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Crisis or self-correction: Rethinking media narratives about the well-being of science

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After documenting the existence and exploring some implications of three alternative news narratives about science and its challenges, this essay outlines ways in which those who communicate science can more accurately convey its investigatory process, self-correcting norms, and remedial actions, without in the process legitimizing an unwarranted "science is broken/in crisis" narrative. The three storylines are: (*i*) quest discovery, which features scientists producing knowledge through an honorable journey; (*ii*) counterfeit quest discovery, which centers on an individual or group of scientists producing a spurious finding through a dishonorable one; and (*iii*) a systemic problem structure, which suggests that some of the practices that protect science are broken, or worse, that science is no longer self-correcting or in crisis.

scientific news coverage | scientific narratives | narrative | framing scientific self-correction

Because the news media not only affect the extent to which we think about a subject (1) but also how we think about it (2), and in the process can bolster or undermine trust in science (3), there is value in understanding the storylines characterizing news accounts both of science and of the scientific community's responses to concerns about such matters as failures to replicate consequential findings (4, 5) and the rise in the rate of retractions (6). After documenting the existence and exploring some implications of three news narratives about science, this essay suggests ways in which scientists and journalists not only can avoid fueling an unwarranted "science is broken" or "in crisis" narrative, but also can more accurately represent the nature of the discovery process and hold scientists accountable for addressing identified failings.

Factors affecting an audience's inferences about a message include its members' cultural identities (7) and biases (8), the context in which the message is embedded (9), and cues in the message itself (10). The likelihood that news consumers will conclude that science is unreliable will increase if: accounts of flawed or fraudulent science are more prominently featured than those of science's successes; a problematic instance has particular salience to the audience; partisans who share the audience's ideology signal that a specific case reveals that scientists have been corrupted by self-interest or ideological dictates; or news conventionalizes a science is broken or in crisis storyline in which self-correction is no longer an honored norm.

Of interest here are three news narratives that embody assumptions about the current state of science: (*i*) quest discovery, with the plotline showcasing scientists producing knowledge through an honorable journey; (*ii*) counterfeit quest discovery, with the narrative concentrating on scientists producing spurious findings through a dishonorable one; and (*iii*) a systemic problem structure that suggests that either science itself, some discipline within it, or some of the practices that protect it from human foibles and counterproductive institutional incentives are no longer functional (Table 1). These three narratives do not exhaust the ways in which news covers science but rather focus on storylines relevant to the reliability of science as a way of knowing.

The "Quest" Analogy in Science

Journalistic use of a quest structure to convey scientific advances is unsurprising since from *Gilgamesh* and *The Odyssey* to *The Lord of the Rings*, the quest, as W. H. Auden noted, is "one of the oldest, hardiest, and most popular of all literary genres" (11). As playwright and Nobel Prize-winning chemist Roald Hoffman demonstrates here, the notion that the process of discovery in science is itself a quest is not a new one:

> [The] paper tells how a much-desired molecule was made for the first time in the laboratory. All the elements of a heroic epic are there—a quest, and in the parts of the paper not shown, battles with the elements, obstacles galore that must be overcome, and in the end, deserved success. . . (12)

Indeed, one of literature's classic quests, the search for the Holy Grail, can be found in scholarly articles ranging from the discovery process involved in understanding the structure of proteins (13), DNA barcodes (14), anxioselective anxiolytics (15), and electromagnetics (16) to kinship influences on behavioral discrimination by Columbian ground squirrels (17).

Unsurprisingly then, quest discovery pervades media coverage of scientific discovery and is the template shaping textbook accounts of the history of science, as well. The structure is also conventionalized in instruction about the scientific method and in scholarly publications, in which the literature review situates the quest in context, the statement of problem and justification of significance establish the importance of the journey, the disclosure of method charts the means used to pursue the desired knowledge, the results section indicates the extent to which the search was successful, and the discussion of limitations telegraphs next steps.

Storyline One: Scientist/Science Produce Discovery Through Honorable Quest

In storyline one, a scientist or group of scientists who arrived at the featured finding are central characters; their search is a process of surmounting challenges; knowledge is their goal and, when achieved, characterized in quest terms, such as "advance," "path-breaking," "a breakthrough," or "discovery." Humankind is the beneficiary. And throughout, science is reliable, scientists trustworthy, and the scientist's report accepted as a faithful account of the search.

Evidence that quest/discovery is a popular optic pervaded *Time*'s publication "100 New Scientific Discoveries: Fascinating, Momentous, and Mind Expanding Breakthroughs" (18), which one could find stacked alongside the tabloids at checkout counters in the winter of 2017. Like the *New York Times'* Tuesday "Science Times," that special edition of the long-lived news weekly was targeting the four of five Americans who report interest in "new scientific discoveries" (19).

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Table 1. Three science story structures in news

Focus of story	Storyline	Object of blame (B)/credit (C)	Main characters
1. Quest discovery	Honorable quest (discovery process)	Individual or group of scientists (C)	Protagonist (C) exemplary scientist/s
2. Counterfeit quest discovery detected and retracted	Revelation of and responses to dishonorable quest (counterfeiting process)	Perpetrator (B) who deceived	Perpetrator (B) caught by Protector of science (C)
		Protector (C) who detected deception	Journal/Editor/Peer reviewers (C/B)
		Journals/institutions that are part of problem (B), solution (C), or both	Institute/University Rep (C/B).
3. Systemic problem	Expose problems	Systemic structures (B)	Problems
		Such as peer review	Scientists identifying problem(s) (C)
		Routine misuse or misapplication of statistics	And if the storyline becomes problem-solution: Scientists/ Institutions offering solutions (C)
		Competitive pressures incentivizing norm-violating practices	Scientists/Institutions thwarting solutions (B)

Year-end reviews of science tell of discovery gotten through quest as well. So, for example, breakthroughs in gene editing, artificial intelligence, and scientific detection of gravitational waves were featured in the subheadline (20) of *The Wall Street Journal*'s roundup of the top science stories of 2016. Where the *Christian Science Monitor* touted "Seven outstanding scientific breakthroughs in 2016" (21), *Wired* featured 16 breakthroughs, including: no long-term health issues among the four descendants of Dolly the sheep, the first mammal to be cloned; virtual reality and brain training helping paraplegics walk; and the approval of the first human CRISPR gene-writing trial (22). Each of these instances testifies that the science underlying it was reliable.

News outlets' selections from the flood of scholarship portray science as not only a valuable way of knowing but also as one that produces results beneficial to humankind. Of the 60 scholarly articles Altmetric credited with the most press pick up, May 2016 through April 2017, nearly half (23) focused on scientific findings related to human health and well-being (three coder agreement, Krippendorff's α: 0.84), 13 featured studies elucidating human or animal ancestry or the past of the earth (α: 0.81), one-sixth reported the results of animal studies with implications for human health and wellbeing (α: 0.83), and one-twelfth detailed discoveries about the extraterrestrial universe (α: 0.93).

The only widely covered science article during this 2016–2017 period that did not detail a valued discovery was the May 2016 one in *BMJ*, titled "Medical error—The third leading cause of death in the US" (24). Nor did any of the leading 2013 and 2014 nightly news storylines on science and technology focus on counterfeit discovery or science as broken or in crisis [see table 7-1 of the 2016 National Science Foundation's General Science and Engineering Indicators (25)].

To determine whether news framed the past year's most frequently covered scholarly publications as quests/discoveries, we coded whether the following elements appeared in the resulting coverage in *USA Today*, *The Wall Street Journal*, *The New York Times*, and *The Washington Post*: a discovery; the words "breakthrough," "advance," "path-breaking," or "paradigm shifting" in the headline or first three paragraphs; a finding characterized as a breakthrough, advance, or their synonym anywhere in the article; the significance of the finding; scientists, institutions or laboratories; past failures or false starts; inquiry as ongoing or a forecast of future research (Table 2).

Although the quest/discovery story is consistent with the process recounted in scholarly publications, lost in the narrative are "the complex intellectual and social intricacies that more correctly characterise the generation of knowledge and understanding from the study of natural phenomena and laboratory experiments" (26). Instead, the quest/discovery plot line inaccurately implies that the path to scientific knowledge is foresighted and the outcome inevitable. Underplayed by it are the false starts, disproven findings, and dead ends that characterize the investigative process. One explanation for these omissions is the preference of humans in general and reporters in particular for uncomplicated narratives with an easily telegraphed dramatic arc (27).

Storyline Two: Scientist Produces Counterfeit Discovery Through Dishonorable Quest

What the quest and counterfeit quest narratives have in common are discovery, quest, and a focus on a specific inquiry rather than on the scientific enterprise writ large. They differ insofar as welcomed knowledge is the outcome celebrated in the former and a repudiated error or a deception-driven finding the object condemned in the latter. Instead of forsaking the quest narrative, counterfeit quest ones chronicle the activities of a deception purveyor who has gulled custodians of knowledge, such as journal editors and peer reviewers.

The resulting news stories follow a sequence evident in the headlines about the retractions of the work of Haruko Obokata, who reported having developed a method of developing pluripotent stem cells, known as stimulus-triggered acquisition of pluripotency (STAP) cells:

> "Study says new method could be a quicker source of stem cells," *The New York Times*, January 9, 2014 (23);
>
> "A breakthrough for science—And young Japanese women," *The Wall Street Journal*, February 3, 2014 (28);
>
> "Prestigious Japanese research institute regroups: Riken weighs whether to retract some stem-cell studies," *The Wall Street Journal*, March 11, 2014 (29);
>
> "Haruko Obokata, who claimed stem cell breakthrough, found guilty of scientific misconduct," *Newsweek*, April 1, 2014 (30);
>
> "Electrifying stem cell finding retracted," *Boston Globe*, July 2, 2014 (31);
>
> "How Japan's most promising young stem-cell scientist duped the scientific journal *Nature*—and destroyed her career," *Washington Post*, July 3, 2014 (32);
>
> "Stem cell scandal scientist Haruko Obokata resigns," *BBC News*, December 19, 2014 (33).

Table 2. Quest/discovery in news on top covered science articles (May 2016 to April 2017; $n = 141$)

Discovery/finding	Scientists/institution credited	Significance noted	Breakthrough/advance anywhere	Specified discovery words early	Failure/false start	Future/ongoing inquiry
$\alpha = 1.0$	$\alpha = 1.0$	$\alpha = 1.0$	$\alpha = 0.89$	$\alpha = 1.0$	$\alpha = 0.84$	$\alpha = 1.0$
128	123	125	62	34	20	87

As these headlines suggest, the reporting on a counterfeit quest overwrites the original discovery story in a predictable sequence that tracks the response of the relevant scientific communities. A credible challenge to a highly publicized finding is covered as a controversy. News accounts then chronicle investigations of the questioned work and, if flaws are admitted or confirmed, the journal's statement of retraction. When fraud is uncovered, the media relay how the perpetrator has been punished, often by losing an academic appointment. Although both types of withdrawn science are called "retractions," the media storyline for inadvertent error does not carry a key element involved in stories of deliberate deceit or fraud: punishment of the perpetrator.

At three points in the retraction process, news accounts are open to incorporating evidence of scientific critique and self-correction at work. The first exists at the detection stage, when the actions of those who identified the problem can elucidate the ways in which scientific norms facilitate the identification of error. The second occurs when institutions involved in the investigation or who funded the research report on plans to prevent comparable instances. The third emerges at the point at which the journal that published the discredited work explains the reason for retraction and announces changes to forestall similar problems.

Because they are among five cases tagged as particularly problematic by the National Academies of Sciences, Engineering, and Medicine's 2017 report *Fostering Integrity in Research* (34), I will illustrate ways in which self-correcting actions were integrated into media reports on the Obokata transgressions and on those of Anil Potti of Duke University, who supposedly discovered a way to match a person's lung cancer tumor to the most suitable treatment. Unlike the Potti case, which involved multiple retractions from journals over an extended period, the Obokata one, which was the most heavily covered of 2014 (35), involved a retraction by a single journal, *Nature*.

Both illustrate the individualizing blame structure of the counterfeit discovery narrative: in the Potti case in a *New York Times* article titled "How bright promise in cancer testing fell apart" (36) and a *60 Minutes* headline, "Deception at Duke: Fraud in cancer care" (37). Both also illustrate how detection as self-correction and the institutional correctives can be fit into a counterfeit quest media narrative.

The *60 Minutes* piece opens by reminding viewers of the importance of the supposed discovery. Here, Potti and his home institution are protagonists:

> Five years ago, Duke University announced it had found the Holy Grail of cancer research. They'd discovered how to match a patient's tumor to the best chemotherapy drug. It was a breakthrough because every person's DNA is unique, so every tumor is different… [M]ore than a 100 desperately ill people invested their last hopes in Duke's innovation (37).

As the counterfeit discovery storyline develops, discovery is recast as deception and the protagonist in the original narrative as its perpetrator:

> In 2010, we learned that the new method was a failure. But what isn't widely known, until tonight, is that the discovery wasn't just a failure, it may end up being one of the biggest medical research frauds ever—one that deceived dying patients, the best medical journals and a great university (37).

Eventually the knowledge stream is cleansed and the perpetrator punished: "In the end, four gene signature papers were retracted. Duke shut down three trials using the results. Dr. Potti resigned from Duke" (36).

The factor responsible for transforming quest/discovery into retraction/punishment in the Potti instance is research by two MD Anderson biostatisticians. As the pieces on *60 Minutes* and in *The New York Times* attest, these scholars "kept finding errors [in Potti's work] that they thought were alarming" (37). Importantly, science's culture of transparency facilitated their access to data and hence their failed efforts "to reproduce Duke's results" (38). Incentivizing their critique was the competition among medical institutions eager to generate consequential knowledge and its rewards.

The same self-correcting culture was on display in the exposure of Obokata's deceptions. As an account in *Science* notes, "the claims started unraveling within days as bloggers and contributors to the PubPeer website started noting problematic images and plagiarized text. Researchers around the world started reporting that they couldn't replicate the results" (39).

In both the Obokata and Potti cases, news noted the search for fixes. Of the latter, *The New York Times* reported that "the National Cancer Institute and the Institute of Medicine… hope to find new ways to evaluate claims based on emerging and complex analyses of patterns of genes and other molecules" (36). In the Obokata case, *Nature* managed to export its intent to self-correct into a number of news reports. A subheadline in *The Wall Street Journal*, for example, proclaimed: "Journal is reviewing internal procedures for vetting papers" (40). In like fashion, the *New York Times* observed that *Nature* "said steps were being taken to improve the rigor of reviews of submitted papers" (41).

Some news accounts even quoted the *Nature* statement directly. After noting that "the lauded scientific publication *Nature*" was "reviewing its method of vetting submissions," an article in *The Washington Post* added (32):

> *Nature* as well says it has "considered" what lessons it can draw from retraction. In its statement, it concluded it "could not have detected the problems that fatally undermined the papers." That said, it plans to amend some of its policies to better discern "image manipulation… Our policies have always discouraged inappropriate manipulation. However, our approach to policing it was never to do more than to check a small proportion of accepted papers. We are now reviewing our practices to increase such checking greatly."

What the Potti and Obokata media coverage also illustrates is that retractions of widely publicized findings do not inevitably spawn news accounts suggesting that science is broken or in crisis (35). Instead, blame is attached to the offending individual and, in some cases, to the institution that promoted and benefited from the discredited discovery as well.

Science Is Broken Is an Overgeneralization

Before exploring the factors driving the systemic problem storyline, let me pause to argue that the notion that science is broken is a generalization unwarranted by the available evidence, including that which shows a failure to replicate key studies, a rising rate of retractions, and problems in widely accepted forms of statistical inference. Because evidence that these problems are widespread is largely limited to a few areas of inquiry and not documented in the rest of science, broad brush indictments are at best overgeneralizations.

Nor does the offered evidence warrant an across-the-board dismissal of the integrity of the disciplines that have elicited concerns. Instead, as is conceded by the authors of the report about the failed Amgen attempts to replicate oncology studies, "These results, although disturbing, do not mean that the entire system is flawed" (42). The authors add: "There are many examples of outstanding research that has been rapidly and reliably translated into clinical benefit" (42).

Since each discipline has been the subject of large studies documenting failures to replicate some key findings, let me argue that the current state of neither psychology nor oncology justifies the conclusion that that area of science remains broken or in crisis: psychology, because self-corrective action is underway, and oncology for the existence of at least one significant course correction and for its demonstrated ability to continue to produce consequential work.

Oncology. Two studies capsulize the case that biomedical science and, more specifically, cancer research are broken. In 2011, scientists at Bayer HealthCare reported that of the findings of 67 projects (most from oncology), only ~20–25% were "completely in line with our in-house findings" (43). A year later, Begley and Ellis reported that over a 10-y period, Amgen was only able to replicate 6 of 53 "landmark" findings in cancer biology (42). One problem with these revelations took the form of the irony involved in alleging that an area of science is failing to satisfy one scientific norm—self-correction—by using evidence that violates another: transparency. To protect their financial interests, neither group revealed which studies failed to replicate, making it impossible for other researchers to assess the fidelity of the replications.

However, even as this controversy was raising questions about the integrity of cancer research, scientists were demonstrating that they could harness the body's immune system to attack cancer. In 2011, the Food and Drug Administration (FDA) approved an immune checkpoint blocker to treat advanced melanoma (44). And in a paradigm shift, cancer immunologists showed that they could reprogram a patient's own cells to attack a lethal cancer, acute lymphoblastic leukemia (45), a process approved by the FDA in 2017 (46). The first person to begin this gene therapy was a girl described in an Associated Press article as "near death" when the treatment began in 2012 (47). By August 2017 she had been cancer-free for 5 y, a remarkable quest/discovery narrative tracked from 2012 to 2017 by *NBC Nightly News* (48). Importantly, as the Associated Press noted, of 63 advanced patients, 83% went into remission (47).

Without underplaying the work still needing to be done to surmount the challenges facing science, we might do well to remember that the girl's treatment started as the Bayer and Amgen failures to replicate were eliciting headlines alleging that cancer research was broken. And importantly, in the interim, by issuing principles for preclinical research "intended to enhance rigor and further support research that is reproducible, robust, and transparent" (49), the National Institutes of Health took a major step toward minimizing unreplicable work.

Psychology. Headlines, including *The Atlantic*'s "Psychology's replication crisis can't be wished away" (50) are grounded in identified but long-ignored problems. Among them, for decades, psychology disregarded evidence showing that its research was underpowered (51–53). Indictments of null hypothesis testing and *P* values were rationalized away as well (54, 55). Such inaction warranted "broken, uncorrecting" and perhaps even "crisis" characterizations, and the inference that such terms were more realistic than histrionic.

Prompted in part by a rhetoric characterizing psychology as "broken," "in crisis," or characterizing areas of inquiry within it as a "mess" (56), self-correction finally ensued within the last half decade. Journals began requiring that methods and data be accessible. Preregistration sites were established and data repositories created. Places to post and publish replications opened. Replication efforts were marshalled. At the same time, once festering problems are being addressed in places able to transform practice. In 2015, *Basic and Applied Social Psychology* declared that it would no longer publish work reporting *P* values (57). In that same year, the editor of *Social Psychological and Personality Science* announced that "because the statistical power of a study is strongly related to its likelihood of being replicable, we will expect authors to plan studies with adequate statistical power. . . or to explain why this standard should not apply to their study. If a study has a simple design. . . and is underpowered, it will have a high chance of being rejected without review" (58). And, in 2016, the American Statistical Association published principles "underlying the proper use and interpretation of the *p*-value" (59). Such changes justify a shift from crisis characterizations to those scrutinizing solutions.

Storyline Three: Systemic Problems (Science Is Broken/in Crisis)

If science is to be self-correcting, scientists must uncover problems that threaten its integrity, identify and implement remedies, and ensure that remedies accomplish their desired ends. Because rigorous problem exploration (e.g., systematic large-scale efforts to replicate important work) is the necessary first step in this chain of activities, it is evidence not of a systemic breakdown or of an area of science in crisis but of the first step in honoring the integrity-sustaining norm of self-correction. Unless the flaws are inherently uncorrectable, or documented problems tolerated, the process should produce remedies.

Nonetheless, the systemic problem headlines indict science in general [e.g., "The replicability crisis in science" (60); "Big science is broken" (61)] and specific areas of inquiry in particular [e.g., "Cancer research is broken: There's a replication crisis in biomedicine—and no one even knows how deep it runs" (62)].

Before exploring the factors prompting the systemic problem storyline, let me reiterate a point made earlier: scientists uncovered the featured problems and are implementing responsive actions. However, neither phenomenon is heralded in *The Economist*'s headline "Unreliable research: Trouble at the lab. Scientists like to think of science as self-correcting. To an alarming degree, it is not" (63). Self-corrections noted in that provocatively but inaccurately titled essay include the Reproducibility Initiative, "through which life scientists can pay to have their work validated by an independent lab" (63), *Nature*'s checklist for authors (64), and *Perspectives on Psychological Science*'s sections devoted to replication (https://www.psychologicalscience.org/publications/replication).

Because those whose work is prominently cited to certify that science is broken [Ioannidis, Oransky, Begley, and Nosek among them (4, 6, 64–67)] are spearheading efforts to solve identified problems, their work is evidence of the resilience of science. The titles and subtitles of their work confirm their intent: "Improving the standard for basic and preclinical research" [Begley and Ioannidis (4)]; "Is there a retraction problem? And, if so, what can we do about it?" [Marcus and Oransky (6)]; "Restructuring incentives and practices to promote truth over publishability" [Nosek et al. (67)].

However, that focus is buried in a problem-focused news narrative. "John Ioannidis has dedicated his life to quantifying how science is broken," reads a *Vox* headline (68). "Science journals screw up hundreds of times each year. This guy keeps track of every mistake" declares another *Vox* piece (69), this one reporting on the work of Ivan Oransky and Adam Marcus, founders of Retraction Watch. The problem frame dominates headlines about efforts to document flaws in science as well in the form of messages, such as "Science, now under scrutiny itself" (70), "Misconduct widespread in retracted science papers, study finds" (71), "Many scientific studies can't be replicated. That's a problem" (72), "Study delivers bleak verdict on validity of psychology experiment results" (73), and "Studies show many studies are false" (74).

In such accounts, scientists are portrayed as publicizing problems, not proffering solutions. So, for example, a 2015 article in *The Atlantic* says that some psychologists "have created an informal movement to draw attention to the 'reproducibility crisis' that threatens the credibility of their field" (75). Reports on these efforts are eliciting crisis characterizations as well. Writing about Nosek and Errington's January 2017 publication, "Reproducibility in cancer biology" (76), a BBC science correspondent states, "Science is facing a 'reproducibility crisis'..." (77). What is rarely featured in such news accounts is the fact that these scholars are not simply indicting, but are as well working to implement correctives.

Factors Contributing to the Systemic Problem Storyline

Among the factors fueling the crisis narrative in news and opinion pieces are use of catastrophizing language by scholars, drawing attention to problems, and a problematic survey of scientists.

Scholarly Work Is Eliciting Crisis/Broken News Accounts. My conclusion that problem probing by scholars is prompting negative media headlines about the state of science is based on two pieces of evidence: Altmetric found that Nosek and his colleagues' paper, "Estimating the reproducibility of psychological science" (78), was the fifth most reported on and discussed in 2015; and scholarly studies and opinion pieces by scientists were noteworthy in the results of a search of the news databases Nexis and Factiva (April 14, 2012 through April 14, 2017) for headlines with "science" near any one of the following terms: "crisis," "broken," "problem," "self-correction," "retraction," "replication," "peer review," "scandal," and "fraud/fake."

That search located 121 articles and opinion pieces. After duplicates and unrelated stories were discarded, each of the surviving 76 pieces was coded to determine whether it: (*i*) was based on a newly reported scientific finding; (*ii*) was authored by a scientist; (*iii*) noted that science is self-correcting and reported at least one solution to the identified problem; or (*iv*) indicated that the problem was not real or exaggerated. The same piece could be placed in none, some, or all of these categories.

As Table 3 shows, 41% focused solely on a new scientific finding, 34% were authored by a scientist, 29% included mention of science as self-correcting (or included a comparable statement) and recommended at least one solution, and 7% indicated that the existence or extent of a problem in science was exaggerated.

By employing crisis language to add urgency to their case for change, scientists license such characterizations in news. In a *Wall Street Journal* essay drawn from his book bearing the systemic problem title *Rigor Mortis: How Sloppy Science Creates Worthless Cures, Crushes Hope, and Wastes Billions* (79), National Public Radio science reporter Richard Harris argues that "Scientists point to what they call the 'reproducibility crisis'—that is, studies whose results can't be duplicated and are untrustworthy if not invalid" (80). Only after this attribution does Harris remove the quotation marks to write: "Dealing with the crisis, which has been in evidence for more than a decade now, has become a priority in the field [of biomedical research]" (80). "I'm actually not convinced it's a crisis," Harris told an interviewer. "What is new is scientists are increasingly aware of these serious problems. That's actually good. Nobody wants science to spin its wheels, and recognizing a problem is the first step toward solving it" (81). Harris is not the only journalist who attributes crisis language to scientists. Writing in the (Canadian) *National Post*, a columnist observes: "In *The Guardian* last week, Jerome Ravetz, considered one of the world's leading philosophers of science, reviewed what he and many others describe as 'the crisis in science'" (82).

Consistent with Harris's conclusion, each of the following essays was penned by a scientist: "The crisis of big science" in the *New York Review of Books* (83), "The statistical crisis in science" in *American Scientist* (84), and "What caused the reproducibility crisis?" in *The Conversation* (85). And in *The Guardian*, a scientist wrote, "I believe the problems discussed here are a crisis for science and the institutions that fund and carry out research. We have a system for communicating results in which the need for retraction is exploding, the replicability of research is diminishing, and the most standard measure of journal quality is becoming a farce" (86).

A "Survey" in *Nature* Says Scientists Think Science Is in Crisis. Also feeding the science is broken/in crisis generalization is a survey that National Public Radio's Harris cites to justify his conclusion that "My sense is most scientists perceive there's a problem (and that's backed up by a 2016 poll in *Nature*)" (81). An editorial in that scholarly outlet about the poorly designed study on which Harris relies (87) answered the question "Is there a reproducibility crisis in science?" by saying: "Yes, according to the readers of *Nature*" (88). However, those variously described as "researchers," "scientists," and "readers" were not a random sample of verified scientists but, rather, *Nature* readers who responded to an emailed questionnaire. Their answers were pooled with those of individuals who responded to an ad posted "on affiliated websites and social media outlets" (87).

To complicate matters further, the study's (87) questionnaire primed the very crisis it reportedly uncovered. Instead of giving respondents the chance to respond either yes or no, and asking a follow-up question of those replying in the affirmative, one question ("Is a 'crisis of reproducibility' something you have heard of before, as an issue in science?") offered six options: (*i*) "Yes, from the mainstream media"; (*ii*) "Yes, from scientific journals"; (*iii*) "Yes, from discussions at conferences"; (*iv*) "Yes, from discussions with my colleagues"; (*v*) "Yes, from elsewhere (please specify)"; and (*vi*) "No."

The posted questionnaire (87) gives no indication that the alternative answers to the next question were rotated. They, too, invite respondents to confirm a crisis. "Which of the following statement [sic] regarding a 'crisis of reproducibility' within the science community do you agree with?": (*i*) "There is a significant crisis of reproducibility"; (*ii*) "There is a slight crisis of reproducibility"; (*iii*) "There is no crisis of reproducibility"; (*iv*) "I

Table 3. Science-related broken/crisis articles (April 14, 2012 to April 14, 2017; $n = 76$; reliability established by three coders using Krippendorff's α)

No. focused solely on new scientific finding	No. authored by scientist	No. saying self-correcting and giving solutions	No. indicating problem is exaggerated or not real
$\alpha = 0.85$	$\alpha = 1.0$	$\alpha = 0.72$	$\alpha = 1.0$
31	26	22	5

don't know." Unsurprisingly, since that answer had been effectively primed, 52% responded that "Yes, there is a significant crisis of reproducibility."

Integrating Needed Elements into the Narrative

Four principles should guide journalists' and scientists' communication both about discovery and about mistaken, flawed, and fraudulent science and corrective responses: (*i*) supplement the quest discovery, counterfeit quest, and systemic problem narratives with content that reflects the practice and protections of science; (*ii*) treat self-correction as a predicate not an afterthought; (*iii*) link indictment to aspiration; and (*iv*) focus on problems without shortchanging solutions and in the process hold the science community accountable for protecting the integrity of science.

Integrate Content That Reflects the Practices and Protections of Science into the Quest Discovery, Counterfeit Quest, and Systemic Problem Narratives. In scholarly and popular publications and in media interviews, scientists and journalists might productively consider the following moves. Flesh out the quest discovery narrative to include the trial and error involved in the process of discovery. Elaborate the counterfeit quest discovery story to feature the ways in which science detects and protects itself from deception and implements correctives when flaws are revealed. Do not shortchange solutions in articles addressing problems and where appropriate feature solution-seeking in headlines. [So, for example, recast "The replication crisis in psychology" (89), which includes a section titled "Solutions to the problem," as "The replication crisis in psychology and what can be done about it."] Characterize the identification of problems as part of science's commitment to self-correction and focus attention both on efforts to solve problems and on asking whether solutions are working. In the process, reserve dire characterizations of the state of science as a whole, or specific disciplines within it, for those instances in which integrity-threatening problems are being ignored.

Treat Self-Correction as a Predicate Not an Afterthought. Before terming a rise in retractions a crisis, scientists and journalists should consider the argument that they are "a signal that science is working" (6). If so, a growth in the numbers is "(mostly) a good sign" because the increase may indicate that "these statistics are proportional not to the prevalence of misconduct but to the efficiency of the system that detects it" (90). When scientists are called upon to comment about a retraction in their field, their statements should reflect the realization that because critique and self-correction are hallmarks of the scientific enterprise, instances in which scientists detect and address flaws constitute evidence of success, not failure, and exemplify the underlying protective mechanisms of science at work. When asked by reporters to respond to the Obokata retractions, a number of distinguished individuals did just that:

> "The scientific process of checks and balances actually works." (Jonathan Garlick, stem cell expert at the Tufts University School of Dental Medicine) (91);
>
> "I would argue this is not an embarrassing day for science, I think it's a good day for science and it shows we work well to weed out inferior publications." (Chris Mason, professor of regenerative medicine at University College London) (92);
>
> "This story illustrates how the stem cell field can rapidly detect bad science and reject it." (Robin Lovell-Badge, United Kingdom Medical Research Council) (92).

Focus on Identifying, Implementing, and Assessing Solutions. The need to retract is an opportunity for journal editors to demonstrate self-correction in action, not only by explaining what went wrong but also by specifying and implementing correctives to prevent similar breaches.

Scholars at the forefront of identifying challenges to the integrity of science should signal existing corrective efforts in both the titles of their publications and opening sentences of their opinion pieces in news outlets. The framing power of the following statement by a leading philosopher of science is magnified by the fact that it is the opening line in his essay in *The Guardian*: "As noted already in *The Guardian*'s science pages, there is no lack of initiatives to tackle science's crisis in all its aspects, from reproducibility to the abuse of metrics, to the problems of peer review" (93). In contrast, the framing power of this sentence is diminished when positioned in the second to last paragraph of a scholarly article: "Any temptation to interpret these results as a defeat for psychology, or science more generally, must contend with the fact that this project demonstrates science behaving as it should" (78).

Because it recalls and hence reinforces the idea it is trying to debunk, replacing "science is broken" with a frame saying "science isn't broken," as the headline of a 2015 article in *FiveThirtyEight* (94) does, is self-defeating (95, 96). By inviting readers to process the norm before the negation, "Science, although imperfect, is self-correcting not broken" is a more effective (and more accurate) statement.

Link Indictment to Aspiration. The goals to which science aspires are well captured in the title of the 2015 National Science Foundation report, "Social, Behavioral, and Economic Sciences Perspectives on Robust and Reliable Science" (97) and by the name of the 2017 National Academies of Science, Engineering, and Medicine (NASEM) report "Fostering Integrity in Research" (34).

Because language can affect how we see and act, that NASEM document made a noteworthy move when it replaced the 1992 label "questionable research practices (QRP)," defined as "actions that violate traditional values of the research enterprise and that may be detrimental to the research process" (98), with "detrimental research practices (DRP)." The reason? Practices "such as the misleading use of statistics" that fall "short of falsification and failure to retain sufficient research data should be recognized as detrimental to research" (34).

However, both "questionable" and "detrimental" reinforce the "science is broken" narrative by focusing on a problem without signaling either what is problematic or the norm being breached. Both formulations are indictments unburdened by aspiration. To specify why the indicted practices are worrisome and at the same time reinforce norms, one might instead cast them as "integrity-compromising research practices" or "integrity-violating research practices." One could also combine indictment with goals by calling out instances in which there is a "failure to employ best statistical practices" or "failure to honor scientific norms."

Focus on Problems Without Shortchanging Solutions. It is not a journalist's job to make science look good but rather to report fairly and accurately on its work and hold it responsible for its failures. The importance of this accountability function was evident when journalist Brian Deer uncovered problematic behavior by Andrew Wakefield, the author of a now discredited article linking the MMR vaccine to autism (99). To perform their accountability function well, reporters should not only alert the public to problems in consequential science but also scrutinize how and how well they are being addressed. The challenge for the science community is making and also communicating the changes that justify transforming the systemic problem storyline into one that incorporates and assesses the solutions being offered.

Conclusion

This essay has explored three news narratives about science (quest discovery, counterfeit quest, systemic problem), argued that the latter is unjustified, and recommended ways to increase the extent to which these storylines convey the realities of scientific discovery and the role of self-correction in protecting the integrity of science. In the process, it has argued that a poorly constructed survey and scholars' efforts to identify and correct problems in scientific practice may be inadvertently increasing news audiences' exposure to an overgeneralized narrative alleging that science itself is broken or in crisis. This is troubling in part because defective narratives can enhance the capacity of partisans to discredit areas of science—including genetic engineering, vaccination, and climate change—containing findings that are ideologically uncongenial to them (35). In contrast, accurate narratives can increase public understanding not only of the nature of the discovery process, but also of the inevitability of false starts and occasional fraud. And by responsibly publicizing both breaches of integrity and attempts to forestall them, news can perform its accountability function without undermining public trust in the most reliable form of knowledge generation humans have devised.

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