probably some under-reporting of misbehaviours among respondents, would suggest that our estimates of misbehaviour are conservative.

Our survey was carried out independently of, but at around the same time as, the ORI proposal. The specific behaviours we chose to examine arose from six focus-group discussions held with 51 scientists from several top-tier research universities, who told us which misbehaviours were of greatest concern to them. The scientists expressed concern about a broad range of specific, sanctionable conducts that may affect the integrity of research.

To affirm the serious nature of the behaviours included in the survey, and to separate potentially sanctionable offences from less serious behaviours, we consulted six compliance officers at five major research universities and one independent research organization in the United States. We asked these compliance officers to assess the likelihood that each behaviour, if discovered, would get a scientist into trouble at the institutional or federal level. The first ten behaviours listed in Table 1 were seen as the most serious: all the officers judged them as likely to be sanctionable, and at least four of the six officers judged them as very likely to be sanctionable. Among the other behaviours are several that may best be classified as carelessness (behaviours 14 to 16).

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Survey respondents were asked to report in each case whether or not ('yes' or 'no') they themselves had engaged in the specified behaviour during the past three years. Table 1 reports the percentages of respondents who said they had engaged in each behaviour. For six of the behaviours, reported frequencies are under 2%, including falsification (behaviour 1) and plagiarism (behaviour 5). This finding is consistent with previous estimates derived from less robust evidence about misconduct. However, the frequencies for the remaining behaviours are 5% or above; most exceed 10%. Overall, 33% of the respondents said they had engaged in at least one of the top ten behaviours during the previous three years. Among mid-career respondents, this proportion was 38%; in the early-career group, it was 28%. This is a significant difference ($\chi^2 = 36.34$, d.f. = 1, $P < 0.001$). For each behaviour where mid- and early-career scientists' percentages differ significantly, the former are higher than the latter.

Although we can only speculate about the observed sub-group differences, several explanations are plausible. For example, opportunities to misbehave, and perceptions of the likelihood or consequences of being caught, may change during a scientist's career. Or it may be that these groups received their education, training, and work experience in eras that had different behavioural standards. The mid-career respondents are, on average, nine years older than their early-career counterparts (44 compared with 35 years) and have held doctoral degrees for nine years longer.

Another possible explanation for sub-group differences is the under-reporting of misbehaviours by those in relatively tenuous, early-career positions. Over half (51%) of the mid-career respondents have positions at the associate-professor level or above, whereas 58% of our early-career sample are post-doctoral fellows.

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Our findings suggest that US scientists engage in a range of behaviours extending far beyond FFP that can damage the integrity of science. Attempts to foster integrity that focus only on FFP therefore miss a great deal. We assume that our reliance on self reports of behaviour is likely to lead to under-reporting and therefore to conservative estimates, despite assurances of anonymity. With as many as 33% of our survey respondents admitting to one or more of the top-ten behaviours, the scientific community can no longer remain complacent about such misbehaviour.

Early approaches to scientific misconduct focused on 'bad apples'. Consequently, analyses of misbehaviour were limited to discussions of individual traits and local (laboratory and departmental) contexts as the most likely determinants. The 1992 academy report[5] helped shift attention from individuals with 'bad traits' towards general scientific integrity and the 'responsible conduct of research.'

Over the past decade, government agencies and professional associations interested in promoting integrity have focused on responsible conduct in research[5,11,12]. However, these efforts still prioritize the immediate laboratory and departmental contexts of scientists' work, and are typically confined to 'fixing' the behaviour of individuals.

"Certain features of the working environment of science may have unexpected and potentially detrimental effects on the ethical dimensions of scientists' work."

Missing from current analyses of scientific integrity is a consideration of the wider research environment, including institutional and systemic structures. A 2002 report from the Institute of Medicine directed attention to the environments in which scientists work, and recommended an institutional (primarily university-level) approach to promoting responsible research[13]. The institute's report also noted the potential importance of the broader scientific environment, including regulatory and funding agencies, and the peer-review system, in fostering or hindering integrity, but remained mostly silent on this issue owing to a dearth of evidence.

In our view, certain features of the research working environment may have unexpected and potentially detrimental effects on the ethical dimensions of scientists' work. In particular, we are concerned about scientists' perceptions of the functioning of resource distribution processes. These processes are embodied in professional societies, through peer-review systems and other features of the funding and publishing environment, and through markets for research positions, graduate students, journal pages and grants. In ongoing analyses, not yet published, we find significant associations between scientific misbehaviour and perceptions of inequities in the resource distribution processes in science. We believe that acknowledging the existence of such perceptions and recognizing that they may negatively affect scientists' behaviours will help in the search for new ways to promote integrity in science.

Little attention has so far been paid to the role of the broader research environment in compromising scientific integrity. It is now time for the scientific community to consider what aspects of this environment are most salient to research integrity, which aspects are most amenable to change, and what changes are likely to be the most fruitful in ensuring integrity in science. ■

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