BioHacking

Biological Hacking And The Future of Homo-Sapien

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Abstract

Abstract is written last.

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1. Introduction

Introduction here.

2. Background

The history of genetic manipulation by humans includes plant and animal breeding, GMOs, IVF, the Human Genome Project, CRISPR etc.

2.1 Selective Breeding

Selective breeding of plants and animals has been practiced since prehistoric times (Buffum). Species of wheat, rice, and dogs are different from their wild ancestors. Maize, i.e. corn, required especially large changes from teosinte, its wild form, and was selectively bred in Mesoamerica. Sources as much as 2,000 years old give advice on selecting animals for different purposes, and these works cite still older authorities, such as Mago the Carthaginian (Lush). These old methods are clumsy and imprecise. We would breed species together in the hopes of generating some desired phenotypic trait. Some of our other methods were quite outrageous. We would bombard plants with radiation, find the rare plant with a desirable trait, e.g. seedless grapes, and then produce more of that plant.

With animals, we have bred swine for meat (University), horses for performance (Evans), and pets such as dogs, cats, and birds. In 2013, researchers at the University of Istanbul created glow-in-the-dark rabbits (Rojhan). Sea jelly genes were engineered into the bunnies' genomes, granting them luminescence. These bunnies were bred in an effort to create animals capable of producing medicines in their milk. We have continued such genetic experimentation on animals, with mice being the chief test subjects.

2.2 Genetically Modified Organisms

With the invention of techniques around Recombinant DNA, we developed Genetically Modified Organisms, i.e. GMOs. These include Golden Rice (Xudong et al.), herbicide (Funke et al.) and insect (Paine et al.) resistant crops. Recognizing the power of Recombinant DNA, the scientists involved congregated at Asilomar in the early 1970s to establish principles to ensure the safety of this budding technology (Berg et al.). However, there was no public engagement from the start and so there is still much fear among the public. Thus, the science has not realized its potential.

2.3 In Vitro Fertilization

Our first steps down the path of human genetic engineering have been with IVF. This involves the extraction of human gametes after which a small number of fertilized embryos are created in a lab. After some time, these are implanted in a womb with the hope that some will take root and a child will be borne to term. The first IVF pregnancy was reported in 1973 (Kretzer et al.) but it resulted in an early miscarriage. The first IVF birth occurred in Oldham, England on July 25, 1978 (Steptoe and Edwards). Since then, IVF has grown in popularity. IVF births account for 2% of the births in the United States, 5% in Japan, and 10% in Norway and Denmark (Metzl).

2.4 Genome Sequencing

With the completion of the Human Genome Project, the cost of sequencing is trending towards negligibility (Wetterstrand). With this ability to cheaply read our genomes, we are starting to demystify our biology. Among other developments, we have learned how to identify Down Syndrome during pre-natal screening (Natoli et al.), and are able to diagnose various genetic disorders in fertilized embryos during IVF (Rycke and Staessen). We have also been able to identify and categorize over 5,000 single-gene-mutations, i.e. Mendelian disorders. These include sickle cell anaemia, color blindness, muscular dystrophy, cystic fibrosis etc. This has opened up choices for which embryos to implant through IVF.

2.5 CRISPR

In addition to reading genomes, we now have the ability to arbitrarily edit genomes. The invention of CRISPR, Clustered Regularly Interspaced Short Palindromic Repeats, and Cas9, CRISPR-associated protein 9, has opened up the world of genetic editing (Zhang, Y. Wen, and Guo). CRISPR works on

genomes much like a text editor works on strings. There is a guide-RNA, the cursor, that can be placed at any desired nucleotide. From here, an arbitrarily long piece of the genome can be cut and either left deleted or replaced by some chosen sequence of nucleotides. This lets us make extremely precise edits to genomes at the expense of little power and time. The near-term applications of tools like CRISPR include potentially curing all Mendelian disorders, while long-term applications include rewriting large sections of human genomes to make "designer babies". In fact, the first genetically edited babies were born in China in October 2018 (Harney, Kelland, and P. Wen). Dr. He Jiankui announced the birth in videos on YouTube saying that he edited the CCR5 gene to grant increased resistance against HIV to the two girls. The Russian scientist Dennis Rebrikov has announced that he has five parents signed up for gene-edited babies (Cohen).

2.6 The Holocaust

When we start talking of the human experimentation, the word eugenics comes to mind. The history of eugenics should terrify us. To make and extreme understatement, many jewish communities were on the losing end of a eugenics experiment writ large, gone mad. We must never forget the atrocities of monsters such as Joseph Mengele. We held the Nürnberg trials in the wake of the Holocaust. These trials shaped the international laws we have around human experimentation.

3. Viewpoints

national level cultures around this topic.

The emerging biotechnologies are going to have species-wide impacts. It is to be expected that people have many different views around various developments.

3.1 Public Engagement and Discourse

It is essential to keep the public engaged, from the very beginning, with new and powerful technologies and their implications for our society. While the scientists involved with Recombinant DNA showed a great deal of responsibility with their conference at Asilomar, they lacked this crucial engagement with the public. Scientists often communicate in a coded language. While this is great for idea transmission within academic communities, the density makes it opaque for the general public to approach. The public lack of understanding of this field has bred fear and uncertainty around GMOs. The ensuing lack of support and

engagement from the public has stunted growth in this field. Indeed, dissociation from the public discourse around a science can kill that science.

However, there is a strong argument to be made for the position that we should let these developments fly under the radar. Scientists are, by and large, responsible and we should let them do their work. The near-term application of technologies like genomic sequencing of embryos during IVF include diagnoses and cures for such terrible ailments as Tay-Sachs disease. Poking the hornets' nest may cause people on one side or the other of the abortion issue to build and man new barricades. We should let this emerge in much the same way as IVF did where, by the time the issue drew public attention, people in evangelical communities were already speaking in their churches of the miracle of life.

3.2 Designer Babies

We have many bugs in our genetic code. These cause our children to die from genetic diseases and our elderly to suffer from the likes of dementia and Alzheimer's. Having already identified thousands of genetic disorders, we know what to look for when sequencing the embryos during IVF. We will know, for example, if a child, if carried to term, will die of Tay-Sachs. Data from European countries show that couples that receive a diagnosis of Down Syndrome from a pre-natal screening at three months, up to 93% choose to abort (Natoli et al.). From this we can impute that almost no one will choose to implant an embryo that we know would be a child who will suffer and die from a genetic disorder.

China's biophysicist He Jiankui is responsible for teh birth of the first known genetically-edited babies in the world. His "achievement" was initially lauded in China in the People's Daily as "a triumph of Chinese science". (The article has since been removed from the online archive of the People's Daily.) There was swift international condemnation of his actions (Harney, Kelland, and P. Wen). The event was controversial for a number of reasons. The consent of the parents was misinformed. He Jiankui did not obtain approval from the hospital. The father had HIV while the mother did not. In such a circumstance in a country with advanced medicine such as China, or the United States, there are many ways for the couple to have a child who will not inherit HIV. He Jiankui targeted the CCR5 gene to make it similar to a mutation that some europeans have. The mutation is two disrupted copies of the gene that grant the carrier increased resistance to HIV but makes them more susceptible to the West Nile virus. He Jiankui was not trying to

solve an existing problem but was trying to make an enhancement. A few months later, a report came out that mice with the same CCR5 mutation were faster at maze-running (Regalado). This sparked rumors that the babies were engineered to be smarter. Soon after, a study was released, analyzing data of almost half a million people from the UK Biobank, that found a link between people with the same CCR5 mutation and their lifespans (Wei and Nielsen). People with the mutations were living shorter lives.

4. Opinion

Opinion here.

We expect our new phones to be better, faster and different from our old phones. But we imagine biology as fixed. This will change over the 21st century.

The scary side of this is that we will make choices about our children based on factors beyond simple health. We will know the probabilities of personality traits, intelligence, height etc. and will choose according to the cultural and economic norms of the day. Take Sickle cell anemia as an example. If you carry two alleles of the trait, you will likely die. However, if you are a recessive carrier then you have much higher resistance against malaria at some cost to you hemoglobin's ability to carry oxygen. This trait emerged as a desperate adaptation to the deadly threat of malaria. However, malaria is nonexistent in the United States and sickle cell anemia is seen as a disease. Through embryo selection, we can select out the gene for sickle cell anemia, leaving us vulnerable to a reemergence of malaria. We have no idea what recessive traits we may be carrying that could help our species survive some threat that we have not faced in recorded history.

5. Conclusion

Conclusion here.

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