much improved. But if these records become the property of employers, insurance companies, or government agencies (or boyfriends, or girlfriends, or mortgage brokers) then the individual's rights have been invaded.

In a total information society where nano-enabled pervasive computing is present everyplace, the ability to protect citizens' privacy is challenged. Things like grades in school, memberships in clubs and organizations, sexual preferences, consumption patterns, and political views can all be captured. Nano-based code breaking would not only allow better cracking of terrorist plots, it could also prevent any personal computer files or Internet browsing habits from remaining private. This could be both a government problem and a corporate one. The Recording Industry Association of America has advocated and received some legislative support for broad rights allowing it to defend its copyrights aggressively by breaking into computers of those it suspects of sharing music files on the Internet. If support for these policies continues and if advanced cryptographic techniques become available, the music industry (and any other similarly treated industry) could easily create a database of personal information more impressive than the FBI's.

To whom does this information belong? To whom should it be revealed? What are the constraints on disseminating that knowledge? These issues, again, predate nanoscience. But when we can monitor individual conversations through walls and windows, when old-fashioned wire taps are replaced by electromagnetic monitoring, and when nanotechnology allows labeling and tracing of every individual pill, computer chip, and pizza box, then the possibilities for loss of privacy and civil liberties are more frightening. At a time when the Attorney General of the United States is pursuing ever broader surveillance rights and continues to develop plans to reward the citizens for

spying on one another these privacy concerns are immediate and deep. Clearly, effective regulation arising from awareness of capabilities and the importance of privacy is part of the answer. Nanoscience simply creates a more pressing need for society to address these issues.

It would seem consistent with the complexity of our society and with many Supreme Court findings to assume an implied federal privacy right. However, the capabilities of nanotechnology, biotechnology, and information technology demand further and more permanent protection. Within an American context, it seems that only a Constitutional amendment directly stating a right to privacy can be trusted in light both of inconsistencies of government policy (as can be seen in the USA "Patriot" Act and the proposed Total Information Awareness Act) and of these advances in technology.

Education and Training

The invention of the automobile required driver's education. The invention of the aircraft required pilot training courses. The development of information technology required many of us to learn more than we might want to know about operating systems, file formats, and networking components. The invention of the telephone brought telephone operators, linemen, telemarketers, and AT&T. Similarly, the development of nanotechnology will mean new jobs, new careers, and new work patterns. It will also mean displacements, economic disruption, and changing employment and investment patterns. Nanotechnology should represent an opportunity for economic gain and for better peace prospects worldwide.

To enable society at large and individuals within that society to take maximum advantage of the opportunities and to overcome the challenges of nanotechnology, new educational

systems will be required. With appropriate education and training, nanotechnology and its products will be no scarier than the bicycle, which was also a tremendous technological advance when it was developed. Education and training can provide security, employment, understanding, and ease in the society as it will exist after nanotechnology has added its modicum of new things. Even in *Prey*, his novel on nano disasters, Michael Crichton shows that the perceived nano dangers can be solved by thought and by education.

People's fear of the unknown can be palpable, and can lead to riots, ostracism, xenophobia, government change, and war. Education, training, and openness are ways around these disruptions. Globalization, economic change, and rapid innovation become familiar, rather than frightening, when our education permits us to understand what they are about.

Nanotechnology will provide new medicine, new energy, new materials, new fabrics, new tennis rackets, new deodorants, new cheeses, and new skis. We will be able to see, hear, smell, and taste better. Since some aspects of this technology will be strange, it will be the responsibility of our educational systems—public, private, and supplemental—to help us understand these things. Books, Web pages, articles, lectures, newspaper columns, and television specials will help us realize the huge capabilities that nanotechnology brings.

Amorality of Technology

Science and technology are at their base value-free and amoral. Insight and wisdom can be used positively or negatively, depending on education, moral values, and social issues. In the words of Deuteronomy 30:19, "I have set before you life and death, blessing and cursing: therefore choose life, that both thou and thy seed may live."

All of science—indeed all of human effort—empowers society in all directions, good and bad. Radio brought communications and safety, but it also brought the boom-box and electric instruments and noise pollution. Prometheus the fire-giver is an image of power, but fire can burn destructively. The Haber process that makes synthetic ammonia from nitrogen and hydrogen was developed at the beginning of the 20th Century, and the fertilizers it produces are essential for world agriculture to feed the billions of people on earth. But the Haber process also makes it much easier to make artificial gunpowder, a result that helped extend World War I, killing millions in the process. In all of these examples, science and technology enable society to do critically important things both good and bad, and it is the responsibility of the society to decide how to use new ideas. Education will help, and all the moral and societal values that we develop will help determine how the world responds to the capabilities of nanotechnology.

Henry David Thoreau claimed that "time is but the stream I go a-fishing in." But the current in the stream has sped up. We now measure time in nanoseconds or less, and as this book has tried to make clear, structures at the nanoscale determine behavior in our tangible and real world. The total information society will make everybody more aware, simply because more information will be available to everybody.

The promises and threats from amoral science and technology are greater than ever. Global society will change tremendously in this century, and nanoscience will play a significant part in this change.

Vigilance, Awareness, and Responsibility

In the Constitution for the State of Massachusetts, John Adams required that the government of the State further the

arts, the sciences, and education as part of its mission. But the individual members of our present society must force the establishment of appropriate government regulatory structures based on knowledge, insight, tradition, and individual rights.

Admiral David Jeremiah, former vice chairman of the Joint Chiefs of Staff, understood the need for vigilance in a world in which the MAD doctrine is no longer adequate when he said, "Military applications of molecular manufacturing have even greater potential than nuclear weapons to radically change the balance of power. In anticipation of that possibility, the uninformed policy maker is likely to impose restrictions on the development of technology in such a way as to inhibit commercial development (ultimately beneficial to mankind) while permitting those operating outside the restrictive bounds to gain irrevocable advantage."

The need, then, is for vigilance, awareness, and action on the part of society. We no longer live in small villages isolated from one another, but in a huge, global village. We can no longer just move to avoid the smoke from the neighbor's chimney, as Abraham Lincoln's family did. Instead, we need to embrace the capabilities and possibilities that technology offers, and to do so within a societal structure that is functional, creative, responsible, and protective of individual rights.

In an article from *Defense Horizons* in March of 2002, Peterson and Egan make the following argument about instability brewing in the world.

> *[Instability is found in] those places where poverty, lack of education and lack of human rights are concentrated. In fact, one could argue that the dichotomy between the haves and have nots (both economic and digital) is by far the greatest looming global security issue ... For the first time in history, a new technology holds forth the promise of providing*

inexpensive food, energy, clean water and probably education for everyone on the planet. Nanotechnology could also be used in innovative ways to encourage national political stability and responsibility. We should begin to think about the future in these terms, for we have a choice: either we'll be defensive and respond to problems as they arise, or we will shift to the offensive and use the military and these new tools in creative new ways to deal with the problems while still we can.

Regulation is one of the legitimate activities of government at all levels. The existence and enforcement of local, county, and state regulations such as noise abatement statutes, air and water quality standards, workplace safety regulations, zoning laws, and toxic waste disposal requirements are very important. These constitute the first level of society's defense in light of the environmental and safety issues associated with nanotechnology and all emerging technologies.

More is needed. Federal action on such issues has become a political football. The current Bush administration has both pluses (the initiatives on hydrogen fuel cells, nuclear fusion, and support for the NNI) and major minuses (refusing to deal responsibly with global warming, advocating drilling in the Alaskan National Wildlife Refuge, and alteration and lagging enforcement of environmental standards). The issues that advanced technologies present require federal attention in both the development and regulatory sectors. We need an FNA (Federal Nanotechnology Agency) to complement the tremendous development efforts of the NNI with appropriate regulation, policy advice, product approval, and monitoring. This agency should undertake development, adoption, and enforcement of statutory and regulatory aspects of nanotechnology and associated advanced technologies.

Just as flight brought the FAA, as radio and TV brought the FCC, and as food health concerns and drug development brought the FDA, so nanotechnology requires (and society

deserves) an independent FNA with deep expertise and broad powers. The reason to propose yet another federal agency, rather than to assign responsibility to existing alphabetical organizations, is that nanotechnology is so different. For example, according to ETC Group reports, the FDA has assigned so-called "functional equivalence" (a designation indicating that a new food or drug operates on the same premise as another and therefore requires less rigorous approval) to nanoscaled structures, such as titanium dioxide nanoparticles used in skin cream and suntan lotion. This means that their toxicity levels may receive less attention than is due, and major concerns over the carcinogenic properties may be glossed over without adequate testing. This reflects a lack of understanding of the vast differences at the nanoscale.

Just as globalization is a major theme in nanotechnology's development and application, so global approaches are needed for effective regulation. As an example of what does work, there is the Montreal Agreement that led to the protection of the ozone layer by phasing out worldwide production of chlorofluorocarbons (CFCs). An example of what doesn't work is the failure to date of the Rio/Kyoto approach to the control of global warming. We now have the UN, the WTO, the World Health Organization (WHO), and the World Bank. We need a World Nanotechnology Organization (WNO), perhaps as a working group within one of these larger and established organizations. The WNO structure must be inclusive—advanced and developing countries, government and labor, industry, public interest, and academic representatives must all be included. To operate, the WNO will require open meetings and clear mandates and powers. This kind of inclusive policy may account for the success of the Montreal Agreement, just as the failure to date of Rio/Kyoto may be due to its lack of inclusion. This WNO should both regulate and document the

technology. It should set standards and help in their enforcement. It should enlist the best minds and the best efforts of humanity in the control, understanding, and applications of nanotechnology.

Visionaries from Isaiah and Zamenhof (the inventor of Esperanto) to Woodrow Wilson and Grotius (founder of international law) have envisioned both world peace and world security through understanding, law, morality, and policy. New capabilities for great economic security through energy, science, biotechnology, nanotechnology, and information technology can hasten the betterment of the world, and of its individual citizens.

The answers to these challenges lie in action and in education, in understanding and in responsibility, in civic awareness and in reaffirmed respect for privacy, civil rights, and individual determination. Big Brother is not the answer. We need the collective will and wisdom of all peoples. We need vision, humility, and peace. Nanoscience and nanotechnology will lead to wealth, to security, to better health and better living, but they will only do so if society welcomes them with awareness, education, and responsibility.

Nanotechnology and Homeland Security

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