Synthetic Biology as Post-Normal Science: Lessons from Empirical Social Science

Dietram A. Scheufele, John E. Ross Professor, University of Wisconsin-Madison

NBIC technologies as postnormal science

Scientific debates in modern societies – including the U.S. – often blur the lines between the science that is being debated and the political, moral and legal implications that come with its societal applications. As a result, the answers that science can provide do not match the questions that different publics want or need answers to.

Science can tell citizens how vaccines work, what their likely side effects are, and what the risks are for individuals and society if a certain percentage of the population ends up not getting vaccinated for various reasons. The vaccination issue, however, also raises a series of ethical and political questions: Should vaccinations be mandated? If yes, should there be exceptions based on religious concerns? What kinds of trade-offs should societies allow between a person's individual choice to not get vaccinated and the increased risks for all members of society if fewer people get vaccinated? And how can we harmonize regulatory frameworks across different political systems with different underlying value systems in order to minimize the likelihood of global epidemics? None of these questions have scientific answers, i.e., answers that are based on scientific facts or even accurate judgments of risks and benefits. Instead, the answers to these questions are moral, philosophical and political in nature.

These challenges are exacerbated by the nature of modern science. Science is in the midst of a rapid emergence of interdisciplinary fields that some have called a Nano-Bio-Info-Cogno (NBIC) revolution, i.e., a convergence (Roco & Bainbridge, 2003) of new interdisciplinary fields at various interfaces of nanotechnology, biotechnology, cognitive science and information technology. NBIC technologies exacerbate a host of existing challenges when it comes to communicating about science with lay audiences. As discussed elsewhere (Scheufele, 2013), these include (a) the scientific complexity of emerging interdisciplinary fields of research, such as synthetic biology or neurobiology, (b) the pace of innovation in some of those fields, and (c) the nature of public (policy) debates that accompany different applications of NBIC technologies (Scheufele, 2013).

Public interfaces for synthetic biology

As a result, public communication about modern science is inherently political, if we like it or not. Many research areas, such as the ones that developed out of the NBIC convergence discussed earlier (e.g. tissue engineering, nanomedicine, and synthetic biology), raise significant ethical, legal and social questions with answers that are both scientific and political in nature. How can we ensure the privacy and safety of human genetic information and weigh commercial interests against the rights of individuals? Is it possible to ensure equal access to medical treatments or applications developed from this research, based on race, ethnicity, and socioeconomic factors? And how can society come to an agreement about the right balance between the scientific importance of research on synthetic biology, for instance, and the ethical, moral and religious concerns that might arise from that research among different public stakeholders?

The tension between what science can do and what might be ethically, legally or socially acceptable, has become particularly visible for NBIC technologies. When J. Craig Venter and his team transplanted a chemically synthesized genome into a bacterial cell in 2010 (Gibson et al., 2010), the potential of their findings for creating "synthetic life" was immediately apparent. In fact, Venter himself referred to the team's work as an "important step … both scientifically and philosophically" and described their work as "the first incidence in science where the extensive bioethical review took place before the experiments were done. It's part of an ongoing process that we've been driving, trying to make sure that the science proceeds in an ethical fashion, that we're being thoughtful about what we do and looking forward to the implications to the future." (Wren, 2010).

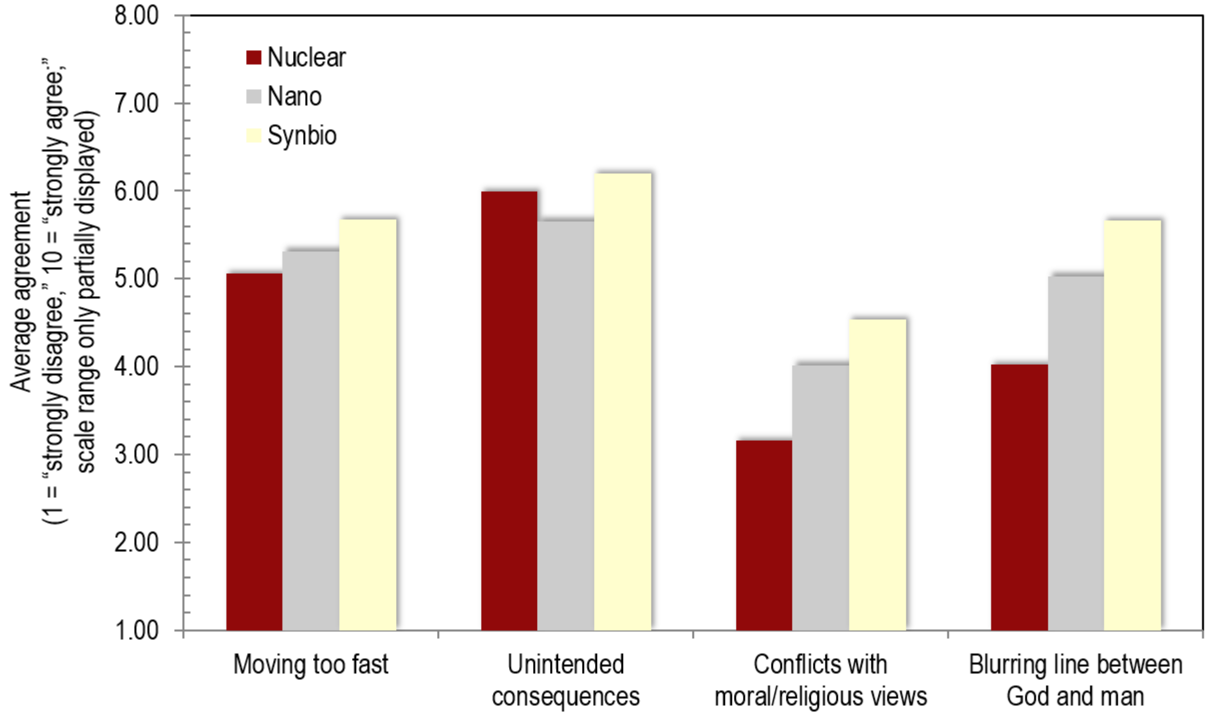
Mapping the landscape

Public opinion data nicely illustrate many of the complexities. Nationally-representative surveys conducted by the Public Opinion and Values Research Team of CNS-ASU show that non-expert audiences have a murky grasp of synthetic biology at best, with a vast majority of respondents indicating little or no familiarity with the technology. Their understanding of the policy landscape is equally tenuous. When asked if they thought that it was true or false that the Obama administration had recently banned all research on synthetic biology, only about one third of respondents were able to identify that statement as false.

A lack of scientific or policy knowledge does not mean, of course, that non-expert audiences will not form judgments about NBIC technologies when they encounter them as consumers, voters or citizens. In fact, research has long documented how mental shortcuts and heuristics become important replacements for information about science (Scheufele, 2006). For post-normal science, i.e., technologies that are characterized by high levels of uncertainty and decision stakes (Funtowicz & Ravetz, 1992), heuristics, such as elite framing or personal value systems, play a particularly important role. Findings about (religious) value systems among different countries and their connection to public attitudes about the use and moral acceptability of nanotechnology, for instance, nicely highlight this phenomenon (Scheufele, Corley, Shih, Dalrymple, & Ho, 2009).

Survey results also suggest that the political, moral and legal aspects will float to the surface even more so for synthetic biology than they did for nanotechnology and other scientific issues. Figure 1, for example, shows public attitudes compared across nuclear energy, nanotechnology and synthetic biology, based on split-ballot national survey designs. Results suggest that as synthetic biology and its various applications emerge on the public agenda, concerns about encountering unintended consequences and overstepping moral and religious boundaries will likely move to the forefront of public (policy) debates. In fact, data from the same surveys also show that non-expert publics are already significantly divided in their views on potential risks of synthetic biology, based on partisanship and levels of religiosity.

Figure 1: Agreement with various concerns about nuclear energy, nanotechnology and synthetic biology



Sustainable social/science collaborations for emerging NBIC technologies

For synthetic biology and related NBIC technologies, we will see highly polarized public debates emerge in real time as new breakthroughs are being announced or new applications are being developed. Should synthetic biologists create life in the lab, for example, as J. Craig Venter infamously claimed he had done in 2010? Is it a good idea to create materials that do not exist in nature? And what are the moral considerations surrounding de-extinction, i.e., the process of restoring extinct species of plants or animals by using genetic engineering or related techniques? None of these questions have exclusively scientific answers, but will require careful societal debates about the amalgam of scientific, political, moral, ethical and religious questions they raise.

Unfortunately, the normative desire to build better public-science interfaces for these debates has not led to the degree of intellectual cross-fertilization between the bench and social sciences that is necessary to get us closer to that goal. This is a direct outcome of two related factors: First, many STEM scientists are not aware of the growing body of work in the social sciences that provides empirical insights into the mechanisms and outcomes of various communication efforts. Second, social scientists often continue to examine science controversies as outside observers, i.e., in a retrospective and narrow disciplinary fashion. Neither phenomenon is particularly surprising, given the inherently disciplinary focus of academia. But they partly explain why there have not been widespread systematic efforts – either from within the social sciences or the bench sciences – to develop on-going working relationships among social and natural scientists to jointly explore the interplay between the scientific promise behind emerging technologies and the social debates surrounding them in democratic societies.

These ongoing collaborations are crucially important in a time where highly diverse sets of NBIC technologies constantly produce new challenges with respect to the types of technologies we are dealing with, the ethical, legal and social concerns that surround them, and the political and communication environments they are embedded in. As a result, academic institutions, funding agencies, and the federal government will have to prioritize institutional capacity building and infrastructure at the science-society interface, including (a) sustained social science efforts surrounding emerging technologies and (b) formalized interfaces between social and natural sciences.

Building these sustainable collaborative infrastructures is not a luxury. It is a necessity for informing public debates, enabling better and more responsible tech transfer, and helping to maintain a robust R&D enterprise in the U.S. (Scheufele, 2014).

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