor, and attended Harvard University. Casadevall fled Cuba for the United States at 11, was reunited with his family in New York, and never left. He enrolled at Queens College of the City University of New York because the first year there was free and worked at McDonald's and as a bank teller to earn spending money. "I never thought about a career in science," Casadevall says. "I didn't know you could get paid to do research."

Despite their differences, they rose on parallel tracks through the ranks of microbiology and immunology, running large labs and securing tenure and various accolades at the University of Washington, Seattle, (Fang) and the Albert Einstein College of Medicine in the Bronx, New York (Casadevall). They were acquaintances, having bumped into each other a handful of times, but nothing more.

Disenchantment brought them together almost 5 years ago. Their own achievements aside, the two had nagging worries about what they saw as an unwelcome transformation in academic science. Dis-

covery for its own sake was being sidelined by a push to publish in high-impact journals. Funding was scarcer than ever. Scientists focused on narrow fields and often couldn't communicate their professional passions at a cocktail party.

None of this is new. But Fang and Casadevall decided to try to do something about it—to recapture what brought them to science in the first place, the thrill of the chase, of being part of something bigger than oneself. They wanted to ask: Are we doing science the best way we can? And if not, what's in our power to change?

The partnership

"The 99%, the majority of scientists, are really driven by fear," Fang says. Wonkish and graying at the temples, he's sitting one November morning in a Philadelphia coffee shop with music blaring, steps from the University of Pennsylvania, where he's just given a talk on nitric oxide and bacteria. As often happens these days, the researchers with whom he met preferred to discuss something else: the toxic mix of pressure to score the next grant or the next publication, and high rates of bad scientific behavior, which Fang has been studying in depth.

Fang and Casadevall came together in 2008. Fang was, and still is, editor-in-chief of *Infection and Immunity*, a journal published by the American Society for Microbiology (ASM). Casadevall was an editor there as well. (He was subsequently asked to head up a new ASM publication, *mBio*.) "I realized that I had this privilege of writing opinion pieces," Fang says. "I started badgering my editors for ideas" about the state of science. "The one who stepped forward was Arturo."

The two quickly recognized a hunger for leadership in the area. One of their first commentaries, published in early 2009 and titled "NIH Peer Review Reform—Change We Need, or Lipstick on a Pig?" explored scientists' dependence on grants to pay their salaries and questioned whether proposed changes to peer review at the National Institutes of Health (NIH) would make much difference. "We started getting wonderful feedback about these essays," Fang says. "Very few people wanted to write a letter to the journal, but they were happy to write to [us]."

Arturo Casadevall

AGE: 55

OCCUPATION:

Immunologist and microbiologist

HOME INSTITUTION:

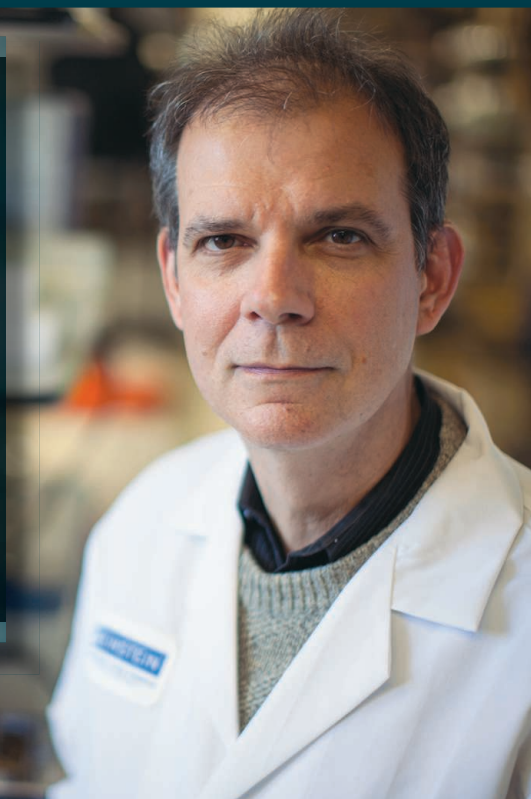
Albert Einstein College of Medicine in New York

EDITS JOURNAL: *mBio*

HOBBY: Reader of history

A FAVORITE BOOK:

Anna Karenina,
Leo Tolstoy



CREDIT: ALBERT EINSTEIN COLLEGE OF MEDICINE

One note came from Hawley Montgomery-Downs, a sleep researcher at West Virginia University in Morgantown. At the time, her tenure was contingent on securing two major NIH grants. She had submitted 10 failed applications in 3 years and was subsisting on number 11, a modest research award. "I have great results ... but no time to publish them," she wrote to Fang and Casadevall. "I am not an emotional person, but after reading your commentary I put my head down on my desk and cried. Your article confirmed all the rumors and affirmed that the situation is 'not just me.'"

Montgomery-Downs, who allowed *Science* to quote from her letter, told Fang in November that although she was awarded tenure, none of her grant applications since then had been successful.

Inspired by letters like this one, Casadevall and Fang kept pushing forward. As drafts of their editorials flew from coast to coast by e-mail, a deep friendship developed. "I found a great comrade in arms," Casadevall says over a recent brunch of eggs and toast at a diner near New York's Times Square. "Whenever there's a disagreement, I always defer to Ferric. He's always right."

"We really see eye to eye, but Arturo is the poet and I'm the prose," Fang says. Casadevall

massages the words, and Fang crunches the numbers. After several joint essays ruminating on peer review, basic science, and how research is character-

ized, Fang was working in his office early one evening when he received an unsettling e-mail that would send the two on a different path.

"We are writing to inform you that in regard to the manuscript indicated below, which was published in the [sic] *Infection and Immunity*, we found repeated use of the same figures within the manuscript as well as the use of figures used in other manuscripts," wrote a dean at the University of the Ryukyus in Okinawa, Japan. Unbeknownst to Fang, the university had been investigating dozens of papers by virologist Naoki Mori following a tip from another journal.

Infection and Immunity had published six of Mori's papers. Three more appeared in ASM's *Journal of Virology*. Digital data experts at ASM performed a pixel by pixel analysis of the figures and came to the same unfortunate conclusion as the university. Mori agreed to retract the papers.

Fang was shaken by the experience. The image manipulation was uncovered almost by chance—a peer reviewer for the journal *Blood* happened to recognize some figures as having been previously published, setting off an inquiry. Until then, Fang had operated under the assumption that science, as many like to say, is self-correcting. Suddenly he realized that probably wasn't the case. "There's a lot of science out there that hasn't been corrected," he now believes.

Still, many journal editors encounter research misconduct during their tenure. Why did the Mori case drive Fang in an obsessive new

Ferric Fang

AGE: 55

OCCUPATION: Microbiologist

HOME INSTITUTION: University of Washington, Seattle

EDITS JOURNAL: *Infection and Immunity*

HOBBY: Jazz musician

A FAVORITE BOOK: *Four Quartets*, T. S. Eliot



direction? "So what's wrong with me?" he asks, echoing the question back. "It's not with me. The problem," he says tongue-in-cheek, "is with Arturo."

The problem

Casadevall's worldview is shaped by his experience as a Cuban exile and gratitude for his own good fortune. His father, an attorney who spent time in a Cuban prison camp and was deemed unqualified to practice law in the United States, encouraged Casadevall to develop a trade that could transfer across national borders. When New York University admitted him off the waitlist to its M.D./Ph.D. program in 1979, he was startled to learn that the stipend he would receive was

Online

sciencemag.org

Podcast interview
with author
Jennifer Couzin-Frankel
(http://scim.ag/pod_6118).

greater than what he'd been earning at four jobs combined. He asked to enroll in June rather than September partly to start drawing that paycheck. The school agreed.

Like Fang, Casadevall began his scientific career full of idealism. But as time passed, he grew troubled by the reluctance of scientists to study how they perform their craft—the science of science, as it were. “We don’t look at our own belly button,” he says. There’s virtually no information about questions he considers critical to running an efficient research enterprise. Are prizes helpful or harmful to science in general? What’s the optimal size of a lab? How common is research misconduct?

Casadevall and Fang chose to tackle the last question first. And they hit upon a rich source of data to help them: the scientific literature, including a treasure trove of high-profile papers and retractions spanning decades.

The two first explored whether there was any connection between a journal’s impact factor—a ranking based on citations of papers published there—and its retraction rate. They speculated that the more prestigious a journal, the more likely scientists might be to cut corners, or even fudge data, to get their work published in it. They searched the biomedical literature database PubMed for retractions in journals with a range of impact factors and found a robust correlation. The pair published their “retraction index” in *Infection and Immunity* in August 2011.

They weren’t the first to uncover this connection, but the paper made a splash: The retraction index was republished in newspapers and magazines worldwide, including this one. In April 2012, *The New York Times* featured Fang and Casadevall’s work on retractions, further elevating their profile.

Their next project was more ambitious. The pair wanted to quantify scientific misconduct as best they could in the published literature. For assistance they recruited R. Grant Steen, a medical writer in North Carolina. Snatching time in airports, on airplanes, and after

that examined 21 surveys of research misconduct. Pooling the data, the author, an Italian researcher at the University of Edinburgh in the United Kingdom named Daniele Fanelli, concluded that 14% of scientists said that they knew of a colleague who had falsified data. About 2% admitted committing misconduct themselves.

The drivers

Fang and Casadevall have given much thought to what’s behind bad behavior. Both now detect signs of a system they consider flawed. For example, faculty applicants to their respective departments are invited for interviews only if they’ve been first authors on a publication in a high-profile journal. “We defer to the editors of *Science* and *Nature* to tell us what’s good,” Casadevall laments. These days, “you get a finding and the whole discussion is not about the finding, it’s where you’re going to publish.”

An underlying issue is funding. Fang’s father, a physician-scientist working in the 1960s, told him that back then, half or more of grants were funded. “He always felt that the challenge in science was science itself,” Fang says. “The level of competition has changed dramatically. ... If you talk to any student or postdoc, they’ll say the picture they’re getting, the name of the game, is to get money.” Sitting on promotion and tenure committees, Fang has watched colleagues pay “lip service” to teaching and quality of science, but the real yardstick is the applicant’s funding levels. In part, this is because universities now depend heavily on “soft money”—grant funding—to support their own infrastructure.

“The most productive scientists are still worried because they have a lot of mouths to feed,” Fang says. Fear struck him a few years ago when his own funding situation grew dire and half a dozen individuals in his lab were at risk of losing their jobs. They were saved—for the moment—by support from the federal stimulus package. “It’s all about money,” Fang says. “How can you be sure that you get money?” The answer comes back to publications—and sometimes skirting the rules to get them.

Fang began his journey with Casadevall thinking cheaters were inherently different from the rest of us. Now, he appreciates how a toxic environment can subtly encourage bad behavior. One influence has been the writings of Dan Ariely, a social scientist at Duke University in Durham, North Carolina, who studies cheating. “We have a tendency to point fingers, we have a tendency to identify some people and say, ‘These are bad people,’” Ariely says. But “it’s unrealistic to create a system that tempts people and expect them to behave very well.” Ariely cites an example from his own history: As a teenager, he was badly burned and spent years receiving treatment. One of his favorite physicians pressured him to tattoo the right side of his face to give the appearance of stubble, which had been erased by the burns. “And then I found out I was going to be the third patient in the paper,” Ariely says, and that the doctor needed a critical mass of volunteers in order to publish his research. “This was an amazing physician who took great care of me for 3 years, ... but at that moment, he wanted the paper out.”

This week, Fang and Casadevall published their latest missive in *mBio*: With Joan Bennett, a prominent microbiologist at Rutgers University in New Brunswick, New Jersey, they analyzed ORI reports to determine whether men were found guilty of misconduct to a disproportionate degree. At the senior level, the gender imbalance was dramatic. The three reviewed the ORI files of 72 faculty members,

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hours, they assembled an enormous Excel file of every retraction they could find in PubMed, more than 2000 dating back to 1977.

They cross-referenced many retractions with other sources, such as reports from the U.S. Office of Research Integrity (ORI), which investigates misconduct. The three attributed about 67% of all the retractions to scientific misconduct, including fraud and plagiarism. The results were published in October 2012 in the *Proceedings of the National Academy of Sciences*.

“We never anticipated that the problem was going to be so widespread, ever,” says Casadevall, who’d expected honest errors to explain the vast majority of retractions. “We need to clean up our act.”

Retractions remain rare, at about one out of every 10,000 papers. But “even a single retracted paper for fraud can be very damaging to the credibility of science,” Fang says. The actual problem rate is much higher.” Backing him up is a 2009 paper in *PLOS ONE*

and only nine of them were women. That's one-third of what one would predict based on female representation in the life sciences. Among trainees, the gap narrowed. Fang and Casadevall speculate that the inclination of male principal investigators to cheat tracks the increased likelihood of men to engage in risky behavior, well documented in the social science literature. Younger scientists—male and female—may cheat to please their boss, or because of pressure to arrive at certain results.

"Scientists love to think that they are totally objective," when in fact they're often not, Bennett says. "I think it's very important to look at these questions."

Fang and Casadevall admit that they're trapped in the system that troubles them. "I think it's crazy to focus so much on impact factors," Fang says. "But I have a postdoc right now who has a great story, and we're going to try to submit his paper to *Nature*. ... I see the rules as they are, and I'm not going to sacrifice his career." At the same time, the two are trying to modulate how they run their labs and mentor their students. Casadevall, ever the broad thinker, urges lab members to read widely outside their field. Fang has postdocs working on multiple projects at once, with the hope that something will pan out and they'll be under less pressure. Fang's partnership with Casadevall has also changed how he'd react to fraud in his own lab. If a trainee faked data, Fang says, "I would question myself, that I had failed strategically and not created the right environment for them, and they felt afraid of failure."

Despite the stresses they face, most scientists, of course, don't cheat. Even as Fang looks inward and contemplates sweeping changes to the system, he doesn't absolve individuals who succumb to its temptations. At ASM, Fang worried about trusting Mori's work in the future, and argued that he should be barred from publishing ever again in ASM journals. He was outvoted in favor of a 10-year ban.

The solutions

With every joint publication on the state of science—they have 14 so far—Fang and Casadevall see more hunger in the community to hash out these topics. Casadevall travels constantly. He spent parts of October and November in Michigan, London, Paris, and Chile. Everywhere, the conversation was the same.

Scientists, especially younger ones, "feel powerless," he says. "The older group is worried, surprised" by the misconduct findings.

Fang and Casadevall find themselves in increasing demand. Fang participated in a roundtable on scientific integrity last month at the National Academy of Sciences in Washington, D.C. Together they're writing an article for *Scientific American Mind* on cheating.

Fang and Casadevall have heard concerns from researchers that their work will be used to discredit science. It's been cited on anti-science blogs, like those questioning the safety of vaccines or the role of human activities in climate change. While they've considered the risks, "I think we need to have this conversation to try and make science better," Fang says.

Casadevall favors a more generalized science education, rather than the extreme specialization that now occurs in graduate school. An enthusiastic reader of history, he points out that in the 19th century and before, scientists such as Isaac Newton and Gottfried Leibniz were philosophers first and scientists second.

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—Arturo Casadevall

He's in discussions with Albert Einstein College of Medicine about "putting the Ph"—philosophy—"back in Ph.D.," and launching a graduate track that includes training in epistemology and metaphysics—or as Casadevall puts it, "How do you know what you know?" and "How much can you push your lab?"

He's also disillusioned by peer review, which he believes yields endless demands to add data to a paper without necessarily improving it. At the open access journal Casadevall runs, *mBio*, the rule is that papers are either accepted or rejected, period.

Fang and Casadevall know that they can't come up with all of the answers. Rather, their goal is to start a conversation and hope others identify solutions. "We have to somehow change the incentives," says economist Paula Stephan of Georgia State University in Atlanta. Her book, *How Economics Shapes Science*, examines the ways in which scientists and institutions compete for resources and rewards. "Historically, a lot of the criticism [of the scientific enterprise] ... comes from people outside science," says Stephan, who met Casadevall and Fang at a Health Research Alliance event in Washington, D.C., last year. Although she doesn't agree with them on everything, "it's very exciting when you see people like the two of them, who are editors of journals, really beginning to question the system."

Casadevall and Fang are shifting gears now, moving away from misconduct and into other issues that may prove tougher to tackle quantitatively. Casadevall hypothesizes that prizes are detrimental to science, because they foster a "winner take all" system and reward cut-throat behavior, rather than cooperation that might better advance knowledge. He is currently cataloguing all the Nobel prizes and assessing which were said to have left out potential awardees. Fang is considering using data from ASM journals to ask how often peer review changes the substance of a paper. "We are going to continue to take on question after question," Casadevall says.

Meanwhile, the two must stay abreast of their day jobs: Editing a journal each, running large labs, in Fang's case directing a bustling clinical laboratory, and in Casadevall's sitting on a national bio-defense advisory post. When Casadevall worries that he's stretched too thin, his 89-year-old mother, who lives in Queens, urges him onward. "She assures me there will come a day when nobody's going to invite me anywhere. ... She says to me, 'Don't turn down an invitation.'" He grins. "If my mom tells me to do it, I'll do it."

Then Casadevall, his glasses folded neatly and hanging from his shirt collar, turns serious. "I really do think that what Ferric and I try to do may be the most important thing I do in my life," he says. Others, he knows, will keep building the edifice of science. These two want to shake its modern foundations.

—JENNIFER COUZIN-FRANKEL

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—Dan Ariely,
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