### Title

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# 20th Century Science Education and 21st Century Genetic Engineering Technologies: A Toxic Mix

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In response to the fallout of the revelation by He Jiankui that he had used CRISPRcas9 techniques to genetically modify human embryos, consensus in the research community formed fairly quickly around the view that He was a kind of “rogue” scientist who likely did what he did in order to make a name for himself. Thus, any problems related to He’s “research” became conveniently attributable to his own bad behavior, meaning that, after taking time to roundly denounce his misconduct on the one hand while deftly reassuring the public of the therapeutic promise of CRISPR tools on the other, we could all more or less get back to business as usual.

In what follows I want us to seriously challenge this “convenient consensus” by considering that He is not some “bad apple” lurking in the occasional bunch. Doing so frees us to consider alternative explanations for why He may have ventured down the ill-considered path he did. And we need not view this search for alternative explanations as a mere academic exercise. Even if He was driven largely by personal ambition, it is not as if he was unaware of the controversial nature of his research, as is borne out by press

accounts of discussions he had with others about prohibitions on germline research. Rather, he was unpersuaded that they should be heeded, posing the critical question for us to ponder of how it was possible that he was unpersuaded. The answer I want to proffer is that He was ill-equipped by his education and training in biomedical research to appropriately weigh the competing goods he encountered and thus was not able to be swayed by the clear guidance that basic ethical considerations would have provided. If so, then this shows us why, much as we would like to take solace in him being a bad apple, we should be prompted by this episode to focus instead on systems level contributors to his decisions that, if left unaddressed, will surely produce similarly reckless future episodes by other researchers.

To see why such a prognostication is warranted, we need only consider what the preconditions are under which it would be possible, perhaps even predictable, that someone in He’s position could make so many ethical miscalculations. An education system that allows people to achieve competency in the techniques of biomedical research - competency which can easily translate into a successful career - which simultaneously fails to equip them with the critical reasoning skills and information they need to recognize and navigate the ethical dimensions of their work emerges as a highly likely culprit. This suggests that the He episode is an expected occurrence in today’s educational milieu. There is lots of relevant evidence for thinking so.

That evidence starts with He's claims that he was merely trying to be of help: He was looking for a way to protect young children not only from HIV-related disease but from the harmful stigma attached to it. What we need to note about these noble intentions is that He apparently thought they constituted sufficient ethical justification, as if wanting to do good on behalf of another trumps all other ethical considerations. Implicit in our first bit of evidence, viz., He's response, is either an inability or discomfort with making what He's professional role required of him: a reasoned ethical judgment. Despite what surely was more than a decade's worth of education and training at some of the world's leading research universities, we find an apparent inability to recognize, let alone navigate, moral values and the myriad ways they can be in conflict, conflict that should induce caution and at times even paralysis in one's actions. Moral ambiguity and uncertainty, common hallmarks of the moral disquiet that can arise in the context of today's research, ought not be able to be shoved aside solely on the basis of good intentions, at least not by someone like He whose training alone places him in the higher echelons of academic biomedical research. After all, it is not as if ethical issues do not routinely arise in genetics research. So, how is it that current science curricula cannot detect when learners lack the skills to responsibly address those issues?

Before readers seek refuge in cultural differences that may have contributed to He's actions, I ask them not to overlook the professional role of academic researcher that he fills, a role that has clear normative standards and responsibilities that span both national boundaries and cultures. So, while culture and even nationality no doubt are constant companions that influence moral agency, they always bump up against professional responsibilities, many of which are meant to be uncompromising.

Before readers also seek refuge in RCR curricular requirements, I ask them to ponder how many of He's peers in that same echelon are conversant enough with the principle of beneficence, the ethical principle that fuels research and the range of goods it seeks, to understand that it is an imperfect, i.e., contingent, duty that admits to significant degrees of discretion on the one hand and which should be easily trumped at times by other, more important duties, on the other? A science education that equipped learners with this basic knowledge would prevent them from thinking that merely invoking good intentions like trying to cure disease is an ethical justification for their work. They would know that many more steps need to be taken before they could reach the point of knowing how to conduct their research in a professionally and ethically responsible manner.

If readers concur that transnational and transcultural responsibilities are embedded in research and that curricula should equip students to recognize

and fulfill them, then we have to ask ourselves how we design and deliver curricula that make that level of facilitation with the ethical dimensions of students' future work possible. Then we can compare current curricula to that standard. To show the need for such a comparison, we need only wonder how many life sciences PhD candidates, or their thesis supervisors for that matter, are conversant about such critical matters as the possible dignitary harms that are frequently embedded in their line of research meant to shed light on disease mechanisms and treatments?[1] Today's powerful research tools like Cas9 can frequently place research in this ethically fraught territory but I worry that the bulk of evidence drawn from our current curricula suggests that most researchers are ill-equipped to navigate within it. Indeed, although this is a topic for another time, what they likely are being taught instead is that it is the job of the IACUC or IRB to navigate it for them, showing a lack of appreciation for those committees limited jurisdictions, intellectual and monetary resources, and portfolios in the research landscape.

Since so many of the ethical challenges intrinsic to new gene-engineering technologies have to do with assuring proportionality between risks and benefits, we also need curricula that graduate students who appreciate how scientific uncertainty needs to attenuate our human tendency to see more potential for benefit than there actually may be, something desperately needed today given both the extent to which science hype pollutes even our

professional discourse about new promissory technologies[2] and the pervasive, apparently unshakeable sense of determinism attached to human genetics.[3] In other words, our curricula need to challenge any naive confidence students may have in the powers of science to understand and change the world. To do this, we need to expose our future researchers to critical insights derived from both the philosophy and history of science, along with the conceptual and epistemological underpinnings of the probabilistic inferences they will draw from data generated by the research methodologies they are being trained, often much too minimally, to employ. Such exposure would give us much greater confidence than we have today that PhD-level trained biomedical researchers will appreciate the range of significant contingencies that characterize the knowledge claims they produce. People with such an education surely will be much less likely than He apparently was to let their good intentions sweep away the ethical complexities of their work because they will appreciate them so much more acutely. They will recognize the ethical challenges along the path they are endeavoring to follow, as well as the elusive nature of the promises at the end of that path. This would help them better understand what those challenges demand from them as they proceed along it.

If He had been required to master the kind of curriculum I have briefly sketched here, it should have paid important dividends, not least of which is that the children being born as a result of his “research” would have been

spared the risks that they will now be exposed to. Changing our current educational systems to create the curricula that deliver the requisite knowledge and skills I am suggesting the He episode indicates is currently missing will obviously not be easy and it will need to start at least at the undergraduate level. Infusing science majors with the values and skills that come from the liberal arts will enhance their critical thinking, moral imagination, and normative deliberation, all of which were in short supply in the episode which is the occasion for this brief commentary. Of course, we could choose instead to embrace the status quo and seek refuge in the “bad apples” defense whenever necessary. We actually are quite good at doing that. Personally, though, I think that defense is a risky one. As He has reminded us, society is gifting the research community with powerful new tools fraught with immense dangers, posing the question of whether the community deserves to be trusted with them. Do we really think that pointing to our current science education practices shows that we do?

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