Genetic Engineering:
The Art of Genetics

by
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Ethics
Abstract:

Genetic engineer is a hot topic in this day and age. But what implications does genetic engineering have for the arts? Advances in genetics have created new dialogues on the ethical issues of genetic study. The genomic editing tool, CRISPR/Cas9, constructs an innovative mode of genetic engineering. It gives scientists and artists alike immeasurable possibilities to form a new world that is edited by human hand. This power to construct an organism’s genome could bring about an entirely new way of existence and also a novel medium of art making for artists around the world.
For ages, artists have been creating life with a stroke of a brush. Artists can produce portrayals of organisms or worlds that could only come from the imagination. With continuing advances in genetics, artist could have a new medium to create, using the very building blocks of biology, the genome. All living things contain DNA. Virtually every organism has its own specific genome, which is an organism’s distinguishing sequence of DNA. In those organisms, each cell contains an identical copy of that specific genome. The genome is a recipe, a set of instructions, for all organisms on earth. When the genome is manipulated or changed by human hands, there are untold possibilities of what could happen to an organism. There are some who are uneasy about the use of genetic engineering, while others embrace it. The reality is, genetic engineering is not something of science fictions but real, tangible, and easier to use than ever. We are entering a new age, where creating and manipulating life is not just done by a brush in the hands of a painter but is now in the hands of scientists across the globe.

Monsters

As stated earlier, each cell in a human body has a copy of an individual’s genome. The expression of a gene causes things like certain hair colors or nose shape in a person. Genes can also give people terrible physical deformities or serious genetic diseases. Not only is there a human genome made up of DNA but animals, plants, and smaller organisms, like bacteria, also have DNA\(^1\). Every time someone eats a leaf of lettuce, accidentally swallows a bug, or chows down on a cheeseburger, they are consuming other organism’s DNA. There is a common misconception that mutant genes, if consumed, will cause a person to mutate. What a person eats can affect their health in profound ways. Now, that does not necessarily mean that eating mashed potatoes with mutated genes will make a person into a hybrid potato monster. What it does mean is DNA is an integral part of sustaining life and manipulating DNA is not as easy as introducing
potatoes into the digestive system. Genes are complex and genetic manipulation is a topic that many in the general public are not fond of.\(^2\)

An interesting commentary on society’s relationship with genetically altered organisms comes from the world of the cinema. There are numerous movies where monsters are created by scientists manipulating genes. An example of this would be Godzilla, Mothra, and The Hulk, who were created by radiation. Cinematic scientists and technological advances have a bad reputation for creating uncontrollable organisms. There are even monsters created in a test tube like in the movies *Splice* and *Jurassic Park*. Scientists in movies have also altered microscopic organism to create epidemics like the zombie creating virus in *Resident Evil*. At times, movies give a commentary on the ethical and socioeconomical issues of creating the perfect test tube babies, like in the movie *Gattaca*. In most of these movies, the genetic manipulations portrayed are of terrifying creatures or monsters. The public only seems to encounter negative views of genetics. Even the recent distaste for eating GMOs is telling. The public does not seem trusting of organisms manipulated by human hands.\(^3\)
Many scholars who write about the ethics of genetic testing, whether they are for or against it, agree that the general public is uneasy when it comes to the subject of genetic engineering\textsuperscript{4} \textsuperscript{5}. This unease has made its way into the mind of scientists as well. An unsettling notion about scientific research is that many times, especially in the field of genetics, scientific research progresses faster than ethical guidelines can be created\textsuperscript{6}. Recently, scientists have called for a moratorium on certain kinds of genetic engineering and in December 2015, scientists called for a worldwide council\textsuperscript{7}. The possibilities of having the tools to create the terrifying monsters of cinema is now a possibility and that is something that needs to be addressed. The scientific community is beginning to reflect some of the general public’s discomfort with genetic engineering.

Regulating Genetic Testing

Scientific research, especially something like genetic engineering, requires pondering and foresight. In an academic paper called “Genetics, Normativity and Ethics”, the author makes the statement that “[bioethics] is rooted as much in the clinic as in philosophy departments.”\textsuperscript{8} There are many different results to consider when it comes to altering the very building blocks of life itself, the genome. The author goes on to mention that there are concerns “with abstract ethical notions of autonomy, consent, property rights in the body, contract, utility… etc.”\textsuperscript{9} Genetic engineering is as much an ethical issue as a scientific topic. There are numerous ethical questions that come up when talking about genetic engineer. Owning parts of human being is generally look down upon but it seems these days you can patent almost anything. If a gene is patented and then used in gene therapy, then the one who holds the patent would own a portion of a human being. Yet, owning genes and organisms is not entirely new. Companies, such as Monsanto, patented some seeds and some companies even own the patent for certain cancer cells\textsuperscript{10}. In terms
of property rights, patenting genes seems like a violation of a person’s right to control their own body. Nevertheless, this is something that needs to be addressed by the scientific community as it moves forward into the ever advancing field of editing genes.

When it comes to cloning, many believe that cloning should only be done if the person being cloned is able to consent. Even then, cloning may recreate the individual as a genetic copy, but there are many other factors like environment, nurture, and life experience that go into making a person what they are as a whole. Cloning pets is legal in some countries. In the book *A Case Against Humanity*, an example is given of a woman who cloned her beloved cat who had passed away. It was quickly realized by the owner that, although genetically identical, the cloned feline had a significantly different personality than the original. Cloning can never create an exact replica of the original’s personality. Even if someone did consent to have themselves cloned, in the case of trying to recreate someone who has passed away, cloning seems somewhat of a frivolous endeavor.

When it comes to consent and autonomy, having a company own a portion of a living person does not seem permissible but having someone make a clone of a person without their consent also seems like a gray area. In order to give people autonomy, using one’s genes should be treated in a similar way as using one’s organs. Yet, organs do not just fall off when a person brushes their hair like genes do. It is much more difficult to regulate who gets a hold of someone’s genes than who gets a hold of someone’s organs. It would be very difficult to regulate something that is so easily accessible.

Continuing with the subject of consent, there should be some regulation when it comes to parents and their unborn fetus or developing infant. If a parent manipulates the genes of a child in the womb, whatever is changed will affect the child for the durations of its life. If parents choose to genetically engineer their child to be smarter, there is the danger of something going
wrong. Whatever is changed in the child during development, whether beneficial or detrimental, will affect them as long as they live.

The risk of creating something that cannot be controlled, whether that be a movie monster, an unstoppable virus, or even a genetically altered race of human beings, is unsettling to many. Some argue that parents who want their kids to be taller, stronger, or smarter will genetically alter their offspring in order to achieve their perfect prodigy\textsuperscript{13}. This, in turn, could create a physical and intellectual gap between those who can afford to genetically manipulate their offspring and those who cannot. The children that are genetically manipulated to be sports stars or geniuses would be at an advantage while the poor would be left to let nature decide their fate. This is an argument that has been used for quite some time but with recent innovations, genetic alterations could be cheaper than a meal at a fancy restaurant\textsuperscript{14}. There are a myriad of unanswered questions when it comes to genetic engineering. A quite terrifying notion is that there are very few regulations in the field of genetics. This is because genetic technology is so new and fresh discoveries are happening every day. Scientist can follow old standards of consent and autonomy but timeworn rules are becoming less and less applicable as science advances.

With every new discovery in the field of genetics, the ability to censor and regulate research becomes more difficult. If there are too many regulations, findings that could save countless human lives could go undiscovered. If the regulations are too broad, scientists could intentionally or unintentionally create unspeakable evils. An example of this regulatory issue comes from an evaluations of the disease, Cystic Fibrosis. This disease in a genetic disorder primary affecting the lungs of an individual. People with Cystic Fibrosis are in and out of the hospital their entire life and usually do not live past 37\textsuperscript{15}. Cystic Fibrosis affects a very small portion of a specific gene and it would be very easy to edit out with the necessary tools\textsuperscript{16}. If scientists are never allowed to test gene editing on humans, this seemingly simple cure could go
undiscovered and many human lives would succumb to this awful disease. Yet, there are other matters to consider when it comes to regulation. With advances in gene editing, there comes the ability to edit genes of other organisms, such as bacteria. If scientists are allowed to research genetic engineering unrestrained, there is the possibility of creating very deadly diseases. This could be something that is unintentional, due to lax guidelines, or intentional, such as biological warfare. There is a fine line between too many restrictions and too little. In the case of genetic engineering, scientists have yet to discover how to walk that line.

Most people would think that getting rid of “bad” genes, those that carry harmful diseases like Cystic Fibrosis, would be a brilliant idea. At the moment, though, there are no protocols for what should be considered “good” genes and “bad” genes. Some genes are obviously detrimental and only cause harm to a person. Yet, genetic disorders that can cause a lot of harm, like Sickle Cell, a genetic deformity of the blood cells, can also be helpful. Those with Sickle Cell are more impervious to the deadly disease, Malaria. Genetic manipulation can cure terrible genetic diseases but it also gives humans a mastery over living things that many people are uncomfortable with. Through genetic engineering, humans are intruding on nature and changing traits that have developed through the slow process of evolution. If the building blocks of an organism are changed, there is no telling what the implications could be in the long run to people or even ecosystems of the earth as a whole

The Reductionist View

While most people take a larger view of genetic engineering, some researchers take a reductionist view. A reductionist view means looking at the individual genes and taking away the organism as a whole. In the case of human cells, scientists only look at a cell and not at an entire person. With humans, genetic testing is done on either adult, fully developed cells in test
tubes, or on gamete cells that will never be permitted to mature. This is important because it means adult somatic human cells are not being tested inside a living person. If testing is done on gamete cells, the cells that are in development and embryo state, they are not allowed to grow into viable offspring\(^{19}\). Many fear that if cells are manipulated in development and allowed to grow up, any trait that is changed will express in offspring of generations to come. At this time, it is illegal to let any gamete cell grow past the developmental stage. Scientists may create monsters in the near future, but at this time, those monster will likely not be made from humans because of these restrictions\(^{20}\).

**CRISPR/Cas9**

In very recent years there have been exciting advances in genetic engineer. Scientists have found a way to edit genes that is new, easy, and cheap. This technique is called CRISPR, which stands for Clustered regularly-interspaced short palindromic repeats\(^{21}\). CRISPR was discovered in the 1980s. It is a mechanism that certain bacteria utilize to defend themselves against invading viruses\(^{22}\). The way this mechanism works is quite simple. A virus infects a bacteria by injects the bacteria with its DNA. Before the bacteria can become infected by the viral DNA, CRISPR comes along and “cuts” the viral DNA, dismantling it\(^{23}\). Someone saw this mechanism and decided to try and utilize it for something completely different. In 2011, researchers at the University of California, Berkley published an article showing their research in
harnessing CRISPR for gene editing. By using target RNA (Ribonucleic acid) as a guide for CRISPR and a protein called Cas9, scientists can tell CRISPR/Cas9 where to go on an organism's DNA. The mechanism will then cleave the DNA in a precise area designated by the target RNA. Then, a new specifically selected sequence is placed in the break in the DNA, replacing the sequence that was cut out. As an example, picture a portion of DNA. That specific portion of DNA expresses for the disease Cystic Fibrosis. CRISPR/Cas9, led by the guide RNA goes in, cuts out the part with the Cystic Fibrosis and replaces it with a “normal” gene. In short, it is possible to replace “bad” genes with “good” genes. This is a monumental breakthrough in science. It almost seems like science fiction has become reality. With CRISPR/Cas9, researchers can edit the DNA of any species. Genetic disorders and disease could be eradicated. People would no longer suffer from diseases like Alzheimer’s or Huntington’s. Even things like crop yield could increase, potentially ending world hunger. Malaria carrying mosquitos could be easily wiped out within a few generations, saving many human lives. The possibilities seem endless. Disease in general could be a thing of the past. In this case, the benefits do seem to outweigh any harm.

There are so many exciting possibilities with CRISPR, but with so many possibilities also comes an enormous amount of risk. There are plenty of ethical issues about how CRISPR/Cas9 should be utilized. Yet, there are also current concerns that are popping up in research that could halt the gene editing process before it can even be fully applied. Researchers are facing problems with CRISPR cleaving the genome off target. When CRISPR breaks the DNA, the body naturally repairs the break. If CRISPR breaks the DNA off target, the repairs the body makes can cause “mistakes” in the genome. In the case of the genome, mistakes generally mean cancer causing. Although this is a current issue, if scientist can remedy this, there is no telling what can be created.
Another reason many researchers and scientists are wary of CRISPR/Cas9 is that it is very easy to use and also inexpensive\textsuperscript{30}. Experimenting with CRISPR is something a high school student could do in a lab or even in a kitchen. In fact, CRISPR can be found online under the “shopping” tab on Google search for only $350\textsuperscript{31, 32}. There are websites and tutorials online about trouble shooting CRISPR, similar to computer programs like Photoshop\textsuperscript{33}. CRISPR is so cheap and easy to use that, theoretically in time, artist could use it to create art out of living organisms. They could create the utopian world of idealized academic paintings or designs an organism’s genome similar to the way an architect designs a building. It is obvious that some artists are aware of this possibility, but like most ethical issues, artists can be found on both sides, those wary of it and those utilizing it.

Genetic Engineering and Art

First, the artist Patricia Piccinini seems to perfectly represent the public’s fear of genetic engineering in a sort of subtle, creepy yet whimsical way. She is very up-to-date on current scientific research in technology and genetics. Her work is a commentary on how nature, or the natural, is being changed by the technology of modern society. She also makes the viewer question what it really means to be human with her humanoid sculptures portraying what could be genetically manipulated beings. Piccinini has a way of making the viewer look at what normal and natural could become with technological advances by comparing sculptures of “normal” hyper-realistic human figure with odd, hybrid sculptures that have human characteristics\textsuperscript{34}.  

11
Unlike Piccinini, there are artists who want to utilize the realm of genetic engineering. An artist by the name of Koby Barhad has an interesting piece that is currently in progress titled *All That I Am*. The artist purchased DNA in the form of hair of certain deceased celebrities such as Princess Diana and Elvis Presley. In this specific piece, he had the DNA of Elvis’ hair sequenced by a lab called Genetrack Biolabs. Then, he sent the genetic sequence to ingenious Targeting Laboratory. There, they grew transgenic cloned mice using the DNA of Elvis. The artist did extensive research into mice cages and built an elaborate, multistory mouse dwelling. He plans to attempt to give the mice a life as similar to Elvis as possible. The mice will have a motherly figure in the form of a companion mouse. The cage is equipped with a wrapped mirror to hopefully give the mice a “false sense of self-importance”. The artist will constantly rewarded the mice with food and toys, so they feel important and loved. Until eventually, Barhad will place the mice on a sloped treadmill symbolizing the final years of Evils’ life. The mice will eventually fall from exhaustion showing Evil’s fall from fame into death. This all seems like a forced reincarnation of Elvis and brings up the earlier discussed issue of consent and autonomy. Taking someone’s DNA and using it for a means that they cannot consent seems to violate the boundaries of consent. Barhad’s utilization of Elvis’ DNA also brings up the issue of
authenticity. There is almost no way of knowing if Barhad even purchased the DNA of Elvis. Yet, people do leave DNA everywhere. It sluffs off any time someone touches a faucet or licks an envelope. DNA is an intimate part of every living thing’s identity but it is also shared with the world people interact with.

With recent discoveries in genetic engineering there is the potential to create a whole new world where scientists and artists alike can easily manipulate the very building blocks of living organisms. This new world that CRISPR could potential form, can be a place of life, free from suffering. It could also be a place riddled by monsters and disease. The genome is now in human hands instead of the stead timeworn hand of nature. When natural processes are overridden by the creative intentions of artists and scientists, there is no telling what new world could be constructed.
Notes

1 Solano, Martin. Interview by Jennifer Cantley. Phone Interview. February, 2016
6 Jagadish, Annervaz. “Ethics in Genetic Engineering”
9 Ibid
13 Ibid
14 Ibid
16 Ibid
17 Shildrick, Margrit. “Genetics, Normality, and Ethics: Some Bioethical Concerns.”
18 Jagadish, Annervaz. “Ethics in Genetic Engineering”.

22 Ibid.

23 Ibid.

24 Ibid.


26 Xiong, Jin-Song, Jing Ding, Yi Li. “Genome-editing Technologies and their Potential Application in Horticultural Crop Breeding.” Horticulture Research. (February, 2016).
http://www.nature.com/articles/hortres201519.


30 Yan, Yongmin, Daoyan Wei. “The CRISPR-Cas9 System: A Powerful Tool for Genome Engineering and Regulation.”

31 “Pax-8 CRISPR Knockout and Activation Plasmids (h).” Santa Cruz Biotechnology.

32 Doudna, Jennifer. “Genome-editing Revolution.”

33 “FAQs and Trouble Shooting Tips.” CRISPR Resources. (March, 2016).
http://www.genome-engineering.org/crispr/?page_id=159.


Xiong, Jin-Song, Jing Ding, Yi Li. “Genome-editing Technologies and their Potential Application in Horticultural Crop Breeding.” Horticulture Research. (February, 2016). [http://www.nature.com/articles/hortres201519](http://www.nature.com/articles/hortres201519)
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CRISPR Design Tool (Click Here to Redirect)

The CRISPR Design Tool allows users to enter a 23-1000bp DNA sequence of interest and will find all SpCas9 target sites within the input sequence. The result will contain a rank ordered list of target sites based on predicted specificity. The algorithm used by this program is based on the specificity analysis performed in Hsu et al., Nature Biotechnology 2013.

Older UCSC Genome Browser tracks

(Important Note: Based on comprehensive analysis of SpCas9 specificity, we have found that the CRISPR design tool is not accurate enough for in vivo experiments. Therefore, we have stopped offering this tool and refer the community to Hsu et al., Nature Biotechnology 2013 for more information.)