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War, Interdependence, and Nanotechnology

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Liberty, security, prosperity, and world peace—from the time of the American Revolution to the present, humankind has made remarkable strides toward these ideals.

Today, more people live in freedom than at any time in history. Although poverty is still a serious worldwide problem, more people are healthier and better fed than ever before. And despite regional wars and terrorist attacks (which have beset civilization for centuries), we have managed to avoid destroying ourselves with full-scale thermonuclear war.

But looming just over the horizon is a grave threat. It is nanotechnology.

From the dawn of the nuclear age until the present day, we have relied on two mechanisms to protect us from World War III: the doctrine of Mutually Assured Destruction (MAD), and the growing interdependence of nations.

However, in the very near future we may not be able to count on these controls. The tenuous balance of MAD and the worldwide network of commercial trade are both threatened by the rise of advanced nanotechnology.

Fortunately, there are things we can do now before it's too late. We need to seek solutions that could save our way of life.

Let's begin by examining the problems in greater detail.

Imagine a world in which every society has the ability to achieve self-sufficiency, making use of local materials to manufacture valuable products when and where they are needed. Imagine that the United States and other leading industrial nations have ample access to clean, low-cost, sustainable energy sources and no longer rely on expensive imported oil. In such a scenario, will vanishing trade imbalances and reduced competition lead to peace and stability?

In today's world, even though each nation is politically independent, they all rely to some degree on other nations for trade or security, or both. No nation—at least no nation of even minimal significance—exists free from this interdependence. But a proposed new form of manufacturing making use of massively parallel, automated molecular machine systems *(molecular manufacturing)*, made possible by advanced nanotechnology, has the potential to change all that.

By building "from the bottom up," with every molecule in a desired position, huge increases in material strength, durability, and flexibility can be attained. Rapid prototyping, enabled by portable manufacturing appliances that produce their own weight in high-quality output every day, will revolutionize design and unleash innovation.

Better built, longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, and for industry—all of that is just the beginning. Add in widely available, inexpensive, renewable energy; cheap, ready access to space flight; and remarkably efficient greenhouses, which reduce our agricultural footprint to a fraction of its current size while sharply increasing output.

Sounds wonderful, right? Unfortunately, it's not that simple.

Molecular manufacturing will be a general-purpose and dual-use technology. What that means is that it will not only make benign products, but can create powerful weapons as well. It promises miraculous benefits, but also dire consequences.

When individual countries are able to provide their own goods and services, without the need for import or export trade, they will have less incentive to maintain good relations with others. When economic security is no longer an issue, the only remaining security concern will be military.

This scenario contains all the elements for a terrible new arms race. Every country possessing unrestricted molecular manufacturing capability will have the ability to design, test, and inexpensively stockpile huge numbers of powerful weapons of any size. If nanotechnology development is allowed to proliferate, we can expect that many countries will achieve both economic independence and unprecedented military prowess.

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Will we then see a stable equilibrium, a tenuous balance of power similar to the Mutually Assured Destruction of the Cold War? Not likely. Nuclear weapons require massive research efforts and industrial development, which can be globally tracked with greater ease than nanotech arms programs. Molecular manufacturing will enable quicker weapons optimization due to cheap, rapid prototyping. Once a design is approved, vast numbers of powerful new weapons could be produced overnight. It will be nearly impossible to know how much war-making capacity your enemy or your neighbor might possess in the near future.

Unless molecular manufacturing capability is contained, the number of nanotech-possessing nations in the world could be much higher than today's number of nuclear nations, increasing the chance of inflaming dangerous regional conflicts that could spin out of control. Greater uncertainty of the capabilities of the adversary could foster caution—but it also could increase the temptation for preemptive strikes to prevent proliferation. Decreased response time to an attack, and better-targeted destruction of an enemy's visible resources, will make for highly unstable conditions.

Worse still, this technology opens the door for the development of rival groups within countries. We might see repeated military coups, devastating civil wars, and dissolution of nations into large numbers of hostile, unpredictable, immensely powerful tribes. Another potential scenario is radical transnational groups, bound by religious, cultural, or ideological extremism, using molecular manufacturing toward terrorist ends.

We also must consider the potential negative impacts of advanced nanotechnology on our current socio-economic structure.

Low-cost local manufacturing and duplication of designs could lead to monetary upheaval, as major economic sectors contract or even collapse. For example, the global steel industry is worth over $700 billion. What will happen to the millions of jobs associated with that industry—and to the capital supporting it—when materials many times stronger than steel can be produced quickly and cheaply wherever (and whenever) they are needed?

Productive nanosystems could make storable solar power a realistic and preferable alternative to traditional energy sources. Around the world, individual energy consumers pay over $600 billion a year for utility bills and fuel supplies. Commercial and industrial uses drive the figures higher still. When much of this spending can be permanently replaced with off-grid solar energy, many more jobs will be displaced.

The worldwide semiconductor industry produces annual billings of over $150 billion. The U.S. Bureau of Labor Statistics reports that the industry employs a domestic workforce of nearly 300,000 people. Additionally, U.S. retail distribution of electronics products amounts to almost $300 billion annually. All of these areas will be impacted significantly if customized electronics products can be produced at home for about a dollar a pound, the likely cost of raw materials. If any individual can make products containing computing power a million times greater than today's PCs, where will those jobs go?

Other nations will be affected as well. For example, the Chinese government may welcome the advent of general-purpose molecular manufacturing for several reasons, including its potential to radically reduce poverty and reduce catastrophic environmental problems. But at the same time, China relies on foreign direct investment (FDI) of over $40 billion annually for much of its current economic strength. When money to purchase Chinese manufactured goods stops flowing in, economic turmoil could spark violent struggles.

Overall, it's not a pretty picture. Without wise planning, molecular manufacturing is likely to produce severe economic disruption and social disorder, as well as a perilously unstable new arms race that could lead to devastating acts of war.

Approached with pessimism, nanotechnology appears far too hazardous to be allowed to progress to anywhere near its full potential. It's tempting to just say no, to urge that we shut Pandora's Box and halt further development.

The possibility of technological relinquishment was made famous by computer scientist Bill Joy in his April 2000 *Wired Magazine* article, "Why the Future Doesn't Need Us." Joy saw great danger to the continued existence of the human race from nanotechnology (as well as from robotics and genetics). He advocated an enforced global relinquishment of so-called "dangerous technologies," which essentially would require an end to further development of almost all new technology.

Although Joy's call met with some support from environmental activists and others, the consensus reaction was largely skeptical of both the feasibility and the advisability of such a shutdown. For one thing, it would be almost impossible to prevent the development of molecular manufacturing technology somewhere in the world. China, Europe, and Japan all have thriving nanotechnology programs. The rapid advance of enabling technologies such as computing, biotechnology, 3D prototyping, MEMS, and scanning-probe microscopy ensures that nanotechnology research and development efforts will be both easier and more cost-effective in the near future than they are today.

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But perhaps the strongest argument against relinquishment is the loss or delay of immense benefits. Molecular manufacturing promises the ability to reduce stress on the environment, alleviate most shortages, raise living standards worldwide, and eradicate nearly all poverty, starvation, and homelessness. Nanotechnology can greatly aid in the provision of safe drinking water, effective sanitation, and protection from many infectious diseases. Clean, cheap, and efficient manufacturing; medical breakthroughs; immensely powerful computers; renewable energy; easier access to space—all these gains are simply too good to pass up. So, what is the answer? Can we find a way to preserve peace, security, and liberty while still enjoying prosperity and abundance?

It is a challenge of the highest order. The Center for Responsible Nanotechnology (CRN), which I co-founded, has studied these issues in depth for years now, and the clearest thing we can say is that there is no simple solution.

We are convinced, however, that two choices are untenable. The first, as discussed above, is relinquishment; which is impractical and probably impossible. The second bad choice is to just wait and see, or take a laissez-faire attitude. Our analysis suggests that, if maintained, this approach leads directly to potentially catastrophic instability.

Other solutions will be required. New mechanisms must be found to replace Mutually Assured Destruction and economic interdependence, the historic safeguards on which we can no longer rely.

CRN has begun the critical work of looking for solutions, producing research papers proposing tentative answers. We have developed a catalog of thirty in-depth studies that should be performed as soon as possible (listed on our website). But much more needs to be done, more than any organization can accomplish alone.

The disruptive and destabilizing implications of advanced nanotechnology must not be underestimated. At the same time, the near miraculous benefits cannot be forfeited. To save our way of life and usher in an even brighter tomorrow, it will be necessary to develop and implement comprehensive, balanced plans for responsible management of this transformative technology.

This essay is original and was specifically prepared for publication at Future Brief. A brief biography of Mike Treder can be found at our main Commentary page. Recent essays written by Mr. Treder can be found at the Center for Responsible Nanotechnology. He receives e-mail at mtreder@crnano.org. Other websites are welcome to link to this essay, with proper credit given to Future Brief and Mr. Treder. This page will remain posted on the Internet indefinitely at this web address to provide a stable page for those linking to it.

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