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Strategic Latency and World Order

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Abstract: *This article examines "strategic latency," a condition in which technologies that could provide military (or economic) advantage remain untapped. As difficult as it is to explain why certain ideas and technologies flourish and find rapid acceptance, it is equally hard to understand why some good ideas languish, only to be rediscovered and exploited under other circumstances. Why is latent capacity so often dormant? What are the indicators that latent capacity is on the verge of being weaponized?*

> *History is merely a list of surprises. . . . It can only prepare us to be surprised yet again.*
> *Kurt Vonnegut, Slapstick*

Natural forces drive human ingenuity in predictable directions. Love, curiosity, ego, and practical necessity combine to inspire great achievements. Fear also inspires—especially for science and technology with military applications. Whatever the original motivations, new circumstances often inspire creative thinking about new applications. Military technologies generate spin-offs for civilian uses and vice-versa. Throughout history, much of the latent potential of new technologies that could have changed the world lay dormant. Today, however, an expanding list of new and emerging technologies are fraught with strategic implications for national and

international security. Natural forces are producing transformative technologies whose latent military potential is, or will soon be, readily available to the strong and weak alike. If left untended, this strategic latency could lead to a radical restructuring of world power.

The Myth of Progress

An optimistic perspective on progress pervades the popular view of evolution, which is seen as the progressive refinement of ever-improving species moving inexorably toward ultimate perfection. Such modern expectations for intellectual and evolutionary progress, however, overlook the circuitous, inconsistent, and sometimes retrograde processes of evolution. The idea of scientific progress in which new knowledge moves us steadily closer to ultimate truth is highly misleading. Greater understanding of developmental mistakes and lapses is needed to appreciate why evolution sometimes turns a blind eye to progress, even when such advancements hold the promise of great power. As technology gives mankind more ways to pursue both good and evil objectives, the occasional timely lack of progress may turn out to be our saving grace.

Despite the clear lineages that 20-20 hindsight enables us to superimpose on increasingly sophisticated theories, these particular pathways to understanding were far from inevitable. Mankind could have followed alternate roads of discovery and arrived at different understandings of the underlying facts. The laws of nature are not socially constructed, but the process of scientific discovery is fraught with human proclivities. Modern civilization could have been organized differently, and technology could have evolved in very different ways. Such underlying uncertainty about the direction of science and technology make it exceedingly difficult to predict or prepare for transformative effects—even when we know they are approaching.

Philosophers of science, such as Thomas Kuhn and Karl Popper, grappled with the inherent limitations of science to maintain steady cumulative progress toward undisputed truth. Both men expected setbacks, "knowledge-losses." when popular theories are found to have fatal flaws. Kuhn accounted for scientific backtracking as a necessary result of his periodic scientific revolutions, and Popper embraced the formal falsification of theories as a main tenet of his philosophy. One thing on which they agreed was the "two steps forward, one step back" pace of scientific progress, which they understood follows a circuitous, non-linear, and unpredictable path.

Incremental progress is sometimes supplanted by great leaps in understanding, as was the case with Einstein's theory of relativity or James Watson and Francis Crick's modeling of DNA. However, such great leaps forward have sometimes failed to achieve liftoff and instead remained frozen in time. Archimedes made his breakthroughs in calculus 2000 years before Gottfried Leibniz

and Isaac Newton arrived at similar conclusions, and some of Leonardo DaVinci's most consequential inventions (parachute, tank, submarine) went unrealized for hundreds of years. Many scientific discoveries could have yielded dramatic results, but went unexploited for centuries. Such lapses in the continuity of knowledge may occur as the result of religion, (as was the case with Galileo Galilei), scientific shortcomings, (as in the prolonged adherence to theories of alchemy and phlogiston), political ideology, (illustrated by Soviet support for Lysenko's bogus genetics), or any number of human failings. There is no guarantee of steady scientific progress, even when powerful incentives are driving the discovery process. These slowdowns may actually serve a purpose.

The late Stephen J. Gould made a cottage industry of poking fun at popular misconceptions about evolution and the notion that selective mutations advance living things toward more ideal forms. Modern man, Gould showed, is not the result of progressive improvements on our prehistoric and less sophisticated ancestors, as depicted in the popular drawing of man's supposed rise from organ-grinder monkey to homo erectus. Rather, our arrival at today's human formula represents one possible and unlikely evolutionary outcome among many that might have developed from our planet's brew of environmental challenges. Evolution is not a linear process. It lurches through periods of boom and bust, sometimes dooming elaborately evolved creatures and perpetuating unlikely candidates, as Gould demonstrated in his book about the fantastic fossils found in Canada's Burgess Shale.[1] Most creatures eventually hit the evolutionary wall and die out, but a few crack the code of longevity. Sharks essentially stopped the "improvement" process, having attained near-perfection millions of years ago. By some measures of merit, bacteria, not man, sit atop the Earth's hierarchy of life. There is no formula to predict evolutionary success and no guarantee that innovation will win out—only that successive mutations will exploit environmental conditions to enhance prospects for long-term survival. Like scientific discovery, it is impossible to predict evolution's next destination. Understanding the roads not taken poses as much of a challenge as explaining those that are documented in the fossil record—or in the history of science.

The challenge of understanding why some ideas are embraced and operationalized for human benefit while others are not—latency—is greatly complicated by cultural and developmental factors. Jared Diamond carries on a tradition of macro history pioneered by historians and philosophers such as Arnold Toynbee (*A Study of History, 1934-1961*) and Oswald Spengler (*Decline of the West, 1918*) in his popular book, *Guns, Germs and Steel*,[2] which seeks to explain the uneven development of the world's civilizations.

[1] Stephen J. Gould, *Wonderful Life: The Burgess Shale and the Nature of History* (New York: WW Norton, 1989).

[2] Jared Diamond, *Guns, Germs and Steel: The Fates of Human Societies* (New York: WW Norton, 1997).

However, the natural sciences provide only incomplete explanations for the myriad variations in human developmental experience. Moreover, grafting social science interpretations onto the story of mankind as seen through the lens of natural history introduces a plague of academic controversies that hopelessly muddy the waters of insight. Diamond's kluge of hard and soft sciences presents much food for thought, but little clarity about the relationships between the dependent and independent variables affecting comparative human societal development. What's missing is the messy business of politics.

Overwhelmed with data from multiple levels of analysis (individuals, tribes, cultures, nation-states, environment, etc), macro historians resort to logical but non-falsifiable meta theories about the rise and fall of social orders. International relations theories suffer from similar limitations, and efforts to inject scientific rigor and parsimony into the study of our anarchic international society[3] have not proven superior to the older traditions of political philosophy. Even the biggest supercomputers armed with the most extensive data cannot reliably predict weather, earthquakes, economic trends, or the outcomes of sports events and political contests. A unified field theory of human development and organization is nowhere in sight, despite continued efforts to develop predictive models eerily reminiscent of Issac Asimov's mathematic "psychohistory," pioneered in his *Foundation* series.[4] Perhaps with enough data and computing power, useful patterns may someday emerge from the annals of human behavior. So far, however, Yogi Berra's observation that "It's tough to make predictions, especially about the future" holds true for all the sciences.

Unsurprisingly, then, technology does not evolve in a gradual, linear, and progressive manner. There are periods of boom and bust, great leaps forward and prolonged droughts. This article examines "strategic latency," a condition in which technologies that could provide military (or economic) advantage remain untapped. As difficult as it is to explain why certain ideas and technologies flourish and find rapid acceptance, it is equally hard to understand why some good ideas languish, only to be rediscovered and exploited under other circumstances. Why is latent capacity so often dormant? What are the indicators that latent capacity is on the verge of being weaponized?

Just because a tool or an idea could be applied to a problem facing society does not mean that it will find acceptance. This is particularly relevant

[3] Hedley Bull, *The Anarchic International Society: A Study of Order in World Politics* (New York: Columbia University Press, 1977).

[4] Current efforts to develop predictive models from historic data include the University of Maryland's Laboratory for Computational Cultural Dynamics which developed their Stochastic Opponent Modeling Agents (SOMA) to calculate probabilities of conflict. In January 2010, the Intelligence Advanced Research Projects Activity—the intelligence community's equivalent to the Defense Advanced Research Project Agency—sought proposals for research on Integrated Cognitive Neuroscience Architecture for Understanding Sensemaking. http://www.iarpa.gov/solicitations_icarus.html.

for innovations possessing obvious military applications that would give the possessor an advantage over competitors. In the moderate state of nature that pervades international relations, we might have seen more frequent exploitation of powerful tools for defense purposes. Instead, latent capabilities often remain so. What are the factors that determine whether ideas or technologies will be enlisted in the quest for power? Understanding this dynamic is the key to formulating rational responses to a world brimming with strategic latency.

The Dogs that Didn't Bark: Failure to Exploit Potentially Powerful Technologies

The lure of decisive military power runs like a red skein throughout human history. From Hannibal to Adolf Hitler, ambitious leaders sought ways to exploit technology for conquest. We would expect nations competing in an anarchic international system to seek advantage wherever possible. And it comes as no surprise that military applications of new technologies often lead the way for civilian "spin-offs." Yet weapons of mass destruction—potentially a source of decisive military power—provide numerous examples of unrealized latent capability in which restraint outstripped ambition. Many countries have possessed the wherewithal to make nuclear, chemical and biological weapons, but nearly all decided to forego their awesome potential.

Despite the extensive proliferation of nuclear technology, only nine counties have crossed the latency threshold to acquire a nuclear arsenal. A few came close but pulled back (Sweden, Taiwan, Argentina, and Brazil), and a few like South Africa, Ukraine, Belarus, and Kazakhstan reversed course and gave up weapons they already possessed. Scores of countries operate nuclear power reactors and even more operate research reactors that give them a running start to pursue weapons. Many of these countries face significant threats to their security, yet only a handful have elected to transform these latent capabilities into powerful weapons. Many factors contribute to national decisions about nuclear weapons, but it is notable that so much latent nuclear capability has gone untapped for such a long time. Only the Soviet Union and the United States gave full throttle to their nuclear potential, and those programs are in the process of being drastically scaled back to reduce the role of nuclear weapons in national and international security. The actual use of nuclear weapons has become almost unthinkable. Whether the norms of nonproliferation and non-use will persist, and for how long, goes to the heart of the issue: latent capabilities often remain dormant until a convergence of political forces trigger the intent to "weaponize." In the case of nuclear weapons, internal constraints combined with manipulation of external forces by powerful nations such as the United States have successfully moderated the weaponization of latent nuclear capabilities.

The pattern of restraint also pervades the history of chemical and biological weapons, which have proliferated far less than one might expect given the ease of access to the relevant technologies and their potential contribution to the military power of insecure and aggressive nations alike. Even those who acquire them tend to abide by the norm of non-use. Latency in chemical and biological technologies is even more extensive than nuclear due to their pervasive civil applications. To be sure, the latent military potential of chemicals has been exploited at various times throughout human history, but these episodes have been followed by long periods (sometimes hundreds of years) of disuse. Only a handful of countries are known to have weaponized biological agents, although many experts remain convinced that increasing latency in this area represents a dire threat.[5] Whatever the reasons for restraint, (cost, uncertain military utility, international norms, domestic politics, counter-proliferation efforts) access to the technologies has not been the main limiting factor. We must look beyond technological determinism to understand why widespread latency has not more often been transformed into weapons, even when such potential was accompanied by powerful motivations of survival and conquest.

Many other technologies were, of course, rapidly adapted for military purposes. Rocketry, radar, communications, computers, and every mode of transportation were quickly drafted into military service. Others, however, were not. For example, various incapacitating agents might enable a country to render an adversary army or population senseless, delusional, and defenseless. Such substances can be distinct from non-lethal crowd control agents such as tear gas, but like tear gas, are not banned by the Chemical Weapons Convention or prohibitions on biological weapons. Incapacitants could be released into air and water supplies to defeat a population's will to resist. HG Wells envisioned such "pacificants" as a precursor to authoritarian control in his 1933 novel *Shape of Things to Come*, and the villainous Goldfinger used sleeping gas against the U.S. Army in the 1964 James Bond spy thriller bearing his name. The use by Russian special forces of the powerful drug fentanyl to overcome Chechen terrorists who took hundreds of hostages in a Moscow theatre in 2002 indicates ongoing interest in incapacitants. However, despite concerted efforts by the Soviet Union and the United States to weaponize psychotropic mind control drugs, these programs were abandoned, and we have not seen large-scale efforts to field weapons of mass delusion. Similarly, the destruction of food supplies by conventional or other means has not received the attention that one might expect.

Other potential technologies of mass effect that were not swiftly drafted into military service include space warfare (including electromagnetic pulse), geo-engineering, and eugenics. Whether the forces that have constrained

[5] See for example the congressionally mandated study *World At Risk: Report of the Commission on the Prevention of WMD Proliferation and Terrorism*, December 2008.

strategic latency in these technologies and prevented their full exploitation for military purposes will be tempted to reap the benefits of their military potential depends on the intentions and motivations of the countries, groups and individuals who posses the technologies. The pattern of restraint will be tested.

Terrorism and Latency: Intent without Capability

Terrorists, like other proliferators, seek to circumvent the forces of moderation that constrain the unauthorized uses of technology. Perhaps driven by necessity, terrorists have proven to be rapid exploiters of technology. There are many examples of terrorists finding innovative ways to use technology, from the weaponization of commercial airliners, to improvised explosive devices and extensive use of electronic media. Such innovations support the terrorist's reliance on unconventional warfare to attack vulnerable parts of a stronger enemy. Terrorist groups are not known to possess WMD capabilities of their own, but rather seek *access* to the latent capabilities derived from the industrial infrastructure of nation states. Nevertheless, a few groups, such as Aum Shinrikyo and al Qaeda, have tried to make chemical weapons using their own small-scale production units. Whether these types of organizations have the wherewithal to produce WMD may depend on their knowledge of—and access to—emerging technologies such as small batch chemical processing that could give them capabilities to match their intentions. We should at the very least expect them to try.

It remains to be seen how terrorist possession or use of WMD might affect the latency calculations of those they threaten. However, we already have seen extensive efforts to increase the security of latent capabilities such as nuclear power plants, air travel, chemical factories, and the handling of biological agents. Terrorists have drawn attention to the destructive potential of latent technologies and triggered new interest in research and development on ways to defend against unauthorized access. Concern about terrorist interest in toxins and pathogens has also spurred research in disease detection and vaccinations. Such research may blur the distinction between offensive and defensive capabilities, even raising suspicions about the true intent behind intensive R&D on certain biological agents and toxins.

By raising concerns about the possible unauthorized weaponization of latent capabilities, terrorists have already forced attention and resources to be directed on the physical protection of latent technologies, and also on defending against their possible use by terrorists should they succeed in acquiring them. The very existence of the Department of Homeland Security reflects the seriousness with which this threat is viewed. Terrorists have already inspired new thinking about latency.

Through a Glass Darkly: Can Latency Be Controlled?

Whether we dwell on the promise or the peril created by technology is a personal judgment. Modern-day Luddites, such as the Unibomber, focus on the dangers inherent in technology, while techno-optimists tend to see scientific progress as a cure-all for everything that ails the human condition. Contentious issues pit the two sides against one another, with both arguing on behalf of the betterment of mankind. For example, technology pessimists see genetically modified organisms ("Frankenfood") leading to global disaster, while proponents see abundant food stocks to feed starving children. Stem cell researchers see miracle cures to ease suffering, while opponents fear a slippery slope to a science fiction nightmare of human cloning. Nuclear fusion advocates hope to realize the dream of energy "too cheap to meter," while critics fear a next generation of nuclear weapons.

Governments employ various policy instruments to regulate international markets for such dual-use technologies. The goal of unilateral and multilateral export controls is to ensure that goods and services that could be used for military applications are sold only to countries, companies, and individuals who pledge not to do so. National and international export controls evolved around the proliferation of technologies underlying nuclear energy, industrial chemicals, and pharmaceuticals, which give the possessor inherent capabilities to produce weapons of mass destruction. Once such capabilities have been transferred, however, the effectiveness of technology controls depends on the intentions of the receiver. Pessimists, therefore, tend to err on the side of caution when exporting dangerous technologies, even at the expense of good relations and lucrative export deals. Optimists split into two camps: fatalists who see efforts to control the spread of technology as futile ("If we don't sell it, someone else will."), and true believers who expect the net benefits of high-tech trade to outweigh any negative consequences.

Export controls have been effective, despite their shortcomings. Restricting access to WMD-related goods and services is common sense, especially in cases where the intent to acquire WMD is clear. Regulating trade in dual-use goods also provides insight into the willingness of buyers to abide by the rules and conditions established for safe, civilian use of potentially dangerous technologies. Conversely, efforts to evade controls serve as a sign of bad intentions. However, governments are losing control over critical technologies they once monopolized. Global supply chains and sophisticated proliferation networks already traffic in nuclear, chemical and biological weapons materials and expertise, easily circumventing governmental controls. Moreover, new technologies are no longer "born secret" in a Manhattan Project-like incubator. More often they originate from the private sector, outside of government auspices. Instead of lording over technology transfers, governments are playing catch up trying to monitor and understand the

implications of the latest developments in science and technology. Latency is overwhelming the bonds that once held it in check.

Cultivating Latency as a Strategic Hedge

Greater understanding of latency may ultimately lead to the emergence of advanced forms of intentional latency in which the potential offensive and defensive applications of various technologies has been explicitly explored, but not fully operationalized. Such hedging, in which the necessary technology and supporting infrastructure for military applications are in place, but without crossing the line separating civilian and military use, might reflect a strategy to have WMD options close at hand without triggering regional and international concerns.

Japan's nuclear program provides an apt example of a country that possesses advanced nuclear capabilities that put them "a few screwdriver turns" away from possessing nuclear weapons. Yet it still boasts its sterling nonproliferation credentials. Few would argue that Japan's ready access to plutonium and its civilian missile program are completely unrelated to Tokyo's concept of national security, despite protestations to the contrary. With latent nuclear capabilities poised on the line dividing civilian and military applications, continued confidence in the U.S. nuclear umbrella to deter historic adversaries such as Korea and China may determine whether Japan's latent capabilities stay that way. Other countries may develop advanced chemical and biological industries that provide them with similar options.

Such hedging strategies may increasingly describe the status of emerging and disruptive technologies in many countries. With WMD and other high-leverage capabilities within reach, understanding the *intentions* of countries, leaders, and organizations will offer the last remaining hope for dissuading or deterring decisions to weaponize, proliferate or attack.

Future Shock: Latency and the Emergence of New Threats

In spite of the foregoing discussion about the difficulties of prediction, some new and emerging technologies will be exploited for strategic purposes—probably in unexpected ways. A few critical dual-use technologies now hang in the balance—already deeply embedded in modern society and temptingly latent with destructive potential. International standards for their use are weak and eroding. These latent technologies are near the "tipping point" and could easily serve man's lesser angels.

Tragedy of the Global Cyber Commons

The creeping omnipresence of interconnected electronic media already pervades peace and war. Chinese hacking of Google in 2010 illustrates

the shrinking relevance of the boundaries that formerly separated countries, organizations, machines, and people. Electronic globalization wiped out distinctions between public and private, peace and war. Cyber warfare among nation states is a done deal, and international criminal enterprises long ago followed legitimate businesses in adopting the latest cyber technologies. Networks of networks pervade social, business and political interactions. What is still emerging is the large-scale manipulation of advanced cyber warfare techniques by terrorists and other non-governmental entities.

Moving beyond the use of electronic media for communications, propaganda, procurement, recruiting and simple operational applications such as triggering explosives, terrorists are trying to get the most bang for the buck from the electronic interconnectedness that links them to their enemies, including everything from major infrastructure to our everyday appliances. Terrorists already hack into the surveillance video from U.S. spy drones, and the November 2008 Mumbai attackers incorporated email, internet, GPS navigation, BlackBerrys, satellite imagery, and live TV coverage into their plan.[6] How long before terrorists wield state-like cyber warfare capabilities?

International norms lag far behind technology in the cyber arena, which increasingly looks more like a mixed martial arts brawl than a global community. Proposals for a convention to limit cyber warfare[7] may offer too little too late to rein in these trends. While it was arguably inevitable that countries would attack one another's electronic infrastructure, it is disconcerting that nation states may be powerless to stop criminals, ideologues and cranks from turning our phones, cars and refrigerators against us.

Star Wars, Star Peace and Extra Terrestrial Governance

Despite mankind's longstanding preoccupation with fighting in the high frontier and our growing capabilities to realize those dreams, a surprising measure of restraint has left the heavens largely peaceful. The initial space race was more about fighting the Cold War back on Earth than dominating the astral plains, although Washington and Moscow certainly kept their options open for future space conflict.

Space is still mostly peaceful, in part due to the emergence of international norms against the prosecution of warfare in and above the Earth's atmosphere. To prevent nuclear proliferation in space, the 1967 Outer Space Treaty prohibited stationing nuclear weapons in space or on the moon, or tampering with another country's space assets. Yet, the treaty does not constrain the use of space to support Earth-bound military and intelligence

[6] "Insurgents Hack US Drones," *The Wall Street Journal*, December 17, 2009; "Gunmen Used Technology as a Tactical Tool," *The Washington Post*, December 3, 2008.

[7] David Elliott, "Weighing the Case for a Convention to Limit Cyberwarfare," *Arms Control Today*, November 2009.

activities. Even defensive initiatives such as President Ronald Reagan's Star Wars program and the George W. Bush administration's emphasis on missile defense met with strong domestic and international opposition. However, China's shoot-down of one of its own satellites in 2007, followed in 2008 by a similar U.S. shoot-down of an ailing spy satellite prompted renewed fears of a new competition for space dominance.

Orbital space is getting dangerously crowded. New space-faring nations such as China, India, and Japan, (and wannabes like Iran and North Korea) are projecting earthly rivalries into the extra-terrestrial commons. Accumulating space-junk threatens to clobber satellites in orbit while new capabilities such as micro-satellites, ground and space-based laser weapons, and space tourism add to the challenge of governing Earth's anarchic space neighborhood. With no slow-down in the development of new space capabilities by more countries (and even non-governmental organizations), calls to strengthen the norms of space etiquette through treaties and agreements face an uphill battle.[8]

Let My People Go: Geo-Engineering for Fun and Profit

Man's desire to command the forces of nature is well documented. Following in the footsteps of Moses, Soviet and American scientists experimented with Peaceful Nuclear Explosions (PNEs), as a means to excavate harbors and reroute rivers. The Nonproliferation Treaty explicitly protected the right to conduct PNEs. So far, nation states have exercised caution regarding possible unintended consequences of large-scale environmental tampering. However, concerns about global climate change could change the way people think about geo-engineering—especially if such schemes promise to benefit politically popular species and habitats. What if cloud seeding could preserve Arctic ice, the disappearing habitat of the endangered Polar Bear? Could we alter the direction of hurricanes or change the chemistry of seas and lakes to halt the growth of undesirable or invasive plants and animals? And, from a military perspective, what if manipulating the weather, seas, or geology could help defeat an enemy? These ideas are not new, but the technology and politics of large-scale geo-engineering are changing. International concerns about climate change could create new constituencies among environmentalists, who might view the injection of particulates into the atmosphere as a reasonable way to reduce global warming, or even avoid conflicts that might result from environmental problems such as rising sea levels.[9] Economic incentives to reduce greenhouse gases could drive countries or companies

[8] Clay Moltz, "Space Jam," *The New York Times*, February 18, 2009.

[9] National Intelligence Council, *The Impact of Climate Change to 2030*, http://www.dni.gov/nic/special_climate2030.html.

to employ geo-engineering techniques to offset their own environmental footprints.

International norms against massive manipulation of the global commons are weak. A 1978 United Nations Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques banned large-scale geo-engineering for warfare, but lacks monitoring or enforcement mechanisms. Nevertheless, the Law of the Sea Treaty, various international fishing conventions, the Partial Test Ban Treaty (which bans nuclear testing in the atmosphere), and other global environmental agreements provide examples of how sovereign rights can be balanced with mutual interests in global governance. Techniques such as cloud seeding, illustrated by Beijing's conjuring of the weather before the 2008 Olympics, intentional fish kills, and overseas waste dumping are already common practice. It is not hard to imagine how sovereign or corporate decisions to modify shared environmental resources could provoke conflict, not to mention the wrath of Mother Nature.

Every Man a King: The Democratization of Advanced Science and Technology

Recent trends in science and technology are poised to revolutionize national and international security. Rapid progress in fields such as nanotechnology, bioengineering, and advanced materials are making it possible to model and manipulate materials at the atomic level. It is now possible to design and build custom molecules that can be constructed like Legos. Distinctions that used to separate fields such as biology and chemistry have all but disappeared. New tools and new materials are inevitably finding applications in medicine, energy, communications, and, of course, warfare. For good or evil, scientific progress is creating new forms of latent weapon potential. We have yet to come to terms with the meaning of this most recent scientific revolution.

Even more than the overall march of scientific progress itself, current trends in micro-level research and manufacturing are making it possible to design and produce extremely sophisticated materials and products on a very small scale.[10] Manufacturers in fields such as the pharmaceutical industry have adopted micro-processing techniques to produce small quantities of specialized chemicals that replace the need to buy and store unwieldy stocks of dangerous items. The ability to produce precise quantities of specialty materials limits safety and security liabilities and enables production of just-in-time inventories. The implications for proliferation are clear: small-scale production units are easier to hide. However, the emergence of micro-batch manufacturing also puts the fruits

[10] Chris Anderson, "Atoms are the New Bits," *Wired*, February 2010.

of large-scale R&D that were formerly available only to established, well-funded institutions such as governments, universities, and industry within the reach of Joe Six Pack. Capabilities once reserved for powerful institutions have trickled down to everyman.

Recent innovations in micro manufacturing techniques put powerful, computer-aided design (CAD) and computer numerically controlled (CNC) machine tools in the hands of individual do-it-yourselfers (DIY). The implications for access to WMD are unsettling. Micro batch processing is a boon for small-scale brewers of beer and spirits, but might also give countries and/or individuals the ability to produce chemical or biological weapons without an associated industrial base. What other materials might be designed, produced and fabricated using these tools? Mad at the government or feuding with your neighbors? You too can produce your own personal WMD.

A.Q. Khan's notorious network demonstrated how proliferators were able to utilize modern global business practices (such as offshore production and global supply chain) to sell do-it-yourself nuclear weapons kits to Libya, North Korea, and Iran. If AQ Khan represented the Walmart model of proliferation, micro-level manufacturing represents a "mom and pop" approach to WMD. We are approaching a threshold in which individuals and groups can cut out the middle men and seize the full power of modern R&D, manufacturing, and distribution methods to acquire advanced weapon capabilities. With strategic latency fully democratized, it is unclear if any form of governance can restrain the free market.

Governance and the Global Commons

When C.P. Snow wrote about the culture clash between the sciences and the humanities, he was mainly interested in how those two groups of intellectuals were thinking about the impact of technology on society. Not only were the two groups not communicating with each other, they were not applying their collective talents to understand and manage the potential for conflict and cooperation that new technologies were forcing on a fragile Cold War world. Like other noted scientists of his time, Snow warned that in the nuclear age, our failure to understand the nexus of technology and security had become down right dangerous. Today, strategic latency presents us with another such challenge.

Even with our limited predictive skills, it is clear that transformative technologies in cyber, space, lasers, and geo-engineering have crossed the tipping point. We can't say we didn't see their security consequences coming. More technologies hang in the balance, their latent power increasingly available to serve the desires of a growing cast of characters. However, a review of history suggests that worst case scenarios based on negative assumptions about technological determinism and crude political realism

seldom come to pass. What is more likely is a prolonged state of advancing latency.

We can take comfort from the restraint that has governed the militarization of some of the most consequential technologies. Our understanding of the complex forces underlying such restraint is insufficient to draw conclusions about the management of new and emerging technologies. We simply cannot predict which discoveries, which latent capabilities, will strike the right chord to emerge as game changers for world history. Yet the incentives and motivations to know the future of latency could not be stronger. We can rely on powerful forces (companies, citizens, politicians, NGOs, venture capitalists, researchers, and power-hungry leaders) to ferret out every opportunity to profit from emerging technology. We cannot stop the march of technology or end mankind's desire for power, but it may be possible to moderate the consequences of strategic latency and its effects on domestic and international security.

Restraint and Transparency

One way to avoid arms racing and promote caution regarding the uses of new technologies for military purposes is for the countries that possess the capabilities to exercise restraint in their weaponization. Unrealized latency is usually less threatening than fully expressed military capability. Conversely, pressing one's technology advantage can drive an adversary to take precipitous actions. Along the same lines, transparency can be a useful way to convey peaceful intentions and ease suspicions. Cooperative threat reduction programs started at the end of the Cold War to assist post-Soviet states retire unwanted WMD, which laid the foundation for extensive international collaboration in legitimate but WMD-related research. Cooperative research in certain emerging and disruptive technologies might help to confirm restraint on all sides and alleviate pressures to develop unnecessary countermeasures and hedge strategies. Unfortunately, restraint in the cyber and space arenas appears to be eroding, but it's not too late for other technologies.

Norms. To avoid a free-for-all in which countries and individuals recklessly exploit innovative technologies without regard for adverse consequences, norms that already govern domestic and international behavior should be applied to latent capabilities. At the international level, existing norms against the use of nuclear, chemical and biological weapons provide a useful model. Even without new treaties and institutions, leaders can establish expectations that delegitimize the military uses of certain emerging and disruptive technologies. Some emerging technologies such as nanotechnology are certain to have global consequences that merit common international understandings, if not regulation. Such norms do not prevent the creation or possession of new weapons, and enforcement is problematic. However, it is

nonetheless useful to stigmatize their use, thereby relegating them to a special category requiring a positive decision to defy internationally held beliefs about the legitimacy of certain weapons. It is also possible to develop expectations for punishment of offenders. Domestically, governments should promulgate tough laws against unauthorized acquisition and use of weapons of mass destruction or disruption as these capabilities fall into the hands of every man.

Global Governance. The natural forces of restraint—supported by foreign policy and diplomacy—have proved somewhat effective in the management of transformative technologies. The nuclear nonproliferation regime illustrates how strategic latency can be managed internationally. However, other technology issues with similarly significant consequences for the global commons have proven more difficult to manage in modern times. Current debates over climate change and other global concerns show how the international system has changed since the old governance regimes such as the Nonproliferation Treaty, the Chemical Weapons Convention, and the entire United Nations system were created as part of the post World War II international order. Rising powers such as Iran, India, Brazil and China are challenging the legitimacy of those mechanisms and their preferable treatment of the progenitors of the old system. These countries and their populations are less inclined than ever to accept constraints on their uses of technology to advance their interests, especially if those constraints come from those they perceive to have already benefitted from unfair advantages.

If there is a future for global governance of technology, unprecedented incentives would be indispensible. The payoff for restraint must be tangible, immediate and lasting. The Atoms for Peace/NPT bargain (access to technology in return for non-militarization) offers lessons on the benefits and perils of such an approach. However, even strong positive and negative incentives are not enough to dissuade the highly motivated from crossing the line from latency to weaponry. And without a Leviathan to enforce the rules of a new order, we should not expect future bargains to prevent the coming surge of strategic latency from reshaping the distribution of global power. In the end, the most important factor determining whether nations decide to exercise their latency options will be protecting their own national security. Nothing will drive latency toward weaponization faster than an international environment that breeds insecurity and causes nations to seek the capabilities necessary to protect themselves against aggression.

The Best of All Possible Worlds?

The unpredictable nature of man's relationship with technology underscores the uneven, retrograde and serendipitous nature of progress, which manifests in many forms and guises. Periods of stagnation and backwardness can be a blessing by providing breathing room to adapt. More than

ever, we need downtime to recoup, rethink, and acclimate to our changed circumstances as pervasive strategic latency channels tremendous power throughout the international system. How we respond to these circumstances will determine our collective fate. However, the scope and pace of technological change may have overtaken our current evolutionary ability to comprehend and adapt to these challenges. In this case, failure is an option, one that may expose the Earth and everything on it to a very different set of survival challenges than we face today. For example, wars fought with emerging and disruptive technologies, involving non-state actors, could radically alter political, physical, environmental, and psychological conditions worldwide. It is also possible that a great technological leap forward in energy, food production, or health might ease the causes of conflict and foment an era of peace and prosperity. The challenge is to court the positive benefits of scientific discovery without, as C.P. Snow said, letting it "stab you in the back." We should try to keep strategic latency as latent as possible for as long as possible.

Einstein famously quipped that "the release of atom power has changed everything except our way of thinking." Humankind, he and others feared, was in danger of flaming out like one of Gould's tragically doomed species. Yet world leaders after the World War II acted quickly to rebuild a global order—one that accommodated new thinking about weapons and capabilities that could instantaneously destroy cities and countries. For all its shortcomings, the Cold War was a period of unprecedented peace and prosperity. Leaders rose to the challenge. However, the structure and institutions of the old order are sagging and in need of repair. By giving great power to those who wish to hasten the demise of the post World War II world order, unleashing the military and economic potential of widespread strategic latency could have revolutionary consequences. Whether such creative destruction constitutes progress will likely be viewed differently by the winners and losers in a reconfigured international alignment.

Amongst this whirlwind of technological and political change, one central variable remains steady: human nature. There is a temporal mismatch between the scope and pace of the progress produced by human ingenuity and the pace of evolutionary adaptation to the changes in our environment. Our poor hunter-gatherer brains are still struggling to catch up with the past few thousand years of technology. However, we have the advantage of being familiar with human nature and its foibles. In St. Augustine's words, "This is the very perfection of a man, to find out his own imperfections." We can take heart in our proven ability to build security arrangements that protect peaceful populations from aggression. Strategic latency demands progress in governance, but does not change what we already know about ourselves.