Society, Ethics, and Geopolitics

"Where there is no vision the people perish" —Proverbs 29:18

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We are the descendants of people who successfully embraced a series of revolutionary new technologies and the changes they enabled. Succeeding generations of our ancestors used their new tools and materials to construct and protect their civilizations. Nanotechnology is our generation's great opportunity and responsibility. Properly developed, nanotechnology has the potential to improve every human-made product and enable entirely new objects not yet conceived. In the shorter term, nanotechnology offers the best defense agains the malicious use of previous technologies.

The last chapter of this book differs from the others because it is much more subjective. It deals with policy, society, and ethics, which are not matters of science or technology alone. These views cannot be proven like mathematical theorems, but we've chosen to include them because we think it is important to present a balanced picture, to show some of the potential problems as well as the benefits of the technology, and to start engaging these issues as soon as possible.

Concerns about technological and scientific advances are not new. In the early 19th Century, the Luddites were concerned about the introduction of machinery that would displace workers, so they destroyed the looms in their workplaces. Eminent scientists such as Lord Rayleigh didn't believe in human flight, saying in effect that if the Lord wanted us to fly He would have given us wings. More recently, genetic cloning and the use of stem cells in medical research have been front-page news, provoking not just debate within the scientific community, but sermons, demonstrations, and even riots. The Luddites' name has become synonymous with the shortsighted opposition to any kind of technology, and the remark about flying is now proverbial for its lack of vision, but there are real issues to discuss regarding the emotional reactions to nanotechnology. Nanotechnology represents a wholly new set of possibilities for human advancement, so a thoughtful and reasoned policy comprised of legal, educational, and financial decisions is needed to allow people worldwide to maximize its benefits and control its risks.

Information Tech, Biotech, Nanotech

Within recent memory, two other major disruptive technologies have been developed: information technology and biotechnology. Examining their records reveals two paths for how nanotechnology could develop.

Information technology has, for the most part, been a good citizen. Since computers, networks, and the Internet have become common, industry groups like the Internet Engineering Task Force (IETF)and the Institute of Electrical and Electronic Engineers (IEEE) have done a good job of promoting standards of interoperability. Schools and professional training programs have smoothly (or by fits and starts) integrated

computers into their curricula. Periodicals and training manuals exist for every level of expertise from the beginner to the expert, and industry watchdog groups such as the Electronic Frontier Foundation (EFF) and the Center for Democracy and Technology (CDT) watch both government legislation and industry practice for illegal or unethical activity. Other groups, including the Computer Emergency Response Team (CERT) and independent computer security vendors, track the spread of computer viruses and software vulnerabilities with such efficiency that major newspapers carry notifications of big problems and fixes are usually released within days. Despite recent antitrust issues, the industry remains quite open and competitive and, for the most part, it has been remarkably constrained in its lobbying for legislative protection (though the same cannot be said of the telecommunications industry). Many questionable laws such as the Communications Decency Act have been defeated or repealed, and potentially threatening legislation like the Total Information Awareness Act are openly debated. Intellectual property protection remains strong enough for companies to make respectable profits, but solid alternatives for almost every software product now exist within the open source community, many of them in the public domain.

Biotech's record is spottier. While basic biology is part of primary education, most people don't have a good understanding of the issues involved. There is less engagement by the press and there are fewer journals for nonexperts. Also, since there is less concern for how different biotech applications interoperate than there is for computer parts, there are fewer open industry associations setting standards. The level of secrecy in biotech research largely prevents watchdog groups from being effective, but this is to some extent justified since the biotech product development cycle is so much longer than

it is for information technology (years as opposed to months), and a key scientist leaving a project can set it back almost to its beginning.

The stakes are also higher in biotech than they are with information technology. Few people march or riot over new software releases (tempting though it can sometimes be), but the biotech industry is almost always vilified as meddling with nature or playing God, even though it has generated greater advancements in medical treatments and in prolonging life than any other technological revolution in history. The stakes are also higher because when research is done incorrectly or when companies act unethically, their behavior is likely to result in serious side effects or death, often at a massive scale. Biotech is an industry that needs more ethical scrutiny than it has received.

Nanotech sits at the crossroads between scientific and engineering disciplines, and it has a lot to learn from each. We hope it will be able to combine the best of both, and we now turn our attention to particular areas.

Public Policy

People may have started, as Rousseau thought, in the state of nature. But the nation state is the organizing structure of current societies almost everywhere on earth, and it is within these nation states that nanotechnology will emerge. People cannot plan for nanotechnology as individuals, so it will be necessary for public organizations to embrace the future and plan for it.

In the United States, the National Nanotechnology Initiative (NNI) was launched during the Clinton administration. This initiative is now funded at a level of almost $1 billion per year, with much of this funding going into research and devel-

opment efforts at universities, national laboratories, and industrial research operations. NNI also has important educational, policy, ethical, and outreach components. Some regulatory structures that were put in place for other concerns, including everything from zoning laws and air pollution regulations to noise abatement statutes and building codes, deal with aspects of nanotechnology. Government-supported education and training initiatives and development zones (including nanotechnology incubators) are also responses to nano. For these reasons NNI, plus extant regulatory structures, represent the nucleus of current nano policy.

More is needed. In Chapter 5, we discussed the environment, energy, and economics. Since the economic impact of nanoscience will be very large, it is the responsibility of public policy to anticipate its effects and to try to cushion some of the possible negative ones. This includes planning for the economic shock that may come if competitive new products and nanomanufacturing cause job losses in older manufacturing sectors. Public policy must also provide appropriate new regulatory bodies to handle the unique challenges of nanoscience.

The set of challenges that nanotechnology will provide might seem intimidating. It is clearly wise for government to look before it leaps, but inaction or unending delays could be destructive. The ETC Group, an international public interest body, advocates a total moratorium on nanotechnology until all of its environmental, economic, and other impacts can be evaluated. This approach is not feasible. Nanoscience is already here and nanotechnology is arriving. Both are already providing great benefits for the society and will provide many more. Delay is not feasible (and from a defense perspective it is strategically suicidal, for even if the work is not done in the United States, it will certainly continue elsewhere), but regulation, planning, and education are needed.

Watchdog groups like ETC are important contributors to the debate. Their studies, along with academic review and open research policies by institutions doing nanoscience research, provide crucial transparency similar to that enjoyed by information technology. Only with this kind of transparency can the nanoscience community hope to maintain public trust while pursuing research that many people find threatening. In addition, it is important to keep public attention focused on nanotechnology. Continued press coverage, open industry meetings, and even coverage in popular fiction are important components of this. On the government side, specialized task forces, panels, committees, reports, and legislative and executive actions help keep attention focused, and they allow for speedy decisions on nanotechnology policy when necessary. This speed will be essential as the nanotechnology industry continues to gather momentum. The rate of innovation for nanotechnology could well exceed that of either information tech or biotech, and the decisions required by the government to regulate it could be at least as complex.

Why is this so important? The discussion surrounding genetically modified (GM) food provides a prime example. In 2002 the United States promised famine relief to Africa, shipping tens of thousands of tons of grains including genetically modified corn. Despite the threat of starvation, African governments in Mozambique, Zambia, and Zimbabwe hemmed and hawed about whether to accept the food, saying they were unsure if it was safe to eat, plant, or even feed to livestock. Genetically modified food of this type has been common in America for years, but regulators in Europe had escalated fears about the safety of GM food, largely due to pressure from farmers' lobbies. Even after years of using GM crops in the United States, old-fashioned trade wrangling combined with

the GM food industry's perceived lack of forthrightness in providing impartial studies about the safety of their products resulted in this crisis. It had nothing to do with science or technology, only with irresponsible policies and a lack of education. Governments have a responsibility to prevent this kind of thing from happening.

Intellectual Property

Technologies are developed by people and organizations, and these inventors have the right to protect their discoveries and developments by securing patents. Nearly all developed countries have a patent system, and some larger entities such as the European Union and World Trade Organization (WTO) are developing even broader patent policies. Patents will be as crucial for nanotechnology as they have been for other technologies. Inventors, developers, and investors need to protect their ideas, devices, and investments. Reasonable patent protection is a necessity for nanotechnology to flourish and to contribute its unique attributes to all aspects of society, including homeland security.

But a key difficulty lurks in the word *reasonable*. For an example, far from nano anything, think for a moment about children's literature. In 1998 Congress approved an extension of copyrights often called the "Mickey Mouse Law," since it was passed under enormous pressure from Disney just before Mickey went out of copyright. In Mickey's case the law extended the copyright to a total of 95 years after first publication. Mickey first appeared in 1928, so this extension to the copyright will preclude any other creators from using Mickey (or Goofy and Unca Scrooge, either of whom might have provided a better name for this copyright policy) until at least 2023. This hyperextended copyright protection reaches well

beyond any reasonable lifespan of the creators and seems arbitrary, unreasonable, and suffocating.

J. K. Rowling, now richer than the Queen of England and worth some $500 million, is seeking very broad copyright protection for her character Harry Potter. She and her publisher are now using copyright protection to limit other creative work involving child magicians. For example, they have sought to block the western publication of a story about a Russian girl apprentice magician called Tanya Grotter as well as Chinese and Bengali take-offs on Rowling's idea. A case could be made that these are noninfringing "fair use" creations covered under laws designed to protect parodies, or that they are derivative works that do not deprive an author of reasonable profit from her work. By pursuing an attack on these works, Rowling and company are potentially stifling other authors whose work could in no way be mistaken for the original Harry Potter stories but could delight children who are culturally removed from Harry (British-style boarding schools, myths, and values not being universal). Based on this behavior, their view of copyright protection seems as draconian as anything Voldemort might have conjured up.

How does this apply to nanotechnology? Copyrights and patents are intricately related, and intellectual property law will be key to the development and use of nanotechnology. In the pharmaceuticals area, for example, patent issues are particularly complex since they can have life and death consequences. Without patent protection, big pharma cannot justify the very large expenditures involved in drug development; it can cost more than $100 million to develop, test, and certify a drug. However, protection that is too strong can be abused, and serious abuses have already been committed. Abuses can take a variety of forms. A few common ones include patenting a drug but not producing it (either to pro-

tect a competing profitable drug or to await a more lucrative offer for distribution), holding a patent back while demanding an exorbitant licensing fee, and keeping prices artificially high long after development costs have been recouped.

Patent law is already very broad. It is possible to patent individual genes, for example. This means that a patent-holder can choose to delay the development of therapies and treatments for any reason at all. Not reading Harry Potter in a Russian setting may not work significant harm to society, but a 20-year delay on a drug for halting breast cancer certainly would. While the pharmaceutical industry has produced remarkable drugs that have made our lives richer, healthier, and longer, the ethical issues that surround patent policies are vexing.

One other aspect of globalization is that it now takes much less time than it has at any other point in history for a product to reach world markets once it is approved for release. Harry Potter was released in markets worldwide on the same day, and drugs can be on pharmacy shelves across the country within weeks after approval by the Food and Drug Administration (FDA). The World Trade Organization has opened many new markets and is working to provide equal protections in all of them. All of this means that it should be easier than ever for companies (or authors) to profit from their inventions in less time than ever. This would seem to make the case for shortening rather than extending protection, and there should be some review of when public policy considerations should allow specific intellectual property rights to be overridden. Led by Brazil, which ignored some international patents to create one of the world's most effective and affordable AIDS treatment programs, this is indeed happening in the developing world. Even as authors, we think it would be nice to live in a world where we could sing iconic American songs by George Gershwin or Irving Berlin without having to slip a copyright notice into the chorus.

In nanotechnology, the patent issues have not yet captured public attention, but clearly there is an overwhelming human need to see that the technology is developed and used. Patents should advance both the society's progress and the developer's income, and we do not want the situation to be similar to the worst of Harry and Mickey on drugs.

Privacy and Civil Liberties

The Constitution of the United States does not specifically mention the right of privacy, but it is a remarkable, strong charter protecting civil liberties. Issues of privacy and civil liberty within American society are clearly much larger than any simple nanotechnology considerations, but nanotechnology does add urgency to them. Our progress toward the use of nanostructures within the society should engender a new concern about secure protection of privacy and civil liberties.

Shakespeare's Brutus was concerned about Caesar taking too much power when he said, "And then, I grant, we put a sting in him, / That at his will he may do danger with." There are obvious ways in which nanotechnology will substantially increase the capability of governmental and large private organizations to ride roughshod over privacy and civil liberties. For example, if we develop the capability to screen any individual's genome in one day for a thousand dollars (and this will happen before the end of this decade), then whose property is that information? The genome will contain, for example, indicators about inherited diseases, allergies, different medical dysfunctions, and genetic traits. Already, screening for particular markers (like the brac gene for breast cancer) has been a great advance in preventive medicine. Full knowledge of a genome would be a great medical advance for the individual patient, whose awareness of his or her own condition would be very