Relinquishment or Regulation: Dealing with Apocalyptic Technological Threats

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For several hundreds years after the Enlightenment political progressives extolled reason, science and the use of technology to extend human powers. Since WWII however progressives have despaired of the ability of the state to control the dangers of technology, and been drawn to a Luddite rejection of technology. A recent example of the growing influence of neo-Luddism is Bill Joy's call for a "relinquishment" of genetic engineering, nanotechnology and robotics/AI on the grounds that these potentially self-reproducing technologies threaten human beings with extinction. In this essay I discuss where I agree and disagree with Joy's argument, and then propose what the appropriate response to these "existential threats."

Joy is correct that the threats are real, and that they require a fundamentally different response than the cost-benefit analyses of traditional environmental accounting. Joy is correct that eliminating any risk of harmful research would require eliminating all research, since the labs that conduct beneficial research are identical to those that could conduct harmful research. But Joy ignores the incalculably large benefits, which might accrue from the new technologies. He is also correct that technology regulation would require state action, although he adds a pointless call for a scientific Hippocratic oath.

Relinquishment is impossible because the benefits of the technology will create enormous corporate, citizen and patient constituencies for their development. The Third World will never agree to ban technologies, which promise to economic development. Attempts to ban beneficial research will therefore drive research underground, making it more difficult to regulate. The labs that conduct genetics, nanotech and robotics/AI research can be small and easily hidden. To the extent that the bans were successful, they would actually endanger more than they protected. Advances in these technologies are required to prepare prophylaxis and counter-measures for the eventual release of dangerous genetic, nano or robotic/AI technology. Also, humanity faces many existential threats that are not the result of human technology, from asteroid impacts to new plagues; advancing technology is the only insurance we have to escape from those existential threats.

Guarding against the existential threats from genetic engineering, nanotechnology and robotics/AI will require a combination of political and scientific responses. We will need to create a global, mandatory regulatory apparatus to ensure that laboratories employ safe designs, guard against accidental release, and have adequate counter-measures. We will need a global system of surveillance to detect escaped reproducing biological or robotic life. We will also need to advance liberal and social democracy, since defense against technological threats require that citizens can investigate and mobilize around threats, pressure accountable governments to defend the public good, and create adequate regulatory institutions. Finally we will need more research to create safe design, surveillance, immune response, and counter-measure technologies.

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Regulating Technology: From Utopian Anticipation to Luddite Machine-Smashing

"Dad, what if there is no future?"
Tristan Bock-Hughes, age 6

When people respond to technological threats to their lives, they do so against the economic and political forces weighing on them. In other words, controlling technological innovation is an inherently radical struggle. Some see the machines as their enemies, while others struggle to take the machines away from their masters. The first landmark of that struggle was the 1811 worker's movement in Britain that blamed steam-driven factory machines for growing unemployment. The textile workers began a campaign of arson and machine-wrecking, and issued public statements that they were being led by a mythical "General Ned Ludd." But like John Henry dying in his vain struggle against the jackhammer, the Luddites were quickly and decisively crushed.

On the other end of the spectrum, the utopian socialists and then the Marxists embraced industrial technology. For the utopians and Marx, technology promised a new age of leisure and prosperity. Rather than attacking machines, they pointed to the exploitation of workers by the owners and the capitalist state. Any problems arising from the new technologies would be eliminated when workers establish human priorities over the profit and domination. Marxian socialism argued that the advance of industrial civilization was in fact necessary to lay the foundation for the egalitarian society to come, in which all humanity would be freed from the drudgery of necessary labor. Industrial trade unionists and socialists, along with people generally around the world, embraced technology, science and industrialization, despite isolated frictions over automation or dangerous work conditions. The early 20th century American Left, Progressive movement and New Deal attacked the horrific working conditions of industrial work and the threats to public safety in unregulated consumer goods, but the solutions they proposed were to empower regulators and trade unions, not to ban science or industrial innovation.

After World War Two, however, nuclear weapons raised a fundamental new challenge to the union of technology with progressive politics. Although every advance in weaponry has inspired horrified calls that the end of civilization is at hand, nuclear weapons were significantly more likely to make the end of civilization a reality. The post-War peace and disarmament movements were followed quickly by Rachel Carson's alarming work on environmental toxins, which helped launch a radical environmental critique of industrial civilization. In the hands of totalitarian regimes, both Nazi and Stalinist, science and technology had become horrific tools of repression, and the emerging New

Left was infused with a Marcuseian critique of industrial society and the romantic pastoralism of the counter-culture.

From Berkeley Free Speech leader Mario Savio's famous speech that people of conscience are called to throw their bodies on the "gears and upon the wheels, upon the levers, upon all the apparatus (of the machine and) make it stop," to the anti-nuclear power organizing of the late 1970s, the pro-science and technology attitudes of progressives were quickly being supplanted by neo-Luddism. Progressives began to give up on the idea that technology could be used in liberatory ways, and that it was their responsibility to build support for stronger and more democratic regulation. Instead, strident neo-Luddite voices, from anti-genetics organizer Jeremy Rifkin to philosopher Kirkpatrick Sale to the monkeywrenchers of Earth First! began to articulate a call to relinquish technology altogether. Anti-biotech activists today regularly destroy research facilities, and the only advocates for a better future through technology are corporate-friendly liberals and conservatives. As the nation-state grows ever weaker in the emerging global political economy, concerned mobilized citizens no longer trust that regulating technological risks for safety and efficacy will work: increasingly they want things banned, from cloning to biotech corn to nuclear power.

The Threat of Self-Replicating Technologies

It was into this fertile landscape that Bill Joy stepped, the unlikeliest of neo-Luddites, the chief technologist and co-founder of Sun Microsystems and inventor of the computer language Java. In April 2000 Joy published a jeremiad in the unlikeliest of places, the militantly pro-technology *Wired* magazine. Joy had developed a serious case of anticipatory doom as he contemplated the potentially apocalyptic consequences of three technologies, genetic engineering, nanotechnology, and robots imbued with artificial intelligence. The key and qualitatively different threat that Joy saw in these technologies is that they all can potentially self-replicate. While guns don't breed other guns and go on killing sprees, gene-tailored plagues, future robots and nanophages can theoretically do just that. Let's take a second to review the proposed threats.

Genetically -Tailored Plagues

The intentional design of bacterial and viral weapons began in a large way in the 1960s in the U.S. and the Soviet Union. In the 1980s the techniques for recombinant redesign of viruses and bacteria became available, and those techniques were applied to smallpox and other vectors before the collapse of the Soviet scientific infrastructure. Tons of weaponized anthrax and smallpox have disappeared from the vaults of the Soviet bioweaponeers, and some of it has presumably been sold to Third World countries such as Iraq, along with some of the scientists who created them. Today, many nations and organizations have access to the technical knowledge and tools necessary to begin a program of bioweapons research, and in particular experiments with genetic manipulation of biological agents. For instance, although very poor, Cuba has a thriving genetics and

biomedical infrastructure, which uses recombinant DNA methods to produce vaccines, and, according to one report (Manuel Cereijo, 1999) bioweapons.

The genomes of plague, smallpox, cholera and other pathogens are public knowledge, posted on the Internet. Using genetic technology organisms could be designed to combine the virulence, latency and lethality from a variety of sources, to only attack specific races or body parts, or to be resistant to antibiotics and antiseptic methods. The Soviet bioweapons program engineered antibiotic-resistant anthrax, and attempted to combine smallpox and Ebola. Although warnings about gene-tailored bioweapons have been sounded for a decade, since September 11 and the anthrax attacks the threat has suddenly galvanized action. The National Institutes of Health and National Academy of Sciences have convened emergency meetings to address the future threats from tailored bioweapons.

However, Joy is not only concerned with the intentional release of gene-tailored infectious agents designed as tools of mass destruction, but also with the accidental release of genetically engineered micro-organisms designed for benign purposes that might have similar catastrophic effects in our bodies or ecosystems. The key to effective gene therapy has been to find viral vectors sufficiently virulent that they would spread the beneficial genes throughout the effected person. Researchers have explored everything from the common cold to HIV as vehicles of gene transfer. Therapeutic success carries the risk that a gene-tweaking plague could have unintended consequences if spread to others. Australian researchers recently discovered that they had created a mousepox virus with 100% lethality (for mice) while trying to create a viral contraceptive (Nowak, 2001). Bacteria engineered to clean up oil spills could mutate to eat plastic. Biotech crops could slip out of their farms and wreak havoc on local ecosystems.

Nanotechnology

The threats from nanotechnology and robotics are more speculative and farther in the future. Nanotechnology is the science of making machines at the nanometer scale, which could eventually manipulate individual molecules or even atoms, and build more copies of themselves. Although this holy grail of a programmable universal replicator is estimated to be 30 to 40 years off, the September 2001 issue of *Scientific American* is devoted to advances in this field and the U.S. government is spending half a billion dollars on nanotechnology research. The European Union, Russia, China, India, Iran and many other countries have nanotechnology research and development programs.

The apocalyptic scenario associated with nanotechnology is known as “gray goo,” in which a set of replicators escape their programmed constraints and begin eating everything, destroying all life on Earth. Greg Bear first depicted this scenario in 1985 in his novel *Blood Music*. According to one estimate (Freitas, 2000) nanobots could eat the Earth entirely in about one week. The gray goo problem has consumed a good deal of attention from aspiring nanotechnologists, and some convincing proofs have been

published showing that masses of nanomachines of any size would starve, burn themselves up, or have to grow slowly enough to permit counter-measures (Freitas, 2000). Nano-engineers have proposed industry standards for making nanomachines dependent on specific resources, or self-limiting in their replication, to prevent outbreaks of nanoplagues. Blue goo, i.e. nano-immune systems, could be deployed to detect and destroy gray goo.

Nonetheless, the threats of widespread destruction through the intentional or accidental release of destructive nanomachines will be very real. As with biotech, even ordinary industrial applications could go seriously awry.

Robotics and AI

Finally, and most speculatively, Joy waxes eloquent about one of the oldest tropes of science fiction, that robots might take over the world and destroy humanity. Says Joy "superior robots would surely affect humans as North American placentals affected South American marsupials (and as humans have affected countless species)… biological humans would be squeezed out of existence."

Joy's concern about self-willed, self-replicating robots is tied up with the extrapolations of Hans Moravec, Ray Kurzweil and others about the eventual emergence of machine minds. Computing power has doubled every 18 months for the last century, an observation dubbed Moore's law. Maintaining that exponential growth rate, personal desktop computers will match the neural complexity of the human brain by 2012, and the memory storage capacity of the human brain by the year 2019. If self-awareness and other features of living minds are emergent properties out of complex information processing, the complexity of all the information technology connected through the Internet will reach human brain levels well before 2012. In the Terminator movies machine minds arose in military computers and decide to wipe out human beings, and many in cyberculture assume that the emergence of AI will be an apocalyptic event.

Joy's Luddite Proposal: Technology Relinquishment

Joy concludes that we need to return to the peace movement's effort to have all nations renounce the development of weapons of mass destruction, and apply it now to genetic, molecular and AI research. "These technologies are too powerful to be shielded against in the time frame of interest... The only realistic alternative I see is relinquishment: to limit development of the technologies that are too dangerous, by limiting our pursuit of certain kinds of knowledge." Joy's call for relinquishment has had little effect on policy deliberation, but has added weight to the growing neo-Luddite movement against biotechnology, which has now added nanotechnology and AI to the list of technology they would like to see banned.

Existential Risk Assessment

Many critics have dismissed Joy's concerns as "science fiction," meaning they do not believe in the possibility of super-plagues, nanorobots and self-willed AI. But even if these threats are of very low probability, we have to take seriously even the slightest threat of so huge a catastrophic effect. I agree with Bill Joy that the apocalyptic threats from these technologies are very real. It may be that the likelihood of self-destruction with these technologies is one reason for the apparent scarcity of intelligent life in the galaxy.

Before the first atomic chain weapon was tested at the Trinity site in Nevada, Edward Teller announced calculations showing that the test would ignite Earth's atmosphere in an uncontrolled chain reaction. Robert Oppenheimer was so troubled that he consulted his mentor, Arthur Compton, who suggested a risk/benefit calculation that losing the war to the Nazis would be the better bet if the risk of destroying the Earth's atmosphere was 3 in a million or more. By the time of the test, the Trinity team had proven that igniting the atmosphere was a theoretical impossibility. But how much of an impossibility is still too possible? How do we know when we have passed the three in a million chance, and is this even the appropriate level of risk to take with the future of life on the planet? How large must the potential rewards of some line of research be to gamble with human existence?

The Benefits to Accrue from the Technologies are Enormous, and Worth Some Risk

On the positive side of this apocalyptic calculus, the new technologies hold enormous promise, unlike nuclear weapons, or even nuclear energy. Like the pastoralist Luddites, Joy belittles their benefits saying "This time - unlike during the Manhattan Project - we aren't in a war, facing an implacable enemy that is threatening our civilization; we are driven, instead, by our habits, our desires, our economic system, and our competitive need to know." Yes, but these technologies also hold out the possibility of ameliorating human suffering and easing the burden of poverty and hunger in the world. Nanotechnology and genetics may indefinitely extend the life span, expand the mind, and sharpen the senses. There is a much stronger promise of benefits from their exploration than we had from nuclear science.

Joy is Right that Banning Harmful R&D Would Require Banning Beneficial R&D

Responding to the very real threat from our existing stockpiles of nuclear weapons, the disarmament movement has argued for fifty years for a verifiable ban on their production. The logic of such a ban is still sound. But the production of nuclear weapons is

fundamentally different than the production of gene, nano or info weapons. Nuclear weapons labs and testing facilities are dramatically different from nuclear medicine labs or nuclear power plants. Nuclear weapons can be banned without banning nuclear medicine and nuclear power, while a lab doing beneficial genetics, nanotechnology, robotics or AI research is very similar to a lab engaged in gene, bio or info weapons work.

U.S. arms control experts are acutely familiar with this problem because of the United Nations Special Commission in Iraq (UNSCOM) experience in attempting to verify Iraqi chemical weapons production. Despite having complete access to all chemical and biological labs and all lab documents that they could find, without notice, inspectors were unable to verify that peaceful production facilities were being used to make weapons. American inspectors testing the verifiability of weapons production in American medical labs in the 1990s had the same difficulty (Zelicoff, 2001).

The conclusion drawn by a Bill Joy would be that this is precisely why we need to close down all labs doing research in these areas. Unfortunately, complete relinquishment is nearly impossible compared to the difficult, but achievable, creation of a transnational regime of technology regulation.

Scientific Self-Regulation is a Fantasy

As an aside, let me also dismiss Joy's call for a scientific Hippocratic oath, as a personal ethical complement to his proposed global ban on research. The biotechnology, molecular engineering, robotics and information technology economies are too large and diverse to imagine that more than a handful of scientists would ever voluntarily heed Joy's Oppenheimeresque call. I am all in favor of every person examining their consciences when they go to work, and quitting if they believe they may be risking the future of the human race. I am even in favor of professional bodies piously adopting codes of ethics that forbid their members from doing unethical work.

But appeals for individual moral courage belong in books of bedside meditations, not in deliberations of public policy. Many nuclear scientists found it easy to morally rationalize weapons research (mutual assured destruction, stopping Communism, etc.); how much easier will it be to rationalize the treatment of disease or the creation of nanoreplicators that can make anything?

Why Relinquishment Won't Work

Bill Joy's proposal is perfectly understandable coming from an engineer and corporate chief: if a new line of R&D in the firm promises to open the firm to huge liabilities and uncertain rewards, you stop the research. But the world is not (or not yet) as easily

administered as a corporate R&D lab. The appeal for relinquishment has a vanishingly small chance of success, and is therefore a dangerous distraction from the more serious and plausible courses of action that can be taken to prevent apocalypse and lessen its impacts. The only safe and feasible approach to the dangers of emerging technology is to build the social and scientific infrastructure to monitor, regulate and respond to their threats.

Relinquishment is impossible and undesirable for several reasons.

Banning All Research into the New Technologies Would Also Stop the Development of Prophylaxis and Treatment for Their Dangers

Joy praises the U.S. signing of conventions against bioweapons saying "Our attempts to deal with weapons of mass destruction in the last century provide a shining example of relinquishment for us to consider: the unilateral US abandonment, without preconditions, of the development of biological weapons. This relinquishment stemmed from the realization that while it would take an enormous effort to create these terrible weapons, they could from then on easily be duplicated and fall into the hands of rogue nations or terrorist groups."

However Joy is calling for much more than the unilateral renunciation of bioweapons, nanoweapons and info-weapons. He is also asking us to forbid research into peaceful applications, vaccines and countermeasures. Unilateral renunciation of the development of chemical and biological weapons does not threaten the U.S. or world security since one tool of mutually assured destruction, nuclear weapons, has been quite enough. Verifiable multilateral agreements forbidding weapons research are wonderful. But the world will not be safer but in fact more dangerous if the U.S. and Europe unilaterally foreswear research in the new technologies fields, as unlikely as that is, while other countries forge ahead.

After the United States signed the Biological Weapons Convention in 1972, and Richard Nixon dismantled the U.S. chemical weapons program, the Soviet Union and a number of other signatories secretly expanded their bioweapons programs. Because we have a thriving biomedical infrastructure in the United States we have several widely available antibiotics to treat anthrax, equipment for the rapid identification of biocontamination, and we have been able to arrange for the production of enough smallpox vaccine to inoculate all Americans by year's end, if necessary. It would be foolish for any democratic group of nations, with relatively open societies, to forbid *all* research in the new technologies, even medical and industrial research in these fields, when they will be

necessary to prepare for the eventual hostile or accidental release from non-cooperating nations and groups.[1]

Existential Risks: The Emerging Technologies are Required to Help us Prepare for Non-Technological Existential Risks

I concede that these technologies pose an "existential risk" (Bostrom, 2001), a risk of human extinction, which appear to make a risk-benefit calculus useless. Unfortunately existential risks abound, and do not just arise from human technology. The threat of human extinction from threats such as naturally occurring antibiotic resistant plagues, asteroid impacts, or gamma-ray blasts from colliding suns are small, but real (Bostrom, 2001). Only the advance of the new technologies promise to make humanity powerful enough to survive the various existential challenges we may face. At the margins of prediction, technological renunciation may be as existentially risky as technological progress.

Regulation Must Be Global, and That Will Be Impossible If the Goal is Banning Technology

To regulate the new technologies at the depth required to prevent apocalyptic outcomes, we need to create new global regulatory institutions. Enormous forces will be arrayed in opposition to their creation. The first will be the alliance of corporate interests who stand to profit from less fettered research and development. The second will the various citizen and consumer beneficiaries of the new technologies, from patients receiving new treatments to those receiving cheaper dwellings, new clothes, better food and better educations. Every step forward with biotechnology, molecular engineering, robotics and information technology will create enormous popular as well as corporate constituencies. Any effort to slow scientific progress will be vigorously fought.

Occasionally Luddite forces, such the right-to-life movement in the case of stem cell research, may erect road blocks. But in the end their efforts will prove meaningless, as research continues in other countries, such as England which is publicly financing embryonic stem cell and therapeutic cloning research. Even cloning, which has inspired paranoiac hysteria far out of proportion to any actual threats it poses, may be impossible for international regulators to prevent as offshore havens shelter experimenters.

As we slowly create transnational regulatory institutions, a third source of resistance will come from the less developed world, seeing that invasive safety regulation will make it more difficult for them to benefit from the new technologies. One of the most contentious issues in global climate talks has been the impact of environmental regulation

[1] Unfortunately, it is difficult to prepare for a bioterrorist attack without making bioterror agents to test your defenses against, making compliance with bans on bioweapons complicated (Miller, Engelberg and Broad, 2001).

on economic and industrial progress in the less developed world. Even if we could coerce or convince developing nations to cooperate with bans on technologies, it would only force the research underground, making it impossible to monitor and regulate.

I believe we will build strong global institutions in the next couple of decades capable of technology regulation. But there will be no support for global governance that attempts to deny consumers, patients, corporations and developing countries the right to benefit from the emerging technologies at all. Global regulation of the new technologies will only be possible if it is focused on safety and not on abolition.

Gene, Nano and Info Labs are Small and Easily Hidden

Unlike nuclear weapons facilities, laboratories capable of offensive or simply accidentally dangerous biological, nano or info research can be very small, the size of a small home, and easily hidden. Unlike telltale radiation signatures of nuclear research, satellite reconnaissance cannot detect the new technologies. Even if we were able to ban all research in these fields, nations and private organizations would have enormous incentives to conduct research in private. By allowing open beneficial research, and attempting strict controls on that research, we have a better chance of reducing industrial accidents and keeping scientists from working in clandestine settings.

Effective Regulation of Apocalyptic Technologies

Prophylactic Global Surveillance and Regulation

The existential risks posed by the new technologies do require a qualitatively different response than those given to previous toxic or dangerous technologies, a response which is more urgent, more pre-emptive, and which supercedes concerns such as national security or economic impact. The emerging technologies join nuclear weapons and global warming as problems best solved by the creation of strong supranational regulatory agencies, empowered to monitor compliance with international industrial protocols and to penalize violators. As an early, weak model, we have the International Atomic Energy Agency (IAEA) which was established in 1957 by the United Nations to monitor the safety of nuclear reactors in member states, and their compliance with agreements not to divert fissionable materials to nuclear weapons under the Non-Proliferation Agreements. As of August 2001, 57 countries have signed on to the "Additional protocols" agreement of the IAEA which would allow unannounced inspections of facilities and the deployment of permanent monitoring equipment where there is nuclear material. This is an improvement, but still short of the types of aggressive investigation into nuclear proliferation, with effective sanctions for non-cooperation, that is necessary.

The difficulty has been that nations have not ceded sufficient authority to the IAEA, and to the U.N. in general, to allow them to aggressively monitor and enforce their mandate. As a consequence there are now half a dozen new nuclear states. Even the isolated and defeated Iraqis have been able to evade and then stop inspection of their nuclear, biological chemical weapons programs.

But it has not been Iraq or North Korea which has forestalled the strengthening of international arms control verification, but the United States. The Bush administration shocked our allies last July by refusing to sign onto new strengthened protocols for the biological weapons treaty. Although, since September 11, the administration has called for some tightening of the international treaty, making it a crime to buy, build or acquire bioweapons, it continues to oppose the mandated openness and spot checks favored by the rest of the world. The administration continues to insist that international inspectors should not be allowed to spot check American corporate and military biotech laboratories on the grounds that this threatens national security and the intellectual property rights of American corporations. Instead the administration wants inspection only upon suspicion that there has been bioweapons activity in a signatory country (Miller, 2001; Rosenberg, 2001). Although this would be a reasonable approach for punishing bioweapons manufacturers with low-lethality technologies, only an international regulatory regime capable of imposing mandatory prophylactic inspections and controls, as favored by all our allies, is adequate in an era of apocalyptic self-reproducing technology.

Since much of the technology which must be regulated is commercial and not military, effective prophylaxis will also require surveillance, controls and penalties to be exercised over industries. Far beyond the weak and unenforceable environmental and worker safety codas tacked onto existing WTO and GATT agreements, prophylaxis against existential risks requires an international army of industrial inspectors, spot-checking research and development facilities. Global surveillance for the signs of aberrant technology will also require strengthened satellite monitoring for the heat signatures of rogue nanotechnology (Freitas, 2000) and strengthening public health systems worldwide, to permit identification of new epidemics, genetyping of the pathogens, rapid containment and development of counter-measures (Drexler, 2001b; Garrett, 2001; Rosenberg, 2001).

The first step in preparing for bioterrorism, for instance, is simply to gather and analyze information about all emerging diseases. Open sharing of epidemiological data is a first step toward identifying the sources of accidental releases of bioagents, as in the case of the 1979 accidental release of weaponized anthrax from a Soviet bioweapons facility, which was identified through epidemiological research by Meselson and Guillemin (2001). The likelihood of mass death from naturally occurring plagues or the accidental release of dangerous agents is actually much greater than the risks from intentional bioterrorist attacks. The U.S. and world public health infrastructure is woefully underfunded and underprepared to monitor disease prevalence, and rapidly respond to emerging plagues. One small positive step has been the Federation of American Scientists' creation of the ProMed global email list [http://www.promedmail.org/] for infectious disease specialists to alert one another of new epidemics. Without any funding, ProMed has grown to 20,000 subscribers in 160 countries, and now there are weekly

epidemiological email bulletins from the WHO . This is wonderful, but the effort needs to become part of governmental health policy at the national and international effort.

For instance, as a part of negotiations around the Biological Weapons Convention, the World Health Organization is seeking $50 million to develop a network of regional centers to recognize outbreaks and identify their causes. The U.S. has developed computer networks to identify emerging outbreaks, and these need to ramped up and deployed here and around the globe (Pueschel, 2001). We need to the build reserve capacity back into our hospitals and clinics, whittled to the bone by managed care, and build up basic capacities in the crippled public health systems of the developing nations (Osterholm, 2000; Garrett, 2001).

Open and Democratic Societies

As we build the treaties and transnational infrastructure to effectively regulate the emerging technologies, we need to remind ourselves that workplace, consumer and environmental regulation is only as good as the civil societies and democratic forces backing them up. To return to the beginning of my talk, and the history of Luddism, the problem with Joy's relinquishment and Luddism in general is that it sees technology as the problem when the problem is really the social, economic and regulatory institutions in which the technologies are embedded. Luddism is always a misplaced attack on technologies that more properly should be directed at the unaccountable powers that deploy those technologies.

Of the various forms of government, liberal and social democracy provide the best assurance that technology can be controlled for the general good. If the state is authoritarian or dominated by corporate interests, citizens are not able to effectively pressure regulatory agencies to do their jobs. Without civil liberties, citizens of authoritarian regimes are unable to organize or express concerns about environmental threats, or nuclear weapons. On the other hand, in liberal, capitalist democracies, while we can organize against those threats, we face an uphill battle against corporate interests and the military-industrial complex. One small example was the success of the Congressional Republicans in eliminating the Office of Technology Assessment in 1995, which is precisely the type of non-partisan agency that might have been tasked to educate Congress about the risks of emerging technologies. The corporate cabal known as the Bush administration has aggressively appointed industry zealots to regulatory offices with the express purpose of stopping federal environmental and work safety regulation. The same dynamic is evident at the level of global regulation. For instance international food hygiene standards are developed and published by the UN's Codex Alimentarius Commission, the overwhelming majority of whose non-governmental members represent the industries they are setting regulations for. As an unsurprising consequence, the Codex standards are lower than American and European standards in many areas.

Without strong, accountable democratic institutions, supported by powerful trade unions, social movements and social democratic parties, the regulatory apparatus in liberal democracies is crippled and underfunded. So although liberal democracy is a necessary condition for technological regulation, it is not a sufficient condition. Preparing for apocalyptic technologies requires that all societies are open, guarantee the rights to investigate, organize and pressure for public health and safety, *and* that citizens are organized to counter corporate and military domination of the national and global state.

More Science, Not Less

Finally, building safety into the emerging technologies, and preparing for their hazards, requires more scientific progress, not less. The crafters of the Human Genome Initiative set aside millions of dollars for research into the social, political and ethical impacts of genetics. The NSF has devoted some attention to the implications of nano and information technology. But there has been little funding devoted to the development of prophylaxis for, or treatment of, the impacts of these technologies. Future public investment in these emerging technologies must be addressed to monitoring and responding to their threats. We must require that private investment also internalize the costs of investing in prophylactic measures, and insurance for accidents, so that we do not repeat the mistake of the Price-Anderson Act, which gave a green light to nuclear power in the 1950s by setting up a half billion dollars of public insurance for nuclear accidents, without ensuring safe nuclear waste disposal or materials management.

More science will needed to create the regime of surveillance of the information infrastructure, laboratories, industrial facilities, and the global ecosystem to identify gene, nano and AI plagues. Alongside our global immune system for computer viruses we need active immune system defenses, and rapidly deployable counter-measures for dangerous nanotechnology, robots and machine intelligence. We need intelligence goo, police goo and Special Forces goo to find and eliminate gray goo and black goo.

More research is required into the safe design of the emerging technologies themselves. When Monsanto explored selling only sterile genetically engineered seed in order to protect its intellectual property rights it was condemned by environmentalists. But the same critics attack fertile biotech seed because of the risks that gene-tweaked crops might spread unchecked. Given the risks of unchecked reproduction, building intentional sterility into gene-tailored microorganisms, gene therapy vectors and nanobots may come to seen as absolutely essential. We may also require that organic or nano critters be dependent on specific growth media, although I can imagine the reaction of the anti-biotech lobby if Monsanto sold seed that *only* grew in the presence of Monsanto fertilizer.

As for robotics, fifty years ago Isaac Asimov proposed programming all artificial intelligence with the "Three Laws of Robotics," which required that a robot put the welfare of humans above its own. But the messiness of self-reflexive minds capable of

learning and changing means that efforts to encode these constraints into AI will probably be as successful as moral education is for human beings.

Conclusion

Calls for the abolition of emerging technologies or a scientists' boycott are politically quixotic, but I think it is important to knock down this straw man because of the growing, distracting influence of Luddism in progressive politics. Luddism is a symptom of the profound weakness that progressives feel toward the power of corporate and military elites. Feeling like all efforts at regulation and public safety are doomed to failure or cooptation the neo-Luddites extol the virtues of the hunter-gatherers and cheer on meaningless acts of vandalism against biotech crops, while ignoring the serious, difficult steps that must be taken to ensure that the unimaginable riches flowing from science do not also result in disaster. Progressives join with Luddite anarchists to oppose the erosion of national sovereignty by economic globalization, without recognizing that it is precisely strengthened global regulation of commerce that we require.

The only way forward is the same way we have addressed all previous technological threats, from toxic chemicals to dangerous cars: investigate, educate the public, create political pressure for regulation, create state agencies to monitor and enforce the laws, spend public dollars on research to make safer technologies, and then keep popular pressure on those agencies to prevent their weakening and cooptation. The qualitative difference with these apocalyptic threats, as compared to unsafe drugs, cars and toasters, is that the regulation must be global and prophylactic. We have no slack within which to make mistakes. We cannot allow a thalidomide, a DDT or a Chernobyl to spur us into action. We must create this regime before the threats emerge.

In 1947 Albert Einstein addressed the new United Nations saying, "The final goal…is the establishment of a supranational authority vested with sufficient legislative and executive powers to keep the peace. The present impasse lies in the fact that there is no sufficient, reliable supra-national authority…There can never be complete agreement on international control and the administration of atomic energy or on general disarmament until there is a modification of the traditional concept of national sovereignty…"

Thirteen years ago the common wisdom was that we would have the Cold War well into the 21st century. Then the Soviet Union collapsed. Five years ago the common wisdom was that capitalism would be unchallenged in the 21st century. Today a global anti-capitalist movement has risen in city after city to protest the unaccountability of global capitalism, and the United Nations has again become the focus of global peacekeeping and human rights. Three months ago the Bush administration was the most rabidly unilateral administration in sixty years. Since September 11, the Bush administration itself has become a quick study in the value and importance of collective security, although it has a lot more to learn.

I do not think it utopian today to echo Einstein's calls for the creation of empowered supranational agencies capable of creating and enforcing regulations on emerging super-technologies. Creating these institutions will require a global struggle against both capitalism and nationalism. But it will be a struggle for our very survival.

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