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# Governing nanotechnology: Codes, citizenship and strong democracy

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**Abstract.** Knowledge is a form of power, but power for those who deploy it, not create it. New technoscientific programs, such as nanotechnology, are crucial realms for democratizing society since they aren't 'locked-in' through technological momentum and because they are sites of cultural and technological production, which is another important form of power. Science and technology in the early 21st Century are mainly shaped by market (profit) and military priorities. Sometimes within these new areas, resistance to these pressures produces new ways of understanding how science and technology can contribute to a just and sustainable future. In nanotechnology research this tension can be seen in the various codes promulgated for its regulation. It is also clear in such theories and practices as cyborg citizenship, hybrid imagination, scientists' social responsibility and activism, prefigurative practices such as art and Do-It-Yourself (DIY) and Do-It-Together (DIT) organizing and the democracy and technology movement. They reveal how the development of nanotechnologies and the nanosciences can lead not just to new inventions and medical treatments, but to stronger democracy as well.
**Keywords:** cyborg citizenship; democratic science; hybrid imagination; nanotechnology codes.

## [es] Gobernar la nanotecnología: Códigos, ciudadanía y democracia fuerte

**Resumen.** El conocimiento es una forma de poder, pero para quienes lo ejercen, no para quienes lo crean. Los nuevos programas tecnocientíficos, como la nanotecnología, son ámbitos cruciales para la democratización social, pues no están 'bloqueados' por el impulso tecnológico y porque son lugares de producción tecnológica y cultural, lo cual sería otra importante forma de poder. La ciencia y la tecnología en los inicios del SIGLO XXI se encuentran determinados por las necesidades mercantiles (beneficios) y militares. En ocasiones, las resistencias ante este tipo de presiones permiten entender las posibles formas en que la ciencia y la tecnología pueden servir para alcanzar un futuro justo y sostenible. En el ámbito de la investigación nanotecnológica estas tensiones están inscritas en los códigos que se han formulado para la regulación de sus mismas prácticas de investigación. Resulta evidente cómo las teorías y prácticas relativas a la ciudadanía cyborg, la imaginación híbrida, así como en las ciencias sociales responsables y comprometidas con el activismo y las disciplinas prefigurativas como el arte, el 'hazlo tú mismo' (Do-It-Yourself o DIY), el 'hacerlo juntos' (Do-It-Together o DIT), al igual que el movimiento relativo a la tecnología democrática, revelan que el desarrollo de la nanotecnología y la nanociencia pueden propiciar nuevos hallazgos y tratamientos médicos y democracias más democráticas o fuertes.
**Palabras clave:** ciencia democrática; ciudadanía cíborg; códigos nanotecnológicos; imaginación híbrida.



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## 1. Democracy and emerging technologies

It is possible to evolve societies in which people live in greater freedom, exert greater influence on their circumstances, and experience greater dignity, self-esteem, purpose, and well-being. The route to such a society must include struggles toward democratic institutions for evolving a more democratic technological order. Is it realistic to envision a Democratic politics of technology? Isn't it unrealistic not to? (Sclove, 1995, p. 244).

New technologies often shift cultural and political balances. Consider the overreach of spy agencies such as the National Security Agency (NSA) in the U.S. and the Government Communications Headquarters (GCHQ) in the United Kingdom. The NSA seeks to collect massive amounts of information on everyone possible. Why? It isn't to fulfill their official mission: their operational successes have been few and their policy of massive collection through embedded malware and other hacks has put much of the U.S. computer industry in peril (Gray, 2005). They do it because they can. But collecting much of the electronic communications of the people of the United States is more than institutional overreach, it threatens democracy directly (Gray and Gordo, 2014). Companies such as Facebook pursue policies that are antithetical to democracy by fostering falsehoods and rage to boost profits (Boler and Davis, 2021; Gray and Gordo, 2021; Zuboff, 2019).

Powerful bureaucracies have great difficulty resisting the temptations of powerful technologies. Current democracies can be seen as technologies, with checks and balances, bills of rights and procedural safeguards. But while the U.S. mail is quite protected, and inaccessible to the government without a specific warrant, the emails the same correspondents send are collected with little, if any, due process at all. Because they can.

The incredible instrumentalist powers that science and technology develop need to be balanced by new forms of social organization that are not susceptible to easy capture by the institutions that find instrumentalist and centralized power so irresistible. Governing, the way societal decisions are made, can be dictatorial (by an individual or small elite) or through a more participatory process broadly considered democratic, where large numbers of members of that society have the power to contribute to the decision-making process as citizens. These new forms must be developed in the context of what functioning democracy we have, for no credible alternatives are on offer.

Democracy is a contested concept, but an ancient one that has emerged around the world, not just in the West (Keane, 2009). We can easily ignore Orwellian claims about the democratic essence of democratic centralism, for example, but neo-liberal Western republics are more confusing. Democracy, rule by the people, has many variations, historically and today. Achieving clarity for the term is not helped by the tremendous struggles over its meaning that frame the politics of many cultures and nation-states. For the argument here, it is fine to accept that democracy is a process, best understood with modifiers. For example, 'deliberative democracy', according to Farrelly (2007, p. 216), which seeks a balance «between conflicting fundamental values» is quite different than 'strong' or 'radical' or 'deep' democracy which postulates that power needs to be more widely diffused throughout society today. In this view, not only should the current 'democratic' institutions (representative government, rights protected by courts, mass media) be reformed to free them from the domination of institutional and capital elites and various prejudices, and in particular, citizenship needs to be reconfigured.

As with democracy, definitions of citizenship extend from the weak to the strong. The history is complicated and contested. The rights Socrates so valued that came from his Athenian citizenship were available through birth (of Athenian citizens), gender (male) and class (although a stonemason, he was wealthy enough to own a hoplite's armor). But only because he put on that armor and went to war, was he a citizen. The citizenship franchise of Imperial Rome was constantly being expanded and diluted. Greece, Rome, the Italian city states, the yeoman of England, the obligations and rights of the Native Americans of the 'civilized tribes' and the individualistic ideals of the Enlightenment, all contributed to the original North American idea of the citizen. But since then, it has continued to evolve. As the right to citizenship has spread the commitment asked of the citizen has not necessarily deepened. Yet new democratic theory, especially new conceptions of citizenship (Gray, 2001; Isin, 1997), argue that all the key institutions in society need to be democratized as well, especially universities and corporations.

These two institutions are particularly relevant here because, along with government, they are the producers of most formalized knowledge, including the practical understandings behind emerging technologies. Many distinctions are drawn between the types of knowledge made in these sites, but it all comes down to power and who gets to deploy it for whose benefit. The complicated and overlapping modes for the contemporary production and elaboration of knowledge makes distinctions between scientific research and technological development difficult to make. This is particularly true of emerging fields such as nanotechnology. Since nanotechnology is a particularly nebulous framework for 'disciplining' knowledge any claim that there are clear differences between nanoscience and nanotechnology needs to be proven. Until then, the terms technoscience and nanotechnology will be used.

Of course, a nano is one billionth of a meter. Most definitions of nanotechnology are based on this measure, although in many cases sizes of up to 100 nanometers are considered to be nanotechnological. For many commentators anything smaller falls within the nanotech realm as well. I have argued (Gray, 2001, pp. 181-183) that nano is a marker of a fundamental shift toward understanding the gigantic is not necessarily as beautiful, let alone powerful, as the miniscule. The fusing and fissioning of atoms (nuclear physics), the little charges that delineate bits and bytes (computing), and the tiny adjustments that shift the function of genes (genetic engineering) do often fall into the atom/molecule at-a-time small-as-one-nano definition, but they are usually ignored. The most common definitions of the field seem only interested in micro-machines and materials engineering.

Much of this can be credited to the origins of the concept. In 1959 at an American Physical Society meeting at Caltech, Richard Feynman gave a famous talk 'There's Plenty of Room at the Bottom' about the potential for building atomic scale systems. The term was first used in much this same way, by the Japanese scientists Prof. Norio Taniguchi, who wrote in 1974 about manipulating atoms one at a time as nanotechnology. But nanotechnology didn't enter into general use until it was popularized by Drexler (1986), an early transhumanist and so cryonics enthusiast, who saw nanotechnology as a way to solve the problem of thawing brain cells, and pretty much anything else you can imagine. In the end, it probably makes the most sense to think of nanotechnology as a brand.

Technoscience in the early 21st Century is usually shaped by market (profit) and military priorities. This has inevitable influences on the very form and utility of new discoveries, especially in established fields. Militarized technosciences, such as chemistry, aeronautics, and applied physics, then continue to influence society in certain ways. Note the genealogy of militarized physicists such as J. Robert Oppenheimer, Ernest Lawrence, Edward Teller, and Lowell Wood. Their hammer world view turns every problem into a nail.

New technoscientific programs, such as nanotechnology, are crucial realms for democratizing society since they aren't 'locked-in' through technological momentum and because they are new sites of cultural and technological production, which is an important form of power. The sooner new discoveries and inventions can be utilized, the greater their advantage, so incredible resources are poured into those new areas of research, such as nanotechnology, that promise maximum returns financially and in military utility. Sometimes within these new areas, resistance to these pressures produces new ways of understanding how science and technology should be in human culture, if they are to help us survive.

Brand, field or discipline, nanotechnology is at the cutting edge of a wide range of transforming research projects among the intersections of chemistry, biology, and physics. New discoveries and inventions will certainly open wonderful and horrible possibilities in the military, in business, and in social engineering. The importance of nanotech and its ethical implications is clear (Allhoff, Lin and Moore, 2010). Which means that codes are being promulgated to regulate it.

## 2. Codes

> Most people think that to understand *law*, you need to understand a set of *rules*. That's a mistake…The law is best understood through stories–stories that teach what is later summarized in a catalog of rules– (Lessig, 1999, p. 9, emphasis in original).

Most human relationships are covered by codes, explicit or implicit. All can be conceived as systems governed by discourse rules and meta-rules, but formalized codes are different. Informal codes are implicit, some have biological origins, but most are culturally shaped. Formal relationships are defined as those with formal codes that determine, at a minimum, membership. The association's functions (theoretical always, and sometimes actual) are almost always at the heart of these agreements. Many associations are regulated by different layers of overlapping codes. Consider the police in California, for example, with whom I have extensive personal experience. They are governed by Federal and State law. They also are supposed to follow county and municipal ordinances, administrative and union regulations, and various technically mandated procedures such as the maintenance on equipment: weapons, communication apparatus, and vehicles. But beyond this, there is also the 'Blue Code', which proscribes a wide range of refusals of all these other codes. In reality, the vast majority of police in California will not testify against other officers or even contradict them in reports, they don't enforce every rule (it would be impossible) and most neglect the less serious offenses, and they break numerous lower level codes, from not cleaning their weapon with the regularity requested to using radios for personal communication to charging everyone they beat up with assault on an officer.

Codes are technologies with different levels of effect from the contextual to the proscriptive. For example, as Lessig (1999, p. 5) points out, constitutions, one of the highest levels of code, are an architecture «that structures and constrains social and legal power». My proposed Cyborg Bill of Rights is an example of this. When it lays out freedoms of travel (virtual and physical), electronic speech, electronic privacy, consciousness, information, and protected rights of bodily autonomy, choosing one's own death, political equality and self-choice in family, sexuality and gender it is both a set of guidelines for policy and an argument for a rethinking of politics (Gray 2001).

When a new techno scientific area develops, how to (self) regulate it is a complicated question. Bobe (2011), a founder of Personal Genomics and the Personal Genome Project, is also involved in the Do-it-Yourself Biology movement (DIYBio.org). In his work on developing a code for it he has run into many complicating factors, including the movement's decentralization, its wildly fluctuating goals and levels of technical expertise, and the wide variety of possible types of codes to deploy. He has found it useful to categorize possible codes as 1) aspirational, 2) practice and 3) enforceable.

Yet he is well aware that in the real world the lines between these categories are far from precise. The aspirational is clear enough. Practice is sometimes described as educational or advisory and the enforceable can be focused on practice if it includes sanctions. Generally, the more powerful the institution the more its codes are enforced. Government laws and regulations carry heavier sanctions, and have more enforcement mechanisms, than even empowered professional organizations such as those of lawyers and doctors, both notorious for the toothless supervision of their members. Codes are sometimes based on these principles, but in many other instances, they are more self-serving. This is particularly true of voluntary self-regulating codes, whose proliferation is notable, but not without issues.

Since the Asilomar meeting of biologists in 1975 to self-regulate genetic engineering, we have seen a profound shift in the way practitioners in technoscientific areas try and keep control of the way they work, the way they produce new knowledge. Many of the recent codes are like the Asilomar agreements, more pre-emptive of limitations on scientific privileges than disinterested attempts to protect the public.

Wiener (2001), tells of hearing the famous geneticist David Baltimore give a talk at MIT in 1974 entitled 'Where Does Molecular Biology Become More of a Hazard Than a Promise?' Baltimore was worried about the potential health problems of the new genetic engineering techniques (recombinant DNA) and he was even more worried about potential government regulations that might hinder this research. So, he explained, the genetic engineers were planning a conference at Asilomar in California (for the following February) to «regulate themselves». Wiener (2001, p. 208) quotes Baltimore that it was to about «avoiding governmental responses». Government regulation, Wiener interpreted Baltimore as saying, would «be too rigid, too hard to reverse, and too hard to work within». Baltimore ended his talk with the conclusion that, «We're stuck between self-determination of limits and imposition of orthodoxy. We're stuck between self-interest of scientists and the public interest» (quoted in Wiener 2001, p. 208). Wiener (2001) admits he was impressed «with this effort for responsibility and self-regulation» but he wondered «how it was possible to exclude the public in a matter that should be of public concern».

Interestingly enough, in 1988, when James Watson, one of the key players in the self-regulation of genetic engineering, became the head of the new Office of Genome Research in the National Institutes of Health, he insisted that 3% of genome research funding be dedicated to looking at the ethical and social implications of the research (Kevles, 1992, p. 35). For a U.S. research program, this was unprecedented. Philosophers joked that it was a «full employment plan for bioethicists» but for scientists, it was letting the public play a role in the regulation of their work, and many were not happy about this.

Unfortunately, the funding of research into the ethical, legal and social implications has not been built into the National Nanotechnology Initiative, which funds a large part of U.S. basic nano research (Cameron, 2005). Still, nano has gotten its codes as well.

## 3. Nano codes

As nanotechnology has grown as a brand, there has been an increasing focus on codes for nanotechnology research. This proliferation might be traced to the strong engineering focus of formal nanotechnology research programs. Engineers, producing knowledge as artifacts and edifices, have a much more direct relationship to liability and litigation than research scientists and so have developed various professional and operational standards, not unlike many of the nanotech research codes. These have included several initiatives pursued by Germany, the Netherlands, and industrial groups (Friedrichs, 2007). There is also Swiss retailer's organization's code for nanoconsumer items (Interessengemeinschaft Detailhandel Schweiz, 2007) and various company codes, such as the code of the chemical company BASF. Perhaps the two most widely disseminated have been the Responsible Nano Code and the European Commission's (EU) Code of Conduct (Commision of the European Communities [CEC], 2008), which has influenced many other national codes, such as Iran's (Biroudian, Abbasi and Kiani, 2019).

The Responsible Nano Code (Working Group of the Responsible Nano Code 2009) was crafted by a group including the Nanotechnology Industries Association, the Royal Society of the United Kingdom, Insight Investment (a large asset manager in the UK), the chemical company BASF, Unilever, the consumer group Which? And the NGO Practical Action (Friedrichs, 2007). Their code is seven principles: Board Accountability, Stakeholder Involvement, Worker Health and Safety, Public Health and Safety, Wider Implications and Engaging Business Partners. It is hard to even connect these with any special aspect of nanotechnology, and they seem as much about liability as society's interests. The principle about wider social impacts, for example is that «Each organization shall consider…». And so it goes. It is all from the point-of-view, and for the benefit of, corporations such as those that dominated the Working Group.

The EU code came out of an extensive public process, and it seems to have made a difference. It is also based on seven principles, but they are quite different than those of the Responsible Nano Code: Meaning, Sustainability, Precaution, Inclusiveness, Excellence, Innovation, and Accountability (CEC, 2008). While most of these are straight forward enough, don't destroy the environment (Sustainability), follow the precautionary principle that equates the level of care with the potential danger (Precaution), public input into decisions (Inclusiveness), follow the rules of practice (Excellence), and Accountability. However, two of them seem a bit out-of-place. 'Meaning' in the Responsible Nano Code means that the research «should be comprehensible to the public» and be conducted in «the interest of the well-being of individuals and society» (CEC, 2008, p. 6). Yet we know that most of such research is only comprehensible to experts and that the research is being conducted to make money or effective weapons or some such, and only indirectly, by accident, is it in the interests of the public as a whole. Which is clear by the principle of Innovation. According to the EU code, the only reason nanotechnology research should «encourage maximum creativity, flexibility and planning ability for innovation and growth» is for competitive success (CEC, 2008, p. 7). Inevitably, the principle of Innovation runs into the principles of Precaution, Inclusiveness, and Excellence, for example.

McGinn (2010a) notes that of 27 guidelines in the EU code, only 5 are really aimed at nanotechnology researchers. The rest are for others involved in nanotechnology production, especially corporations, and governments. McGinn (2010a) proposes his own code for actual researchers. He builds it on three fundamental Ethical Responsibilities of Scientists and Engineers: 1. Do not knowing harm; 2. Prevent harm as much as possible; and 3. Warn anyone who might be harmed.

But his nanoethics code goes way beyond this, and is based on decades of experience, first as an engineer, then as an academic studying engineer and helping establish Stanford University's Values, Technology and Society program. The rules he advocates are very concrete and specific, dealing with safety principles, violations of procedures, and responsibility. Two of them, however, deserve special attention. Rules nineth and tenth are against promulgating hype or allowing media distortions to go unchallenged.

McGinn's focus on the actual researchers gives the rules a specificity that isn't in other codes, including that of the chemical company BASF (also part of the Responsible Nano Code Working Group) that includes the fascinating principle that "Producing artificial organisms and self-replicating nanorobots using nanotechnology is, on the basis of all available scientific information, not possible and for us merely science fiction" (BASF, 2009). A strange statement considering a totally synthetic organism has been made already (Holz, 2010) and nanorobots (more often called nanobots) are a major research area within the $1 Trillion plus nanotechnology industry. Major scientific advances (in using DNA, for example) are encouraging many research programs into autonomous reproducing nanosystems (Del Monte, 2017).

So, most of these codes are self-servicing, pre-emptive, unenforceable, paradoxical and confusing. Codes alone are not enough. From 'The Law' to tacit agreements, they rest on richer foundations by necessity. Codes are abstractions, they are maps, and the map is never the territory. When Lessig writes of the computer code of the Internet he is clear that what the code does is make some things, freedom or oppression say, likely or possible or impossible. But what actually happens is more complicated, an interplay between the social, and the technical (Lessig, 1999). The code of the Internet, and the codes meant to regulate nanotechnology are important, but they are only the process of producing the world we inhabit.

The «evolving of a more democratic technological order» is dependent on a more democratic society, as Sclove (1995, p. 244) argues so clearly. How this larger democratization project works in relation to nanotechnology is a process that is far from over. But looking at the various modes beyond codes, it is clear that while it is constantly changing, it grows out of earlier initiatives in other new technoscientific projects. At the center of these interventions, which go to the heart of knowledge production in ways that earlier reforms did not, are challenges to the meanings of key terms in the discourses that mobilize and deploy the power that comes from the discovery of new ways of manipulating nature.

## 4. Emerging democracy and nanotechnology

> It is our contention that the social, political, and environmental challenges facing science and engineering in the world today require the fostering of what we have come to call a 'hybrid imagination', mixing scientific technical skills with a sense of social responsibility or global citizenship, if science and engineering are to help solve social problems rather than create new ones (Jamison and Mejlgaard, 2010, p. 351).

We can see, historically, that democracy is always in transition. It wanes and dies or waxes and emerges from tyranny, or even a weaker version of itself, to become stronger (Keane, 2009). This happens everywhere in culture but particularly at the edge of the new, in art or fashion or science. New forms of cultural production (and knowledge is certainly cultural production) are the sites of the most contestation. This seems to be the case with nanotechnology research. It is becoming a central focus of a wide range of social interventions beyond, or even against, the massive influence of military contracts and the venture capital context. Much of this is in the realms of science-fiction texts, art, and film and is beyond the scope of this essay, but there is also a wide range of initiatives dealing directly with nanotechnology practices which makes a good map of current struggles over the shaping of technoscience.

Among these theories and practices are educational approaches such as hybrid imagination and new conceptions of citizenship, new fields such as nanoethics, prefigurative art and other practices embodied in DIY/DIT, and the democracy and technology movement. The growing interweb of Internet, telecommunications, especially social and other new media, is integral to this process as well, from intensifying networking and coordination of the best practices of practitioners, to offering a platform to critics of today's world order, from distributed open-source knowledge production (Wikipedia) to direct challenges to its truth regime, such as Wikileaks and its offshoots.

A good example of distributed knowledge production among nanotechnology practitioners is the collection of best practices facilitated by the International Council on Nanotechnology's (ICON). Their website allowed members to post and discuss the best practices for handling materials, creating a 'GoodNanoGuide' in the process, and fostering a culture of safety among nanotech engineers. Important as this is, attempts to rethink who an engineer should be are even more important.

Jamison and Mejlgaard (2010, pp. 353-354, drawing on Hard and Jamison 2005) put forward the concept of 'hybrid identity in action' based on:

> [A] cultural historical perspective in which hybrids are seen as the critical counterpoint to the 'hubris' that has been fundamental throughout history to

scientific and technological achievement. What it means concretely is that scientific practitioners with a hybrid imagination combine «an understanding of changing contextual conditions» with the «relevant scientific and technical skills and knowledge».

McGinn (2010a, p. 12) goes so far as to argue that «society needs and is beginning to demand researchers with a hybrid competence: state-of-the-art technical knowledge coupled with a sensitive ethical compass».

I argue in *Cyborg Citizen* that considering the transformative and dangerous possibilities of emerging technologies, a very strong idea of citizenship is needed today, more than ever (Gray, 2001). While I call it 'cyborg citizen', Jamison and Mejlgaard (2010) use the concept of 'world citizenship'. They could just as well say 'hybrid citizen'. The label is unimportant, as long as the critique of what passes for citizenship today, and therefore democracy now, is clear. The glimmerings of this can be seen in such experimental institutions as citizen juries to evaluate new technologies.

Jamison, Mejlgaard, McGinn (my advisor at Stanford in the early 1970s) and I all have used these ideas in teaching ethics and social responsibility to engineering and science students. We also incorporate practice into the teaching, forms of service learning where the expertise and skill of the students is mobilized for society's betterment (Jamison and Mejlgaard, 2010; Gray, 1999). These are not the only possible approaches. A good overview of teaching nanotech ethics that links to traditional engineering codes of conduct and best practices for teaching nanoethics can be found in Barakat and Jiao (2010), for example.

And the teaching of ethics, especially to experts in particular research programs, benefits from the academic infrastructure of centers and journals, which has been expanding in the case of nanoethics. One doesn't have to agree intellectually that nanoethics deserves its own field (any more than cyberethics, computer ethics, bioethics or neuroethics, to name a few of the new ethical specializations) to recognize that it is valuable to have institutions (see McGinn, 2010b, for a discussion of whether nanoethics should be its own ethical domain). But in any event, to put resources into ethical teaching and learning is to prefigure a more ethical world, and that is certainly worth doing.

Prefiguration is when a practice instantiates what it is aiming to foster. Prefigurative politics, popularized in the 1960s, focuses on living the social change that is advocated. Activism for a decentralized, nonviolent, sustainable world should be decentralized, nonviolent, and sustainable, for example. Art can be prefigurative, if it actually brings about what it advocates. The body artists Stelarc and Orlan advocate personal control of cyborgian technologies, and they achieve that in their art mobilizing doctors and other experts to serve their artistic vision (Gray, 2002).

The clearest example of this in nanotechnology is the Do-It-Yourself/Do-It-Together (DIY/CIT) movement, a major force in computing and social media (open-source projects are the most known DIY/DIT initiatives), which includes nanotechnology practitioners. The wide range of reasons people do DIY biology or nanotechnology complicates this issue, however. While much DIY activism is explicitly anti-authoritarian (anarchist, horizontalist, libertarian), some tech DIY people are clearly motivated more by dreams of capitalism, or at least profit, than any techno-utopian possibilities. For a rich discussion of how DIY/DIT offer a revitalization of democracy, see Ratto and Bolar's (2014) edited collection, *DIY Citizenship*.

These social initiatives represent a refiguring of knowledge production and control. They reveal how the development of nanotechnologies and the nanosciences can lead not just to new inventions and medical treatments, but to stronger democracy as well. The alternative is pretty much a science fiction nightmare. One only has to look at the potential power of Big Data (broadly defined) to see that the relentless progress of technoscience even puts individual autonomy at risk (Gray, 2014).

To make nanotechnology part of the solution, instead of the problem, the profound democratization of technoscience production and use is necessary, and therefore of society as a whole. Codes are only as good as the culture they are part of. Societies are wholes. They are discrete systems. It is impossible to have some key sectors democratized and others not. Although the illusion of uneven freedom is possible, power is not so easily containerized. If the sites of power are not democratic, the society is not democratic, whatever its trappings. To have technoscientific production controlled by elites that are focused on war, profits, and self-promotion is to not have democracy, whatever elections are held. Strong democracy needs people who, whatever else they may be (user or scientist or engineer or manager or worker), are strong citizens as well.

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