

Human genetic engineering demands more than a moratorium

Expert calls for a moratorium on germline gene engineering are no substitute for richer public debate on the ethics and politics of our biotechnological futures.

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On April 3 2015, a group of prominent biologists and ethicists writing in *Science* called for a moratorium on germline gene engineering; modifications to the human genome that will be passed on to future generations. The moratorium would apply to a technology called CRISPR/Cas9, which enables the removal of undesirable genes, insertion of desirable ones, and the broad recoding of nearly any DNA sequence.

Such modifications could affect every cell in an adult human being, including germ cells, and therefore be passed down through the generations. Many organisms across the range of biological complexity have already been edited in this way to generate designer bacteria, plants and primates. There is little reason to believe the same could not be done with human eggs, sperm and embryos. Now that the technology to engineer human germlines is here, the advocates for a moratorium declared, it is time to chart a prudent path forward. They recommend four actions: a hold on clinical applications; creation of expert forums; transparent research; and a globally representative group to recommend policy approaches.

If these recommendations seem familiar, it is because this is not the first time science leaders have responded to a similar problem. In calling for a moratorium on germline modification, the group invoked a famous precedent: the 1975 meeting at Asilomar, California on recombinant DNA. Two years before that meeting, scientists declared a voluntary moratorium on experiments that they worried might endanger human health and the environment. The moratorium allowed for a period of reflection to ensure that scientific progress would proceed without putting society's wellbeing at risk.

Asilomar is remembered as a great success because it defused public anxiety and opened up the market for biotechnology. It is frequently cited when people are uncertain about what is at stake in emerging scientific domains. Asilomar offers an easy recipe for public policy: a research moratorium followed by an expert assessment of which risks are acceptable and which warrant regulation. It is a tonic to cure public anxiety and create safe spaces for science.

But how good is the Asilomar model for governing controversial biotechnological advances? The answers are ambiguous at best. The Asilomar meeting achieved agreement in part by

bracketing off three serious concerns: environmental release of engineered organisms; biosecurity; and ethical and social aspects of human genetic engineering. Decades later, these are precisely the issues we are still wrestling with in the public domain.

The molecular biologists at Asilomar sidestepped ecological concerns by prohibiting the release of genetically engineered organisms into the environment. A few years later, scientists on the US Recombinant DNA Advisory Committee unilaterally tried to end the prohibition on release of genetically modified (GM) organisms into the environment without asking for an environmental impact assessment. They judged the issues to be purely technical, to be resolved by scientific expertise alone. But history suggests their confidence was misplaced. Persistent controversy over GM crops and foods, longstanding in Europe and on the rise in the United States, indicate that legitimate public concerns about the benefits of these technologies could not simply be wished away.

Biosecurity came back to haunt us in 2012 when a Dutch researcher at Erasmus University used research funding from the US National Institutes of Health to create an H5N1 flu virus that could cause a pandemic. He sought to publish the results, raising sudden concern that this knowledge could be used as a tool of bioterrorism. Yet multiple rounds of scientific peer review had essentially failed to question whether the research itself was beneficial or appropriate.

Ethical questions, too, continue to swirl around genetic engineering and embryo research. Rumors that genes of human embryos have already been edited resurrect anxieties that the Asilomar scientists neither defused nor eliminated.

The experts calling for a moratorium on human germline editing assert that more research must be done before we can judge the ethical propriety of genetically modifying children. Besides, they argue, global publics must be educated by experts before an informed dialogue can take place. But the problem is not simply a lack of technical knowledge. The answer to how we should act does not lie in the technological details of CRISPR. It is our responsibility to decide, as parents and citizens, whether our current genetic preferences should be edited, for all time, into our children and our children's children.

A moratorium without provisions for ongoing public deliberation narrows our understanding of risks and bypasses democracy. Regrettably, we have not yet developed the habits of deliberation that could guide research agendas before technological innovation renders neglected ethical questions immediate and urgent. Even in technologically advanced societies, we tend to defer to expert judgments about which risks are reasonable to worry about, and which are not. This is a democratic deficit. It inhibits our capacity to participate thoughtfully in imagining the futures we want and governing technological change accordingly.

An effective moratorium must be grounded in the principle that the power to modify the human genome demands serious engagement not only from scientists and ethicists but from all citizens. We need a more complex architecture for public deliberation, built on the recognition that we, as citizens, have a duty to participate in shaping our biotechnological futures, just as governments have a duty to empower us to participate in that process. Decisions such as whether or not to edit human genes should not be left to elite and invisible experts, whether in universities, ad hoc commissions, or parliamentary advisory committees.

Nor should public deliberation be temporally limited by the span of a moratorium or narrowed to topics that experts deem reasonable to debate.

Education has a vital role to play in remedying the democratic deficit, but what citizens need is not simply more STEM (science, technology, engineering, and mathematics) courses. Knowing science does not teach us how to live well with its power. Our universities need to devote more resources to teaching the relationship between science, technology and society so as to produce the citizens, the concepts, and the conversations capable of guiding our common future.

Prudence demands that we marshal the full force of democracy to imagine the lives we want. Otherwise we will find ourselves governed by technologies whose implications we did not foresee and whose development we chose to neglect.

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