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Beyond Cloning

The Larger Agenda of Human Engineering

by Brian Halweil and Dick Bell

Advances in human engineering are moving ahead largely without public debate. Industry proponents have hyped the benefits, but a growing number of experts are now warning that the risks may be substantial.

How do you feel about altering human nature… forever?

There's probably not a parent in the world who hasn't wished for a magic wand that would make a sad child happy, or transform an unruly child into a civil one. And history is littered with the myriad methods cultures have applied to bend their members toward a particular definition of human nature.

But for the first time in human history, we are confronted with an entirely new approach to altering human nature, one that could have great benefits but could also carry great risks. Geneticists are closing in on a mythic power that humans once only dreamed of, the power to alter the genetic materials we pass on to future generations by engaging in "inheritable genetic modification" (IGM) or "germline engineering." (In contrast, "somatic engineering" affects only the person being treated, without producing changes in patients' germ cells—their eggs or sperm—that can be passed on to future generations.)

The personal, social, and political dangers inherent in asserting control over the human germline were well apparent when Aldous Huxley published his prophetic novel *Brave New World* in 1932. At that time, well-intentioned, highly educated scientists and politicians were wielding the surgeon's scalpel to realize a vision of genetically "improving" human nature by eliminating "bad genes" from the human gene pool.

Starting in 1907, several dozen U.S. states adopted laws allowing involuntary surgical sterilization for people deemed to be "feebleminded," "mentally defective," or "epileptics." In an infamous 8-1 ruling in 1927 upholding a Virginia forced sterilization law (*Buck v. Bell*), U.S. Supreme Court Justice Oliver Wendell Homes wrote, "It is better for all the world, if instead of waiting to execute degenerate offspring for crime, or to let them starve for their imbecility, society can prevent those who are manifestly unfit from continuing their kind.… Three generations of imbeciles are enough."

When *Brave New World* appeared, Adolf Hitler was only one year away

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from seizing power and passing his own "Law for the Prevention of Offspring with Hereditary Diseases," a 1933 statute that closely followed sterilization statutes in the United States. The Nazis began by sterilizing the blind, the deaf, chronic alcoholics, and the physically and mentally handicapped, before moving on to the extermination of Jews, gays, and gypsies.

The sobering history of the role of eugenics in the darkest moments of modern history looms in the background of any discussion about heredity and human nature. As environmentalists, we have always been interested in how different cultures defined human nature, since these definitions bear heavily on how those cultures interact with their physical environments and the rest of life on the planet. And we would be the last to claim that we know what human nature "is."

But our study of the history of science and technology has led us to be deeply skeptical about faith in the unexamined, unregulated power of science and technology to solve all our problems. This faith has been sorely tested time and again, as the large-scale rollout of one new technology after another has confronted us with unpredicted consequences. In contemplating the internal combustion engine, no one foresaw traffic jams, urban sprawl, smog, and global warming. DDT was hailed as a miracle pesticide, until whole populations of birds began to crash. Dams and levees built to control floods have resulted in even more destructive floods.

These repeated encounters with the unanticipated have led environmentalists to fight for a new approach to regulating the introduction of new technologies, the "precautionary principle." Under this principle, before we unleash a new technology, its proponents must first demonstrate convincingly that the technology is not likely to subject us to major new risks. In the event that there are serious uncertainties about what problems may appear, governments are empowered to regulate and restrict development until these uncertainties can be resolved.

In a sense, the precautionary principle is a way of legislating the humility which humanity has so long lacked in dealing with technological change. We have put this special issue of *World Watch* together because we believe that if ever there were a time to apply the precautionary principle, the advent of human germline engineering is it.

Some proponents of germline engineering want to race ahead with experiments specifically designed to alter human nature, to correct "mistakes," add "improvements," or even to launch an entirely new species that will leave *Homo sapiens* behind.

But the more sophisticated supporters of germline engineering are fully aware of the dark history of eugenics, and they reassure us by disparaging scientists and companies who try to move too fast as "cowboys." They take pains to distance themselves from the likes of Severino Antinori, the Italian doctor who claimed this spring that one or more women in his care were pregnant with human clones.

Instead, these proponents argue that new regulation of germline engineering will curb patient autonomy, reproductive choice, and disease prevention. They are willing to gamble that the possible gains from this technology outweigh the still poorly understood risks. They use images that play on our desire to be healthy and to live long lives. They avoid a bold frontal assault, and sell us on the idea of germline engineering in small, incre-

mental steps, one "modest" intervention at a time, while characterizing those who advocate greater caution as unconcerned with human welfare.

Environmentalists are hardly opposed to the betterment of the human condition through the development of science and technology. At the Worldwatch Institute, we have welcomed many technologies that promise to lighten the impact of humanity on the natural world, such as solar panels to replace fossil fuels in generating electricity or sophisticated crop rotations to foil agricultural pests without using pesticides. And we have championed improving the lot of all of humanity, and especially the poor, through greater spending on education, strengthening women's rights, providing universal access to contraception, and funding simple public health measures like access to clean water.

But the biotechnology industry's failure to proceed under the precautionary principle has left us less sanguine about genetic engineering in all its forms. Many of the concerns that our contributors raise about human germline engineering apply with almost equal force to the exploding use of such techniques to alter the germlines of other species. Our sense of caution is reinforced by the growing body of knowledge demonstrating that genes do not act in a vacuum—that the function of a particular gene changes, depending on the environment, on the stage in the organism's life, and on interaction with other genes. In such a complex context, trying to distinguish "good" genes from "bad" genes becomes a fool's errand.

But as the old torch song goes, fools rush in where angels fear to tread. Instead of proceeding thoughtfully, the genetic industry is rushing ahead pell-mell in the commercial marketplace, developing a plethora of techniques that could be used for human germline engineering. The United States Patent Office now accepts patent claims for sections of human DNA. The number of patents pending for these human DNA sequences has gone from 4,000 in 1991 to 500,000 in 1998 to several million today. Aided by the equally rapid revolution in computing, laboratories that once took two months to sequence 150 nucleotides can now process over 30 million in a day, and at a small fraction of the earlier cost. The U.S. biotech industry—which dominates the global industry—has become an increasingly powerful economic and political force, with revenues growing fivefold between 1989 ($5 billion) and 2000 ($25 billion).

Aldous Huxley is not the only great artist who has wrestled with the implications of genetic engineering. In the dramatic Sorcerer's Apprentice sequence in the 1940 cartoon *Fantasia*, Walt Disney and his cartoonists gave us an animated metaphor of the unintended consequences of a kind of magical genetic manipulation. The sorcerer's apprentice brings a broom to life to speed his chores, failing to anticipate the dangers of creating new forms of life. But when the living broom proves too mindlessly efficient and starts to flood the Sorcerer's quarters, efforts to bring his creation under control by chopping it up backfire: the pieces of the shattered broom multiply out of control, and wreak even greater havoc.

For Disney, all is well in the end, because a higher power intervenes to set everything right. The angry sorcerer appears and casts the necessary spell to vanquish the brooms, stem the flood, and restore order in the universe, while the apprentice hangs his head in shame.

There is no sorcerer who will come for us once we have waved the wand of human germline engineering and begun to "people" the earth with offspring that carry new and novel combinations of DNA.

We are under no illusions that the arguments our contributors make here are ahead of the curve. The hour is already late; there appears to be little disagreement that to actually wield this wand will be technologically possible within a decade or two, if not sooner. We publish this issue in the hope that we still have enough time remaining for a fully informed public debate about this technology that could change human nature forever.

Somatic, or Non-inheritable, Genetic Modification: a procedure that changes the genes in cells other than egg or sperm cells, in order to treat a disease. This kind of change is not passed on to the person's children. Applications of this sort are currently in clinical trials, and are generally considered socially acceptable.

Germline Engineering, or Inheritable Genetic Modification: a procedure that changes genes in eggs or sperm cells or very early embryos, so that the child will have certain characteristics. The procedure changes not only the child being born, but the child's descendants as well. Such applications have not yet been tried on humans.

Cloning: the creation of a genetic duplicate of an existing person. In ***research cloning***, embryos created through cloning are used for research purposes, with the eventual goal of treating disease. In ***reproductive cloning***, the embryo is implanted in a woman's uterus to produce a child. This process has been banned in over 30 countries.

Stem cells: cells from the membrane around an embryo which have the potential to develop into almost any type of tissue. Therapy using stem cells offers great potential for repairing damaged or diseased tissue in an individual.

Richard Hayes

The Science and Politics of Genetically Modified Humans

Will new genetic technologies be carefully controlled for their benefits–or will they inadvertently destroy civil society? Say hello to the post-human ideology.

The new human genetic technologies are arguably the most consequential technologies ever developed. Many applications have great potential to prevent disease and alleviate suffering, but others would open the door to a new, high-tech eugenics that could destabilize human biology and undermine the foundations of civil society.

Humanity needs a crash course in the science and politics of the new human genetic technologies. We need to distinguish benign applications from pernicious ones, and we need to adopt policies affirming the former and proscribing the latter. We need to repudiate eugenic political ideologies and deepen our commitment to the integrity of the human species and the dignity of all people. We need to do this on a global scale and within less than a decade.

Two new technologies are of critical concern: *reproductive cloning* and *inheritable genetic modification*.

Reproductive cloning is the creation of a genetic

Modern science reveals that genetic differences across peoples are trivial and that "race" is an almost meaningless descriptor. But a century ago, the notion was highly elaborated, as illustrated by this sample of the 51 "chief living races" from *The Book of History* (circa 1914). In our ignorance, we once perceived rifts that did not really exist; now genetic science has corrected the error but also given us tools to create rifts where they should not exist.

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near-duplicate of an existing person. If I cloned myself, would the child be my son or my twin brother? In truth, he would be neither. He would be a new category of biological relationship—my clone. Opposition to reproductive cloning is nearly universal, and the United Nations has begun negotiations on an international treaty to ban it.

Inheritable genetic modification (IGM) means modifying the genes we pass to our children. Most people intuitively understand that if IGM were allowed it would change forever the nature of human life. People would quite literally have become artifacts. If cloning is the atomic bomb of the new human genetic technologies, IGM is the multi-megaton hydrogen bomb. Only the most egotistical or deluded would want to clone themselves, but if IGM were allowed even many who are appalled at the prospect of using it would feel compelled to do so, lest their children be left behind in the new techno-eugenic rat-race.

Once we begin genetically modifying our children, where would we stop? If it were acceptable to engineer one gene, why not two? If two, why not twenty, or two hundred? IGM would put into play wholly unprecedented biological, social, and political forces that would feed back upon themselves with impacts quite beyond our ability to foresee, much less control.

People often assume that IGM is needed to enable couples to avoid passing inheritable genetic diseases such as Tay Sachs and cystic fibrosis to their children. This is not so, and those who say it is are either misinformed or seeking to mislead. Pre-implantation genetic diagnosis and other options available today allow such couples to have children completely free of the harmful genes, in all but a very small number of situations. IGM would be necessary only if a couple wished to "enhance" a child with genes that neither of them carry.

The new eugenic technologies are being actively promoted by influential scientists, writers, and others who see themselves ushering in a new epoch for human life on earth. They speak with enthusiasm of a "post-human" future in which the health, appearance, personality, cognitive ability, sensory capacity, and lifespan of our children have all been genetically modified. They anticipate, with scant concern, the inevitable segregation of humanity into genetic sub-species, the "GenRich" and the "Naturals."

This new techno-eugenic vision is an integral element of an emerging socio-political ideology. It differs from conservative ideologies in its antipathy towards religion and traditional social values, from left-progressive ideologies in its rejection of egalitarian values and social welfare as a public purpose, and from Green ideologies in its enthusiastic advocacy of a technologically reconfigured and transformed natural world. It embraces a triad of ideological commitments: to science and technology as autonomous endeavors properly exempt from social control; to the priority of market outcomes; and to a political philosophy grounded in social Darwinism.

In recent months, leaders of a wide range of civil society constituencies have begun speaking out against the new techno-eugenics. Pro-choice feminists and women's health advocates charge that high-tech consumer eugenics would commodify and industrialize the process of child-bearing. Environmentalists know that genetically altered humans would have few qualms about genetically altering the rest of the natural world. Human rights and civil rights advocates worry that new eugenic technologies would stoke the fires of racial and ethnic hatred. Disability rights leaders know that a society obsessed with genetic perfection could regard the disabled as mistakes that should have been prevented. Peace and justice activists fear brutal international conflict as countries race to create genetically superior populations.

What policies do we need? We need domestic and international bans on reproductive human cloning and inheritable genetic modification, and effective, accountable regulation of all other genetic technologies. At the same time we need to affirm the many beneficial applications of genetic science—in diagnostics, therapeutics, pharmaceutical development, and other medical fields—and to ensure that these are available to all people, regardless of economic status or geography.

Many countries have already adopted such policies. Our challenge now is to extend them world-wide. If successful, the United Nations treaty negotiations to ban reproductive cloning will be both an historic achievement and a model for international policy on IGM and other human genetic technologies.

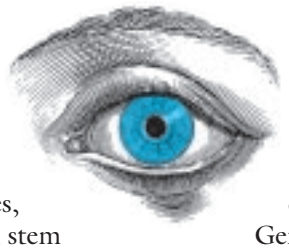
Nothing will happen, however, unless people organize to make it happen. We need to foster new levels of awareness, organization, and engagement—in short, a new social movement—committed to affirming the integrity of the human species and opposing the new techno-eugenics and the post-human ideology. Such a movement will need to be of the same intensity, scope, and scale as the great movements of the past century that struggled on behalf of working people, anti-colonialism, civil rights, peace and justice, women's equality, and environmental protection. There is no greater challenge. Our common humanity is at stake.

Pat Mooney

Making Well People "Better"

The strategy of the biotech firms is to use sympathy for the sick to get genetic modification techniques approved, then go for the real profits–selling traits to people who aren't particularly sick.

When heads of state gathered for the Earth Summit in Rio de Janeiro 10 years ago, biotechnology was the buzzword miracle cure for world hunger and disease. A decade later, biotech has brought the poor no closer to the dinner table or better health. The reason is obvious: as ever, the poor are no one's market. Not that progress in biopharmaceuticals has lagged; advances in mapping the human genome have spawned new opportunities, and the prospects for human cloning and stem cell therapies have made headlines. However, the companies involved are actually pursuing more strategic agendas. Reproductive cloning might never be more than a niche market that the industry is happy to leave to quacks. The real money is in human performance enhancement drugs (call them "HyPEs"). And whether the focus is on pharmaceuticals developed the old-fashioned way or those that are linked via research or function to biotechnologies, they employ the same self-serving strategies.



HEALTHY MARKETS

The pharmaceutical industry has always suffered from a seemingly incurable marketing problem. Its customers are sick, and sick people are unreliable. If they die or get well, they stop buying drugs. If they remain sick, they tend to become unemployable. Unemployable sick people either can't afford drugs or (worse) they elicit sympathy and threaten prices. In the mid-1970s, pharmaceutical companies saw that the solution to the uncertainty of an ill clientele was to develop drugs for well people, who not only remain employed but never get "better." Best of all, well customers don't create sympathy and threaten price margins and profits. Now, biotechnology and the map of the human genome are making the task of creating new drugs for well people much easier.

Although the birth of biotech a quarter-century ago inspired the drive for a brave new market in well-people products, the industry has always been open to the opportunities. Morphine was purified from opium at the outset of the nineteenth century and first commercialized by Merck in Germany in 1827. Bayer was an early proponent of amphetamines and brought the world two blockbuster commercial winners, aspirin and heroin. In 1892, a Parke-Davis publication for doctors provided 240 pages of documentation extolling coca and cocaine, its two leading products; only three of the 240 pages discussed the drugs' unfortunate side effects.[1*] Following World War II, the industry routinely blended barbiturates with amphetamines in diet drugs in order to encourage consumers to stay on the regime (and keep buying).[2] Sandoz (now Novartis) invented LSD, though the company was horrified by its abuses.[3]

The industry's view of "recreational" drugs has always been ambiguous. The annual global pharma-

* *Endnotes can be found on page 43.*

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ceutical market is worth roughly $300 billion, and the illicit narcotics market, valued at $400 billion in 1995,[4] is hugely inviting. New HyPE drugs could allow the industry to claim a share of this market by offering a battery of well-people products without the stigma society attaches to addictive drugs.

DRUG ETHICS

Originally "ethical drugs" were defined as drugs advertised only to doctors and pharmacists, but not to potential patients. Now the industry is advertising on television in the United States and elsewhere and has gone so far as to blend Internet advertising and medical research studies on websites targeting doctors. The ethical obfuscation is exemplified by the television ads that quietly have transformed Viagra from a drug to combat erectile dysfunction into an aphrodisiac.

The industry's selective ethical concern for the sick is also clear. For example, of the 1,223 drugs brought to market between 1975 and 1996, only 13 targeted the deadly tropical diseases that afflict millions of the world's poor, and just four of those drugs came from the private sector.[5] The nature of private pharmaceutical companies' commitment to patients was underscored in a 1993 study by the federal Office of Technology Assessment showing that 97 percent of the 348 ethical drugs brought to market by the 25 leading U.S. drug companies between 1981 and 1988 were copies of existing medications. Of the 3 percent offering genuine therapeutic advances, 70 percent resulted from public research. More than half had to be eventually withdrawn from sale due to unanticipated side effects.[6]

WORKING HyPE-OTHESIS

Making "well" people "better" could have significant benefits for employers. Try as we will to automate every kind of work, people are likely to remain the most versatile and efficient tool of production for many jobs. But we do have our defects, and the pharmaceutical industry is working on developing performance enhancement drugs to turn workers into superhumans. Employers (and governments) are lining up to try the new drugs. Here are some examples of recent genome-inspired innovations and some old drugs being given new, augmented lives through genetic research:

8 Days a Week: Cephalon Inc. has developed a drug called Provigil for the treatment of narcolepsy (a neurological disease that causes irrepressible sleep attacks). Because Provigil is not an amphetamine, it is attracting attention as a possible alertness aid for healthy people.

Rhythm and blues: Northwestern University has patented the circadian rhythm gene. The circadian clock regulates 24-hour rhythms in physiological systems. The patent covers the gene's uses for sleep-related problems, jet lag, alertness, stress response, diet, and sexual function, and could be exploited to enhance mood in intensive care units.

Stringed-out quartets: A "beta-blocker" drug meant for treatment of congestive cardiac failure is best known as "the musicians' underground drug" because of its effect on musical performance. (The drug blocks stage fright.) Twenty-seven percent of symphony orchestra musicians take beta-blockers.[7] A drug therapy capable of blocking anxiety would have major workplace applications.

Company genes: In 2001 a U.S. railroad agreed under threat of a lawsuit to stop genetic testing of employees. The company had required employees claiming carpal tunnel injuries to submit to blood tests, which included searching for a genetic cause for the syndrome. Also last year, an 18-year-old Australian with a family history of Huntington's disease was told by a government official that he would be hired only if he submitted to a genetic test demonstrating that he did not have the Huntington's gene.

Our new understanding of genomics and the neurosciences is also making possible a generation of HyPE medicines that could be used in more sinister ways, e.g., to control dissent. Mood-altering drugs that dispel discontent might be individually prescribed, pressed upon workers, or even hosed into crowds. Enhancement technologies could also become disabling technologies in military or police hands. Those refusing to take HyPEs could be punished by their teachers, employers, or governments because they are refusing to maximize their potential. And if it is possible to "enhance" an infantryman's performance with a drug that turns off the brain's fear mechanism, for example, then it is also possible to switch on irrational fear in the enemy. Drugs that target hearing, memory, or alertness could be mirrored by drugs that weaken those qualities.

SMARTIES

Scientists call drugs being developed to improve memory "cognitive enhancers" or "nootropics." Consumers know them as "smart drugs" or "smarties." The market for smart drugs is already vast. Nootropics used to alleviate dementia in Alzheimer's disease victims were worth $94.5 million in 1995. The illicit market is unknown. A quick Internet search brings up dozens of companies specializing in the sale of nootropics not approved by the Food and Drug Administration.

Pharmaceutical companies are using human

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genomic data in their race to meet the growing demand for nootropic therapies. Ignorance of drug interactions has many worried about the long-term effects of such therapies. The excitement over using genomics to improve memory and intelligence spiked when a Princeton scientist inserted an extra copy of the gene for a particular brain receptor into a mouse. The mouse out-performed other mice on intelligence tests, and the research was hailed as a step toward decreased dementia and increased memory. However, the mouse's increased intelligence seems to have come at the cost of chronic pain.[8]

OPTIONAL EQUIPMENT

Brain Viagra? In 1995, Cold Spring Harbor Laboratory created a fruit fly with an apparently photographic memory. The lab then partnered with Hoffman-La Roche to see if the human mind could be similarly modified. Roche Pharmaceuticals later announced a breakthrough in learning and memory that could lead to treatment for cognitive deficit diseases such as Alzheimer's, depression, schizophrenia, or aging. Several drugs are readily available and widely used as memory enhancers, though they are not proven, tested, or approved for such uses.

Trauma tamers: After demonstrating that the fruit fly's ability to learn could also be abolished by subtle genetic alterations, Cold Spring Harbor researchers launched Helicon Therapeutics Inc. to make drugs aimed at different brain molecules. They see lucrative markets in products for boosting failing memory and medicines for blocking trauma recollection.

Learning too much? Scientists have genetically engineered mice with enhanced memory that persists until researchers use genetic trait control technology to switch off a key memory-governing enzyme.

Social IQ: Those who exhibit "anti-social" behavior could be subjected to genetic therapies to "cure" them of conditions such as depression, obsessive behavior, and hyperactivity. Even shyness is now being treated with the drug Seratox, originally developed as an anti-depressant. It is believed that a gene inherited from the father might act to fine-tune a part of the brain involved in social abilities.

HyPES: HOPE FOR THE POOR?

The choice between developing drugs to make ill people well or well people better is best manifested in the enormous corporate investment in diet-related medicine. Research on new forms of proteins, and on old woes like obesity and diabetes, suggests that it may be possible to develop drugs that could help people utilize food and energy more effectively.

It's clear, however, that the world's roughly 820 million malnourished poor are suffering most from a political failure to have their basic needs and human rights met by a world that is richer in food than in justice. Drug companies could at least collaborate with plant breeders to develop nutriceuticals that would enable the poor to make better use of the food they have. Instead, the pharmaceutical industry is hard at

work at developing drugs that allow people to eat gluttonously without getting fat. With obesity a major health problem in industrialized countries, companies are in hot pursuit of "uncoupling protein" (UCP) molecules that interfere with the conversion of food calories into metabolic energy and release them instead as waste heat. Of course the logical solution is to eat less and exercise more. But there is a multi-billion-dollar market waiting for any pharmaceutical company that can turn UCP molecules into drugs that let people stuff their faces without losing their figures.

The poor are not entirely excluded from the search for the glutton genie. Some hunter-gatherer societies have had their own harsh encounter with obesity when they have been pushed into sedentary occupations and environments. Rising obesity has led to a rising incidence of diabetes. Under the pretext of treating it, some companies have struck deals with tropical island peoples to access their genes and identify those that aggravate obesity. Others are roving among indigenous communities in North America, studying diabetes. An estimated 15 percent of aboriginal peoples in North America are pre-diabetic, compared to less than 8 percent in the "white" population. However, the goal of this research is not to develop drugs that will block full-blown diabetes among the 105,000 U.S. pre-diabetic aboriginals, but to target the 11.4 million pre-diabetic white Americans.[9] But since the incidence of diabetes is correlated with rising obesity, the real goal is a magic elixir that converts indulgence into a virtue (or at least into something that is not a fashion *faux pas*). In this work, the poor are a tool, not a target.

FROM HyPE TO HEALTH

If we continue to rely upon the world's giant pharmaceutical corporations to determine research goals, our societies will remain unhealthy and become unhealthily dependent. We need to strengthen socially oriented public research and public health initiatives and, simultaneously, eliminate the patent incentive that distorts medical innovation and dictates profiteering. Until we dispel the myth that the biotech and pharmaceutical industries are working on our behalf, the prognosis is poor.

Paul R. Billings

A Medical Geneticist's View

Unexpected outcomes, chance and serendipity have always been significant in scientific progress. Science is such a hopeful enterprise partly because we cannot know or control everything beforehand. Something new or surprising may emerge from any investigation.

As a physician-scientist, I confront each day the limits of our current knowledge and depend on the work of biomedical scientists to give me new remedies for my patients. For those already suffering, or who worry about suffering in the future, I often have only the work of researchers to offer as treatment. Those researchers are the producers of hope.

So it is difficult to think about limiting what scientists do. How can we close out the possibility of the unexpected benefit? If we want scientists to be creative, how can we limit their freedom to do certain experiments or try particular applications?

We can because we must. Just as we prohibit moviemakers or graphic artists from killing animals or people in the pursuit of creative expression, so too we must set generous but clear guidelines for scientists. Even desperately ill people seeking new therapies must be protected from harmful experimentation. And as we approach a time when we can create new life forms, combine animal and human parts, or insert novel genes into human embryos, strict limits will be essential if we are to retain our sense of humanness. For example, nearly all scientists and physicians oppose reproductive cloning, and those doing it now should be sanctioned and punished. If a rogue scientist should succeed in creating a human clone, he or she should be treated as a criminal and the occasion should be used to strengthen our bans to prevent it happening again.

Limiting science and, when appropriate, only allowing its conduct under clear and enforceable regulatory conditions will not suppress the creativity of cell biologists and geneticists trying to understand human development, the etiology of disease, and possible treatments. In fact, if such understanding encourages irresponsible scientists who seek to "improve" humans through basic genomic changes (eugenics), caution and societal governance will safeguard scientific pursuits and provide hope, not extinguish it.

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