# Technology Optimism or Pessimism about Genomic Science: Variation among Experts and Scholarly Disciplines

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Like lay people, experts vary in their technology optimism or pessimism about scientific endeavors, for reasons that are poorly understood. We explore experts' technology optimism through a focus on genomics; its novelty, life-and-death implications, complex technology, and broad but as yet unknown societal implications make it an excellent subject for studying views about new knowledge. We use interviews with scientific and medical elites to show a wide range of views about genomics, and we analyze about 750 articles by prominent social scientists, law professors, and biologists to explore how values and norms reinforce or supersede experts' shared scientific knowledge. We find that experts in some fields give genomics more attention than experts in others; that they differ in the aspects of genomics on which they focus; and that within a discipline or field, scholars differ in the extent to which they find genomics attractive or aversive. Overall, however, experts in more liberal or humanities-oriented disciplines tend to be less optimistic about genomics than scholars in relatively more conservative or scientifically oriented disciplines. We speculate on why genomics is an exception to the usual finding that liberals support science more than conservatives do.

*Keywords:* technology optimism; genomics; scientific expertise; scientific literacy; academic disciplines; ideology; DNA

Scientists are optimists—why else would we devote so much effort to devising intricate experiments to tease out new knowledge? We also continue to innovate, to solve problems, perceived and real. Our world is rife with

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> potential tragedies. … The role of science in protecting our lives and our planet is crucial and dramatic. … We are learning quickly.
>
> —Frances Arnold (2012, 10)

> Forensic DNA repositories are gathered by the state without consent and are maintained for the purpose of implicating people in crimes. They signal the potential use of genetic technologies to reinforce the racial order not only by incorporating a biological definition of race but also by imposing genetic regulation on the basis of race.
>
> —Dorothy Roberts (2011, 264–65)

Scholars, corporate actors, and citizens alike vary in the extent to which they are technology optimists or pessimists. Frances Arnold's commitment to solving "our world['s] … potential tragedies" through science represents one pole of the dichotomy; Dorothy Roberts's view of forensic DNA biobanks as a "particularly brutal form of state control" represents the other. The distinction has various names: risk-seeking versus risk aversion, preference for type I or type II errors, technology optimism or pessimism, and perhaps others.[1] At its core is the question of the degree to which an individual, group, or polity should, at the margin, choose to take risks in the hope that the benefits associated with the risky activity will outweigh the potential costs.[2] Actors differ both in the risks and benefits that they anticipate and in their propensity to accept greater hazards in the hope of greater gains.

The scientific optimist "is centered on advancement concerns. … [He or she is driven] by motivations for attaining growth and supports eager strategies of seeking possible gains even at the risk of committing errors or accepting some loss." A technology pessimist, in contrast, "is centered on security concerns … [and] supports vigilant strategies of protecting against possible losses even at the risk of missing opportunities of potential gains" (Hazlett, Molden, and Sackett 2011, 77). An optimist may see nuclear power plants as a source of clean, cheap energy to replace coal and oil; a pessimist may fear the nuclear catastrophe that natural disasters or human error could unleash. An optimist envisions the medical benefits emerging

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from research on embryonic stem cells; a pessimist sees a threat to society's recognition of human life as sacred. In a 2013 *Scientific American* poll, World Economic Forum experts and industry leaders found only the risk of economic failure in emerging nations to outweigh the danger from "unforeseen consequences of new life science technologies" (Guterl 2013, 82).

As these examples suggest, technological risk aversion does not map onto conventional political ideologies of the Left and Right. In fact, alternative theories about why individuals, organizations, or policies have different tolerances for risk are many and inconclusive. They range from personality characteristics to cognitive biases (Slovic 1987; Tetlock 2005), a history of group oppression or privilege (Urban and Hoban 1997), the play of market forces or electoral calculations, or modernity itself (Ghatak 2011; Beck 1992).

This article uses the concept of risk tolerance to frame an analysis of links between scholarly disciplines and experts' preference for type I or type II errors. We focus on experts in genomic science because of genomics' novelty in the public arena, along with its unusual combination of life-and-death implications for individuals, complex technology, and broad but as yet unknown societal impacts. Together, these characteristics make it an excellent subject for studying the development of views about science. We first demonstrate and discuss two important patterns. Scholars in the more humanities-oriented social sciences tend to be technology pessimists about genomics, while biologists and scholars in the more scientifically oriented social sciences tend to be technology optimists. In addition, there is deep division among scholars within some but not all disciplines. Despite traditional assumptions that scientific literacy is associated with support for science, expertise does not yield a consensus about the relative risks and benefits of genomic science.

We explore several reasons for these variations in technology optimism, but we use them mainly to draw attention to a crucial paradox: the most liberal disciplines tend to be the most pessimistic about genomics, while the more conservative disciplines are the most open to its possibilities. This reverses the usual finding that liberals support scientific endeavors, or tolerate risk, more than conservatives do. We conclude by exploring the distinctive nature of genomic science as a possible explanation for this paradox and the dynamics of technological risk aversion underlying it.

## What Is at Stake? The *Aedes Aegypti* Mosquito

We motivate the discussion with an example of how technology optimism and pessimism are manifested in public discourse and decision-making. The *Aedes aegypti* mosquito transmits yellow fever and the "terrible … break-bone fever," dengue (Specter 2012, 40). Dengue has no vaccine or cure; an outbreak is controlled only by the use of insecticides. A British company has developed a technology for genetically modifying male mosquitoes so that their offspring die before reaching maturity, with the goal of eradicating the species.

In 2009, dengue broke out in Key West, Florida, which is dependent on tourism. Should the genetically modified *Aedes* be released in Key West? The director of the Florida Keys Mosquito Control District was cautiously optimistic: "If this actually worked we would win in every possible way. Other approaches are more costly and more environmentally challenging. The data looked solid, and certainly we need to think differently about mosquito control than we have in the past" (Specter 2012, 43). But all speakers at a public hearing were opposed and emotions ran high. A researcher spelled out the concern: "Genetic modification leads to both intended and unintended effects. … What will fill the gap or occupy the niche should the target mosquitoes have been eliminated? Will other pests increase in number? Will targeted diseases be able to switch vectors?" (p. 44). Although not at the hearing, the director of the environmental group GeneWatch was blunter: the genetically modified *Aedes* is "Dr. Frankenstein's monster, plain and simple. To open a box and let these man-made creatures fly free is a risk with dangers we haven't even begun to contemplate" (p. 39).

Scientists say that these concerns have been addressed, and "if the results [of the research] were put to the vote of biologists, the overwhelming response would be: the potential benefits far outweigh the risks" (p. 44). It is unclear, however, who does "vote" in this sort of case. Are genetically modified mosquitoes animals (governed by the Department of Agriculture) or drugs (governed by the FDA)? Should citizens or legislators vote on trial releases of the modified *Aedes*? Since mosquitoes know no borders, what happens if the government in one country approves their release and the government in a neighboring country forbids it? Who can and should balance the risks of "robo-Franken mosquitoes" (p. 46) against the fact that "people are dying here" (p. 39)? At least one Brazilian official responsible for controlling dengue in his country is a committed democrat: "There is only one way to get people on your side: talk to them. This is a new technology. It is scary. But it also carries tremendous possibilities. People are not stupid. You just have to tell them all of that. Lay it out so they can decide" (p. 46). But as he knows, the politics of genomics innovations, from the *Aedes* mosquito to fetal genetic testing, are at least as difficult as the science itself. And the politics depend largely on how people compare the possible dangers of new technologies to their potential benefits.

## Proposed Links among Scientific Literacy, Values, and Technology Optimism or Pessimism

Emotional public hearings in an aroused community are one way to compare the possible dangers of new technologies to their potential benefits, as the Florida Keys Mosquito Control director is now painfully aware. But there are other, hopefully more considered, mechanisms through which people judge the balance between risks and gains. Scholars have investigated when and why individuals become technological optimists or pessimists; many theories are promising but none have generated widespread consensus. Psychologists, not surprisingly, focus on personality traits, cognitions, and emotions when exploring the hopes of gain or the fear of loss. Sociologists focus on demographic characteristics, information flows, and context, and the subject's position in a structure of inequality. Economists focus on the role of technology in corporate activity and in markets, communications scholars on the nature and impact of the media.

As political scientists, we are mainly interested in the political and ideological consequences of excitement about or fear of genomics. But where does excitement or fear come from? One would ordinarily expect the public's views on a new and complex subject to resemble the positions of their preferred political party (Goren 2005; Kuklinski and Quirk 2000; Lau and Redlawsk 2001)—but neither Democrats nor Republicans have distinct positions on genomic science or its uses. Public leaders such as the president or governors, members of Congress, or judges and justices have seldom taken visible stances on genomics. In this leadership vacuum, the public may follow the lead of relevant experts (Zaller 1992; Brossard and Nisbet 2007), as they have done with regard to reducing cigarette consumption, abjuring the extended use of hormonal therapy after menopause, or believing that Iraq possessed weapons of mass destruction. Experts, in other words, can sometimes shape public attitudes and behaviors if no one else does, so their views warrant careful consideration when examining the underpinnings of decisions such as whether to release the modified *Aedes* mosquito.

In sum, experts in the arena of genomic science matter in constructing political disputes arguably more than experts usually matter because their technologically optimistic or pessimistic framing has little competition from elected officials, regulators or bureaucrats, or judges. Knowing how experts view this innovation, therefore, can give us clues as to how the citizenry might come to view it. We begin our exploration of experts' views by extrapolating from the central, well supported theories of public opinion about technological risk and gain.

## *Scientific literacy*

Extrapolation from the most fully developed argument implies that virtually all experts will be technology optimists about genomics. Researchers have frequently shown a strong positive association between knowledge about scientific facts or the nature of scientific inquiry on one hand and support for the scientific enterprise on the other (Nisbet and Goidel 2007; Durant 1994; Miller 2004). As Jon Miller puts it, civic scientific literacy "is the key link between science and technology policy and democratic government. As modern science has become more expensive and more controversial, it has inevitably moved into the public arena. … Scientific literacy is … a prerequisite for preserving a society that values science and is able to sustain its democratic values and traditions" (Miller 2010, 253).

Nothing in the literature on the scientific literacy model implies that the link between knowledge of scientific facts or procedures and support for scientific endeavors would break, decrease, or reverse itself at any point. Since experts by definition know a great deal about the science in their field, under the scientific literacy model they should be especially likely to endorse scientific research. Furthermore, like all professionals, they have a self-interest in promoting their own distinct niche—in this case, the enterprise of research on genomic science. This leads us to anticipate that genomics experts are strong technology optimists.

### *Value predisposition models*

Two strong critiques, however, challenge the scientific literacy model. In the aggregate, although Americans are fairly low in scientific literacy, they remain optimistic about science and technology (Miller 2004). For example, more than two-fifths of the 34,600 General Social Survey respondents accumulated since 1973 have "a great deal" of confidence in "the scientific community"—roughly twice the proportion with a reasonable level of scientific literacy. Conversely, attitudes toward different scientific topics vary among people who are similarly literate in science (Allum et al. 2008). Studies have even found negative associations between scientific literacy and support for innovative arenas such as manipulation of human embryos (Evans and Durant 1995).

The value predisposition model was developed to account for the mixed evidence on the scientific literacy model (Nisbet 2005; Ho, Scheufele, and Corley 2010). In this view, beyond knowledge or use of contextual cues to help form one's judgment (Fiske and Taylor 1991; Scheufele and Lewenstein 2005), a person might invoke values, political beliefs, or religious commitments when evaluating science (Brossard et al. 2009; Ho, Brossard, and Scheufele 2008; Sturgis and Allum 2004). For example, ideological conservatives are generally more risk averse and cautious about changes to the status quo than are liberals (Hirschman 1991; Carney et al. 2008). They also tend to be more religious. Researchers therefore expect conservatives to be more skeptical about scientific and technological innovations regardless of their level of scientific literacy; some even discern a "Republican war on science" in which conservative elites seek to distort or inhibit scientific research (Mooney 2005). Usually the evidence supports the expectation of conservative skepticism; in the 2012 American National Election Study, for instance, three-fifths of self-identified liberals compared with just over a quarter of conservatives agreed that government should usually use the scientific method to solve important problems (see also Binder 2002; Gauchat 2012).

Expertise does not immunize one from values; in fact, people may be especially driven by value commitments in arenas where their knowledge and experience are most extensive (Gross 2013; Tetlock 2005; Kahan 2013; Nyhan and Reifler 2010). Since biologists spend their working lives exploring aspects of genomics—and many seek to develop its societal uses—their value predispositions are likely to reinforce their scientific literacy. Furthermore, although this point is more speculative, we expect that social scientists on the scientific end of the social science spectrum will be similarly fascinated by the scientific frontier represented by genomics and similarly excited about its potential societal uses; thus, like those of biologists', the values of scientifically oriented social scientists may reinforce their scientific literacy. Both bench scientists and people committed to the *science* in social science will be reinforced by professional commitments, reputational concerns, and the norms of their disciplinary colleagues. All of those forces are likely to promote high levels of technology optimism about genomics.

In contrast, for humanists and social scientists on the humanities end of the social science spectrum, knowledge and values may compete rather than reinforce each other. Scientific literacy implies technology optimism, at least according to the standard theory. But the heritability implied by genomics may be seen as contradicting disciplinary and personal commitments to, and one's own research on, the importance of social contexts, culture, individual choice, group identities, or resource constraints in shaping human behavior. In that case, value predispositions—along with professional commitments, reputational concerns, and the norms of disciplinary colleagues—may make many humanities-oriented social scientists and humanists concerned about the social implications of genomic science. Their scientific literacy will in this case be used in the service of analyzing the dangers—rather than the promise—of genomics.

## Genomics Experts' Technology Optimism or Pessimism

We frame our systematic study of experts' disparate levels of technology optimism about genomics through illustrative comments from a set of recent interviews. We have, so far, interviewed fifty-five genetics and genomics researchers, medical personnel, government officials, legal scholars, social scientists, and representatives of advocacy or interest groups. We selected these individuals purposively, because of either their position at the time of the interview, or their published arguments and analyses, or their particular expertise. It is not intended to be a random sample—or indeed, any other kind of sample—so we offer no summary statistics. Instead, the interviews were designed to explore experts' viewpoints in more informal language and in response to more pointed queries and observations than are possible in formal publications.[3]

We also sent a brief email survey with eight open-ended questions about technology optimism and pessimism to more than one hundred genomics experts in several disciplines. We received too few responses to draw any statistical conclusions about the survey results. Instead, since we had similar information about the online respondents as about the interview subjects, we treat the respondents as though they were subjects of a brief interview. Their comments provide additional insights into how and why an expert in a particular aspect of genomics balances genomics' marginal risks and benefits.

In that light, consider the following pairs of contrasting quotations from interviews or verbatim responses to the online questionnaire. On genetic ancestry testing, respondents indicated, for example:

> People have the right to gain access to [their] own genetic information. The government should [only] control companies to ensure that tests are accurate and based on real science, [and] to ensure that companies explain results and give consumers access to genetic counselors.[4]

Or

> Less than 0.1 percent of [a] genome accounts for racial differences. That pushes the question: Why are you defining yourselves in racial groups that are less than 1 percent of your total inheritance? What if I require that you use the whole of your inheritance and then come up with a definition? Dividing ourselves into racial groups is not biologically sound.[5]

On regulation of direct-to-consumer genetic medical information:

> The ApoE data show that people did not become depressed [after being informed about an increased risk of Alzheimer's disease].[6] We are psychological animals that know how to protect ourselves. People already have a lot of information regarding family, and make attributions that may be highly inaccurate. So one could argue that genetic information could *relieve* people. … The public gets it regarding the complexity of gene/environment [interaction].[7]

Or

> [The idea that] "knowing your own genome is empowering" is just silly, [it comes from] a political motivation to get money, is wildly oversold, will come back to bite us later. … Some tests do harm; returning everything will increase costs [as people demand new medical tests]. How can we do this responsibly in a context where medical professionals *should* exercise stewardship?[8]

On forensic biobanks:

> DNA is not much different from fingerprint in the logic of use, but DNA is more likely to be left at crime scenes. Americans accepted that if [they are] taken into custody, police will collect name, photo, fingerprints. That will go into a file. Advantages of DNA sample: positive identification at trial, since offenders steal the identity of other offenders—this prevents that.[9]

Or

> The establishment of a database containing every person's genomic information [is a big risk of genomic science]. The potential for abuse is truly frightening. In addition, imagine all the errors that would creep in and the difficulty in correcting them. Imagine hackers stealing this information. It makes identity theft look benign in comparison.[10]

Finally, overall optimism or pessimism about genomic science:

> [Benefits include] increasing tolerance. Appreciating the fact that genetic differences exist from one individual to the next will diminish the extent to which people have biologically driven biases across groups. … It will help us to understand the human condition.[11]

Or

> [Risks include] the tendency to build on and, because of its cultural power, continue or even exacerbate longstanding inequities in knowledge production practices. Who or

> what types of people get to be the knowing inquirers and which people are usually asked to offer up their bodies/biologicals as the raw materials for scientific research that has little likelihood of actually benefiting them?[12]

These evocative—and contradictory—observations barely scratch the surface of debates about the impact of genomics in a variety of arenas; views range from eagerness to plunge into the unknown to concern about threats to vulnerable individuals, groups, or the society at large. The theory of and evidence about scientific literacy are what make these contradictions surprising; that literature implies that the more one knows about science, the more, roughly speaking, one endorses it (regardless of the causal direction between knowledge and endorsement). The research on value predispositions does suggest such contradictions, so we turn now to a more systematic examination of how values and norms reinforce or supersede experts' shared scientific knowledge.

## *Article coding*

We explored experts' views by analyzing prominent articles by social scientists, legal scholars, and life scientists. We began with the assumption that people in all disciplines who become experts in genomic science think it is intrinsically important or consequential in ways that they care deeply about. We also added the stronger assumption that published arguments and choices of types of evidence and its interpretation can reveal the author's worldviews and perhaps even political commitments. That assumption seems most persuasive for humanists, legal scholars, and humanities-oriented social scientists; in some of those disciplines, the link between scholarship and values is intentionally explicit. It is less compelling for life scientists and scientifically oriented social scientists in the sense that it is not demonstrable through our methods because some disciplines have a strong norm of value-neutral scholarship. Nonetheless, a robust scholarly literature argues that even scholars in the hard sciences inevitably, albeit implicitly, reveal their values in their publications (Latour and Woolgar 1986; Jasanoff 2004; Douglas 2009).

We concur, but our coders were cautious in imputing values so not to push this assumption too far. That is, they coded an article as having a positive or negative valence about genomics only if the author explicitly stated a view on some aspect of the subject; coders did not infer valence from implicit cues such as the choice of words, the topics emphasized, or the interpretive spin put on empirical results.

We used two sampling strategies. The first focused on the most cited articles across all relevant disciplines in the social sciences. Using the Thomson Reuters Web of Science Social Sciences Citation Index and Arts and Humanities Index, we identified the 150 articles with the largest number of citations from 2002 through 2011, using keywords "DNA," "genetic(s)," or "genomic(s)." We searched in thirty-three fields as defined by these two indices. We eliminated thirty-two articles because they were not social science as usually understood (e.g., "Genetic Evidence Implicating Multiple Genes in the MET Receptor Tyrosine Kinase Pathway in Autism Spectrum Disorder"), or because the coder deemed them irrelevant to genomic science (e.g., the keyword search found "It is in politicians'

TABLE 1
**Valence Regarding Genomics, 2002–2011**

| Discipline | 1. Number coded | 2. % Positive | 3. % Negative | 4. % Mixed | 5. % Neutral or no occasion for valence |
|---|---|---|---|---|---|
| *A: Most consistently optimistic among articles with valence* | | | | | |
| Criminology | 31 | 45% | 0% | 0% | 55% |
| Economics | 13 | 15 | 0 | 8 | 77 |
| Psychology | 107 | 29 | 5 | 2 | 65 |
| Ethics | 106 | 43 | 15 | 13 | 28 |
| Political science | 31 | 21 | 11 | 0 | 68 |
| Sociology | 36 | 17 | 8 | 4 | 71 |
| *B: Most consistently pessimistic among articles with valence* | | | | | |
| Ethnic and racial studies | 26 | 0% | 35% | 46% | 19 |
| Cultural studies | 5 | 0 | 20 | 80 | 0 |
| *C: Most evenly split among articles with valence* | | | | | |
| History, philosophy, or sociology of science and technology | 81 | 17% | 17% | 14% | 52 |
| Cultural anthropology | 102 | 7 | 6 | 2 | 86 |
| Law | 28 | 39 | 29 | 11 | 21 |
| Average percent | — | 21% | 13% | 17% | 49% |
| *D. Biological sciences* | | | | | |
| Biology | 38 | 32% | 8% | 5% | 55 |
| Biological anthropology | 36 | 6 | 0 | 3 | 92 |

NOTE: Results are for the 640 most-cited articles in the most prominent journals across thirteen disciplines.

DNA to promote laws that benefit themselves"). That left 118 articles with complete coding.

This sampling procedure identified the most visible articles, but the resulting list was skewed by discipline because of disciplinary citation norms. It also excluded some small but analytically important disciplines. We therefore also used a second selection procedure to identify the most prominent articles in the highest-impact journals within a given discipline. We collapsed the various cataloguing choices into ten social science disciplines (see Table 1) and law, and added articles in the biological sciences and biological anthropology to permit comparison with hard sciences. We identified the ten journals in each discipline with the highest five-year impact factors as of 2011, using the *Journal Citation Reports for the Social Sciences*. The Social Sciences Citation Index identified the twenty most cited papers in each journal for 2002–2008 and the twenty most cited papers for 2009–2012. (We searched separately in those two periods to control roughly for time since publication; otherwise even the most prominent of the very recent articles would have had fewer citations than some less prominent ones published a decade earlier.) We used the same keywords: "genetic(s)," "genomic(s)," and "DNA." We followed an analogous procedure for the hard sciences.[13] Reflecting its deep internal splits (Wood 2013), we separated Anthropology into cultural and biological, treating the former as a social science and the latter as a hard science.

This strategy could have yielded up to 400 articles per discipline (20 articles in each of 2 time periods × 10 journals) for thirteen disciplines, or a total of 5,200 articles. Luckily, in some disciplines the search yielded only a few articles in many journals and no articles in some. The number of articles per discipline ranges from five in Cultural Studies to almost 200 each in Psychology and the two types of Anthropology; where necessary, we truncated the analyses at approximately the 100 most-cited articles within a single discipline.

Four trained PhD students who did not know the goals of this project hand-coded all of the articles. For both sampling procedures, the coding instruction most relevant for this article was "What is the author(s)' overall valence and intensity with regard to the impact or value of genetics/genomics *on the outside*—that is, its actual or likely effect on society, or in medicine, law, racial definition, etc." Coders could choose among six answer categories: strongly positive; moderately positive; neutral or no occasion for authorial stance (irrelevant, technical/descriptive/methods); moderately negative; strongly negative; mixed views. In the analyses below, we combine the two positive and the two negative categories for ease of analysis and exposition; for the same reasons, we also combine neutral/no occasion and mixed views.

## Results

We can readily summarize valences about genetics or genomics in the first sampling procedure of the 118 social science articles most cited during the 2000s. Note first that 30 percent of the articles are in the field of Education. That presumably reflects disciplinary norms about publication and citation as well as scholarly interest in genetic components of intelligence or achievement. Another 20 percent are in Ethics, suggesting the impact of ELSI funding (Ethical, Legal, and Social Implications [of Genomics])[14] and bioethicists' interest in the moral implications of genomics in society. Sociology, Law, and History or Philosophy of Science each account for about 7 percent, with a few remaining articles (in descending order) in each of Political Science, Psychology, Economics, Anthropology, and Cultural Studies.

Turning to the results of the coding, almost two-thirds were coded as "neutral, mixed, or no occasion for valence." That result reflects the caution in our coding decisions as well as the dominant norms of value-free scholarship in most of these disciplines. Among those with a codeable valence, twice as many of the most cited articles are optimistic than are pessimistic. Technology optimism was especially strong in Education (7 optimistic to 0 pessimistic) and Political Science (4 to 0). Overall, the theory of scientific literacy holds; authors of the most prominent recent articles in the social sciences are not only experts but also likely to endorse the field of their expertise.

Table 1 shows the coding results from the second sampling procedure—the 640 most-cited articles in the most prominent journals in thirteen disciplines. We present results in four panels: disciplines showing the greatest technology optimism, disciplines showing the greatest technology pessimism, disciplines that are most internally split, and the hard sciences (for comparison).

As in the analysis of the 118 most cited articles, column 1 shows disciplinary variation in engagement with genomics. Again we see a great deal of attention in Ethics and in Psychology (probably what was categorized as Education in the first sampling procedure falls into the category of Psychology in this one). "History, Philosophy, or Sociology of Science and Technology" is a broadly defined field in the *Journal Citation Reports*, so the large number of articles may be somewhat artifactual. Perhaps most surprising is the cultural anthropologists' very strong interest in genomics. In other disciplines—Cultural Studies, Economics, Ethnic and Racial Studies, and (surprisingly) Law—genomics is not an important disciplinary concern, at least in the most prominent journals.

Also as we saw in the most-cited analysis, a majority of articles were coded as expressing neither technology optimism nor pessimism about genomics (column 5). Much of the variation in willingness to express a view reflects disciplinary norms, ranging from journal articles intended to persuade readers of a particular viewpoint (law professors and ethicists) to articles reflecting strong norms of objectivity and authorial silence (the core social sciences and the hard sciences). The high proportion of "neutral" coding also results in part from our coders' across-the-board caution about attributing views. Thus, the results in columns 2 and 3 most likely understate the differences in valence within and across disciplines.

Nonetheless, we see clear patterns in levels of technology optimism and pessimism. Our "control group" of biologists and biological anthropologists (panel D) is much more likely to be positive than negative about genomics when its members express a valence. The most scientifically oriented social sciences (panel A) are similar. Conversely, the most humanities-oriented social sciences and legal scholarship range from deep pessimism about genomics when they express a viewpoint (panel B) to a roughly even split between risk acceptance and risk avoidance (panel C). The sole exception to this pattern is Ethics, which tends toward the humanities but also shows a tendency toward technology optimism on genomic science.

Combining the results of two sampling procedures reveals a complex layering of valences and reasons for them. First, attention to genomics varies widely across disciplines. Second, published articles in most though not all disciplines seek to avoid any expression of optimism or pessimism, at least in overt and readily identifiable language. Third, the theory of scientific literacy receives considerable support; twice as many of the articles that do express a clear opinion are positive than are negative about genomics. Fourth, the theory of scientific literacy needs to be refined when focusing on experts to account for disciplinary conventions. Their strength appears not only in a scholar's willingness to express an opinion but also in the features of genomics that scholars focus on.[15] Criminologists care deeply about the utility of DNA forensic testing, the general success of which enables their optimism. Racial and ethnic scholars care deeply about the possibility that DNA testing can create a new racial biology, the risk of which generates their pessimism. That is, technology pessimism or optimism about genomics partly reflects the fact that different disciplines attend to different facets of this enormously protean new science.

Finally—and in some tension with the point just made—some disciplinary frameworks leave a great deal of room for differences in personal value predispositions and substantive focus. That is the lesson of panel C in Table 1. Within legal scholarship, to choose only one illustration, scholars of civil liberties might fear the potential of genomic testing to invade individual privacy while scholars of the criminal justice system might laud the potential of DNA testing to exonerate those falsely convicted of rape or murder. Like the theory of scientific literacy, the theory of value predispositions needs refinement to account not only for the particular values that hold sway in a given case but also for disciplinary conventions; ideological differences play a larger role in the humanities-oriented disciplines than in the scientifically oriented ones.

## Discussion

Rising above these various layers, one pattern predominates, albeit with some noise: the more leftist or liberal a discipline, the more technological pessimism its experts express about genomic science. Several surveys have shown academics in the humanities, law, and some social sciences to be disproportionately on the ideological Left. The most extensive recent survey was conducted in 2006 with a stratified sample yielding 1,416 full-time faculty respondents in almost all disciplines and type of institution (Gross 2013; see also Ladd and Lipset 1975). Overall, 58 percent of social scientists, 52 percent of humanists, and 45 percent of biological and physical scientists identified as liberal (Gross and Simmons 2014). Almost no biologists, but 38 percent of sociologists and 15 percent of political scientists and historians, are radicals or on the far Left (Gross 2013, 46–47). Gross and Simmons also report data on political party identification for eight disciplines relevant to this article (2014, Table 1-8). Those with the highest proportion of Republicans (scholars of Elementary Education, Economics, and Criminology) are, in our analysis, strong technology optimists with regard to genomics.

We can infer nothing from discipline-wide patterns about the ideology of individual authors. And the match between a discipline's average ideology and its average level of technology optimism in our coded analysis is far from perfect. Nonetheless, in the aggregate, social scientists and humanists are both more liberal and more concerned about the risks of genomics than are hard scientists. And scholars in the social science and humanities disciplines that are more liberal, less Republican, or more politically activist in left-wing causes (Schuster and Finkelstein 2006) tend to be more skeptical about genomic science than their counterparts in other disciplines.

This pattern contradicts the standard political wisdom and the considerable research evidence about ideology and science, which finds that the Left is more proscience than the Right. Why is that? We offer two possible answers.

One explanation focuses specifically on genomics. As one interview subject put it, "the long tail [of genomics] is eugenics." The concept of genetic inheritance at the core of genomic science can be put to frightening uses; everyone in this arena knows the history of nineteenth-century racial science, early twentieth-century eugenics, and mid-century Nazi "science." Racism in the medical arena, as in the Tuskegee syphilis experiment, is equally well known; many fear that if genomics seems to imply a biology of race, history will repeat itself. Given the parallel history of racism in the criminal justice system, some similarly perceive forensic DNA testing to be "building Jim Crow's database" (Levine et al. 2008). Furthermore, liberals tend to be more skeptical about genetically modified food than are conservatives, (e.g., CBS News 2013a), perhaps because they associate it with agribusiness. More generally, genetic inheritance can be seen as a threat to free will, human agency, social constructivism, social context, political activism, and other versions of "nurture" rather than "nature." Hence, we see articles with titles such as "Genes, Genomes and Genealogies: The Return of Scientific Racism?" (Carter 2007), or "Coding and Consent: Moral Challenges of the Database Project in Iceland" (Árnason 2004), or Dorothy Roberts's warning in the epigraph to this article.

A second explanation challenges the broad claim that liberals support science and its findings more than do conservatives. That claim is clearly true with regard to climate change,[16] evolutionary theory, stem cell research, and "government . . . use [of] the scientific method to solve important problems" (see American National Election Study finding above, and Gauchat 2012 on similar patterns in the General Social Survey). But it is not uniformly true; Leftists tend to be more skeptical than those on the Right about use of nuclear power for energy, deployment of unmanned drones,[17] and use of government surveillance technology.[18] Thus, we need more careful and systematic analyses of what kinds of scientific or technological endeavors evoke concerns about type I or type II errors in people with particular value predispositions; genomics opens that issue in a dramatic way.

It remains to be seen whether disciplinary differences in evaluations of genomic science persist, harden, or diminish; what impact experts have on public discourse about genomics; and whether technology optimists or pessimists turn out to be more correct in their expectations for genomic science. But in the meantime, it is useful to reflect on the range of views among experts on this new enterprise, and on the ways in which discipline, individual, and subject matter are all implicated in whether one prefers to pursue benefits even at the cost of dangers or to avoid risks even at the expense of gains. The future of the *Aedes aegypti* mosquito, among many other species, may be at stake.

## Notes

1. A type I error is the incorrect rejection of something that is actually true (that is, a false positive), whereas a type II error is the incorrect acceptance of something that is false (that is, a false negative). We

first read the phrase "technology optimism" in the genomics context in Hjörleifsson. Árnason, and Schei (2008).

2. Institutions and policies are also implicitly technologically optimistic or pessimistic. An optimistic institution or policy promotes research and development, provides funding, minimizes regulation, and creates incentives for innovation. It focuses, in short, on achievement. A pessimistic institution or policy encourages oversight, sets barriers to approving controversial new products, moves cautiously in reconfiguring governmental agencies, and promotes rules to limit misuse of genetic information. It focuses on protection.

3. The interviews were open-ended and loosely structured. We took detailed notes that we transcribed soon after the conversations. Although some people put their comments on the record, all responses are anonymous in this article.

4. Interview #29.

5. Interview #27.

6. ApoE is the abbreviation for apolipoprotein E. The reference here is to Green et al. (2009).

7. Interview #35.

8. Interview #40.

9. Interview #41.

10. Survey #46.

11. Survey #17.

12. Survey #14.

13. For Law, we chose the ten journals that averaged the highest across three ranking systems, the *Journal Citation Reports*; law review impact factors as determined by Washington and Lee University School of Law, see http://lawlib.wlu.edu/LJ/index.aspx; and the top law reviews as measured by the Eigen factor, see www.concurringopinions.com/archives/2010/10/the-top-law-reviews-eigenfactor.html.

14. ELSI is an extensive set of federally funded research programs "to foster basic and applied research on the ethical, legal, and social implications of genetic and genomic research"; see www.genome.gov/10001618.

15. Causation undoubtedly runs in both directions here. Scholars in a particular discipline are socialized to study the aspects of genomics of interest to that discipline, and people move into a particular discipline because they want to study the aspects of genomics of interest to that discipline. Our thanks to Heather Douglas for helping us to clarify the points in this section.

16. Schuldt, Roh, and Schwarz (this volume) show that expressed views on climate change are affected by question wording or other survey effects. Nevertheless, partisanship remains crucial. As the Gallup Organization puts it, "party identification is a major factor in Americans' views of global warming. [In 2014], Democrats are nearly twice as likely as Republicans to believe the effects of global warming will occur in their lifetimes [83 to 42 percent], and nearly three times as likely to believe it will seriously threaten their way of life [56 to 19 percent]" (Jones 2014). Similarly, asked if "climate change is an environmental problem that is causing a serious impact now," that will have a serious impact "sometime in the future", or that will never have a serious impact, 57 percent of Democratic respondents to a 2013 CBS News poll said "now" and only 6 percent said "never." The comparable percentages of Republicans were 33 for "now" and 25 for never. The results are a good deal more disparate when one compares liberals to conservatives (CBS News 2013b). For further analysis, see Hochschild and Einstein (forthcoming).

17. A recent Gallup Poll, for example, found that 70 percent of conservatives and 41 percent of liberals endorsed the U.S. government using "drones … to launch airstrikes in other countries against suspected terrorists" (Gallup 2013). Partisan splits were larger, but not all surveys show the same division.

18. In an April 2013 CNN/*Time* poll, 79 percent of liberals and 87 percent of conservatives supported "expanded camera surveillance … in public places" (CNN/*Time* 2013). Partisan splits were similar, but not all surveys show the same division.

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