PART 4

Science, Technology, and the Human Condition

Overview

The 30th Anniversary Planning Committee decided early on to focus one panel exclusively on the impact of scientific discovery over the next 30 years on the human condition. We wanted not only to understand the potential problems and benefits of scientific discovery, but also to discuss how we should identify and minimize the problems while maximizing the benefits. The panel provided a fascinating discussion that focused on three areas of science and technology: Genetics, information technology, and bioethics.

The panel included presentations from R. Alta Charo, a professor of law and bioethics at the University of Wisconsin at Madison; Irving Wladawsky-Berger, vice president for technology and strategy at IBM; and Kenneth F. Schaffner, a professor of medical humanities and philosophy at the George Washington University. Dee Perry, the host and producer of a weekday public radio talk show and a weekly public television series, moderated the discussion, which included commentaries by Patrick Hines, a recent graduate of the M.D./Ph.D. program at University of North Carolina at Chapel Hill, and Bruce Sterling, a science fiction writer, journalist, editor, and critic.

The panel touched on topics ranging from the world of political manipulation to the nuances of medical training and the role of science fiction in the public understanding of science and technology. This first panel of the conference helped to launch us on a scientific journey that can lead to a better understand the world in which we live and a better world for all living creatures.

The panel's articulate presentations and discussions suggest that our journey over the next 30 years will require careful strategies, constant thoughtfulness, and even some leaps of faith. This panel helped to elevate our thinking about the issues and policies that may affect our ability to apply scientific discovery to advance the human condition. The panel discussed our celebration and fear of science and recommended placing more value on science literacy to help society better evaluate and understand science and technology and its role in our lives. As Dee Perry affirmed "science and technology are just other prisms, like the prisms of art and culture that I talk about daily, through which we might squint, trying to understand who we are, how the world works, and how to make it work better."

Our panelists presented a sampling of the complex issues we face with bioethics, information technology, and genetics. We must better understand the interplay between genetics and the environment, as well as the intricacy of human thought and emotion, to be able to use current genetic knowledge to inform some of our most critical decisions about child development and social prejudice. Realizing the strong role that beliefs about morality and cultural acceptance

play in social decisions, scientists must open dialogues with other members of society to work through strategies together—humility and communication are indispensable. Research on the impact of science and technology on society can help us address and reduce the negative consequences of scientific discoveries. And our own dedication to resolving inequities, such as the digital divide between the rich and poor, can help ensure that many people in our society benefit from scientific breakthroughs.

In recognizing that many of society's problems demand innovation and collaboration among the forces of science, policy, and culture, we must focus on gaining the ingenuity necessary to advance. Whether that ingenuity requires creating scientists who are politically engaged and who can represent our society at large or placing the onus on the public to become more scientifically literate, we have a lot to consider and change if we are to ensure that advances in science will improve the human condition.

Introduction: Dee Perry

Dee Perry has made her home at public radio station 90.3WCPN in for the past 15 years. She is currently the host and producer of a weekday magazine talk show called "Around Noon," which focuses on visual and performing arts, cultural trends, and current events. In addition, she serves as host and producer for the public television series, "Applause," a half-hour weekly production of WVIZ Cleveland, also devoted to arts and culture. Ms. Perry has been a part of the Cleveland broadcasting scene for 28 years, having started her career at WABQ-AM in 1976. She was born and raised in Cleveland, graduated from Cleveland State University, and has performed in several local theater productions.

I am very pleased but surprised to be part of this celebration. I was not a good prospect to excel in science and technology. As a teenager, I got my first D ever in junior high school algebra class. In biology I empathized with the frog too much, and in chemistry my table of elements was usually a few place settings short. Plus I was a fan of the florid nineteenth century novels, such as Robert Louis Stevenson's *Dr. Jekyll and Mr. Hyde* and Mary Shelley's *Frankenstein*, where scientific risk-taking always went wrong. Now in Shelley's novel, Frankenstein, the doctor, doesn't really dance around gleefully saying, "It's alive, it's alive." Rather he views his creation's first movements, his first signs of life, with dread because Frankenstein's man-made creation doesn't at all resemble the superman that he had in mind. With all that in mind, then, I really didn't see much of a future for myself in science and technology.

We'll flash forward about 39 years, and I still didn't see myself in that light, when I got a call from a very pleasant young man named Mark Tumeo, who said, "Dee, would you be a speaker, a moderator, in fact, for the American Association for the Advancement of Science." Well, Mark had heard my show in Cleveland, but I thought he must have the wrong person. Maybe he had me confused with our environmental reporter. But Mark explained, No, I was the person he had in mind, and as he hung up, I thought about why and what I could bring to this table.

It began to occur to me that what I brought was a proxy from the millions of people all over the world who think that they just don't get science and technology and who believe those things don't have much to do with their everyday lives. The more I thought about the symposium as the weeks and months went on, the more it became clear to me that science and technology are just other prisms, like the prisms of art and culture that I talk about daily, through which we might squint, trying to understand who we are, how the world works, and how to make it work better.

Science and technology are just other prisms, like the prisms of art and culture...through which we might squint, trying to understand who we are, how the world works, and how to make it work better.

I recently had the chance to talk with a physicist at Case Western Reserve University, Dr. Lawrence Krauss. Dr. Krauss has received lots of media attention in the past few years for his writings that combine science and popular culture. One of the things that he said during the course of our conversation was that he deplored the national trend toward eliminating arts education from public schools. He saw the arts as an integral part of shaping a deep-thinking, deep-feeling human being. But he went on to say that he was equally passionate about the contributions that science and math make in shaping that well-rounded individual and that it was important to integrate both viewpoints.

Well, that chat was my "eureka" moment in preparing for this symposium, because it echoed the mission and goal statements that I had received from the AAAS. Those goals are to foster communication among scientists, engineers, and the public; to enhance international cooperation in science and its application; to promote the responsible conduct and use of science and technology; to foster education in science and technology for everyone; to enhance the science and tech-

nology workforce and infrastructure; to increase public understanding and appreciation of science and technology; and to strengthen support for the science and technology enterprise, all of which are designed to get to the ultimate AAAS goal of advancing science and innovation throughout the world for the benefit of all people.

The association has a long history of partnering with policymakers to help shape a better world, as you have just been hearing from our previous speakers. That partnership began in 1973 with the AAAS Science and Technology Policy Fellowship Programs, which has led to contributions in the fields of community energy response planning; energy legislation, energy technology, wildlife preservation, family support systems for military families, and that's just the short list.

Actually, very few of society's major problems will improve without input from science and technology. Think about health, the environment, or the economy. In the past hundred years, science and technology have extended our lifespan, enabled us to fly higher and farther than we ever dreamed, connected us to a World Wide Web, and put the universe at our fingertips. What more is there to discover? Well, that's the overarching question for this Vision 2033 Symposium on Linking Science and Policy for Tomorrow's World. Our first discussion is about science, technology, and the human condition. Together, we'll explore the societal impacts and policy implications of advances in science and technology over the next 30 years. We will focus on topics such as health, genomics, bioethics, personal privacy, and information technology, with an opportunity for discussion after each presentation and questions from our audience at the end of the session.

Science and technology have extended our lifespan, enabled us to fly higher and farther than we ever dreamed, connected us to a World Wide Web, and put the universe at our fingertips. What more is there to discover?

R. Alta Charo

R. Alta Charo is the Elizabeth S. Wilson-Bascom Professor of Law and Bioethics at the University of Wisconsin at Madison, where she is on the faculty of the Law School and the Medical School's Department of Medical History and Bioethics. She has served on the university hospital's clinical ethics committee and the university's bioethics advisory committee and review board for the protection of human subjects in medical research. She has also been a visiting professor at law and medical schools in Argentina, Australia, Canada, China, Cuba, France, Germany, and New Zealand. In 1994 Professor Charo served on National Institutes of Health's Human Embryo Research Panel, and from 1996 to 2001 she was a member of the presidential National Bioethics Advisory Commission. She is a member of the National Academy of Sciences' Board on Life Sciences and the Institute of Medicine's Committee on Smallpox Vaccination Program Implementation.

Professor Charo is the author of more than 75 articles, book chapters, and government reports on topics including voting rights, environmental law, family planning and abortion law, medical genetics law, reproductive technology policy, and science policy and ethics. She currently serves on the editorial boards of the *Journal of Law, Medicine and Ethics,* the journal *Cloning: Science and Policy*, and the *Monash Bioethics Review.* Holding an A.B. in biology from Harvard and a law degree from Columbia, Professor Charo is a former AAAS Diplomacy Fellow, having served in the Policy Development Division of the Office of Population at the U.S. Agency for International Development.

It is a real pleasure to be here among those of you who are currently Fellows. I admit that I envy you because my year as an AAAS Diplomacy Fellow, floating around West Africa and Central America, was one of the best years of my life.

I would like to talk with you about the enduring tension between bioethics and public policy and to alert you to the cultural war that is going on. It's not a new war, but it is one that I think will still be with us in 2033. It will be resolved in part by the degree to which people who are science literate affect the culture of those who are science illiterate in the United States.

The cultural war that is going on...will be resolved in part by the degree to which people who are science literate affect the culture of those who are science illiterate in the United States.

There has long been a tension in the United States with regard to the government's role in regulating morals, which is pertinent because the same tension arises over regulating the life sciences. Although I know we are supposed to be talking about 2033,I would like to drop back briefly to the nineteenth century to show you how this tension playing out in the aftermath of the Civil War. Whether from the North or the South, men came home changed by their experiences in that incredibly brutal conflict. Besides their diseases and their infestations, they came back with a habit of, to be frank about it, whoring and drinking and wife-battering. This really was the pattern of behavior in the immediate post–Civil War period.

One result was a strong postwar movement across the United States to develop federal morals regulation of behaviors that were seen as socially disruptive. In that era, we begin to see support converging around the notion that biblical teachings should be incorporated into law, so that biblical sin would become federal crime. As attention turned to the behaviors associated with soldiers, we see the beginning of antipornography legislation. That legislation in turn became the basis for criminalization of anybody who sent through the U.S. mails information about contraception, lest knowledge of contraception facilitate and encourage fornication.

The same movement underlay the great debates

about polygamy that dogged the territory of Utah, in which criminalization of polygamy and renunciation of the practice by the Mormon population became a condition for the admission to the United States. And, of course, the movement's greatest success came in the long battle over drinking that resulted in Prohibition, one of the great public policy experiments of America. Prohibition of alcohol was ultimately repealed, but not before we decided to embark upon a similar experiment still going on today with respect to other recreational mind-altering substances, such as marijuana.

Thus we see in every era an instinct that collective good requires morals regulation. In the post–Civil War period, movements converged around the notion that it is appropriate for the federal government to take a role in identifying the collective good, identifying those areas of personal behavior that undermine the collective good, and then legislating with the use of both civil and criminal penalties to shape and enforce majoritarian morality. And lest you think these movements were entirely the result of the nineteenth century equivalent of today's extreme moral regulators, they also included the nascent feminist movement, concerned about the effect of drinking on wife battering.

After World War II, however, we begin to see in the legal arena a movement toward a new jurisprudence of individual rights associated with ideologies such as moral pluralism or even moral relativism, in which different groups could have distinctly different ideas or different individuals could have distinctly eccentric ideas about what constituted the appropriate forum of behavior. This jurisprudence based on individual liberties led to, among other things, the vast increase in privacy for reproductive decision making and a retreat by the government in the regulation of people's personal reproductive choices.

But that movement, which started in the 1960s with court cases that overturned the criminalization of contraception and later abortion, has not completed its job. Indeed, to this day we see tremendous tensions. Recent court decisions in Ohio and New York, for example, have told men and women that they may not have any more children until they have enough money to support them. In 1992, this movement toward individual rights and moral pluralism, which had spawned not only the reproductive rights movement but the gay rights movement, the women's rights movement, the civil rights movement, and many other movements for the protection of individuals who did not conform to notions of mainstream society, this moral pluralism came under attack. The attack was explicit at the Republican National Convention when Pat Buchanan announced that we had now entered an era of culture wars. Some people thought at the time that he exaggerated, but many found his rhetoric alarming.

By June 2003, we find a Supreme Court decision that identifies culture wars as exactly what is going on in the world of morals regulation. I will suggest later in this presentation that the same kind of culture wars are exactly what's going on in the world of bioethics.

The U.S. Supreme Court decided a case called *Lawrence v. Texas* in June 2003. It concerned a Texas statute that criminalized sodomy between homosexuals, but not between heterosexuals. Therefore, most people had been anticipating that, if the Court struck the law down, it would do so because the law made an inappropriate distinction between homosexuality and heterosexuality, but that the Court would not challenge the underlying act of criminalizing a particular sex act.

To the surprise of many observers, however, the Supreme Court struck down the Texas statute in what is really a clarion call to the world of moral pluralism. Justice Kennedy identified the Texas statute as one that attempted to take a particular form of majoritarian morality and enforce it on all people within the state. This majoritarian morality held that sodomy was somehow bestial and inappropriate, and therefore nobody should do it. Rather than accept this notion of collective good as an adequate justification for state interference, Justice Kennedy found that states could only write laws concerning morals to protect a specific third party who might be harmed in some way. In other words, states must analyze the consequences of an act and search for an actual bad consequence before they can regulate. In *Lawrence,* the regulation did not involve persons who might be injured or coerced or situated in relationships where consent might not easily be refused; it did not involve public conduct or prosti-

tution; and it did not raise the issue of whether the government must give formal recognition to any such relationship. In remarkably strong language, Justice Kennedy concluded that the Texas statute forbidding homosexual sodomy furthered no legitimate state interest that could justify its intrusion into the personal and private life of the individual.

This was really throwing a gauntlet down, because it was saying that the state's legitimate interests do not extend to promoting what the majority of the state's citizens view as an appropriate code of personal moral behavior. As you might imagine, Justice Scalia wrote a dissenting opinion, in which he reiterated some comments that he had made ten years earlier in an abortion case that had touched on states' entitlements to regulate in the area of personal morality. Justice Scalia's blistering dissent went as follows: "The Texas statute undeniably seeks to further the belief of its citizens that certain forms of sexual behavior are immoral and unacceptable. The same interests [are] furthered by criminal laws against fornication, bigamy, adultery, adult incest, bestiality, and obscenity. *Bowers* held that this was a legitimate state interest. The Court today reaches the opposite conclusion. The Texas statute, it says, furthers no legitimate state interest that can justify its intrusion into the personal and private life of the individual. The Court embraces instead the dissenting opinion in *Bowers* that the fact that the governing majority in a state has traditionally viewed a practice as immoral is not a sufficient reason for upholding a law prohibiting the practice." And then Scalia continues: "This effectively decrees the end of all morals legislation. If, as the Court asserts, the promotion of majoritarian sexual morality is not even a legitimate state interest, none of the above-mentioned laws can survive even the most minimal judicial review."

Now, the majority view in *Lawrence* was a shot across the bow in the world of Supreme Court decisions because it rejected the nonconsequentialist, communitarian morals regulation that had been previously upheld. That shift is also significant in the world of bioethics, because the same kind of struggle between consequentialist and nonconsequentialist approaches has been happening in our field and is likely to continue for the next few decades. Those who favor a consequentialist approach want to examine scientific technologies for their precise consequences to those who are minors, those who are vulnerable in situations where consent is not possible, or those who are in settings otherwise subject to coercion, in which case safeguards should be sought to protect those specifically at risk, but nowhere else. Those who take a nonconsequentialist, more communitarian, and neoconservative approach see science operating as a subtle threat to undermine society by fostering novelty and evolution in social norms. For the nonconsequentialists, it is irrelevant that a particular technology may in fact be harming no one. Rather, it is relevant only that the technology changes our notions of things like human dignity, the meaning of being male and female, or the meaning of being a mother, father, or sibling. The mere fact of change provides the legitimate state interest that can trigger authority to restrain science or, in the case of things like stem cell research, actually criminalize it.

[The] neoconservative approach sees science operating as a subtle threat to undermine society by fostering novelty and evolution in social norms

It is crucial here that we address this struggle in the world of bioethics, because bioethics is increasingly part of public policy. In public policy we like to ask who specifically is going to be harmed by these new and forthcoming technologies, including genetic testing, gene therapy, stem cell research, and neurobiology or biological enhancement. It isn't individuals, right? With some small exceptions, the harm tends to be directed toward concepts of social stability and order.

Nowhere can we see this trend more clearly than in an examination of the work of the President's Council on Bioethics (PCB). (For the sake of transparency, you should know that I served on a previous bioethics commission appointed by President Clinton.) Most of you, I suspect, are familiar with the phenomenon of politics in bioethics because you have seen the stories of how Elizabeth Blackburn, a highly regarded scientist from the University of California-San Francisco, was dismissed from President Bush's bioethics council. Many people believe she was dismissed because of her active dissent, both publicly and behind the scenes, with regard to the council's reports on cloning and stem cells, and her persistent complaints in the press and in published articles that science was being distorted in the council's reports.

She charged that the risks were being overplayed and the current constraints, both technical and regulatory, were underplayed.

Of course, public bioethics debates intended to influence public policy discussions can never be free of politics. All the previous commissions were set up with some degree of political ideology in mind. To my knowledge, there were no active Republican Party members on the bioethics commission set up by President Clinton. But neither has there ever before been a litmus test on particular issues, not even on the abortion issue, nor has there ever been turnover in a bioethics commission specifically because of distress with the views that were espoused both at the commission table and in private by the members.

But what is more significant, I think, about what we are seeing on the Bush council, led by Dr. Leon Kass from the University of Chicago, is not the politics of the personalities, but the politics of the ideology that permeates the work. The intriguing aspect for me about this bioethics council is its deep connections, both among the staff and among the members, with the neoconservative movement, a movement that we usually associate with debates about U.S. international policy and the use of military force. These particularly deep connections may explain the generally worried tone about science that has been the hallmark of this bioethics council ever since its first meeting, which was organized around a discussion of Nathaniel Hawthorne's short story "The Birth Mark," a story of science run amok. As one critic of the leadership of the President's Council on Bioethics put it, "One of Leon Kass's primary intellectual influences is…Hans Jonas,…one of the first bioethicists who advocated a 'heuristics of fear' to help stave off biomedical advance. According to Jonas, bioethicists ought to employ a 'comparative futurology' of possible sci-fi horror stories, because we humans need 'a threat to the image of man to assure ourselves of his true image by the very recoil from these threats.'" Indeed, Kass has frequently cited Aldous Huxley's *Brave New World,* and C.S. Lewis's *The Abolition of Man,* as the most influential books he's read in the areas of bioethics.

This strain of disutopian thinking was noted by a number of members of the President's council, including Blackburn, who had commented in print, "There is always the strong implication in the council's reports that medical research is not what God intended, that there is something unnatural about it." Indeed, she may be onto something. As described in a lengthy piece in the journal *Science*, this concern about science may be one that Leon Kass has shared or even inherited from an earlier neoconservative thinker, Leo Strauss. "In 1962, political philosopher Leo Strauss, guru of many neoconservatives like Kass (and an influence on other bioethics commission members like Francis Fukuyama), wrote an essay titled 'The New Political Science.' In it, he worried that science risked upsetting the 'natural order.' We should know our place, Strauss wrote. 'Man is radically distinguished from non-man, from brutes as well as from gods.'" You can see echoes of this writing in Leon Kass's own work, in which he has developed Strauss's notion of common sense into something Kass calls "the wisdom of repugnance," in which those things we recoil from are things that we should approach cautiously, with a presumption that we should forbid them, criminalize them, and squelch them, because that very instinct of repugnance is one that should be heeded. It should be noted that this is exactly the argument that was made by Kass and others back in the 1970s about the then-novel technology of in vitro fertilization, which he said was repugnant because of the way it would dehumanize the intimacy of reproduction and personal relations.

One of the hallmarks of neoconservatism is wariness born of a pessimistic view of human nature. The neoconservative tends to see the world as a struggle between the forces of good and evil, light and dark, and therefore advocates more strenuous measures than might be found in the more restrained international policy of traditional forms of conservatism.

Now, the neocon movement is associated with certain journals and certain names that everybody will recognize, the Wolfowitzes and the Perles, for example. Fewer people are aware that neoconservatism has also insinuated itself into bioethics. So you have the Project for the New American Century (PNAC), a neoconservative think tank closely affiliated with the New Citizen-

ship Project, founded by one of the most prominent neoconservatives, William Kristol, who himself chairs his own bioethics project. PNAC also has strong ties to the American Enterprise Institute (AEI), where Leon Kass, head of the Bush bioethics council, along with Newt Gingrich, Irving Kristol, and Charles Murray (author of *The Bell Curve*) were all scholars and fellows. James Q. Wilson, another member of the President's Council on Bioethics, is also tied to AEI, having served as chair of its Board of Academic Advisors.

Other members of the President's Council on Bioethics have similar neoconservative ties. PNAC's members include Francis Fukuyama, who has written about the need to squelch biotechnological advances and subject them to both global and national regulatory systems that would not regulate solely for safety, but would really look at the uses of biotechnology that were considered to be morally suspect. Fukuyama appears over and over in these circles, often in conjunction with William Kristol, J. Bottum (who founded the neocon publication *The Weekly Standard*), and Wesley Smith, who is a frequent defender of the bioethics council in *The Weekly Standard* and who himself is associated with the creationist Discovery Institute in Seattle. All of them signed the "Open Letter to President George Bush on Human Cloning," a letter that was sponsored by the Center for Bioethics and Human Dignity. The letter called for the criminalization of basic cloning research, even nonreproductive work. Benjamin Carson, a new appointee to the PCB substituting for Liz Blackburn, also signed the open letter.

Other PCB members have their own neoconservative ties. Gilbert Meilaender, a professor of Christian ethics at Valparaiso University, is a board member of *First Things,* a journal on religion edited by the neoconservative Richard John Neuhaus, which has featured articles by Wesley Smith and PCB member Mary Ann Glendon, member of the anti-gay Alliance for Marriage. I could go on and on, but what I would like to emphasize is that at least half of the members of the council belong to organizations that are devoted explicitly to a neoconservative agenda in bioethics. They work together privately; they come to the council; they take the council work back; they contribute to their own journals and newspapers. This is a degree of interlacing that we have never seen before.

Even more interesting is the degree to which the council's staffing represents the same degree of interlacing. Since many people here as Fellows have worked as staff, I think most of you are aware that staffs are not completely free of politics. Nonetheless, for these kinds of advisory councils staff members are usually selected on the quality of their thinking and their academic skills, rather than their partisan affiliations. The goal, quite specifically, is for staff to provide a solid base of good science—social science and natural science—which then frees up the politically appointed members to use that information as political actors.

Instead, the bioethics council has an executive director who is considered a health expert because he worked for Dick Armey and whose credentials include signing a call for an end to public education and a return to home and often religious schooling.

Another example of hiring conservative staff concerns Eric Cohen, who is the council's senior research consultant. He runs the Bioethics in American Democracy Project at the Ethics and Public Policy Center, which promotes the infusion of religious values into public policy and which is described by Leon Kass as "a beacon of moral clarity." Cohen is also the managing editor of *The Public Interest,* another neoconservative publication that has featured the writings of many of these same people. Kass, for example, has written some very provocative things for *The Public Interest*, including his 1980s condemnation of in vitro fertilization and his late 1990s condemnation of premarital sexual activity among what he called careerist women and his call for women to stop having sex before marriage and to stop marrying men that their fathers don't approve of. Indeed, the publication committee for *The Public Interest* reads like a *Who's Who* of the bioethics council.

Now, of course, if you were to look at other organizations and other bioethics groups on a different end of the political spectrum, you would find some degree of overlap. I might be an elected fellow of the Hastings Center, and the Hastings Center might have as its current director somebody who served on the Clinton

commission. Nonetheless, you would not see the degree of overlap—joint publications, joint public policy projects, and overlapping hiring and consultancies—that I have outlined here.

One member of the Bush council has argued that liberal, consequentialist bioethics as a field has in recent years developed a political agenda itself that is just as distinctive as the science-skeptical agenda that I was discussing earlier. That bioethics agenda includes a commitment to scientific progress within a structure that values personal autonomy. Indeed, bioethics council member Gil Meilaender has argued that bioethicists were co-opted by the enticement of being allowed onto advisory bodies and in exchange they agreed to never argue for regulation of science in any setting.

I think this characterization is erroneous. Far from playing solely an advisory role, bioethics in the 1970s was crucial to the passage of several key pieces of regulatory legislation. Support from bioethicists led to the most comprehensive (although still inadequate) regulation that we have ever had with regard to the practice of research on human subjects, as well as the development of model laws on topics such as defining death, regulating organ donation, and managing fetal tissue research. Bioethicists were also crucial in developing the regulations for federally funding embryo research prior to the 12-year Reagan and Bush, Sr., moratorium on embryo research funding from 1980 to 1992. Far from suggesting that science shouldn't be regulated, the debate going on now is about whether regulation should be limited to protecting vulnerable parties from concrete, foreseeable harms, or whether regulation should protect society from any change in current majority notions of human dignity and personal relations.

Far from suggesting that science shouldn't be regulated, there is a debate going on about whether regulation should be limited to protecting vulnerable parties from concrete, foreseeable harms, or whether regulation should protect society from any change in current majority notions of human dignity and personal relations.

Yul Levin, who is currently the deputy executive director of the bioethics council and also senior editor of the conservative bioethics journal *The New Atlantis,* has written that among the more prominent peculiarities of our politics in recent years is that something called bioethics has become a key conservative priority. After describing the angst some feel about science uncovering the origins of life, behavior, and even consciousness, Yul Levin notes: "The resulting intellectual and political activity has melded some of the interests of the pro-life movement with those of conservatives more concerned with the general culture and its institutions, and it has formed through that combination, an altogether plausible conservative program…. The present task of conservative bioethics, therefore, must be to develop and articulate a coherent worldview, to put meat on the bones of loosely defined terms like 'human dignity' and 'brave new world' and turn ethical disquiet into public arguments."

This is an overtly partisan agenda about turning angst into public policy. What is even more interesting is that it's a conservative angst-ridden agenda that is not based on grassroots democracy. Instead, it follows another one of Leo Strauss's great themes, which has to do with elitism. The current bioethics council does not have elected politicians, nor does it have representatives of the public. It was deliberately and explicitly designed to have so-called public intellectuals and elites. Such elitism is another hallmark of this movement, a movement in which the leadership believes that essential truths about human society and history should be held by an elite. Philosophy is dangerous because it brings into question the conventions on which civil order and morality depend. This risks promoting a destructive nihilism. According to Strauss, the relativism of modern American society is a moral disorder, and moral clarity is essential. And if you look at the bioethics council's Web page and its opening vision statement, it talks about one of its goals being to address the creeping moral relativism and moral disorder of American society.

In many ways, the council is representing a combination of the administration's views and the views of its current chair, Dr. Kass. Yet, despite this profound shift in the notion of the appropriate role of government in morals regulation with regard to the life sciences, there's really very little discussion of the appropriate boundaries of governmental intervention here, a discussion that is actively taking place in other venues, such as the *Lawrence v. Texas* decision I mentioned earlier.

Moral angst is one thing; federal criminalization of research or medical practice is another. The PCB's work tends to feature chapters and chapters of discussions

about the meaning of human dignity and the loss of romance in human intimacy, with scant attention to the political philosophy questions about the role of government and the role of majoritarian morality.

It is in this most fundamental of cultural divides that the special characteristics of the bioethics council emerge. In the widespread attachment to a neoconservative world view that is suspicious of technological advance, opposed to moral relativism and moral pluralism, determined to identify moral absolutes, and open to an increasing permeation of religious values into public policy and bioethics analysis, this council appears to reflexively endorse the view that science is a threat to both society and government. Listen to what Leon Kass himself wrote before he became chair of the council. Although this quotation is from many years ago, it's quite consistent with where he is now taking the council: "Science essentially endangers society by endangering the supremacy of its ruling beliefs.... Science—however much it contributes to health, wealth, and safety—is neither in spirit nor in manner friendly to the concerns of governance or the moral and civic education of human beings and citizens. Science fosters and encourages novelty; political society, governed by the rule of law, cannot do without stability. Science rejects all authority save the truth, and prefers skepticism to submission when truth is unavailing. The political community requires trust in, submission to, and even reverence for its ruling beliefs and practices."

This is about as clear a statement as you can get for the source of the angst about science. This is basically a divide between those who celebrate the transformative power of science and those who fear it. And it is a divide that is both broad and profound. It's broad because it reaches into many other areas of the national debate. It's hardly a leap to move from asserting that each child has a human right to be conceived by both a man and a woman, as the bioethics council did in its recently released report on reproductive technologies, to claiming that each child has a human right to be reared by a father and a mother, with obvious implications for today's debates about gay marriage and adoption by gay couples.

It is also a profound divide because it reflects competing fears, with one group most fearful of social change wrought by technology and the other most fearful of oppressive overreaching by a government bent on controlling those changes. It would be most unfortunate if the future of bioethics lies in the identification of science as fundamentally incompatible with civil society. Bioethics should be a field that helps society to evolve, not to stagnate. And while bioethicists on both sides of the divide will continue to find some common ground in federal and state policies that guide technological development through funding decisions and oversight to protect identifiable individuals from avoidable harm, they will continue for the foreseeable future to engage in a more fundamental debate that is simply an echo of the national debate, a debate about political philosophy and the role of government in morals regulation and in the construction of societal norms. What has changed is simply the explicitness with which this debate has now been joined. I think we're going to need a new word to describe this field. I don't think bioethics will be sufficient. We may need a word that suggests more than the ethics of biology or medicine and incorporates the ethics of governance. To the extent that the debate is about whether science uncovers the secrets of life and permits change or instead demystifies life and threatens faith, the great task ahead will be for those who are science literate to explain to those who are science illiterate why we should not be scared of the future, but simply curious to see what it brings.

Bioethics should be a field that helps society to evolve, not to stagnate. This is basically a divide between those who celebrate the transformative power of science and those who fear it.

The work [of the President's Council on Bioethics] tends to feature chapters and chapters of discussions about the meaning of human dignity and the loss of romance in human intimacy, with scant attention to the political philosophy questions about the role of government and the role of majoritarian morality.

Note:

Much of the content of this presentation is developed more fully in R. Alto Charo's forthcoming article, "Passing on the Right: Conservative Bioethics Is Closer Than It Appears," *Journal of Law, Medicine & Ethics,* 32 (2004).

Discussion: Patrick Hines and Bruce Sterling

Patrick Hines is a recent graduate of the M.D./Ph.D. program at the University of North Carolina. Prior to entering the program, Dr. Hines attended Hampton University on a Minority Access to Research Careers Award and a music departmental scholarship. He received a B.A. in chemistry in 1996. After completing his first two years of medical school and two laboratory rotations, Dr. Hines joined the laboratory of Leslie Parise (Pharmacology), where he studied the regulation of sickle cell adhesion to the extracellular matrix. He received the Michiko Kuno Award for outstanding oral presentation at the medical school's annual Student Research Day (1998) and was elected National Chairman of the Board of Directors for the Student National Medical Association (SNMA).

Bruce Sterling, author, journalist, editor, and critic, has written eight science fiction novels and three short story collections. He edited the anthology Mirrorshades, the definitive document of the cyberpunk movement. He also wrote the nonfiction books *The Hacker Crackdown: Law And Disorder On The Electronic Frontier* (1992) and *Tomorrow Now: Envisioning The Next Fifty Years* (2003). He is a contributing editor of Wired magazine. He also writes a weblog and runs a Web site and Internet mailing list on the topic of environmental activism and postindustrial design. He has appeared on ABC's "Nightline," BBC's "The Late Show," CBC's "Morningside," on MTV, and in the *Wall Street Journal, Time, Newsweek, Fortune, Nature, New York Times,* and *Der Spiegel.* He lives in Austin with his wife and two daughters.

MS. PERRY: Our discussants will address the topics raised by Dr. Charo on bioethics. Let's ask those neoconservative questions, Is progress in science and technology always desirable? Do we do things just because we can?

MR. HINES: Those are interesting questions. Often scientists and physicians aren't necessarily trained to take views outside of science and technology into account. We are usually trained to accept a one-sided view that science and technology always yield positive results. We don't focus on the negative aspects of science and technology. However, even given that tendency, I think that the bridge to folks who are reluctant to embrace the new advances in science and technology wouldn't be quite as large, if the public were better educated on at least the fundamentals of science. It would then be easier to see the difference between advances and things that shouldn't be tampered with.

If you look back in history, a lot of the issues that we see now with stem cell research, cloning, and the discovery of the human genome are similar to issues that were raised when we were looking at just the simplest types of cloning in basic research, which now are very well accepted. We now have a much better appreciation of how they benefit us by advancing science and medical technology.

These are discussions that we are going to have any time that we push the envelope in science and medicine, because they make us confront issues that we haven't had to deal with before. For science to progress, we are going to have to have these difficult discussions. However, I think that as scientists and as physicians the onus is on us to educate the public, so that they will be more accepting of the advances that we are trying to pursue.

One last comment: It's easy for us to become frustrated with the impediments that are put in the path of advancement of science, because we are

unable to see things from the other side. If we didn't have quite as strong an understanding of the science, we might have the same reservations as some members of the public. I think the onus is on us to become more involved in policy issues and to help the public become better educated, so that these advances won't be met with such resistance.

MR. STERLING: I thought it was great to see a little Elizabeth Blackburn bloody-shirt-waving in public. I didn't really think people were going to get right to the gist of the matter with so much admirable passion. I'm absolutely confident there is going to be a straight-out culture war 30 years from now, just as there is today. There are still people in our society who don't get it about Charles Darwin in 1857. They're not going to go away. You're never going to be able to hide from it inside some lab, anymore than abortion doctors can hide from those assassins with rifles. That battle still rages, even though abortion and reproductive rights were decided by the Supreme Court decades ago. There's still a huge march here in town every year on the anniversary of *Roe v. Wade.*

These enduring differences mark a long-term chasm in our society, and I don't think it can be really stated any more clearly than it is in that council on bioethics. It's silly to soft-pedal it, when the K Street strategy is to polarize it to the greatest extent possible. So I suggest a few future names for your organization, because I think American Association for the Advancement of Science does kind of beg the question. It suggests that all scientific discovery always advances, and I don't think that it does. I think that science clearly moves in crablike fashion and goes in and out of vogue, as people have their funding cut and lines of inquiry get discredited. So maybe you could try some of these alternatives. If you ever see the establishment of the American Association for the Corruption of Science, I would worry about that. Or you might name yourselves the American Association for the Creeping Advancement of Moral Relativism. Or you might take it right to the streets and rename yourselves the American Association for the Preservation of Science from Luddite Assaults by Creepy Ideological Cranks.

Kenneth F. Schaffner

Kenneth F. Schaffner is University Professor of Medical Humanities and Professor of Philosophy at the George Washington University. Previously, he was University Professor of History and Philosophy of Science and Research Professor of Medicine at the University of Pittsburgh, where he also was co-director for the Center for Medical Ethics. Dr. Schaffner, who holds an M.D. from the University of Pittsburgh and a Ph.D. in philosophy from Columbia University, has been a Guggenheim fellow and has published extensively in philosophical and medical journals on ethical and conceptual issues in science and medicine. His most recent book is *Discovery and Explanation in Biology and Medicine,* published in 1993 by the University of Chicago Press. Other recent work has been on ethical and philosophical issues in human behavioral and psychiatric genetics, and he is completing a book for Oxford University Press on *Behaving: What's Genetic and What's Not, and Why Should We Care?* Dr. Schaffner is a fellow of both the Hastings Center and the American Association for the Advancement of Science. He was also section editor for psychiatry and philosophy of medicine of the recently published third edition of the *Encyclopedia of Bioethics.*

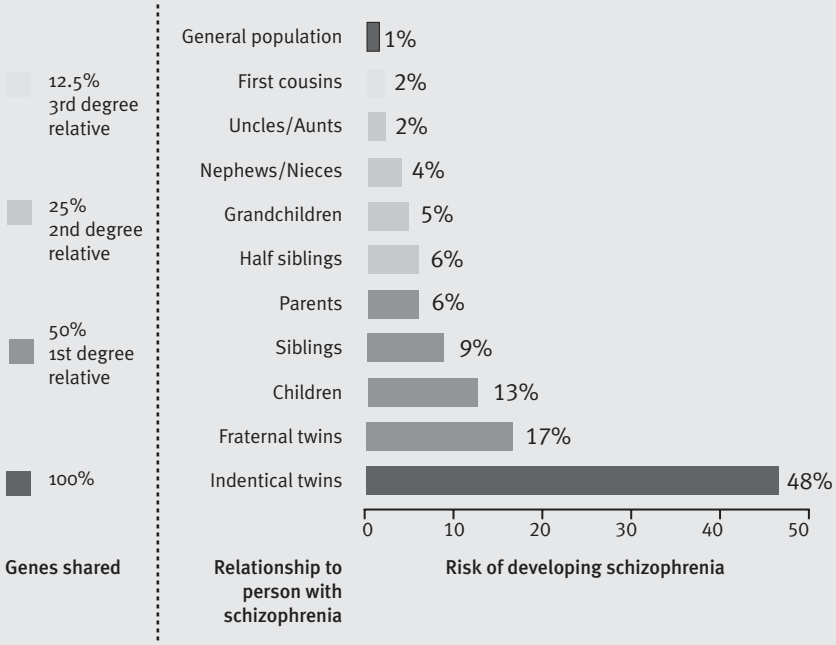
I'm going to talk to you today about the current state and outlook for behavioral and psychiatric genomics (BPG). Behavioral and psychiatric genomics is important because severe mental illness devastates millions of lives worldwide. In the United States, for example, about 11.6 million adults have a serious mental illness in any one-year period, and of these, 5.6 million have a severe and persistent form of mental illness. Individuals with serious mental illness make up about a third of the homeless population, and major mental disorders, such as schizophrenia and bipolar illness, have turned out to have very strong familial risk factors. The family of a person with schizophrenia, for example, has greater likelihood of developing the disease themselves the closer their genes match the victim's (see Figure 1). If your identical twin has developed schizophrenia, your risk of developing schizophrenia in your lifetime is almost 50 percent. If you have a sibling and your sibling has developed schizophrenia, your risk is about 10 percent. If there are no relatives in the family that have developed the disorder, then you're part of the general population, and your risk is only 1 percent. This suggests that the genetic relationship is significant in that disorder.

These disorders are very difficult to understand, and in the long run will almost certainly require complex and intertwined genetic, proteomic, neuroscientific studies that draw upon brain imaging, phenotype refinement through clinical dialogues, and environmental studies. But genetic etiology (or, the genetic causes) and the genomically related pathophysiology might give us the best purchase on these illnesses in the short run.

Genomics is a new term that supplements the notion of genetics by taking into account *many* genes simultaneously, rather than focusing on just one gene at a time, although frequently genetics is also used in this broader sense.

Now, social risks are associated with using genetics or genomics to explain differences in behavior. Studies

FIGURE 1. Genetic Influence on the Risk of Developing Schizophrenia



Source: I. I. Gottesman, "Psychopathology through a life span–genetic prism," *American Psychologist* (November 2001), p. 871.

Major mental disorders, such as schizophrenia and bipolar illness, have turned out to have very strong familial risk factors.

of a person's or group's intelligence quotient (IQ) can be misappropriated to further a social agenda of "benign neglect." I refer to *The Bell Curve* debate that many of you may remember from the 1990s, which revisited some of the claims that Arthur Jensen had made regarding IQ heritability back in 1969. Similarly, careless interpretation of BPG results might be used to impugn ethnic groups with socially disfavored behavioral patterns of aggression or criminality. We have seen instances of that kind of misuse in the not too distant past, as well as some horrific stories that come out of the 1920s, 1930s, and 1940s, including the Holocaust.

I'm going to give you an overview of some past states of behavioral and psychiatric genetics and genomics to indicate where current trends might be going as we project forward to 2033. Currently, the discipline is in an optimistic mood, maybe too optimistic. To understand the history of BPG, we need a framework of the fourfold structure of the field, within which we can discuss the advances and situate the forecasts. Now keep in mind during all of this discussion that the genes or the alleles (the different forms of the gene) that I discuss are not deterministic, in the sense that, if you have the gene, you have the disorder. Rather they indicate susceptibility and reflect risk factors that are related to the disorder, much as cholesterol level is a risk factor for cardiac disease.

Figure 2 shows four paradigms or approaches to behavioral and psychiatric genetics or genomics. *The Bell Curve* studies on heritability, as well as Jensen's earlier studies, are based on studies of twins. That's traditional, basic genetic epidemiology. That's what most people have heard about in a number of different kinds of cases.

What you probably haven't studied, unless you are scientists or social scientists, is the notion of advanced genetic epidemiology. This paradigm still uses twin studies and includes adoption cases as well. But, it is much more complicated. It can divide up the factors in different ways and study the interactions. It still does not identify *individual* genes, nor did the other twin studies of basic genetic epidemiology.

FIGURE 2. Four Paradigms of Behavioral and Psychiatric Genomics

Paradigm	Samples studied	Method of inquiry	Scientific goals
Basic genetic epidemiology	Family, twin, and adoption studies *Example:* IQ heritability ff o.8	Statistical: simple twin studies; no specific genes	To quantify the degree of familial aggregation and heritability
Advanced genetic epidemiology	Family, twin, and adoption studies *Example:* genetic effects double the risk that stress produces depression	Statistical: complex path analysis models; no specific genes	To explore the nature and mode of action of genetic risk factors
Gene finding	High-density families, trios, case-control samples *Example:* MAOA gene affects aggression	Statistical: linkage and association studies; specific genes	To determine genomic location and identity of susceptibility genes
Molecular genetics	Individuals *Example:* RGS4 affects presynapse neuron function in schizophrenia	Biological: specific gene knock-out and knock-in; gene chips	To identify critical DNA changes and trace the biological pathways from DNA to disorder

Source: Adapted from K. S. Kendler, "Psychiatric genetics: a methodologic critique," *American Journal of Psychiatry* 162 (2005). pp. 3–11.

What has come to the fore over the past 15 to 20 years are the gene-finding and molecular genetics paradigms. Gene finding studies specific genes that are involved in various kinds of behaviors. One that I will consider is the MAOA gene, which can affect aggression. I will also discuss some other genes, which are associated with schizophrenia, for which we have better biological models at the molecular level. So most of my discussion is going to focus on the gene-finding and molecular genetics paradigms, but the backdrop is some of the more traditional twin studies.

The gene-finding approach had some initial breakthroughs in the late 1980s in schizophrenia and depression, where genes were identified, but later turned out to be false positive errors. The discipline began to flourish more generally in the 1990s, but with high expectations often accompanied by excessive hype. For example, a 1993 research news headline from *Science*, based on a finding by Dean Hamer's group, proclaimed "Evidence of Homosexuality Gene." There was never such a gene. Researchers had identified a large region, and the work did not pan out, but people did take away the notion that there was a genetic determinant for homosexuality.

Also in *Science* in the same year was a publication by Brunner's group in the Netherlands entitled "Abnormal Behavior Associated with a Point Mutation in the Structural Gene for Monoamine oxidase A." Thisenzyme, known as MAOA, metabolizes or breaks down neurotransmitters. Brunner found that in a small, extended Dutch family several males were affected by a syndrome of borderline mental retardation and abnormal behavior, and the types of behavior that occurred included compulsive aggression, arson, attempted rape, and exhibitionism. That study has never been withdrawn, but researchers were never able to find another family that had that same kind of mutation. We'll come back to the MAOA in a different guise later.

In 1996, we had a publication by Dean Hamer and several others that announced the discovery of a novelty-seeking gene, which accounts for about 10 percent of the genetic variance of novelty-seeking. This was replicated a number of time; then it turned out not to be replicated; and in the most recent analyses that I have seen the novelty-seeking gene effect does not exist. That is to say, the gene (DRD4) is there, but it

does not have the imputed effect.

Nonetheless, during the late 1990s there were a number of concerns about the impact of behavioral genetics. A cartoon from the *New York Times,* for example, depicted a human genome with traits encoded such as an inability to find the cell phone off button in the theater, a fixation on reality-based TV, and a belief that all bags are carry-on bags. Another cartoon, with a more troubling interpretation, was titled "Waiting for Ethics to Catch Up With Science." It showed a scientist telling a pregnant woman that "embryonic DNA tests indicate a future domestic terrorist. You may choose late-term lethal objection or the electric high chair." A final example, which provided everybody's favorite excuse, was a Time magazine cover from the 1990s, headlined "Infidelity: It May Be In Our Genes."

Just like the novelty-seeking gene, almost all of the genetic links indicated in the late 1990s failed to replicate. That is, additional studies did not support the first one or two reported findings that linked specific genes to traits such as homosexuality, aggression, schizophrenia, or depression. This experimental result was a kind of Y2K crash for behavioral and psychiatric genomics. By mid-2002, it produced a period of handwringing for scientists in the field, which was expressed by a rather unusual spokesperson, Dean Hamer, who had been a cheerleader for psychiatric and behavioral genetics. In an October 2002 essay in *Science,* he spoke of his concern and the gloom in the field, but also of emerging promise, if the field were to change its paradigm. He said:

> *The results [in human behavioral and psychiatric genetics or genomics] have been disappointing and inconsistent. Large and well-funded linkage studies of the major psychiatric disorders, including schizophrenia, alcoholism, Tourette syndrome, and bipolar disorder have come up empty-handed; not a single new gene had been conclusively identified. Most candidate gene findings have failed consistent replication, and even those that have been verified account for only a small fraction of total variation. Meanwhile, the statisticians who are supposed to be guiding and evaluating the research are unable to agree on how to design experiments or to interpret the results; their advice has proven as faddish and as useful as the Hula Hoop.*

Hamer went on to say that the problem was "not the basic premise of linkage and candidate gene analysis. These basic approaches had successfully identified dozens of genes involved in inherited diseases." Nor was the problem the lack of DNA sequence information, since virtually the entire code of the human genome is now known. The real culprit, he said, was "the assumption that the rich complexity of human thought and emotion could be reduced to a simple linear relation between individual genes and behaviors…." This oversimplified model, which is shown in Part A of Figure 3, underlay most current research in behavioral genetics, at least as of 2002. This model, Hamer stresses, "ignores the critical importance of the brain, the environment, and gene expression networks." Thus, Hamer concluded that he model he had pursued in his work on novelty-seeking and homosexuality research no longer worked. He recommended a much more complex model, as shown in Part B of Figure 3, which recognizes that genes function in networks, interact with the environment, and work through the brain to produce behavior.

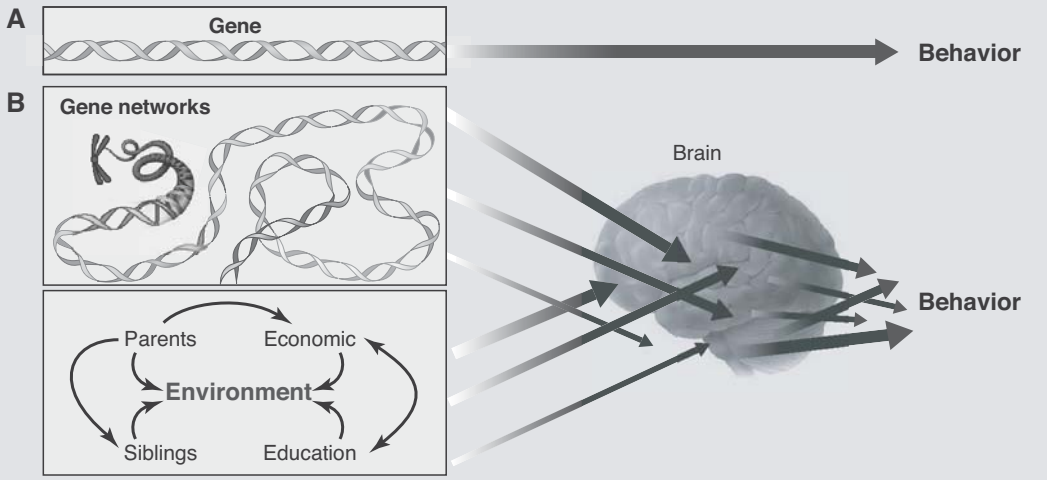
We are already beginning to see the results of thinking along the lines that Hamer suggested, and he was not the only person who moved toward this newer, reticulate model. Hamer, in fact, in his 2002 article referred to a study that had just appeared several months earlier in *Science,* which was beginning to meet his suggestion that we deal with the environment in a serious way. This is the Caspi study, also done with Terry Moffitt and others, based in the United Kingdom. They looked at two different MAOA allele. Now, this is the same gene that Brunner's group had looked at in the Dutch kindred, but Caspi and others looked not at a known mutation, but rather at two different forms of the gene, one that has a low effect and another that has a high effect in metabolizing neurotransmitters. They found some large associations of these differences with conduct disorder, a conviction record, violent behavior, and antisocial personality disorder. But, the gene differ-

Additional studies did not support the first one or two reported findings that linked specific genes to traits such as homosexuality, aggression, schizophrenia, or depression. This experimental result was a kind of Y2K crash for behavioral and psychiatric genomics.

FIGURE 3. Hamer's Old and New Models of Behavioral Genetics

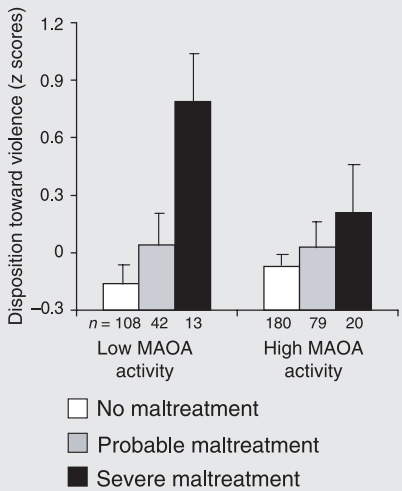
A. Old Model—This simplified model underlies much behavioral genetics research and envisages a direct linear relationship between individual genes and behaviors.

B. New Model—The new model is more complex with gene networks and multiple environmental factors affecting brain development and functions, which in turn influence behavior.



Source: D.H. Hamer, "Genetics: rethinking behavior genetics," *Science* 298 (October 4, 2002), pp. 71–72.

FIGURE 4. Influence of Childhood Maltreatment and Level of MAOA Allele Activity on Disposition toward Violence



Source: A. Caspi and others, "Role of genotype in the cycle of violence in maltreated children," *Science* 297 (August 2, 2002), pp. 851–54.

ence showed itself fully only if the subject experienced abuse or maltreatment during childhood. What Caspi et al. did was to use the environment as a lens through which to look at the effects of gene (allele) differences.

In Figure 4, which comes from that Science article, the risk of a disposition toward violence is significant if you have the bad gene, but only if you have also suffered a severe or probable maltreatment as a child. Otherwise, the effect is not especially large. Thus the findings show there is a coupling between gene and environment. By the way, this study by Caspi and others was done with a New Zealand population, but it has just been replicated by the Eaves group at Virginia Commonwealth University (their paper is in press).

The same methodology, using the environment as a lens to link behavior and genetic traits, was followed in a subsequent study in *Science* by Caspi and others. They investigated the link between depression and two serotonin transporter alleles (5-HTT). They found that, if you have the short form of the serotonin transporter gene *and* you have experienced some stressful life

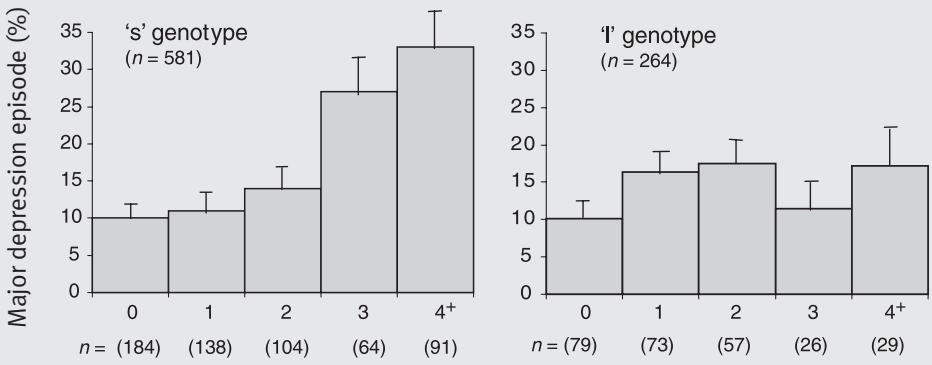
events, then you are likely to develop depression. If you have the long form of the allele, however, then you are more protected (Figure 5).

So, we've made a start at folding the environment into considerations of genetic interactions. But these are still single-gene approaches. Is there a better way to approach genomics in the behavioral and psychiatric area that moves beyond just single genes and also involves the brain in some explicit way? Well, one way that is currently being investigated, and this is on the cutting edge at the moment, is to couple neuroscience with genomics. One approach uses what are called endophenotypes. These are gene effects that are intermediate between gene action and the final disorder, such as schizophrenia. The National Institute of Mental Health (NIMH) has just funded a very large seven-center study to examine endophenotypes in the area of schizophrenia. The study will look at memory changes, disturbances in eye tracking, and several other behaviors that seem to be associated with early schizophrenia, in conjunction with brain functions revealed through neuroimaging patterns to get a clearer signal of the effect of gene interaction.

There's another way to involve the brain and also involve many genes at the same time, and that is to use microarrays. Microarrays are gene chips, which are small glass slides, less than an inch square, on which you can paint or print many thousands of gene detectors. These are small stretches of complementary DNA, and they are sequentially arranged in a very precise pattern. Cells can be obtained by autopsy from disordered brains and also from normal brains that are used as controls. The messenger RNA can be taken out of the cells, indicating what genes are turned on and off. The RNA can be smeared over the gene chips and examined to determine the different expression profiles. For example, an automated process has been developed that compares reference RNA from normal versus tumor tissue and then does a statistical analysis to see how the tumor genes in this case track with the tumors.

This microarray methodology is being used to track behaviors such as schizophrenia with relevant genes as well. There is a microarray-based study that was published from the University of Pittsburgh group of Mir-

FIGURE 5. Percentage of Individuals Meeting the Diagnostic Criteria for Depression at Age 26 as a Function of 5-HTT Genotype and Number of Stressful Events between the Ages of 21 and 26



Note: The figure shows individuals with either one or two copies of the short allele (left) and individuals homozygous for the long allele (right). In a hierarchical logistical regression model, the main effect of genotype (coded as s group = 0 and l group = 1) was not significant b = –0.15, SE = 0.21, z = 0.72, P = 0.47; the main effect of number of life events was significant b = 0.34, SE = 0.06, z = 5.70, P < 0.001; and the interaction between genotype and number of life events was significant b = –0.30, SE = 0.15, z = 1.97, P = 0.05.

Source: A. Caspi and others, "Influence of life stress on depression: moderation by a polymorphism in the 5-HTT gene," *Science* 301 (July 18, 2003), pp. 386–89.

nics, Lewis, and Levitt, who discovered a new susceptibility gene related to schizophrenia on chromosome 1. Over the past 20 years, a number of lines of evidence had suggested that the dorsal lateral prefrontal cortex of the brain is critically involved in schizophrenia. What the Mirnics group did was to obtain prefrontal cortex tissue from the brains of 15 or so schizophrenic persons, match it with tissue from control individuals, and then use genetic chip or microarray technology to screen the 7,800 genes from the prefrontal cortex. They found complex patterns of altered gene expression between controls and schizophrenics, and they identified several neuronal genes affecting neurotransmitter secretion that heretofore had not been associated with schizophrenia. They did a follow-up study in 2001 that showed a consistent and significant decrease in one of those genes, a regulator gene (RGS4) that affects G–protein signaling in cells, a rather common intercellular pathway. This RGS4 gene happily fell within a chromosome region (chromosome 1 in the q21-22 for those of you who know the language) that had been previously identified in an article in Science, using traditional linkage analysis, but hadn't been replicated and hadn't been identified with a specific gene. But with the microarray technology, they were able to suggest that the specific gene was RGS4.

Microarray experiments that are being done recently on the worm, *C. elegans,* are likely to generate more than a terabyte of data per year, which has to be dealt with. Thus data *interpretation* is a key problem.

This finding was synergistic, because not only did it allow the identification of a specific gene to be pinpointed, it also allowed its biological function to be sketched. The specific details of the circuit that involves the effect of RGS4 and the neurotransmitters that are involved are still not known, but the general features of this signal pathway are now fairly well understood.

Initially, RGS4 did not look like it was replicating, but two replications have been published in 2004, and there is now a consensus that RGS4 is one of the genes related to schizophrenia. Similarly, the dysbindin and neuregulin genes have survived multiple studies and now seem to be related to schizophrenia, albeit in a statistical way as susceptibility genes. The findings from the Pittsburgh group, as well as from others, imply that schizophrenia is a multiple gene or a polygenic disease that involves basic dysfunction of neuronal communication associated with altered proteins that affect synaptic transmission. This also is interpolated with a neurodevelopmental model of schizophrenia in which environment plays key roles.

There are problems with this microarray technology. It has limited applications, and it's still a young technology. I began to see papers published only in 1997. In fact, when I did look at one of the papers, which was on yeast, a one-celled organism, I could see that an enormous amount of data has to be analyzed. As you look at the changes yeast goes through between when it feeds on sugar to when it feeds on alcohol, you get 43,000 expression ratio measurements, a very, very long data sheet. And microarray experiments that are being done recently on the worm, *C. elegans,* are likely to generate more than a terabyte of data per year, which has to be dealt with. Thus data interpretation is a key problem that will require the development of appropriate tools for summarizing the data, detecting meaningful patterns, representing the data, and using more sophisticated network models for explanation. Nor does the field of microarray analysis have a set of standards yet. There are still variations and false positives.

Although the technology is young, it's already beginning to produce some interesting results. The gene chip results are underscoring Hamer's point, noted earlier, that any simple gene disorder models are likely to fail. Results from simple systems, such as yeast, the worm *C. elegans,* or the fruit fly *drosophila,* show that the neuroscience of behavior involves very complicated ways that genes act to build and maintain neural circuits and interact with environmental stimuli. In one paper from MIT on yeast, it turned out that of the 6,000 genes that are involved in yeast activity, 4,000 are turned on and off by environmental signals like temperature and acidity. So if you didn't model the environment, you wouldn't model the behavior.

Here are a few predictions for the future, maybe for the next 30 days rather than the next 30 years in the area of behavioral and psychiatric genomics. I think fairly steady progress will occur, but there will be false starts. Maybe it will be crablike. I think we will need protein chips before the results from the gene chips clarify. Protein chips are harder to make and probably involve monitoring more than 200,000 proteins. We

think there are 30,000 or 40,000 genes in humans, and proteins interact in very complicated ways. So there's a lot of complexity that we'll need to be able to deal with.

Progress will be steady, but slow. Probably many sets of genes with small effects interact to produce disorders, and sorting out all of that genetic heterogeneity will take many studies. It will be expensive.

The mental disorders will themselves turn out to be a mix that needs further clarification. We know that what we call schizophrenia is a hodgepodge. It may actually overlap with bipolar disorder in funny ways, and we haven't adequately sorted that out. *The Diagnostic and Statistical Manual,* 4th edition (*DSM-IV-TR,* is the latest version) is still only a work in progress. DSM-V will make a little bit more progress, but not that much. We have learned from studies of Alzheimer's disease that the work in genomics will help clarify different subtypes of the disease, but Alzheimer's is a rather special case. Schizophrenia and bipolar illness will be more difficult. Reclassification and clarification will involve many levels of simultaneous study, not just genomics and proteomics. Neuroimaging studies will help, but we'll also need human subjective reports from patients or their clinical records to understand how these correlate to one another. I think that the methods will have to be integrative, not reductionist, and they will have to be multilevel.

In terms of a time line, I think at least ten more years of research will be needed to achieve broad and consistent replications of genes of small effect and further clarifications of the phenotypes of disorder. Probably another ten years' work will be needed to develop and start testing therapies and interventions based on this knowledge.

This knowledge will produce some troubling implications. First, further discovery of genes that make us different and can be screened for may well stigmatize some individuals behaviorally. Recall the MAOA studies of Brunner and Caspi. Second, we may find correlations with ethnicity of both harmful and protective genes, which could lead to new forms of stereotyping and discrimination. The National Human Genome Research Institute (NHGRI) of the National Institutes of Health has already expressed this concern through the Ethical, Legal and Social Implications (ELSI) program. They are beginning to look at some of the implications of this new form of genomics for various subgroups.

Some additional troubling implications, although I have not discussed them at length here, concern the genomics of intelligence. There is a molecular genetics IQ program that is run in the UK by Robert Plomin. Not terribly successful, it's had to withdraw one of its more publicized findings within the past year, but in the May 2004 issue of *Molecular Psychiatry,* it has published another result of a gene or allele with small effect on IQ. I have written on this program in a publication forthcoming from the Hastings Center. Eric Parens, in a supplement in the *Hastings Center Report* issue that was published in the February-March 2004, gives a summary of this kind of work. An electronic copy is also available for free at the Hastings website (www.thehastingscenter.org). Soon we may have new and powerful therapies for mental disorders based upon this work, and we will probably also identify cognitive capacity genes relating to IQ and memory. If this comes to pass, what we will see then is the pursuit of *enhancement therapies.* These will include new "smart drugs," and *Fortune* magazine has labeled them "Viagra for the mind."

In conclusion, behavioral and psychiatric genomics seems to have turned a corner from the gloomy days of 2002 and begun to get replicable results again. But these results detect small signals related to gene differences, which are seen in the context of a complex web of other genetic and epigenetic signals and environmental interactions. Finding one-size-fits-all therapies amid all of this variation and complexity will be difficult. Treatments may involve highly individualized therapies and regimens. What is called pharmacogenomics will be increasingly important. Understanding and utilizing these advances will also require the public, as patients and consumers, to have a greater appreciation of these complexities. Policy-makers will have to proceed knowledgeably and cautiously to avoid creating a stampede for enhancements and to protect against individual and group discrimination.

Probably many sets of genes with small effects interact to produce disorders, and sorting out all of that genetic heterogeneity will take many studies. It will be expensive.

Discussion: Bruce Sterling and Patrick Hines

MS. PERRY: Dr. Schaffner seems to be coming down on the side of nurture in the debate on the importance of nature versus nurture in determining behavior. I'm wondering whether, looking down the road 30 years, that question is still going to be on the table, and where do you think it will be at that point?

MR. STERLING: Well, this is a fascinating topic for me because it's a very novelistic question: Why do people do as they do? I'm a fan of the many efforts to answer that question, including phrenology, neurasthenia, the mix of humors, and even astrological descriptions. Maybe it's all about the lumps on my skull. I'm totally with it when society uses its coolest, hottest buzzwords to talk about how people behave, like "we'll just figure that out if we can only get some synergetic data mining hidden in the chaos emergent networking of genomes." I got e-mail from the Santa Fe Institute, and it made me bipolar. I'm totally cool about that.

My suspicion is that when we do get a handle on this—and I agree that we are actually making a little headway now inside the head—it's going to reveal things about us that are extremely embarrassing. I mean really deeply humiliating, because this kind of understanding is cosmological in scope. Whenever we really learn about our place in the universe, it takes us down 10 or 12 pegs.

We're trying to explain ourselves to ourselves. Just try to imagine explaining, say, all the possible behaviors of an ant. Do you really believe that science is going to be capable of that in 60 years? Are we really going to have the ant figured out? I don't buy it. You know, compared with the ant's head, we have a colony of ants in our heads. My suspicion is that we're going to find out that we do most things for no particular reason at all. We imagine ourselves to be conscious, but that consciousness is something like 4 percent of what's going on in our heads, and the rest is just dark energy and dark matter. And we're never going to go there.

If we actually get a grip on mental illnesses, I think we're going to discover that sanity is an illness. And that the human brain doesn't work very well, has never worked very well, and is kind of an evolutionary kludge, just a mishmash that doesn't really work any better than an appendix or any other kind of misbehaving gland. If you look at the brain, it's really kind of a big testicle, basically, and you know, those are not easy to discuss or to figure out. They determine our behavior in ways that our frontal cortex doesn't seem to be able to control.

I worry about what might be ahead, because I think that cognition studies in particular are really the cat among the pigeons in the advancement of science. It's like the stuff is catnip for the intelligentsia, right? I mean this is heroin for smart people. You know, they call it Viagra for the mind, but that implies that we're losing function. I was once asked, if I could have any kind of imaginary machine, what kind would I most like, and what I said that I most wanted was just a box with a dial on the front that I could just turn to the right and boost my IQ to 800. I don't think I could resist the temptation to do that, even if I knew that in twisting that dial I was going to start reciting straight Bob Oppenheimer Sanskrit in a deep basso voice, "I am death, the destroyer of worlds." You know, how could I not put my hot little monkey hand on that box? How could I possibly relinquish that box, just being who I am and what I am. I think that's one of the keenest temptations that I could possibly face as a moral actor.

So, you know, if there's a single issue that is really going to make the Straussians come out of their skin, it would be something like this. I mean they'd be the first in line to have some, they'd want the box real bad, but they'd want to make absolutely sure that gays, women, and liberals never got one.

It also marks the limits of science fiction writers to say anything coherent, because once people are walking around with juiced-up cognition, we have absolutely no idea what their capacities are, what they want, what they desire, what their motivations are. You can't say novelistic things about them; you can't say political things about them. It wipes the human slate clean to really turbocharge cognition. It's the death of the human condition, and its replacement by something we cannot predict.

MS. PERRY: Actually you raised some interesting points that I would like Patrick speak to, because he has worked with the sickle cell disease. Patrick, would you take that box to improve those genes if you had the choice?

MR. HINES: Sickle cell, as you know, is probably the first disease that we linked with a single genetic cause, and when we discovered that we became really excited. Knowing the genetic roots of that disease, we felt that this may be the answer to so many questions about other diseases. However, here in 2004, sickle cell disease still remains one of the most complex disorders with probably more questions than answers. The lesson that teaches us in the realm of psychiatric and other possibly genetically based disorders is that understanding single genes, as was mentioned in the presentation, is not the answer to understanding the cause of disease.

It's really going to be a challenge for us as scientists and as physicians to understand the interplay between environment—not only the external environment, but the internal environment. You know, years ago we began to develop technologies whereby we could develop animal models for diseases. That was a really exciting time. We could manipulate specific genes, and we believed that we were actually replicating a human disease state. As our knowledge progresses, however, we are going to understand that the things we discover on microchips and arrays about genetic causes of disease are acting on a genetic background that differs in each one of us. That enormously complicates the questions of understanding how diseases are caused and what the role of a given gene is in the manifestation of a disease.

As I learn more about becoming a scientist and becoming a physician, I can see that our explanation for how a disease manifests is really based on our current level of understanding. One of the new technologies being pursued involves creating animal models with a number of different genetic backgrounds, then selecting a genetic background that more closely matches the person affected, then manipulating that gene, and then seeing the effect. The whole discovery process thus becomes much more complex, and it's a challenge that we are going to have to take up.

We talk about advances in science and focus mainly on the positive, but there is a lot of potential not only for misinterpretation, but also for stereotyping of individuals based on some genetic discovery. That is one of the reasons we put a lot of emphasis on creating a world of physicians that reflects society at large. Patients need physicians they can relate to, but I think it's going to be a similar argument when we look at scientists in this country, that society needs scientists it can relate to. With all the new data that will be generated in genetics and genomics, there will be a lot of room for interpretations that can have very detrimental effects on specific people in our society. To ensure that the interpretations are valid, the people doing the interpreting need to reflect the people who are being affected.

Irving Wladawsky-Berger

Irving Wladawsky-Berger is vice president for technology, strategy, and innovation at IBM. Dr. Wladawsky-Berger has responsibility for key IBM initiatives critical to the future of the information technology industry. In that capacity, he leads IBM's companywide On Demand business initiative. In conjunction with this responsibility, Dr. Wladawsky-Berger leads IBM's participation in the movement toward open standards and open source software such as Linux, and he guides the company's Next Generation Internet efforts. In addition, he collaborates closely on IBM's Grid and Autonomic Computing efforts to make the Internet a self-managing, distributed computing platform capable of delivering computing services on demand.

Dr. Wladawsky-Berger began his IBM career in 1970 at the company's Thomas J. Watson Research Center, where he started technology transfer programs to move the innovations of computer science from IBM's research labs into its product divisions. After joining IBM's product development organization in 1985, he continued his efforts to bring advanced technologies to the marketplace, leading IBM's initiatives in supercomputing and parallel computing including the transformation of IBM's large commercial systems to parallel architectures. He has managed a number of IBM's businesses, including the large systems software and the UNIX systems divisions.

Dr. Wladawsky-Berger is a founding member of the Computer Sciences and Telecommunications Board of the National Research Council, and a fellow of the American Academy of Arts and Sciences. A native of Cuba, he was named the 2001 Hispanic Engineer of the Year. Dr. Wladawsky-Berger received an M.S. and a Ph.D. in physics from the University of Chicago.

Few things are having and will continue to have such a profound impact on the human condition as information technology. I want to talk about its evolution from a slightly different point of view.

Because of the incredible technological advances that we see all around us—from microprocessor speeds to memory volumes—society as a whole is moving to a new and different stage, that is, from an industrial society to a more information-based society. That ongoing transformation has some significant implications that I'd like to address. And, by way of treating them, I'd like to first address some of the critical technologies that are providing the impetus for this profound shift. There are many that we could examine, but three come to mind as particularly consequential. The first one is the good old Internet.

I'm assuming that everybody here is a heavy user of the Internet; that we all receive more e-mail than we know what to do with or, for that matter, even wish to get; in short, that we are all hooked on the World Wide Web. The Internet—and its open standards—is really at the heart of the incredible development in information technology (IT) over the last ten years. It's what makes this conversation on the impact of technology on human behavior possible; we couldn't have had it 10 years ago. Ten years ago only a small, select number of people could use the Internet because, though incredibly useful to research scientists sharing information, it was very difficult to use unless you were really adept at handling computers. You even had to know the IP address of a server holding whatever information you needed.

Once things like the World Wide Web, URLs, and graphical user interfaces like Mosaic were invented, and it became so much easier to use, the Internet showed us the incredible power of connectivity. When you can quickly connect to whatever you need, the result is almost magical. I think we've all experienced epiphanies when we've said, "Oh, my God, this stuff is really

powerful." Mine came seven or eight years ago while I was on a business trip to Tokyo.

I remember, I was in my hotel room on a Monday morning; I had awakened early at, I think, 4 a.m. I remembered that the Mets were playing back in New York. Obviously, they wouldn't be televising it in Japan, at least back then; now, with Hideki Matsui on the Yankees, in fact, they do televise all the Yankees' games.

In any event, it dawned on me that I could try the Internet. I did that and wound up at 4 in the morning in my Tokyo hotel room listening to the New York Mets play an afternoon game the day before. I just connected to the live audio feed. All of a sudden in subtle ways like that life begins to change, and the technology to accomplish that is no big deal.

But the Internet hasn't stood still. It has continued to progress at an incredible rate. The number of people on line is estimated to be over a half-billion and will soon approach a billion people. The number of devices on line will amount to many, many billions. (See Figure 1.) Later, I'll talk a bit more about embedded devices on line.

When the Internet first started, it was primarily a U.S.-based technology. That is no longer true. It's catching on around the world, causing change everywhere, and those changes will all continue and intensify.

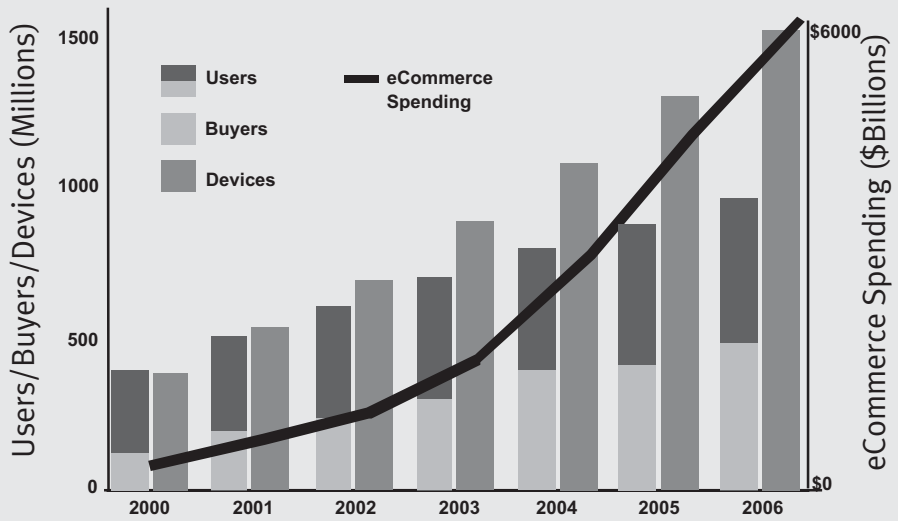
The second major force driving us toward the information-based society is the world of industry-wide open standards. Now standards may not sound like such a big deal, but consider this: Right now IBM is being sued by a small company for billions of dollars over the Linux operating system, itself an open and growing industry standard that has sparked considerable controversy.

More important, though, we are seeing professional organizations and various communities joining to develop industry standards to better link technologies with each other and with all the processes that support our daily lives in business and other of society's institutions.

Of course, it all started with the Internet and its communications standards, like TCP/IP, which took over the world of networking, then the World Wide Web, URLs, HTML, HTTP, and so on. And now there is a whole set of standards out there called Web services, about which I'll talk a bit later. For the moment, it will suffice to say that they all flow from the evolution of Internet standards like HTTP and HTML.

Professional organizations and communities are joining to develop industry standards to better link technologies with each other and with all the processes that support our daily lives.

FIGURE 1. The Future of the Internet and e-Commerce



Source: IBM Corporation, 2004

Then, there are lots of industry-vertical standards that enable the exchange of, for example, medical information or information across the retail industry supply chain. As a consequence, organizations at all levels are coming together to collaborate because they see how much more they can accomplish in that collaborative environment enabled by open standards–based IT.

A third element in this transformation to an information-based society is, obviously, the technology itself. The advance of information technology is truly astounding. If I showed you a graph illustrating the progress of microprocessors, bandwidth, memory, and all the other technologies, you would see improvements of 30 percent a year, 40 percent a year, 50 percent a year, even 70 percent a year.

What are the consequences of technologies that improve at such incredible rates? Let's look at the two extremes—that is, technology at the low end and at the high end.

The continuing improvement in IT prices and performance, with more and more power in smaller and smaller packages, means that computers are being embedded in just about everything.

At the low end, the continuing improvement in IT prices and performance, with more and more power in smaller and smaller packages, means that computers are being embedded in just about everything. Clearly, I don't mean just personal computers and laptops.

Computers are going inside medical equipment, inside all sorts of consumer appliances, being embedded throughout the petroleum industry, for example, all the way from the wellhead to the pump. Likewise, they are turning up inside all kinds of entertainment devices for the home. You'll find them in all kinds of mobile devices, like BlackBerries and PDAs. The list is endless.

Automobile companies estimate that relatively soon over 50 percent of the design process for a car will be the electronics, the computers. Of course, that's already the case with aircraft, in which the pilot commands the electronics, and the electronics command the plane.

And these are really powerful 32-bit or 64-bit microprocessors with plenty of memory and capable of running sophisticated operating systems like Linux. So this world of pervasive computing embedded in all kinds of physical things is rapidly becoming a reality. It's not totally there yet, it's just starting, but it is fast becoming a reality.

That's what's going on at the micro level. At the other end, we are aggregating these same technologies to build the most incredibly powerful supercomputers.

In fact, this morning I testified at a meeting of the House Science Committee, looking at the evolution of supercomputing. I told them about a major IBM program called Blue Gene, which is a very advanced supercomputer, initially designed for proteomics research and some of the most advanced life sciences applications. (By the way, life sciences is a discipline that didn't exist until two or three years ago, and only came into being because of advances in supercomputing).

When Blue Gene is delivered to the Lawrence Livermore Lab next year, it will comprise 65,000 nodes, 128,000 microprocessors, and pack 250 teraflops of processing power. That is, 250 X 1012 operations per second. In layman's terms, 250 teraflops amounts to 250 trillion operations per second.

That's a lot of operations per second. And we are on our way to petaflops, a level at which we will be able to talk about 1015 operations per second, or quadrillions of operations per second.

Why do we need that much processing power? Well, for one thing it will support a far more scientific understanding in many areas. There's a whole area of understanding in brain mapping that is highly dependent on these kinds of incredibly powerful supercomputers to do a better job of analyzing brain function.

And remember, all that pervasive and embedded technology that I spoke about will be connected across the Internet, transmitting huge volumes of information to those massive teraflop- and petaflop-scale supercomputers for processing.

Now all of us in the scientific community can appreciate the implications of that infrastructure for research. I'd like to reflect a bit on the implications for a business. At base, most organizations are collections of people engaged in processes that are directed toward specific ends, whether it's a consumer products company, a university, or a government agency. So, for purposes of this discussion, think of a business as any organization that somebody has to run.

All these technologies with all their possibilities will cause some very significant changes in how we think about managing businesses and every other organiza-

tion. In my opinion, the design and operation of a business will evolve into a more, if you will, "scientific" kind of discipline.

What do I mean by that? Well, the ancient Greeks knew about acetylsalicylic acid—what's come to be known as aspirin—and how to get it from willow trees. They had a very pragmatic knowledge.

Over the centuries, we came to know much more about the elements and chemistry. We built a structure of knowledge and theory that was tested and verified, and we became more scientific in our approach to medicine, rather than continuing to rely on barbers' leeches to bleed someone who was ill. We have advanced largely because of a huge improvement in our understanding of what works and what doesn't work.

Business will benefit from that same kind of disciplined development of knowledge and understanding of its basic processes and how to organize them and run them better. I really think it will create whole new disciplines focused on how to manage organizations more productively and more efficiently.

More and more, technology is making integration a major factor for a business or any other organization. How do you integrate all the processes of a business so that everything runs more efficiently?

I know. You're thinking, "Irving, nothing is more boring than talking about integrating business processes." Well, don't be too sure of that. Look at the world of e-commerce. You can do everything online, from gathering preliminary research on whatever you want to buy to making the actual transaction and obtaining post-purchase customer service. Meanwhile, the business you bought the good or service from can automatically relate to you with marketing and to all its trading partners and suppliers to satisfy your needs.

The reason? Business process integration that results from a much better understanding of the various processes that help you market better to people, offer better support, keep track of inventory, do business with dealer networks—all those activities that it takes to get a good or a service from one part of the world to your doorstep.

So, the expectations that everybody from consumers to producers has of these processes are much, much higher the more they are integrated. But a lot of businesses don't even know what processes to link.

That's part of what I mean by business institutions—and other organizations—addressing business processes as a more serious discipline, understanding the processes, understanding the linkages, and conducting their operations more efficiently and productively. Ultimately, in the aggregate we are talking about raising standards of living.

One by-product of all this information technology, understandably, is information. Leveraging all that information is a prime advantage of a truly integrated organization.

I talked a few moments ago about the fact that technology is being embedded in everything. All that technology is generating and transmitting information. For example, we are working with automobile companies, and as they put microprocessors in their cars, those micros can monitor and transmit the status of the car to the company or to the dealer. They can then analyze the information to detect potential problems. If the auto has a software problem, which happens more and more, you can download a fix and, if it's a hardware problem, they can direct you to the nearest dealer.

This notion of getting real-time information, analyzing it, and reacting in real time is more and more becoming the rule. It's among the most exciting developments in providing better health care.

Take the University of Pennsylvania's National Digital Mammography Archive. It can digitally store a woman's mammographic history and share it, with the appropriate privacy safeguards, among practitioners. They take the mammograms and analyze them with incredibly sophisticated supercomputers. The resulting broad picture of the patients' history lets radiologist more readily detect any changes. Likewise, researchers can compare some particular feature with thousands of similar mammograms in search of broader implications. Pattern matching on that scale, virtually impossible for a radiologist to do unaided, is routine for computers. (Please note: The computer is acting strictly as a tool to help the human being do a better job. It is not making the diagnosis).

In application after application, we can now gather

Getting real-time information, analyzing it, and reacting in real time is more and more becoming the rule. It's among the most exciting developments in providing better health care.

huge volumes of information and analyze it in real-time with these powerful supercomputers that are increasingly at our disposal. And that can totally change the way things happen in everything from health care to inventory management—in a business or any other activity.

Likewise, the incredible advance of technology is making the institutions of society much more flexible. That's imperative because it's not enough for a business or a government agency or a hospital or any other institution to get information, analyze it, and detect something. One must be able to react to it. But, if your organization is relatively static, like many conventional, vertically integrated enterprises, and takes excessive amounts of time to reprogram a strategy or a business plan, the information is useless and the opportunity is lost.

It's not enough for a business or a government agency or a hospital or any other institution to get information, analyze it, and detect something. One must be able to react to it.

In contrast, if one has a more modular, flexible organization built out of technological and process components, connected with industry standards, it becomes much easier to pull them together dynamically to react to real-time information in real time and to quickly change a strategy or a business plan.

Modularity also lets an enterprise analyze and understand itself at the most basic level to determine which of its processes are the essence of its business and which are marginal. It can then invest in the essential processes, enhancing them and turning to others who are more expert for the nonessential processes. That's why we're seeing the emergence of "industry networks" that supply expertise to each other.

Procter and Gamble, for example, in focusing on its core processes has engaged IBM to handle a number of its human relations functions. IBM will support nearly 98,000 P&G employees in close to 80 countries with services like payroll processing, benefits administration, compensation planning, and travel and expense accounting.

To give you another example of the "component" approach, the reason the World Wide Web is so useful is because nobody, repeat nobody, programs the World Wide Web. The World Wide Web is a sort of organic system that grows incrementally. As you add Web sites and change Web sites, the Web recognizes it, gives it an address, and grows site by site. Nobody has to take down the Internet because you want to add a Web server. That's because it is a completely modular and flexible organization.

Most of our institutions—business, government, or any other—are not designed that way. But as our world becomes more and more interconnected and subject to sudden and unpredictable change, all our institutions will require the same kind of modularity and flexibility. Lots and lots of the research on software involved with something called Web services is designed to move us in that direction.

Let me conclude by remarking on a few critical areas that require considerable research.

One is virtualization, which gives us the ability to make many, many distributed systems behave as one system—a single computer. You may have heard terms like Grid computing; virtualization is what Grids are meant to achieve. They give you the ability to get at a server, or memory, or an application, or storage when you need it, regardless of where it is.

It's that simple. Virtualization means that finding what you want and getting it to you is the system's problem, not your problem.

Virtualization means that finding what you want and getting it to you is the system's problem, not your problem.

Anybody who has a computer knows we are very far from this state of Nirvana. Far too often, we are confronted by the ugly, complex face of the technology. And what we in the industry are all trying to do is push that complexity down into the system where it can be managed by the system itself, leaving us facing only some very intuitive interfaces.

Again, a shining example is e-mail. If you're mailing somebody, you just type in the address, send it, and somehow it gets there. You don't have to deal with IP addresses, domain servers, and all the rest. None of that is your problem.

Likewise, if you want to access a Web site, you type in something very simple and give it to the system. Behind the scenes, an incredible amount of stuff goes on—stuff that has and will keep lots of scientists, engineers, and technologists gainfully employed for many,

many years. But all that complexity is their problem, not yours.

We want to do that for all of IT. We want the complexities of all these massive infrastructures to be virtualized. This is especially important because we want to make it much easier for people to collaborate and work together around the world, sharing information no matter where it is.

The last point I want to talk about is the notion of managing these systems. In fact, at the House Science Committee this morning, the last question we were asked was whether we are worried about computers developing so much intelligence that they will take over, or something to that effect. The answer I gave, as I recall, is that rather than fearing a take-over by computers with some malign purpose, I am far more worried that the damn things will overcome us with the frustration of taking care of them. You know, crashing at the most inopportune times, not understanding what we want to do, going somewhere where wireless should work and it doesn't.

Perhaps more than anything, what we really need to do is use all of this technology to make the underlying systems much more self-healing, self-protecting, self-configuring, and self-optimizing—in short, much more self-managing.

The industry—with IBM very much included—has some massive initiatives under way to achieve that, because we think making systems much more "self-managing" is absolutely critical.

The term we use at IBM is autonomic computing, an analogy with the autonomic nervous system found in biological organisms. They are the systems that keep us alive. If you cut yourself, you don't have to think, "Gee, I better not forget to coagulate my blood." Something autonomic is monitoring it; you don't do it consciously.

Computers have advanced a lot in structured things like playing chess, but they are babes in the woods when it comes to taking care of themselves. A lot of our future advances will focus on bringing computers to a state of maturity in which they take care of themselves and are smart enough to figure out their environment for themselves.

A lot of our future advances will focus on bringing computers to a state of maturity in which they take care of themselves and are smart enough to figure out their environment for themselves.

So information technology is becoming embedded in everything. We can argue whether that's good or bad, but I think it's fair to say that the historic opportunities it brings us for collaborative innovation are so positive that it's like electricity or the interstate highway system. It's hard to imagine the continued evolution of civilization without them.

Granted, it will take a tremendous amount of work to make sure that IT continues to grow into a powerful infrastructure capable of supporting the information-based society. That challenge will involve many issues, some of which I've discussed and others, like privacy protection and ease of use, that I haven't. There's enough to keep the skills and energies of the entire scientific community engaged for many, many years to come.

Discussion: Bruce Sterling and Patrick Hines

MS. PERRY: In the medical field, it seems that computers have taken over, storing the information, analyzing data. Is that a correct perception?

MR. HINES: Pretty much. In preparing ourselves for the medical advances that will are inevitably take place, we are going to have to organize, analyze, and figure out how to use the huge volume of patient data that will be available. We will need to apply it to different research and to share samples with medical institutions around the world. It's going to be tremendously important to organize that data in some logical way that physicians can interpret and apply.

Since most of the medical data are managed by computers and more and more of the diagnostic methods that we use are driven by computers, a big concern is that the dependence on computers and technology will limit our ability to think and be analytical in how we approach problems. That is definitely going to have to be considered in both medical education and scientific education.

Obviously, we could be here all day talking about the benefits of advances in technology, but one of my biggest concerns right now is the potential inequality in access to those advances. We are really talking about revisiting *Brown v. Board of Education.* Young people and kids who have access to facilities where they can learn how to use computers are going to be in a much better position to apply this technology when they become scientists, doctors, lawyers, or whatever their positions may be, compared with those who don't have access. That divide is going to grow exponentially as technology grows. It's going to be more difficult for people who don't have access to keep up. Where are they going to fit in? How will they be able to overcome those limitations, so they can advance and contribute? So, that's something I hope will be addressed in the educational system from higher education down to kindergarten.

MS. PERRY: Bruce, what has the Internet done for you lately?

MR. STERLING: Well, I am a staffer for *Wired* magazine, so I was absolutely eating that up that presentation with a spoon. I am a technology journalist, as well as a science fiction writer, but I'm not a hard artificial-intelligence guy, so I would never write a book about computers taking over. That's really kind of banal and very 1960s. However, I have just written a book about Irving Wladawsky-Berger taking over, and I'm not kidding. In my new novel, *Zenith Angle,* the hero is a vice president of research and development for a big telecom company. He is an MIT grad and a Stanford computer science professor, who gets drafted after 9/11 to advise a computer security policy board, working for President Bush on cyber warfare. He's a policy consultant, just like the people in this room, and it's a techno-thriller novel with a villain and a superweapon. I had to put those in because otherwise it's hard to make people keep turning pages.

But none of the reviews of this book have been the least bit frightened by the villain or the superweapon. They're all very concerned about my Catch-22 portrayal of how policy is made in contemporary Washington. I did not expect that response when I wrote the book, because I really put a lot of energy into that superweapon and, if I had it to do over again, I think I might get a little closer to the bone.

The new book I'm working on is about embedded computation, and it's exactly about this "manage the monster" issue. It's about ubiquitous computation and embedded technology, which has never been dealt with by my genre before. It's a really profound change in the means of distribution, the means of business. It has military and social implications. It's got ethical, legal, and social implications out the wazoo. And the material there

is dynamite. I mean I've been working on this thing for, I don't know, a couple of years, and there's just such an embarrassment of riches there, I can't even fly my way through chapter 1. But, you know, I understand how it ends, and I think this is going to be one of my better books because it's a great topic.

Questions and Responses

MS. PERRY: Now we get to your questions, and we will begin with one for the entire panel. The question is: Regarding the interplay of the environment and genetics, as we learn more about the effects of in utero and early childhood environment on the behavior and health of adults, what potential do you see for increased regulation of pregnancy and child-rearing, either through formal legislation or social stigmatization?

DR. CHARO: The future is here—and I suspect the person who wrote that question may know this—because we have now got more than a decade's worth of efforts in just that direction. We have criminal prosecutions of women who refused their physicians' advice to have a Caesarean section. We have criminal prosecutions of women for delivery of a drug to a minor through the umbilical cord, when an addict continued using cocaine while pregnant, after having failed to use contraception. We had active discussions back in the early 1980s about whether advances in genetic diagnosis would lead us to develop a theory of obligation by which parents were obliged to use every genetic testing tool available to avoid the conception of a child with a birth defect or to abort such a fetus.

Every time we come to understand a gene—environment interaction, we are going to revisit this discussion. We will have to reconsider the wisdom of having the government add its power to the power of persuasion that's brought by your family, your physician, and your friends in the effort to help people optimize the outcomes of their reproductive decisions. We may be saved, however, because genetics is now getting so complex. That is, for every potentially harmful condition, there will be no one single factor, genetic or environmental, that definitively determines an outcome. And that will keep everybody yammering about the data long enough to let the power-hungry government officials chill out just a little bit in their efforts to enforce healthy pregnancy.

DR. SCHAFFNER: I agree that the future is already here, in the sense of governmental compulsions interfering with individual decisions. There are forces with us now that tend to be increasingly intrusive. I also agree with what you said about the complexity of the genetics. Even where we understand the genetics, as we do in simple situations such as the development of cystic fibrosis, translating that understanding into decisions that individuals can make within the family and with their physicians is horribly difficult.

As we look at the interplay between genes and environments, I suspect that we will not find all that much more that we can use in the short run. Nonetheless, I think that as scientists we should do what we can to increase people's knowledge and attention to those complexities. One of the things that I have been happy to participate in is a AAAS-Hastings Center (HC) working group on behavioral genetics. Catherine Baker has put together a marvelous book on that subject written at the level of high school students, which has just appeared. Baker's book is called *Behavioral Genetics: An Introduction to How Genes and Environments Interact through Development To Shape Differences in Mood, Personality, and Intelligence* (Washington, DC: AAAS, 2004). You can get a hard copy by contacting AAAS's Scientific Freedom, Responsibility and Law Program (kallema@aaas.org) or an electronic copy by going to: www.aaas.org/spp/bgenes/publications.shtml. The book was a direct outcome of the AAAS-HC working-group process, which identified and then answered basic questions about the science. That's one of the ways that we should be able to share information with people at a level that they can understand and use.

DR. WLADAWSKY-BERGER: The subject is outside my own expertise, but I would like to mention something we all need to be careful of, which is this policy issue: It is difficult enough to decide what to do about societal issues when there is good scientific evidence. It's much more difficult when the social decisions are not based on science but on somebody's morality, somebody's view of what's right and wrong. Because our understanding of genomics is still fairly rudimentary about what causes what, what links with what, a lot of the debate involves people bringing their own morality into play rather than hard scientific evidence. We really need to be very careful about that.

MR. HINES: To touch on another side of the issue, from the perspective of those in training about to make career decisions, my medical school colleagues are becoming anxious about going into the fields of obstetrics and gynecology, reproductive endocrinology, and all of the clinical fields that address these specific issues about the beginning of life. Fewer folks coming out of medical school are interested in pursuing careers in these fields because of the tremendous liability they may face if a patient's outcome 10 or 15 years down the road could be attributed to something that happened in utero and that could ultimately be put on the physician who was managing that mother's case at the time. Thus, over the next 30 years, we may see a decline in professionals who are trained to deal with these issues, unless something can be done to manage the litigation and the ridiculously astronomical insurance premiums that these particular specialists have to pay to be able to practice that craft.

MR. STERLING: I'm interested in the applications of pervasive computing to the task of raising small children. If you've ever had small children (and I have two), you find that a lot of the productive capacity of the parents is spent child-proofing the environment. This is really something that could be automated and networked pretty easily. You could call it "K-12 Now." It would be an outgrowth of the baby monitors that already infest cribs all over America. You know, the child would be MRIed in utero and then popped out and immediately put under video surveillance. And why not just spread that to the environment, so you wouldn't have these moments of, you know, "Why can't Mr. Fork and Ms. Wall Socket be friends," which every two-year-old tries to pursue.

There's a thin edge of the wedge there, because we have a notion of computers and networks as these hostile and invasive forces that are violating our privacy, acting Orwellian, or restricting our freedom. There are many dark fictional scenarios about this, but children never complain about Orwellian surveillance. They do when they're teenagers, but not as infants. Since almost all parents are crippled by the emotional burdens of child rearing, this is a place where I think there could be a kind of sea change in parental attitudes.

MS. PERRY: Words to live by. We have several questions that we probably won't get to, but I'll try to address one each to our speakers, beginning with Dr. Alta Charo. The question asks: Is the culture war that you mentioned a particularly American phenomenon? And the questioner suspects it is. If so, why? And what does that portend for this country's place in the world?

DR. CHARO: It is a somewhat American phenomenon. If you were to go to the European Union and take a look at the domestic constitutions of those countries, you would not find anything that resembles ours. You would not find a government of limited powers; you would not find a list of individual rights that further curtail what the government can do. European countries were developed with a notion of a central government having unlimited power. The courts have a very different role as a check on governmental power, and individual rights are considered a privilege granted by the legislature rather than something enshrined in a constitution.

If you look around Europe—and I use Europe as an example because it's another group of countries with fast-evolving technologies—you will see two trends simultaneously: One is a pattern of acceptance of governmental authority in the name of the collective good, a kind of acceptance of authority that is still hotly debated here. The other is an absence of constitutional protections for individual rights, protections that are enshrined in the United States.

You see evidence all over Europe of the use of authority to uphold collective values. France, for years, has had laws prohibiting single women from getting artificial insemination, because we all know that the world is better off when single women don't have kids. They don't stop single women from getting pregnant through ordinary sex, but they will stop them from getting access to reproductive technology.

In Germany, because of its history in World War II, people have had a very wary eye on all things biotechnological. Because of the relationship of genetics to eugenics, government rules there prohibit many of the genetic tests that we consider to be quite ordinary in the United States. A lot of the embryo research that is unfunded but nonetheless legal in the United States is illegal in Germany.

Italy, in reaction to the excesses of just one of its fertility doctors, passed probably the most draconian set of reproductive technology laws in all of Europe after having been kind of a Wild West of Europe for a long time. So, in that sense Europe is far more stifling than the United States, because governments use their authority to regulate the way these technologies are used in the name of avoiding social disruption of traditional family structures.

At the same time, because of the absence of a tradition of rights-based conversation in Europe, in contrast to the United States, the European political dialogue is much less rancorous, and solutions can be far more enduring. In the American dynamic, everybody wants to write a law to do something, but there's this prickly little problem of one eccentric individual standing up and saying, "I have a constitutional right and you can't do it." The result is a kind of zero sum game in the U.S. political dialogue, which Europeans have often managed to avoid. In the United Kingdom, for example, some people oppose abortion and think embryos have a moral status equivalent to that of babies; nonetheless, the government funds research to create embryos through in vitro fertilization or even cloning for very specific research purposes. So, on the one hand, European governments have greater capacity than we do to be far more stifling, but, on the other hand, whether they exercise it is really quite varied.

MS. PERRY: Thank you. For Dr. Kenneth Schaffner, a question: A major justification of the human genome project was the potential for improving human health. What progress do you see as likely in the next 30 years on AIDS and cancer?

DR. SCHAFFNER: Well, for AIDS, the record of being able to develop pharmacological interventions is pretty good. I remember how desperate people were when we didn't have any interventions whatsoever. That's not to say that we have magic bullets. These drugs have very serious side effects, and resistance does develop.

For at least 10 years, we have had the full genome of the HIV virus. We know an awful lot about the way that virus works and replicates; yet our power of intervention isn't quite where we would like it to be. We know about the HIV life cycle and the enzymes it uses. Those are the rational background for the development of appropriate pharmacological interventions. But more work needs to be done.

Similarly, genetics has been relatively slow in impacting general health levels, although there have been some very nice breakthroughs for cancer. Even in the application of gene chips, where the microarrays are likely to be most powerful in assisting with diagnosis, we don't yet have the appropriate interventions. There is some anecdotal evidence that the microarray and the use of

genomics has already worked to put patients in the right kind of treatment category. So, the situation is hopeful, but again, relatively slow, because of the complexities in the interactions.

MS. PERRY: Thank you. And you touched on a word that's coming up in the next question for Dr. Wladawsky-Berger. The question asks: You speak of the incredible advances in information technology and its effects on business management, medical diagnosis, et cetera, but what about the consequences for the human condition in terms of social interaction in societies dominated by this advanced technology? It's actually a three-part question. Part two is: In less-developed societies, how will this improve or perhaps worsen the human condition? And part three: Will the inequities of our current modern world move further apart? Let's see.

DR. WLADAWSKY-BERGER: As to the first question, again the truth is we don't know. If we look for comparison at the implications of the transition from an agricultural society to an industrial society, we would see right away that the implications were incredible and kept changing over time, as people came to cities and earned more but became more and more overcrowded. Some changes were really not good, and some were very good. I am an optimist about the good uses of technology, but being an optimist doesn't mean thinking everything is hunky-dory. It means that I believe there will be a lot more positive than negative results and that, with proper research and understanding, we can address the negatives, and at least lower their negative consequences. I'm also very optimistic about the power of science to help us cope with change. If you look at how people today use technologies—how people use BlackBerries, how kids go on the Web, for example—you see that nobody is forcing them, so there is something very appealing and incredibly empowering to individuals in being able to use all these communications technologies. But we also need to address the problems they can cause. So, there is a lot to study to understand the implications of the evolution to an information-based society.

MS. PERRY: And that leads to the second question about the impact on less-developed societies.

DR. WLADAWSKY-BERGER: Yes. I think Patrick touched on it, that these technologies are so incredibly empowering for individuals, for communities, for societies, that the gap between those who master them and those who do not will keep growing. We have a huge responsibility as a society to reduce that gap, to minimize it as much as possible, both within our own country and with the world at large. You know, the Chinese and the Indian societies are trying to increase their standards of living by becoming more educated, getting better jobs. I would say, my God, they are just doing what we are doing.

So, we are exporting the goods of America, and yes, there are some consequences that we need to address, like the loss of jobs here. But isn't it wonderful that those societies are bettering themselves! We barely understand the applications of the new technologies to education, for example, because we don't understand very well how we learn or how kids learn. I hope that is something we can understand better, so that we can apply technologies to reduce the gap. It's definitely a major responsibility of government and society to address the gap.

MS. PERRY: And that actually speaks to the third question as well about the gap in the haves and the have-nots.

DR. WLADAWSKY-BERGER: Yes, it is a serious gap, and again the good news here is, when you have the right resources and when you apply them, people take to the new technologies very quickly. We in the United States just need to decide that applying those resources is something we absolutely must do to help around the world, and then we must do that. The consequences of creating more divisiveness in our own society and around the world are

not pretty. You know, people who don't have hope in the future become suicide bombers, and that's not good. It's much better to ask them to dream about Porsches or whatever. It may sound silly, but that's a much better thing to aspire to than the alternative.

MR. HINES: One quick thing. I'm probably one of the most involved users of the new technologies. I have one of the BlackBerries, and I try to keep up with all the new stuff, but one of my big concerns is that, the more technology we have and the more that we can do, the more we are expected to do. People are becoming less and less understanding of people who still want to protect private time when they're not accessible. In talking about the positives and our ability to do more and more and more work, we need to remember that, as more and more work is expected to be done, there will be more stress and more pressure. People don't think about it all the time, but you wake up one day and you realize, my God, I'm accessible at home, I'm accessible wherever I am because of all these little gadgets I have attached to myself.

MS. PERRY: Not necessarily a good thing. Actually there's a question for you, Patrick. We've been talking a lot about the science and the technology, but as a physician in training, how do you deal with the human condition? Is that part of your training as well, how to interact with people? Or is that something that you learn on the job?

MR. HINES: That's a good question. In terms of my training, I actually graduated this past Sunday, so I'm no longer in training.

MS. PERRY: Congratulations. [Applause.]

MR. HINES: Learning how to interact with people is definitely becoming a bigger part of medical education. A decade ago, our medical board exams, which we have to pass to be licensed physicians, didn't even include a component that tested our ability to interact with people. The test was all circling the bubbles on a scorecard. And if you're good at it and you get a high score, you can basically have your pick of medical specialties. And those who aren't necessarily good at circling the bubbles may not have those same opportunities. We're finding, however, that those test skills don't necessarily measure who can best deliver care, who can best connect with patients, and who patients prefer to have as their physician. So now as a part of our medical education, we are required to pass a portion of our board on our abilities to interact with patients. We have hired actors and actresses who portray patients with specific medical problems, and we are observed on hidden cameras to see how we make them feel comfortable, how we ask open-ended questions that allow them to really explain to us what's going on, rather than answering questions for them and assuming that we understand the type of problems that the patient is presenting to us. Dealing with patients and understanding patients has become a huge part of our medical education now.

MS. PERRY: One for Bruce directly. Is there reason to believe that the relationship between science and science fiction literature will undergo significant change by 2033?

MR. STERLING: Yes, and I attribute it mostly to the Internet. I have seen my compositional process radically reformed by computer networks and these, well, subcultural groups—you know, I belong to one. I'm seeing a phenomenon I call Google erudition—where you see someone writing for, say, *The Atlantic* or *Harper's,* and let's just say the issue of tangerines comes up. Suddenly the author goes off on wild tangents about tangerines—they are from Tangiers; they were crossbred by some obscure Moorish guy; and then they got shipped to southern Texas by a family of exiled Sephardic Jews or something. You're like, What the heck is going on? Then you realize he's got Google next to his word processor.

You know, the World Wide Web was set up for physicists. I went to CERN, the European Organization for Nuclear Research, where the Web was invented in 1990 by staff scientist Tim Berners-Lee. They said the number one thing they hated about Tim Berners-Lee is that he hadn't written C-E-R-N instead of W-W-W as the prefix to every Web address in the world. Then everybody would have known that the whole thing was patched together so you could grab the world's most obscure physics paper. But now this technology is in the hands of the general population, and I consider it really impossible to do either technical journalism or creative fiction writing without this interface at hand. And we are all on the same net. You could send me e-mail, Google me. How hard can it be?

MS. PERRY: Here's one that is addressed to Dr. Alta Charo, but I think others can weigh in on this as well. Could you respond to the view that rather than a linear political spectrum, right to left, there is a circular spectrum where the extreme right and the extreme left support the same agenda? Take, for example, the opposition to genetic engineering or opposition to research among population groups, i.e., race or gender groups because they are racist or sexist could affect public policy or could be misused. I think the question is, What are your views on the idea of a circular spectrum where the extreme right and the extreme left support the same agenda.

DR. CHARO: Well, I think that it's absolutely correct that the political spectrum is not linear. In fact, circular may still be too simple. It's a matrix. But you're right that there are very interesting examples of convergence, and I do believe that lessons should be learned from them. I mentioned that the nineteenth century feminists who were worried about women's safety joined forces with those who wanted to make the United States an explicitly religious—in that case Christian—country, and then both joined forces with those who were simply opposed to drinking, so that together they became a three-movement convergence, all aimed at Prohibition. This convergence also lent importance and power to the movement to prohibit pornography, which led to prohibiting contraception, which led to women having back-alley abortions, et cetera. So the creation of political alliances is a very chancy business. There is a risk in not really understanding the degree to which what you agree upon is some very narrow specific outcome rather than broad underlying principles.

More recently, years of medical research into reproductive health left some women feeling suspicious about the medical community's lack of empathy for women's experiences, lack of oversight of the research, and lack of caution evidenced by the periodic outbursts of rather aggressive medicine on behalf of future children. That research led to things like the prosecution of women for failing to have a C-section, as I mentioned earlier. So now you have a group of skeptics within the women's health movement.

When cloning comes along, you would ordinarily expect that such an issue should not occasion any problem for the women's movement, because we consider reproductive privacy a line in the sand. No matter how wacky the form of reproduction, we're not going to come out against it. Even the nonreproductive research applications of cloning shouldn't have been that hard to come to grips with, because the women's movement had already come to grips with the idea of the destruction of fetuses for abortion. Nonetheless, a small kernel of women got very concerned, not so much because cloning was genetic engineering, but because cloning requires eggs. And they got it into their heads that we couldn't possibly get eggs safety from female volunteers because of the whole history of bad relationships between doctors and women on reproduction. Therefore, what I believe to be a poorly informed wing of the women's health movement joined forces with a group that opposed cloning research entirely because of an agenda that was driven by abortion politics and the moral status of embryos. They joined forces in their opposition

to maintaining the legality of this form of research. Together they supported things like the Brownback bill, which tried (but failed) in the Senate to criminalize cloning research. In the end, what you have is actually much more than just right and left converging. I think what you've got are groups that have entirely separate agendas, that wouldn't ordinarily be talking to each other at all. Every once in a while, they come together, like particles in an accelerator happen to collide, and when they do, I think that the consequences are sometimes magical, but often quite destructive as all sorts of political fallout occurs, going on in different directions.

DR. SCHAFFNER: Sometimes the left and the right come together in the area of behavioral genetics. For example, the extreme left did not like any kind of genetic determinism, and the right didn't like the fact that some genes might be able to be used in some sense as excuses for unacceptable behavior. So a coalition often depended on the topic and the state of the society within which these things presented themselves. Politics has always made strange bedfellows, but sometimes it depends on the particular bed as to which fellows you find in it.

MS. PERRY: Dr. Wladawsky-Berger, have you run into extremes of political opinion in regard to information technology, or the Internet?

DR. WLADAWSKY-BERGER: Well, yes, for sure. For example, some of the people most against the global economy are also in the extremes. You know, some of the left tends to be more protectionist, and also some at the right don't care about anybody else sometimes. I think Professor Charo said something in her remarks that might underlie the connection across the extremes. Some of the more extreme groups seem to have a very negative view of human nature, and they think that therefore they need somebody to protect people from themselves. You know, if you're a real Communist or Socialist, you believe that the state has that power, and if you are at the extreme right, you often think that God told you what to do and you want to take over the state for your purposes. A more humanitarian view of life recognizes that, yes, there are bad things out there, but if you do the right things, generally people will come to the right conclusions. That position tends to congregate more around the middle, which is a more trusting position without having to have control. The extremes tend to like control, and the middles tend to be more comfortable having a more democratic society and trust that the right things will happen.

DR. CHARO: I think it gets even more complex than that, and it's very much related to how people view science. There is a wing of people in the United States, and perhaps globally, too, who come with a particular religious viewpoint. Not all religions share this viewpoint, but in certain Christian denominations there is a notion of attaining grace through the acceptance of limits and fate. For these groups, whether the issue is computers or genetics, one of the enduring questions is whether or not it goes beyond man's appropriate role on earth. Sometimes things are wrong just because they were not supposed to be in man's hands. And you will often see in the newspapers the phrase "playing God." If you take certain powers, you're playing God, and you shouldn't do that. I would just note that other religions, even other Christian denominations, have very different views. Islam and Judaism, for example, have a much more activist role for humanity.

Others get to that same place about why we shouldn't be engaged in certain technologies out of a neoconservative viewpoint, rather than a religious viewpoint. They have a very dark view of human nature, in which the forces of good and evil are always in conflict. Then you've got other people that get to the same place, not because they see human nature as evil, but because they see the world in terms of power relationships and are persuaded that in the world of inequities, those who are vulnerable will always wind up being victimized. I think this view may be typical of some parts

of the left. They see many advances in science as having the capacity for exacerbating existing inequities, and so would remove their objections if the world had a different set of background conditions. So you have three very different ways of getting to the same position of being extremely suspicious of technological innovation without extremely strong central control over its development and application.

MS. PERRY: Thank you, Dr. Charo. I want to start with Bruce and have everyone address this question: What do you think is the correct balance between science, politics, and values in the creation of public policy?

MR. STERLING: 36, 24, 38. [Laughter.]

MR. HINES: That's a really tough question. You can't really generalize it. It's got to be situation-specific. I mean there definitely needs to be interplay between all those different perspectives, and all those different perspectives need to appreciate the other people's perspectives and also appreciate the fact that they don't know it all. As scientists, we're very optimistic about technological advances and about where science can take us as a society. Nonetheless, we need to appreciate the comments and values of others and take them into consideration in coming to final decisions.

DR. SCHAFFNER: I was struck when Alta was talking about all of the divergent groups in the United States. But I think underlying that diversity is actually a fairly broad-based morality that filters through, though it doesn't always produce the kind of sound bites that make the news. Now, maybe I should be less optimistic than I am, but it seems to me that people have an inherent good sense, which shows up in the interaction between science and politics. I don't think we're in a Stalinist environment, even though one has to be continually vigilant about those individuals who would like to take on more than I think we should let them take on.

DR. WLADAWSKY-BERGER: I think that as scientists and technologists, we need to approach what we do with a certain humility. Whatever we do has to be accepted by society at large, and it's not always accepted. Look at nuclear energy in the United States, for example. Whether right or wrong, it's not accepted. And we need the humility to realize that, despite all of the advances in information technology, if people are convinced that they will lose privacy, they'll reject the technology. And trust me, people vote; they vote for members of Congress who will then vote for whatever the voters want. We need the humility to listen to what the public at large is telling us about the things we need to do, so that we get permission to succeed with our science and technology. Now I know that's not a black-and-white answer, because that requires an interplay between our role as scientists and our role as citizens. We should never, ever assume that we know the answer. We may know it in the science, but we surely don't know whether it's right for society. And in a democratic society like ours, that's what we learn through that interplay.

MS. PERRY: Thank you. Actually, I have one other for Bruce that I wanted to ask, Are there lessons from sci-fi that science has yet to learn?

MR. STERLING: Well, yeah. You know, people in science like to whine and moan and wring their hands about literary culture, and they feel picked on because there are stories like *Dr. Jekyll and Mr. Hyde* or *Frankenstein.* When you are decrying these things, you're picking on a really nice tubercular guy and a romantic teenaged girl, while the planet is full of concrete-lined silos full of MIRVs. This isn't exactly a fair fight from your perspective. I'm not calling out for any particular ideological approach to this problem, but it's just that these are people who are cultural workers rather than scientific workers, and you need to engage with them on a human level instead of thinking that somehow they are deliberately picking on you.

MS. PERRY: Thank you. Dr. Charo, would you like to respond to that?

DR. CHARO: Well, I feel like I have to because I'm such a devoted science fiction reader, although I have to confess an awful lot of it is focused on that wonderful universe of Star Trek. One of the things that struck me about the scientific community and the medical community's promotion of all of its new technologies is how little it's noticed what it is that gets many of us reading all the science fiction. It's not because Dr. Crusher can cure the next disease. It's the fun applications. I suspect that genetic engineering will gain public acceptance the day that they come up with a way to squirt yourself and get a glow-in-the-dark tattoo, so that you don't need to wear bicycle reflector stripes anymore at night. Or where women could have hair dye that would be some kind of shampoo that actually changes the hair as it emerges from your scalp, putting an end to the problem of dark roots. I am absolutely convinced that it's this stuff—the toss-offs of the fiction that many of us have been reading since we were children—that will win people over. If people see connections with the fictional life of characters they know, that's part of how these new technologies will integrate themselves and will become less frightening, less mysterious. It's not going to be the newspaper article that says, "This may turn out to be the cure for Alzheimer's." That might motivate the disease groups or lobbyists, but for the general public, cultural acceptance is going to be at an entirely different level. I think that the sci-fi genre is replete with novels that might give people wonderful ideas about the recreational uses of technology, as opposed to the serious, economically significant ones, in order to help jolly everybody along a little.

MS. PERRY: Well said. One question specifically for Dr. Irving Wladawsky-Berger: What do you see as some of the positive and negative aspects of embedded Internet technology or information technology for society at large, as opposed to just business alone? And they're speaking in particular of safety, security, and privacy implications.

DR. WLADAWSKY-BERGER: Well, I'll talk, and, Bruce, you said you've been thinking a lot about that, so probably it would be good if you comment as well.

MR. STERLING: If you want me to jump in there, yeah, I completely agree that the thin edge of the wedge is consumer acceptance of the technologies. I mean the reason that the nuclear thing fell off the edge of the truck is that you never got to have a personal nuclear-powered helicopter. You know, I've got cyber gizmos galore in here. I've got more circuitry on my person and in my bag than I can count. None of it is nuclear-powered. I don't have personal isotopes. The Star Trek thing is problematic because nobody has ever had a personal spacecraft. But, yeah, if you can move things out of the lab, really put them through the industrial design conduit, and have them appeal to human desire as consumer items, that really is the camel's nose in the tent in a general popular acceptance of high technology. The real people to talk to in this line of work are not science fiction writers, who generally are either expansive and mind-blowing or sort of darkly alarmist. The people you want to hang out with are industrial design people. I steal more ideas from them than I count. I mean they are a really influential and exciting part of our society now, and they bridge between the two cultures. They are becoming a third way, really. You know, Kevin Kelly, my friend from *Wired* magazine, talks about this a lot, just a group of people who are neither scientists nor artists, but yield to the hands-on imperative. They want to grab it, package it, ship it.

DR. WLADAWSKY-BERGER: I totally agree with Bruce's view. Certainly, we will have more technology than we know what to do with. Certain combinations will just be unappealing, and certain others will be very appealing, and the difference is what we could call good design. In a free marketplace the good design makes it and gets bought, and the bad design

disappears. A huge part of good design is that you just don't notice it. It's just so appealing, it's right there, and it does what you want it to do.

MR. STERLING: You forget to turn it off in your pocket. [Laughter.]

DR. WLADAWSKY-BERGER: And the good thing is that a lot of people all over the world will be trying to innovate, because if they hit it big, then they really get their Porsche. That's the key, I think. Really, really good design makes the technology disappear into the woodwork.

MS. PERRY: And that seems to apply to all the science and technology we have been talking about today. And thank you so much. You have been a really enlightening, funny, and informative audience. Thank you, too, for great questions.