Brave New World War

Genetic engineering will soon turn science fiction into fact. Why we need a new global treaty to control it.

In the fall of 2006, a BBC wire report speculated that global economic inequality and rapid advances in genetic engineering would some day combine to split mankind into two subspecies. "The descendants of the genetic upper classes would be tall, slim, healthy, attractive, intelligent, and creative and a far cry from the 'underclass' humans who would have evolved into dim-witted, ugly, squat goblin-like creatures." The BBC was careful to put its sci-fi scenario far into the future—100,000 years down the road. But whether or not such Wellsian predictions are realized, one thing is becoming increasingly clear: The day will come, perhaps even within a decade, when at least a subset of the human race will have the ability to control key aspects of its own evolution.

Although individuals with superhuman capacities have long been the domain of religious texts and science fiction, in the not-so-distant future, in the immortal

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words of the 1970s series *The Six Million Dollar Man*, we very well could make people "better, stronger, faster" than their unenhanced counterparts. But while the fictional Steve Austin was modified with high-tech electronics, tomorrow's alterations will be biological—embryos modified with genes to lengthen life spans, enhance brain capacity and sense perception, increase endurance, and protect from deadly diseases.

The early stages of this technology already have been contentious; think of the fierce fight over stem cell use here in the United States. But these debates pale in comparison to the conflicts that will emerge as our capacity to alter our offspring's genetic makeup grows exponentially. As different national approaches develop worldwide, they will become a source of instability, conflict, and even potentially armed intervention. Consider how a set of relatively small genetic changes to crops has created a flurry of trade tensions over genetically modified food. Being unable to sell American soybeans to Europe is one thing; the conflict over different approaches to changes to the human genome will be of an entirely different magnitude.

But despite this looming threat, the world remains dangerously unprepared for the international genetic "arms race" that could one day emerge, in which countries or even corporations compete to generate the most competitive offspring, even as they may recognize the dangers of following this path. I'm not talking about China or Russia genetically engineering a battalion of men capable of running 100 miles per hour and leaping tall buildings in a single bound. But what about a nation that has soldiers who need only an hour of sleep a night, have the eyesight of the best sharpshooter, or possess the endurance of Lance Armstrong? Would other countries be willing to wait 30 years to see what the repurcussions are before starting down the same path themselves? Or would they feel forced to start immediately, setting off a genetic arms race? As soon as one country heads down this path, others will immediately set out to keep pace. Sound improbable? The nuclear arms race resulted in the irrational production of more than 30,000 nuclear warheads, and the world came dangerously close to nuclear war more than once. The genetic arms race could well turn out the same way, and this time, we might not be so lucky.

To maximize the benefits of advances in genetic technologies while minimizing their potential harms, the world community must develop global standards and a multilateral structure capable of both promoting advances in human genetic manipulation and preventing abuses. Call it a Genetic Heritage Safeguard Treaty. The science is moving extremely fast. The policy framework must now catch up.

Beyond Darwin

Just as advances in agriculture, sanitation, and health care have dramatically enhanced the length and quality of our lives, so too will advances in bioengineering help secure and enhance our future. Converging advances across fields as diverse as nanoscience, biotechnology, information technology, human fertility, gene therapy, molecular biology, and cognitive science ensure the arrival of revolutionary capabilities in human reproductive engineering. As this occurs, our species will develop the Promethean ability to manage its own evolutionary process to an extent that Charles Darwin never could have imagined. It will extend our lives, make us immune to diseases, and massively expand our memory capabilities and our sense perceptions—to name only a few possibilities. But as these capabilities spread quickly around the world, we could also see the loss of genetic diversity, the creation of "Frankenpeople," and even unknown outcomes of meddling with a system as infinitely complex as the human being.

To a very limited extent, some genetic manipulation is already happening. In today's IVF clinics, pre-implantation genetic diagnosis (PGD) enables parents to choose the healthiest of their fertilized eggs, or select a gender, prior to re-implantation in the womb. In the near future, a relatively simple, additional step will allow doctors to insert an artificial chromosome with a targeted genetic manipulation—perhaps to eliminate the threat of Down Syndrome or even cancer—into such a fertilized egg.

As opposed to the somatic gene therapies in use today which target non-reproductive cells, so-called "germline" technology alters reproductive cells at the outset of the fertilization process, allowing genetic changes to be replicated in every ensuing cell and, potentially, permanently altering the gene pool of a given species. Germline engineering is not currently used on humans, but the process is being utilized widely in experiments with laboratory animals. Scientists disagree over the timeframe, but most generally agree that this technology will soon reach a stage where it could be used on humans. As UCLA Professor Gregory Stock has asserted, "The question is no longer whether we will manipulate embryos, but when, where, and how."

These capabilities hold the key to potentially massive enhancements to the human experience. In addition to enhancing cognitive abilities, endurance, and other traits, Princeton molecular biologist Lee Silver has suggested in his book *Remaking Eden: How Cloning and Beyond Will Change the Human Family* that humans might be able to expand our sensory perception by replicating genetic adaptation of animals. Imagine humans with the high- and low-frequency hearing of a bat or the acute smell of a dog.

Although spectacular debates will rage over the human genetic manipulation process, and although some states (and groups of states) will certainly continue to mandate tough restrictions on these capabilities, it will be extremely difficult to stop motivated groups from engaging in human genetic manipulations. On the contrary, competition will drive many to move forward aggressively, creating new fissures both within societies and between them.

Social Darwinists have long claimed that elites were smarter and had a greater natural capacity than the masses, a concept proven wrong as opportunity has democratized and societies have become more internally mobile. Taken to its extreme, this has led to the eugenics movement of the early part of the last century and, of course, the murderous ideology of Nazi Germany. But what if, in addition to having better nutrition, more exposure to ideas, and better schooling, the rich and privileged within a society also had genetic manipulations that actually made their brains function better? Princeton's Silver takes this argument a frightening step further, arguing, as the BBC report does, that societies will eventually bifurcate into genetically enhanced people and lower-capacity "naturals," two groups that will become "entirely separate species with no ability to cross breed."

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In this context, would it begin to make sense for the enhanced people to assume leading roles in running institutions and governments, or making decisions on behalf of the less-enhanced populace? Uneven genetic enhancement would challenge our basic concepts of equality and place enormous or even existential strains on the democratic process. What is the life expectancy of a democracy where people are literally not born equal?

Among nations, two types of strains might emerge, and sooner than some think. First, enormous conflict could erupt between the states that ban or restrict new forms of human genetic manipulation and those that do not. If the current debate over genetically modified crops is anything to go by—where many Europeans see an existential threat, while Americans and Asians are generally far less concerned—the stress on international systems over genetically modified people would be monumental.

Consider, for example, a scenario in which China developed genetically modified people with better brain capacities for innovation, who can work longer hours and increase productivity, and have stronger sensory perceptions. Competitive pressures would force the United States, Europe, and other countries to choose between 1) doing nothing and potentially seeing their relative global position decline; 2) beginning such genetic enhancement activities themselves to keep up—in international terms—with the Joneses; or 3) working to halt the activities going on in the more scientifically adventurous country. Whenever this genetic Sputnik moment comes, it is easy to believe that states would resort to armed intervention to prevent what they see as inalterable manipulations of the human genetic code and intolerable changes in the balance of power. What begins as a scientific and moral issue would fast become a significant cause of global instability.

Second, the existing divide between rich and poor countries would become even greater. If unequal access to adequate food, health care, governance, and education make it seem like developed and underdeveloped countries are different worlds, uneven access to human genetic manipulation will make them seem like different universes. At the same time, to keep themselves from falling even further behind the more developed countries, it is possible that less-developed countries would see a relative advantage in loosening regulations on genetics and biotechnology applications, engaging in a regulatory "race to the bottom."

These enormous competitive pressures within and between societies will propel the human species into the unknown territory of human genetic manipulation at warp speed. The ease of transferring scientific knowledge, and its implications for all humans, will require a far more concerted approach on a global level. The challenge for the United States and the world, therefore, will be to maximize the enormous benefits of the inevitable scientific progress while developing globally accepted norms and standards for human genetic research and its applications.

Hello, Dolly

Since even before Dolly the cloned sheep was introduced to the world by scientists in Scotland, international organizations and governments have struggled to establish standards for genetic manipulation techniques. In 1997, UNESCO adopted the Declaration on the Human Genome and Human Rights, a non-binding document that prohibits "practices which are contrary to human dignity, such as reproductive cloning of human beings." The following year, the Council of Europe adopted its Convention on Human Rights and Dignity with Regard to Biomedicine, which asserts that modifying the human genome can only be undertaken "for preventive, diagnostic or therapeutic purposes and only if its aim is not to introduce any modification in the genome of any descendents" (this protocol has been ratified by only 21 of the Council's 41 member states).

Then, in February 2002, the U.N. Ad Hoc Committee for an International Convention Banning Human Reproductive Cloning convened high-level exchanges by experts on genetics and bioethics and drafted text that was eventually brought to the General Assembly for a vote. The non-binding General Assembly resolution, the United Nations Declaration on Human Cloning, was adopted in March 2005 by a vote of 84 in favor, 34 against, and 37 abstentions. It called on member states to "prohibit all forms of human cloning inasmuch as they are incompatible with human dignity and the protection of human life." In the Declaration, "[m]ember States were also called on to protect adequately human life in the application of life sciences; to prohibit the application of genetic engineering techniques that may be contrary to human dignity; to prevent the exploitation of women in the application of life sciences; and to adopt and implement national legislation in that connection." Unsurprisingly, many states which see themselves at the forefront of the life sciences revolution, including Belgium, Canada, China, India, Singapore, South Korea, Sweden, and the United Kingdom, opposed the treaty. In what was widely seen as a political gesture toward America's religious right, the United States voted for the resolution. But as a non-binding, unenforceable resolution, its meaning is limited regardless.

A total ban on reproductive cloning is appealing on its face, and it is strongly supported by leading experts associated with the U.S. National Academy of Sciences and others. These experts argue that the failure and complication rate in other mammals makes this process too dangerous for human application. So far, this argument generally holds sway internationally. But it is one likely to be overcome by scientific process in the not-so-distant future. As knowledge and technological skill advance, the leading arguments against reproductive cloning will fade and the global convention will have to focus ever-more on philosophical and ethical codes that will vary among populations and nations.

The weakness of all current international conventions, and of the standards they seek to set, is their lack of consensus and enforcement power. As in the UN resolution, the countries with the most to gain from such scientific advancement are, and will remain, extremely reluctant to have their activities limited in any way by others, especially those less scientifically advanced. And even if a consensus did emerge, enforcement power is, with the partial exception of Europe, focused on the national level, while the knowledge is increasingly mobile and able to find a home wherever standards are more lax.

These documents also say very little about setting standards for research that fit in principle with accepted norms. In addition, technology could also render some genetic manipulation acceptable, such as chromosomes inscribed with genetic instructions to prevent mutations from being transferred to future generations, or artificial chromosomes that contain chemical "switches" to activate or deactivate specific genes. Nevertheless, issues concerning genetic manipulation may not be about whether a certain mutation is introduced, but how it is introduced.

Any international regime to prevent abuses and ensure that those engaged in legitimate activity do so according to internationally accepted standards would therefore have to play a dual role: as an enabler of responsible research and an enforcer of limitations as to how far these activities can go. Of course, determining what constitutes an abuse will be enormously difficult and complicated, and it is entirely unclear whether enhancing human capacities such as cognition, memory, sense perception, and strength would be considered by all to be, in fact, abuses.

How do we move forward? There are few successful models for fulfilling this dual role effectively. But in spite of its flaws and limitations, the Nuclear Non-Proliferation Treaty (NPT) may be the least-bad among them.

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As is well known, the 1970 NPT sought to limit the spread of nuclear weapons by establishing both standards for non-proliferation beyond the five states permitted to legitimately possess nuclear weapons (Great Britain, China, France, the United States, and the USSR) and a set of incentives to encourage non-nuclear armed states to remain so. The non-nuclear signatories agreed to refrain from acquiring or developing nuclear weapons in exchange for a promise from the five nuclear-armed states to help them develop peaceful nuclear energy capacities.

A genetic "arms race" and a nuclear arms race share certain characteristics. Both deal with cutting-edge technologies whose applications become increasingly accessible to wider groups of people and states. Both involve capabilities that have enormous potential to improve people's lives, matched by a similarly great potential to harm them. And both involve technological capabilities developed in more advanced countries that become desirable the world over.

The NPT has come under increasing strain as the technology required to develop nuclear arms has become far more easily transferable, as non-signatory states like Pakistan have transferred requisite knowledge and equipment; and as exceptions to the treaty norms have been carved out for India, a non-signatory state. But the treaty still boasts an overall impressive track record. Signatory states South Africa and Ukraine voluntarily gave up their nuclear weapons. Libya publicly renounced its secret effort to develop them. And the acquisition of nuclear weapons by non-nuclear states remains a taboo, albeit a weakening one.

What would a Genetic Heritage Safeguard Treaty (GHST), based on the NPT model, look like? Above all, it would require states possessing greater knowledge in the field to share basic-science capabilities with others, in exchange for all members agreeing to common protocols and appropriate regulations (requiring, for example, the non-inheritability of germline genetic manipulations and the banning of human reproductive cloning). Students from signatory states would, perhaps, get priority in applications to genetic research programs abroad, while access to those from non-signatory states might be restricted. Similarly, research grants from signatory states couldn't go to institutions in non-signatory states, even for research conducted by foreign nationals. Those states that allowed systematic violations of the treaty on their territory might face stiff economic sanctions. As part of the ratification process, all signatory states would be required to pass enforcing legislation in their own countries, based on the principles of the treaty.

Because scientific standards will change over time, such a treaty would also need to establish an international advisory committee, made up of experts and ethicists, to report annually on developments in human genetic engineering, both globally and country-by-country. As with the NPT, at regular intervals the basic tenets of the treaty, including the list of abuses of the genetic modification process, will need to be re-negotiated.

Such a framework would be incredibly difficult to negotiate. It would need to respect the sensibilities of powerful constituencies deeply uncomfortable with the technology. Nor could it impede the beneficial development of new generations of knowledge and discovery. And the standard for such a framework would need to be flexible enough to keep the more scientifically aggressive countries on board.

Nevertheless, finding a workable balance will be critical to preventing an unimpeded, unregulated human genetic arms race. Some aspects of finding such a balance could be relatively straightforward; others could be far more complicated. It would make sense, for example, to seek international guarantees that germline genetic manipulations should be universally non-inheritable. But it would be far more difficult to determine which manipulations enhance the human experience and which undermine it.

Two serious objections demonstrate the significant imperfections of such a treaty, but they do not suggest a better course. For one, it could be argued that states should first develop their own standards for genetic modification before they consider an international regime. Although this makes some logical sense, science is likely moving too quickly; many states will therefore necessarily face the challenging issue of genetic manipulation before their leaders and populations will be able to assess it in any meaningful way. The international community cannot wait for a gradual paradigm shift to happen across the globe.

The second objection is that this type of regulation, particularly if armed with enforcement mechanisms, will be used by critics of legitimate research to impede the genetic engineering process as a whole, as is the case of religious opposition to stem-cell research in the United States. This is a real danger. But it is outweighed by the need to maintain a progressive framework to keep the most advanced countries on board. If enforcement is too aggressive, the regime would collapse.

Just 70 years ago, few people seriously imagined that a single bomb could destroy an entire city. But within a decade, the nuclear age was upon us. Fortunately, the world responded, and nuclear technology has proved extremely helpful to humankind despite the looming danger it continues to pose. We stand at a similar precipice today, when our minds are opening up to a new set of technologically-induced realities that our imaginations and our policy strategies are not yet ready for.

Although the prospect of human genetic modification is terrifying to many, it is an emergent reality that holds both tremendous promise and unimaginable danger for the world community. As difficult as it will be to establish an international framework for maximizing the benefits and minimizing the dangers of this revolutionary advance, the alternative—allowing these capabilities to emerge unregulated and unchecked—will prove nationally and internationally destabilizing and dangerous to the future of our species. This may sound like science fiction, but it is fast on its way to becoming our reality. America and the world must do far more to prepare. A Genetic Heritage Safeguard Treaty, modeled after the Nuclear Non-Proliferation Treaty, can be one important step in the right direction. **D**