Where to? Genetic Engineering - Genetically Modified Organisms, GMO, Synthetic Life and Bioethics

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FOREWARD

An article entitled : "What if? Genetically Modified Organisms and Synthetic Life: Future Ethics Questions" by Gioietta Kuo and Lane Jennings appeared in the "World Future Review" Volume 6, number 2 Summer 2014 Page 130 [article A] It is also online: http://wfr.sagepub.com/content/6/2/130.full.pdf?ijkey=9M0T5IL1KFuRuYa&keytype=ref

The present article is an abbreviated version of A with excerpts of the most succient and fundamental sections together with new material like 2 new synthetic bases-amino acids building blocks - d5Sics and dNaM.

A full rendition of the bizarre examples of GMO society has achieved update is extremely interesting if not earth shaking. They should not be missed.

ABSTRACT

Our body consists of billions of cells. In the cells are strands of DNA - our genetic hereditary material. DNA consists of bases - amino acids, briefly denoted by A,G, C,T. Scientists have already mapped the human genome with its 3 billion bases, and successfully applied their knowledge of this structure, its sequence, to correct defects and improve healing. But this same knowledge can be used to artificially

to enhance human capabilities, or even produce variations on existing human physiology and reasoning far beyond our present powers to imagine—let alone predict or plan for. The sequence of these bases gives what we are. But modern technology has advanced to such an extent that we can modify the sequence of DNA and modify some animals and plants. These result in the bizarre examples we show here. Some are good and beneficial, some are bad. Whatever, our society is changing in a big way in front of our eyes. We should be aware and we need to know and take action if possible.

Using techniques we have gathered, we can decode the entire sequence of a bacterium and store in a computer. With the bases A,G,C,T we can insert into the cells this sequence and synthesize the animal. Given this ability, we can then change and produce new life. This opens up great vistas for the future we can only imagine.

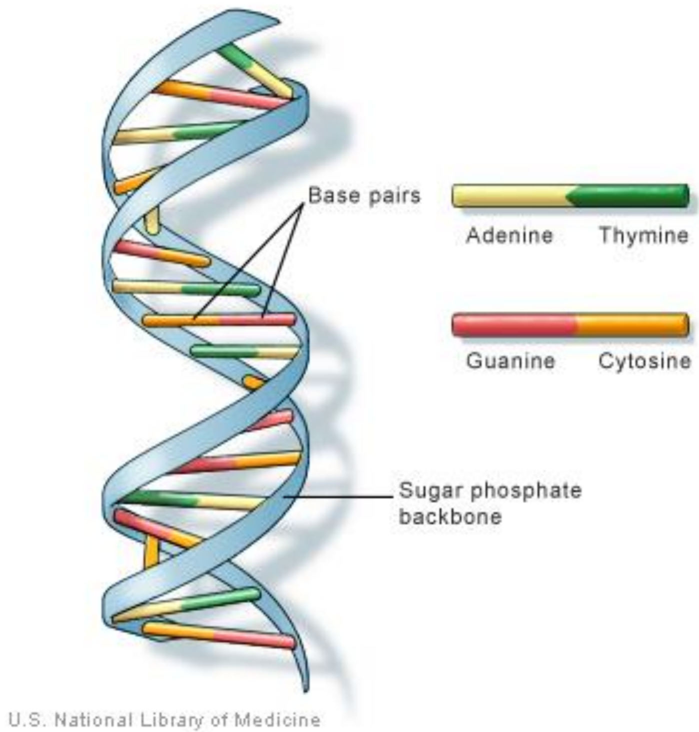
Our modern ethical considerations of this power tend to focus on the "rights" and "duties" of human beings as we know them today as the one desirable norm. This paper briefly reviews the progress of Genetically Modified Organisms, GMO, technology to date, and considers how different conditions in the future might justify—or even require—applying various genetic modification techniques to help ensure the survival of the human species.

FUNDAMENTALS OF DNA

I. Life, What is it? The structure of DNA

The fundamental element of life is the cell. The human body consists of many cells, and within the nucleus of each are found chromosomes made from strands of dioxyribonucleic acid or DNA. Most human cells contain 46 of these chromosomes. Each contains genetic information stored as a sequence of DNA strands arranged in the form of a double helix:

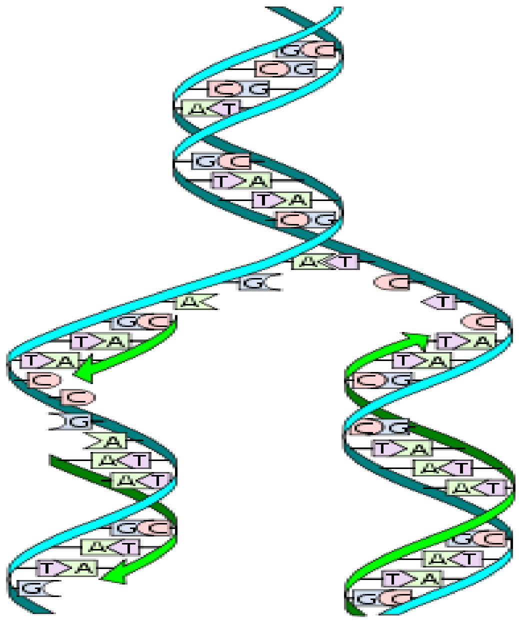
Figure 1.



The double helix has a beautiful structure. It consists basically of 4 molecules: Adeniine(A), Guanine(G), Cytosine(C) and Thymine(T), which pair up as chemical bases: A with T and G with C. Each is tied to a sugar molecule and phosphate molecule. In a human, there are about 3 billion bases - amino acids and the sequence of these bases gives us the genetic information. 99% of these bases are the same in all people, But the one percent is what differentiates one person and another.

The fact that Adenine pairs up only with Thymine and Guanine only pairs with Cytosine, is important because it gives DNA its ability to replicate, or make copies of itself. Each double strand of DNA can split down the middle forming two halves. Each of these single strands can then act as a template. Since A always pairs with T and G with C, single strands of DNA from different sources can link up to produce a new and original DNA molecule.

Figure 2 DNA Replication[2]



[Source: U.S. National Library of Medicine]

In brief, figures 1 and 2 depict the essence of life. By manipulating the chemistry of these molecules we have reached an understanding of how life work—and can even change what life is.

II. New Synthesis of Life

Recently, scientists at Scripps Institute, led by Romesberg [3,4,5] have added a synthetic base pair- nucleotides amino acids to DNA. These are: d5Sics and dNaM.[3] Amazingly these have been made to copy itself in the cell. It is interesting to speculate that if million years ago there existed in addition to A, G, C, T we had these 2 more. Then over years of evolution, we would have totally different creatures walking the earth today.
Of course, this new pair will not lead to new creatures today. But one day, they might!!! What food for thought.

III. The Human Genome Project [6] [7]

The International Human Genome Sequencing Consortium—an international effort to decode the sequence of human DNA—announced its completion in April 2003. It found that there are about 20,500 genes and altogether about 3 billion base pairs. To have mapped the size and the locations of such a large system. In other words the sequence of such a number must rank as one of the most striking achievements of the human race comparable only to the Apollo program for sending a man to the moon.

Thanks to this monumental effort by thousands of research scientists throughout the world, it has become possible in recent years not only to isolate and identify the functions of specific gene sequences, but to actively intervene and change the nature of their influence on living organisms.

Needless to say, the knowledge which mapping the human genome has given us will prove invaluable for understanding the genetic basis of health, and the pathology of human diseases. It will also facilitate diagnosis and will aid in the invention of new drugs. Already we are using genetic material in preventive medicine. For example, to predict the future health risks of an individual with breast cancer and take appropriate actions.

But this knowledge also has another and more controversial and earth shaking applications: it gives human beings the power to re-design themselves anew by rearranging or expanding genetic sequences in an almost limitless variety of ways.

IV. How to Create Synthetic Cells

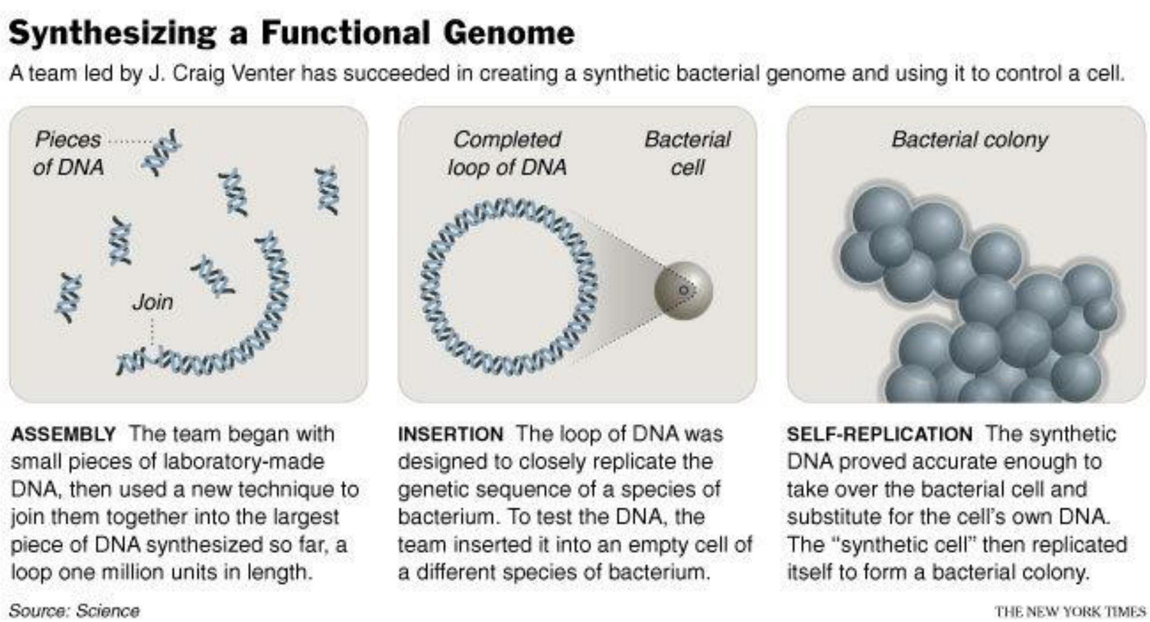
After deciphering the human genome, two main pioneers of the project diverged in their research purpose. Francis Collins has led a team at The National Institutes of Health (NIH), in using the human genome map to isolate specific genes for medical purposes.

Another genome pioneer, J. Craig Venter [8], decided to take a different approach studying the simplest organisms and mapping their complete DNA. Once able to completely map an organism's DNA in the computer, he reasoned, it might be possible to change a gene or two and create a new life form.

The tools created for slicing and identifying the DNA in humans have also been used extensively in biological research on many other creatures including mice, fruit flies, and flatworms. One of Venter's first objectives was to modify the genome of a bacterium, so as to render it able to manufacture vaccines, or genetically engineer algae to naturally produce biofuels.

In his recent book:" *Life at the Speed of Light*"[8] Venter describes how to synthesize a functional genome. Venter and his team took the genome from a natural bacterium present in goats, then, using the 4 base chemicals A, T, G, C from the laboratory, synthesized and mimicked the complete gene of this bacterium which is one million bases long—a feat which was a triumph success in itself. This new artificial gene was then injected into a host cell, and the new bacterium proved to be an accurate enough version of the original goat bacterium that it was able to manufacture a specified sequence of proteins simply by following the instructions implicit in the structure of the synthesized DNA.

Figure 3



The process is deceptively simple[6]:

* Step 1. ASSEMBLY. Venter's team began with small pieces of laboratory-made DNA - the 4 bases. Then using a new technique to join them together into the largest piece of DNA. So far synthesized —a million bases in length.

* Step 2 INSERTION. The loop of DNA was designed to closely replicate the genetic sequence of the chosen goat bacterium. To test the DNA, one then inserted it into the empty cell of a different species of bacteria.

* Step 3 SELF- REPLICATION The synthetic DNA sequence proved accurate enough to take over the bacterial cell and substitute for the cell's own DNA. A bacterial colony was then formed from the "synthetic cell" replicating itself

From such simple beginnings have come a number of intriguing new genetically enhanced plants and animals. Some possess qualities that may appear trivial or even disturbing; but others hold the promise of helping humanity deal more effectively with current threats, such as overpopulation and global warming, and perhaps of enabling still more startling changes in the mid- to long-term future.[9]

For example we could produce genetically-modified algae for growing food in salt water, for mopping oil spills, or for gobbling up CO_2 in the air. Venter is currently working on how to make algae that produce biofuel or food more efficiently.[9]

Just to show how the synthesized DNA can be manipulated [10]. It is possible to code a secret message - 'watermarks' into the synthetic DNA using the 4 bases. The presence of these watermarks verifies that the genes are truly from the synthetic gene. These messages use the codons - groups of 3 letters which code for amino acids, to stand for the 20 letters of the alphabet. For example:

Figure 4

CRAIGVENTER coded as:
TTAACTAGCTAATGTCGTGCAATTGGAGTAGAGAACACAGAACGATTAACTA
GCTAA

VENTERINSTITVTE coded as:

TTAACTAGCTAAGTAGAAAACACCGAACGAATTAATTCTACGATTACCGTGA CTGAGTTAA

The message is started by TTA and terminated by TAA.

When this synthesized DNA is injected into host cell. This message is correctly replicated.

The future for Synthetic life

The ability to design a new life form with specific characteristics in the computer and then assemble it using modified DNA in a host cell is an exciting yet daunting prospect.

An important aspect of Venter's experiments is that they prove that copying the DNA of a naturally occurring cell by gene slicing techniques and introducing this into a cell from another organism, is often sufficient to produce a predictable change in that cell's function. In the case of algae and bacteria, this has already meant creating new and viable species capable of surviving outside the laboratory in the real world. Altering a single strand of million-base long DNA by even a little bit, could produce a new creature.

But who is responsible for this new life?

We have come to bio-ethics. Our technical ability has now reached the point where we can we alter life for the better or for worse. Is it good or bad? Noted authors like Aldous Huxley in "Brave New World"[11] and George Orwell in "1984"[12] have shown us how easily an existence could prove intolerable or truly evil. In other words we may well have the power to produce a utopia or a dystopia. But which of these actually comes into being may depend on what we consider "desirable' or 'undesirable' for individuals and for society. Do we truly know what ought to be developed or discouraged?

PRESENT POLEMIC ON GENETICALLY MODIFIED ORGANISMS. EXAMPLES OF BIZARRE GMO

A recent essay by Emily Swanson in *The Huffington Post* [13] reported ambivalent public opinion concerning technical advances in manipulating DNA. Polls show that Americans by and large applaud DNA breakthroughs, but at the same time worry about scientists 'playing God':[13]

In a new poll in [14] it seems that 71% of Americans are excited about DNA research because it is obvious that it could bring major scientific and medical breakthroughs. But at the same time, 44% say they worry about unforseen dangers. In sum, 33% say they were both worried and excited. For instance, take the idea—proposed by some in the scientific community—of cloning extinct species. By a 55 percent to 27 percent margin, most respondents said they opposed the artificial resurrection of woolly mammoths and other long-extinct creatures.

Even more people were wary of using DNA research to create "designer babies." Seventy-two percent said they would disapprove of efforts to create children with unusually high intelligence or other advantageous traits. As we know, Hitler propagated the idea of eugenics, and basically, most Americans seem to feel that certain subjects are better left unexplored—even by scientists. Yet, when there appear to be clear advantages to DNA research, these opinions can change.

We may not realize it, but here in America many genetically modified organisms are already part of our daily lives—and in our daily diet. For example, genetically altered corn and seeds. Yet, GMO, though being research on, is generally banned in Europe.

Today, 45 percent of U.S. corn and 85 percent of U.S. soybeans are genetically engineered, and it is estimated that 70 to 75 percent of processed foods on grocery store shelves contain genetically engineered ingredients[13]. In a recent poll, 93% of Americans asked said that there should be labeling of GMO food on the market[15]. However, U S Senate recently voted down labeling of GMO foods on May 29 2013[16]. Yet the Vermont senate has passed a bill by 28-2 for GMO labeling[17]. This will be the leader in this field. Many other states are expected to follow suit such as the state of Virginia.

Following are some more of the most impressive and most controversial results achieved to date through genetic engineering. We have reached a stage in which the technology has progressed faster than we can understand all the implications and effects. In other words we are running faster than we know where we are going. As many skeptics have pointed out, especially in Europe, genetic engineering brings along the possibility of:

* Increased risk of allergic reactions and associated allergy related diseases.
* Change in Nutritional value of diet.
* Antibiotic resistance.
* Increased risk of immuno-suppression and cancer risks.
* Soil contamination.

Only time will tell. Where are we going? Here we show you some examples at the forefront of genetic engineering. Some of good and others bad. Who is to judge? Only future will tell. As some members of public would say: Are we unwittingly playing 'GOD'?[13][14]

Some Examples of Bizarre GMO Changes

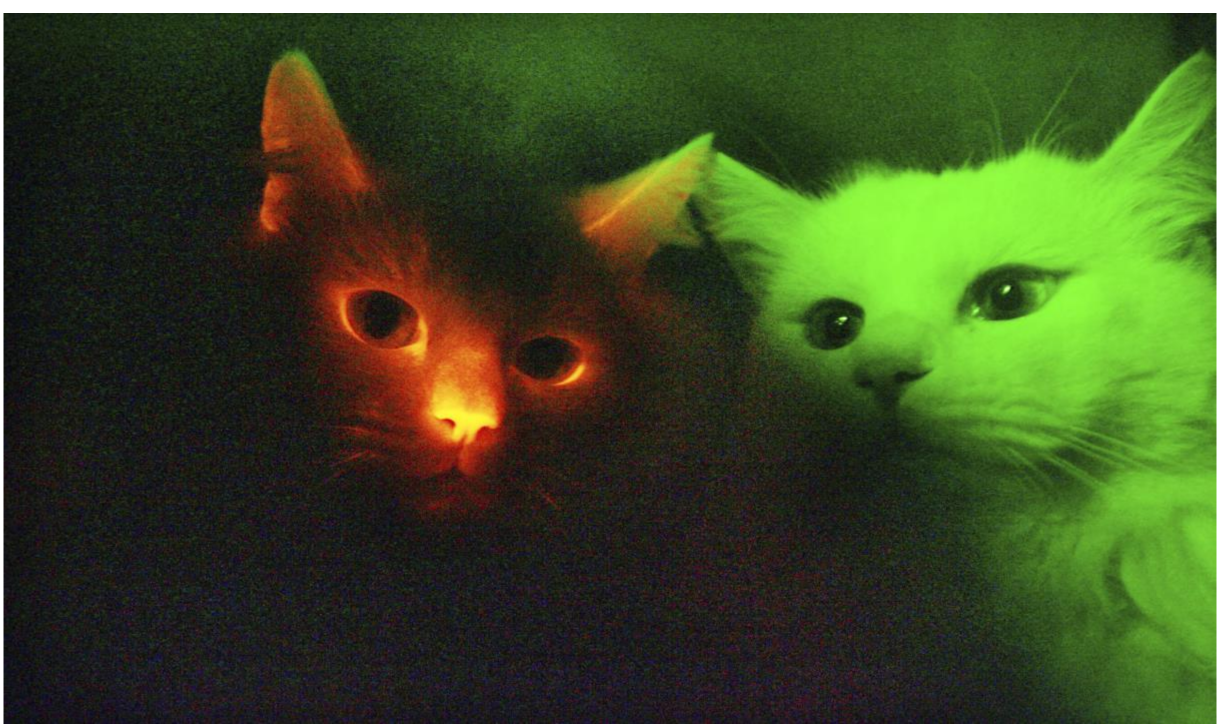
[To see the entire collection: goto

A. google and key in "www.huffpost bizarre GMO" Click on " the Green..."

B. www.mnn.com then click on 'bizarre examples']

1 **Genetically Altered Corn and Seeds** [18].

Farmers choose to use GM seeds to reduce crop damage from weeds, diseases and insects, as well as from extreme weather conditions, such as drought.



2. **Glow-in-the-Dark Cats [19][20]** [note: we have copyright from AP]
In 2007, South Korean scientists altered a cat's DNA to make it glow in the dark and then took that DNA and cloned other cats from it — creating a set of fluffy, fluorescent felines. Here's how they did it: The researchers took skin cells from Turkish Angora female cats and used a virus to insert genetic instructions for making red fluorescent protein. Then they put the gene-altered nuclei into the eggs for cloning, and the cloned embryos were implanted back into the donor cats — making the cats the surrogate mothers for their own clones.

What's the point of creating a pet that doubles as a nightlight? Scientists say the ability to engineer animals with fluorescent proteins will enable them to artificially create animals with human genetic diseases.

3. Enviropig or Frankenswine[21]

Enviropig is a pig that has been genetically altered to better digest and process phosphorus. Pig manure is high in phytate, a form of phosphorus. In normal farming ,the pig manure is used as fertilizer and this chemical enters watershed and causes algae to blossom which depletes water of oxygen and kills marine life So scientists added an E. Coli bacteria and mouse DNA to a pig embryo. This modification decreases a pig's phosphorous output by as much as 70 percent — making the pig more environmentally friendly.

4. Pollution-Fighting Plants[22]

Scientists at the University of Washington are engineering poplar trees that can clean up contamination sites by absorbing groundwater pollutants through their roots. The plants then break the pollutants down into harmless byproducts that they use themselves or release into the air. In laboratory tests, the transgenic plants are able to extract up to 91 percent of trichloroethylene — the most common groundwater contaminant at U.S. Superfund sites — from a liquid solution. Regular poplar plants remove just 3 percent of this contaminant.

5. Venomous Cabbage[23]

Scientist have recently taken the gene that programs the poison in scorpion tails and combined it with cabbage. Their goal was to cut pesticide use while still preventing caterpillars from damaging cabbage crops. These genetically modified cabbages produce scorpion poison that kills caterpillars when they bite its leaves — but the toxin has been modified so as not to harm humans.

6. Fast-Growing Salmon[24]

Genetically modified salmon of AquaBounty grows faster, twice as fast, as the conventional variety. Apparently the fish has the same flavor, texture, color and odor as a regular salmon; but is the fish is safe to eat? Atlantic salmon also can have has a growth hormone added from from the Chinook salmon (native of a Pacific coast). This allows it to produce growth hormone year-round. It is also possible to keep the growth hormone active year round by using a gene from still another fish called an Ocean Pout. If the FDA approves sale of the salmon, it will be the first genetically-modified animal approved for human consumption. According to current federal guidelines, the fish would not have to be labeled as genetically modified.

7. Web-Spinning Goats[25] [note:we have copyright)

Strong, flexible spider silk is one of the most valuable materials in nature, and it could be used to make an array of products — from artificial ligaments to parachute cords — if we could just produce it on a commercial scale. In 2000, Nexia Biotechnologies announced it had the answer: a goat that produced spiders' web protein in its milk.

Researchers inserted a spiders' dragline silk gene into the goats' DNA in such a way that the goats would make the silk protein only in their milk. This "silk milk" could then be used to manufacture a web-like material called Biosteel. rusm/iStockphoto

6.666666 Web-spinning goats

8. Flavr Savr Tomato[26]

Is this the beautiful red tomato we are used to seeing in the supermarket?

The Flavr Savr tomato was the first commercially grown genetically engineered food to be granted a license for human consumption. The Californian based company added an antisense gene which tried to slow the ripening process so that it does not soften and rot so quickly. At the same time it allowed the tomato to retain its natural flavor and color.

The FDA approved the Flavr Savr in 1994; however, the tomatoes were so delicate that they were difficult to transport, and were taken off the market by 1997. Apart from production and shipping problems, in addition, the tomatoes were also reported to have a very bland taste: This stems from the variety it was developed from. Today, what we find on the market is an almost a perfect tomato.

9. Banana Vaccine[21]

Soon, it is possible that one can be vaccinated against hepatitis B and cholera and others by simply having a bite of banana. Genetic engineers have successfully altered bananas, potatoes ,lettuce, carrots and tobacco to produce vaccines. However, bananas has been the best production vehicle for this delivery.

It is found that when an altered virus is injected into a banana sapling, the virus's genetic content soon becomes a permanent part of the plant's cells. .So as the plant grows,its **cells** produce the the virus protein. Only, it does not produce the infectious part of the virus. When people are given such a genetically altered banana, their immune systems build up antibodies to fight the disease, in a way which is like ordinary traditional vaccine.

10. **Less Flatulent Cows[23]**

It is well known that cows produce a large quantity of methane as a by product of their digestive process. This comes from cow's high cellulose diets of grass and hay. Methane is second only to carbon dioxide as a green house gas. So it is important to reduce cow's methane.
Agriculture research scientists at the University of Alberta have identified the bacterium responsible for producing methane and designed a line of cattle that creates 25 percent less methane than the average cow.

11. **Genetically-Modified Trees[27]**

It is very important to make trees grow faster, to yield better wood and also to detect biological attacks by insects. By achieving so one can hope to reverse the blight of deforestation and reduce carbon dioxide. As the same time produce the world's high demand for wood and paper products. An example is the eucalyptus tree in Australia which has been genetically altered to withstand freezing temperatures. Loblolly pines have been created with less lignin - the substance that give trees their rigidity.

In 2003, the Pentagon awarded Colorado State researchers $500,000 to develop pine trees that change color when exposed to biological or chemical attack. However, critics argue too little is known about designer trees' effect on their natural surroundings —for example they could spread their genes to natural trees or increase wildfire risk, among other drawbacks.

12. Medicinal Eggs[28]

Eggs are starting point for much bio-research. British scientists have created a breed of genetically modified hens that produce cancer-fighting medicines in their eggs. What is controversial is the animals have had human genes added to their DNA so that human proteins are secreted into the whites of their eggs, along with other complex proteins similar to the drugs used to treat skin cancer and other diseases.

These disease-fighting eggs contain miR24, a molecule with potential for treating malignant melanoma and arthritis, and human interferon b-1a, an antiviral drug that resembles modern treatments for multiple sclerosis.

One can foresee much benefits in disease control.   Yet what are side effects?

13. Super-Carbon-Capturing Plants [29]

It is well known that we add about nine gigatons of carbon to the atmosphere annually, and plants and trees only absorb about five of those gigatons. The remaining carbon contributes to the greenhouse effect and global warming, but scientists are working to create genetically engineered plants and trees that are optimized for capturing this excess carbon.

Carbon can spend decades housed in the leaves, branches, seeds and flowers of plants; however, carbon allocated to a plant's roots can spend centuries there. Therefore, researchers hope to create bioenergy crops with large root systems that can capture and store carbon underground. Scientists are currently working to genetically modify perennials like switchgrass and miscanthus because of their extensive root systems.   They are also fast growing, so that they can be used to produce bio-fuel.

The Case for Genetically Modified Life, GMO

Effectively, scientists such as J. Craig Venter answer "Yes!" Venter argues that since the world's population is expected to reach 9 billion by 2050, we urgently need to produce new creatures, such as forms of algae, which could significantly increase the world's food supply. Of course on the other hand, one might just as easily argue that *reducing* the world's food supply could prove even more helpful, since it would bring home the need to stabilize world population and to stop ravaging Earth's limited resources.[30]

Genetically Modified Organisms (GMOs) remain controversial as sources of nutrition (all GMOs are currently banned from food products in the EU, and the use of genetically modified grains and animals is a subject of concern to many in the United States and elsewhere[13]). Yet, the proven ability of GMO plants to resist damage from drought, weeds, and insects [18] may ultimately lead to their general use worldwide. Already there appears to be far less reluctance to use genetic modification to boost available stocks of fuel or structural materials—for example to promote faster-growing trees [27] or adapt wild plants or algae to serve as bio fuels.[8][9]

The prospects for applying synthesized genomes in plant life are even more exciting. For example we may soon be able to fashion salt-water algae that thrive on cleaning up contaminated oil spills, or that can extract large quantities of CO_2 from the air [29].

Yet these same synthesized cells also raise ethical problems. Suppose these organisms somehow malfunction—modify themselves in unplanned ways, manage to infest areas they were never designed to live in, or otherwise “go wild” and escape human control?

BIO-ETHICAL ISSUES

I. Presidential Commission for the Study of Bioethical issues [31]

In May 2010, scientists at the J. Craig Venter Institute announced that they had created the world's first self-replicating synthetic (human-made from chemical parts) genome in a bacterial cell of a different species. Intense media coverage followed, and the announcement ricocheted across the globe within hours as proponents and critics made striking claims about potential risks and benefits of this discovery and whether it amounted to an early-stage example of "creating life."

In response, President Barack Obama asked the Commission to review the developing field of synthetic biology and identify appropriate ethical boundaries to maximize public benefits and minimize risks. The Commission approached this task through inclusive and deliberative engagement with a wide variety of sources, including scientists, engineers, faith-based and secular ethicists, and others who voiced, as expected, sometimes conflicting views on the science, ethics, and social issues surrounding synthetic biology. Through public meetings in Washington, D.C., Philadelphia, and Atlanta, the Commission created a forum for open dialogue to hear and assess competing claims about the science, ethics, and public policy relating to synthetic biology.

II. Ethics Affecting GMO Research on Protozoa and Plant life

Humans tend to worry less about the welfare of “lower” life forms; but they care a great deal about dangers posed by infection and pests. Thus engineering algae or seaweed to make a new biofuel, or even designing a better bee—that pollinates more widely and stings not at all—would probably not encounter much resistance. In much the same way, faster-growing strains of bamboo or other lumber-yielding trees might be welcomed by potential producers in the tropics and by many users in developed countries hungry for new building materials.

Without question, there is a trade-off here—particularly in the early stages of GMO applications. Tomatoes like the Flavr Savr [26]—genetically modified to grow faster, stay ripe longer, and have tougher skins to safely survive transport over long distances, may not taste as good, or be as nourishing as the smaller, more delicate varieties from which they were derived. But defects in designer vegetables (as in any new machine) once spotted, can always be improved in later models. So long as the “originals” are preserved and available for comparison, there seems no limit to how greatly genetic scientists might enhance specific traits to not only equal but perhaps *exceed* the very qualities for which heirloom fruits and vegetables are rightly praised. In fact, we suspect that the tomato in the supermarkets are already of the GMO kind. Do we complain? No. They seem to have the right smell and they last much longer!

For the near future, GMO foods will likely remain “experimental,” and strongly controlled to guard against negative outcomes. Specific possibilities to be feared include unintended cross-breeding between natural and GMO species; spontaneous mutations that produce actively harmful creatures; and not least, the danger that one or more researchers may create a new life form or mutate an existing species deliberately to damage crops or kill human beings. Over the longer term however, as the true benefits and dangers of genetic manipulation become clearer, it should be possible to develop rules and oversight mechanisms that allow us to apply GMO technology safely in many different situations and environments. Are we going to do it?

III. Ethics of GM Experiments with Higher Animals

The motives for attempting to improve food-producing plants and animals are fairly unambiguous: obtaining more edible material in a shorter time means greater profits for producers, and, presumably, lower prices for consumers. But even if GMO plants and animals are proven safe and nutritious (still a matter of doubt for many) the perceived morality of attempting to modify genetic codes may vary greatly from species to species. Tampering with baby seals or pandas, for example, would be far more broadly condemned than similar work involving reptiles, fish or other animals whose appearance, habitat or reputation keep them from being considered cute or noble. The publicity surrounding GMO programs may prove decisive here. If the public believes that the modified animals are truly more useful to humanity, less damaging to the environment, or even just more likely to survive in their natural habitat, then the work may be hailed as beneficial. But any experiments that appear cruel or insensitive will probably be opposed.

Artificial Meat?

One potentially revolutionary advance that GMO research alone can make possible is the production of food without killing live animals and plants to obtain their nutrients. Consider the ethical implications if one could construct a juicy steak, or replicate a plate of beans simply by cloning cells obtained in small quantities from a natural source without doing any lasting harm. For the first time humans could live without the need to raise, tend, gather, and inevitably kill any other living creatures—animal or plant. Yet even here, any widely publicized incidents involving evidence of preventable suffering inflicted on animals or any serious threat to human health and safety could seriously set back research in this area or end it entirely.

IV. Ethics of Genetic Research Involving Humans

Polls suggest that few people today favor attempts to clone an adult man or woman. But this situation could easily change. Human ego being such, human cloning is sure to be one of the controversial uses of GMO.

What are the rules for cloning? Will it be based on wealth, fame, social achievement? This is sure to becomes a problem which is both interesting and unfathomable.

Take the example of stem cells, which hold the potential to restore damaged tissue, replace lost limbs and treat diseases of all kinds. About the only objection to exploiting this potential comes from the fact that these cells can be obtained by destroying fetal tissue. If a way is found to generate stem cells reliably in a “non-controversial” manner, a major hurdle to human genetic research will vanish. And even moderate success using these “clean” stem cells to repair damaged limbs and organs will soon lead people to contemplate using them not just to repair but to improve their appearance and abilities.

Consider changing skins. The market for replacing areas now carrying tattoos could become a major application for future stem cell use. As age alters physical appearance, or simply as tastes and fashions change, people may regret having ever been tattooed, and want a clean slate—if only so that they can fill it with new designs that better suit their current age and interests.

Stem cell and Children

Then there is the matter of children. Why wait until an illness or accident occurs, when you might set aside a collection of their own stem cells at birth—or even before birth—to be used as needed to form “spare parts” at some later date? Here again, success at repairing birth defects or fighting childhood diseases would surely encourage parents to seek many kinds of physical and mental enhancements that might improve a child’s chances of success in life.

A key question to ask is: how soon might such enhancements become the new “normal?” Will parents be pressured by school systems or the law to raise a child’s potential IQ or athletic promise as routinely as they now are pressured to help prevent the spread of communicable diseases by having them vaccinated? The answer may depend on which way the future goes. The four alternative futures outlined in general terms below, suggest how GMO research could develop in different ways and be either shunned or welcomed depending on future environmental and social conditions and humanity’s changed values in response to these.

WHITHER? FUTURE WITH GMO - 4 ALTERNATIVES

Which way will GMO lead our society? It will depend on which way society itself will develop. Following are 4 different ways society might develop:

1. GMO in a High Tech / High Prosperity Future

2. GMO in a High-Tech/High Problem Future

3. GMO on a Green and Happy Planet

4. Prospects for GMO in a Green but Lean Future

Seriously, the most likely development for our future is probably # 2. So we shall concentrate on #2 and leave the other options for the reader to consult the original article A.

GMO in a High-Tech/High Problem Future

In a world in which high technology brings benefits as well as disappointments. Instead of solving humanity's problems, the pollution and resource depletion that has grown since the beginning of the industrial age continues and leaves the world facing major dangers with few attractive options for dealing with them. If science and technology are unable to halt global climate change, ease population pressure, or mitigate weather-related catastrophes, the impact on genetic research will be mixed.

On the one hand, governments and the general public will become more skeptical of promised sci/tech "progress." GMO crops that boost yields but also raise production costs and/or cannot be reliably contained but spread indiscriminately producing hybrid plants with unpredictable traits, could undercut genetic research, and cause governments and donors to divert funds toward other ways to assure survival. Perceived unreliability may also intensify conflicts between supporters and opponents of GMO.

On the other hand, the very fact that funds are limited could channel GMO research into a few key projects—for instance enabling grain crops to withstand extended drought, or to flourish on brackish water. Other key research could involve modifying algae for bio fuel or plants that can quickly make large quantities of salt water potable for humans.

In such a world, the phenomenon of inequality in wealth distribution could well become more pronounced everywhere. This would certainly slow down the spread of efforts at genetic enhancement among the general public, but it might offer a nearly irresistible perk to the super rich minority: enhancement or extension of life itself. The fact that such benefits were not available to all might actually serve to make them appear still more desirable.

Over the long term, if environmental damage proves irreversible, this could gradually increase demand for more research into the genetic modification of human beings. But instead of making humans more comfortable living on Mars, or better able to survive in outer space, the emphasis would be on enhancing human survival on a less-hospitable Earth. New habitats might now include underwater structures for mining and processing deep-water minerals or tending massive herds of fish (or even domesticated whales as envisioned by Arthur C. Clarke). [32]

The strain of extended hardship for the many co-existing with protected enclaves of luxury for the very few, could drive some governments or even individuals into weaponizing GMO research. One possible gene-weapon might be a disease that attacks only people with certain distinctive racial characteristics. Another possibility could be a microbe that would kill indiscriminately reducing the global population "without prejudice," not killing everyone, but "weeding" out all but the hardiest and most adaptable individuals in all parts of the world.

As is already obvious today. Our economic system has led to a forever chase for higher and higher economic GDP. This is leading to much destruction, mostly irreparable to our fragile environment. This is where genetic engineering becomes really useful- what damage we humans do, we try to repair by inventive genetic engineering. Global water scarcity is the number one scarcity in the world today, effecting agriculture, hunger and leading finally to massive poverty and disease. Already, we have shown in this article what genetic engineering can overcome global pollution, especially water pollution. Can we reduce the carbon dioxide in the atmosphere? reduce climate change?

All this is up to our society to strive to perform - with the help of GMO.

Perhaps the most optimistic interpretation of this particular future would involve a return to taking seriously the warnings of Malthus and Darwin—that the fittest always survive. The all pervasive phenomena of poverty and disease in certain parts of the world today could encourage us to use GMO as a tool for eradicating poverty. The fact that global population keeps on rising while global food and water are not in synch is a sign that we should seriously consider GMO's potential for reducing global population (aided perhaps by widely promoted campaigns to promote voluntary sterility) before the planet comes face to face with a true mega- crises. [30]

CONCLUSIONS

Those four scenarios are offered not as predictions, but merely as examples of how distinctly different futures could push GMO research in very different directions. While we make no claim that one of these four futures is "most likely", we do think it entirely possible that some combination of these four could well occur, and that key elements from several could exert their contradictory influences simultaneously.

Our point is that the legal status and public perception of genetic manipulation in future will depend upon prevailing social conditions and technologies more than on any set of current moral precepts or logical reasoning. We believe there is no "right answer" to the dilemmas that GMO research present. Instead, promising opportunities and frightening dangers seem inherent in any course of action—including inaction.

Looking at the world today, there seems little likelihood that existing governments can agree on any enforceable regulations to control or even limit genetic research. It will take a major breakthrough (such as easy guilt-free access to stem cells) or a major disaster (a global pandemic or crop failure clearly traceable to genetic tinkering) to achieve that.

Meanwhile, can we remain alert to dangers, choose to reject frivolous GMO applications, and give sustained support to promising initiatives by responsible agencies and individuals? It really is up to us, how we organize our society.

Whether genetically-enhanced life forms, including human beings, ultimately dominate existence or merely "fit in" among pre-existing creatures and environments will depend in large part on human planning. But there are also elements involved which we cannot predict.

At this juncture, our number one responsibility as individuals and societies should be to steer a wise path, to assure the survival of all species and in particular to ensure the survival and wellbeing of all human generations to come.

Bios

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