Inventum Biologicum: *An International Journal of Biological Research*
2024, Vol. 4, Issue 4, pp. 67-72

Inventum Biologicum

Journal homepage: www.journals.worldbiologica.com/ib

Review paper

Genetically Modified Organisms: From Cloning to Designer Babies

Samaira Gupta [a] *

[a] *Student, Indus International School, Pune, India*

ARTICLE INFO

Keywords

DNA
Genetic engineering
Genetic modification
CRISPR-Cas9
Cloning
Designer babies

DOI
10.5281/ib-903024

Corresponding author
Samaira Gupta
Email
dats.me.samtastic@gmail.com

ABSTRACT

From cloning to designer babies, genetic engineering in the field of biotechnology has rapidly developed, to the point where ethical debates among scientists and the media have been sparked. Cloning is a process in genetic engineering in which an exact genetic replica of a cell, tissue, or organism is produced with the same DNA as the original. Clones can be manufactured in a lab through embryonic twinning or somatic cell nuclear transfer (SCNT). In 1996, Scottish scientists successfully cloned the first animal using SCNT; a sheep named Dolly. Designer babies are babies whose DNA has been modified either to eradicate certain genes which produce unfavorable traits such as genetic diseases, or to insert certain genes which produce favorable traits such as enhanced intelligence. Designer babies can be produced through preimplantation genetic testing (PGT) or through CRISPR-Cas9 technology. Using PGT, embryos are created through in vitro fertilization (IVF) and after developing, PGT can be performed, allowing embryos that carry desired traits to be selected and transferred into the mother's uterus. CRISPR-Cas9 works like molecular scissors, allowing genes to be inserted, removed, or replaced. In 2018, Chinese biophysicist Dr. He Jiankui created the world's first genetically modified humans (twins named Lulu and Nana) by disabling the CCR5 gene to make the twins HIV immune. Major ethical questions are raised with these processes; do they cross ethical boundaries? What exactly are these boundaries? This gray area of bioethics makes it challenging to determine what is ethical and what is not.

1. Introduction

Biotechnology is a branch of science that uses biological systems to develop technology. Genetic engineering is a process in the field of biotechnology in which the DNA of an organism is altered. This can include editing, inserting, or removing genes of DNA.
Cloning is a recurring concept in television shows, from *Star Wars* to *The Flash*, often portrayed as futuristic technology. Yet cloning does not just exist in science fiction, in fact scientists have already produced clones of living organisms. Similarly, when we think of the term 'designer,' purses, shoes, and accessories come to mind. A designer item is one that is considered a luxury good, characterized by its exclusivity and uniqueness, however, due to developments made in the field of genetic engineering, 'designer babies' have come into the picture—genetically modified babies. Yet cloning and designer babies are particularly controversial in genetic engineering, as they involve the direct modification of the genetic material of living organisms, resulting in the ethical questioning of these processes.

This paper delves into the genetic engineering of living organisms, specifically cloning and designer babies, and further explores the associated ethical implications. The paper additionally highlights the

advantages and disadvantages of both cloning and designer babies, as well as looks into key case studies to illustrate the real-world implications of the genetic engineering of living organisms.

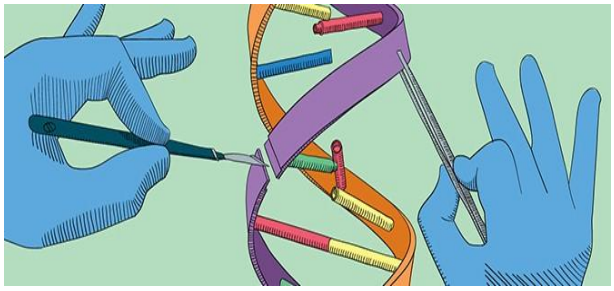

Fig. 1 Illustration of Genetic Engineering

2. Genetic Engineering

Genetic engineering can use different techniques. Using the gene insertion technique, a foreign gene is inserted into the DNA strand, resulting in the organism taking on improved traits associated with the new gene. For example, this technique can be used to create transgenic animals with improved traits, such as disease resistance or enhanced growth rates. Another technique is the CRISPR-Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats and CRISPR-associated protein 9) gene editing technique, allowing a gene to be cut and its DNA modified, therefore changing the organism's traits.

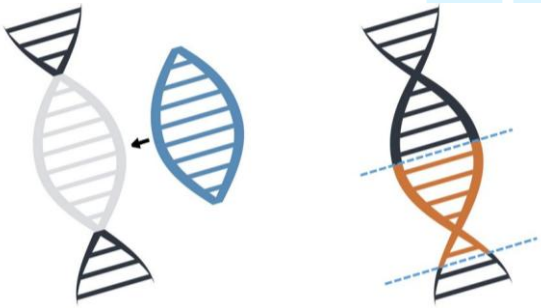

Fig. 2 Techniques of Genetic Engineering (Gene Insertion and CRISPR-Cas9)

3. Cloning

Cloning is the process used to create an exact genetic replica of a cell, tissue, or organism, and the replica (clone) has the same DNA as the original. Clones can happen naturally or they can be manufactured in a lab. An example of cloning that occurs in nature is when a cell replicates itself asexually. Prokaryotic organisms such as bacteria create genetically identical copies of themselves through binary fission, which is an example of asexual reproduction, producing clones of the organisms. In humans, identical twins are similar to clones. They are created when a fertilized egg splits in two, and they share almost the exact same DNA. However, in terms of genetic modification, laboratory cloning involves creating an organism by ensuring that it has identical DNA to the original organism.

3.1 Types of Cloning

1. Gene cloning, which creates copies of genes or segments of DNA.
2. Reproductive cloning, which creates copies of whole organisms.
3. Therapeutic cloning, which creates embryonic stem cells, and can be used to grow healthy tissues or replace injured or diseased tissues in the human body.

3.2 Cloning Mechanisms

3.2.1 Embryonic Twinning

1. An embryo is artificially split into two smaller embryos.
2. The embryos grow and develop in a laboratory setting.
3. They are then implanted in the uterus of a surrogate mother.
4. Each embryo develops into a unique organism, and the two organisms are genetically identical.

3.2.2 Somatic Cell Nuclear Transfer (SCNT)

1. A donor somatic cell is taken from an organism which is to be cloned (organism A).
2. The nucleus is extracted from this somatic cell.
3. An egg cell is taken from another adult female organism of the same species (organism B).
4. The nucleus is removed from this egg cell.
5. The nucleus from the somatic cell of organism A, and the enucleated egg cell from organism B are fused together through an electric shock.
6. This fused cell begins dividing normally in a laboratory setting to form an embryo.
7. The embryo is implanted in the uterus of a surrogate mother of the same species.
8. The embryo develops into a young clone of organism A, as it contains the same DNA from the nucleus taken from organism A.

3.3 Advantages of Cloning

- Cloning certain animal species such as endangered animals can help increase their population, allowing for the preservation of these species.
- Can be used to clone organs such as kidneys and this can solve the global shortage of organs available for donation.
- Allows infertile parents to have a child that is biologically their own, through cloning of one of the parents.
- Animals that have been cloned to have gene mutations can help scientists study diseases that develop in the animals.
- Livestock such as cows and pigs can be cloned to produce more milk or meat which can address food insecurity.

3.4 Disadvantages of Cloning

- There are high risks of the embryo being deformed and having a shorter lifespan due to the unpredictable process of cloning, which raises ethical concerns.
- Eliminates genetic diversity, which makes cloned organisms more susceptible to diseases and pests and may face an increased risk of extinction.
- The process can easily be commercialized and misused in large industries.
- Specifically for humans, a significant disadvantage is the potential for cloned individuals to feel alienated or unnatural, as they may be seen as copies rather than unique individuals, and this may lead to discrimination.

3.5 Case Study: Dolly the Sheep

"*Dolly the sheep was the first cloned mammal ever to be created from an adult cell. Affectionately named after country music legend Dolly Parton, Dolly caused excitement and controversy among both scientists and the public*" (National Museums Scotland).

In 1996, Scottish scientists successfully cloned the first animal, a sheep named Dolly, using SCNT. It took 276 unsuccessful attempts before Dolly was successfully produced, and since then, scientists have cloned cows, cats, deer, horses, and rabbits.

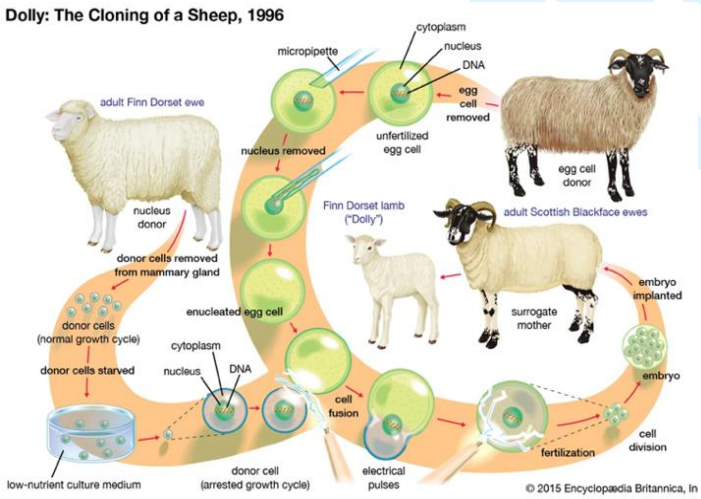

Fig. 3 Cloning Process of Dolly the Sheep

In 2001, X-rays confirmed that Dolly had arthritis after it was observed that she had been walking stiffly. The cause of the arthritis was never established, but treatment resolved the clinical signs within a few months. However, this fueled concerns that cloned animals could age prematurely, and that cloning might produce organisms with reduced lifespans and compromised health.

Dolly remained healthy until 10 February 2003, when it was noticed that she was coughing. A CT scan was carried out on 14 February 2003, which confirmed that tumors were growing in Dolly's chest, and Dolly was ultimately euthanized at the age of six.

4. Designer Babies

Designer babies are exactly what the name suggests: babies who have been "designed," in other words, genetically modified. The purpose of designer babies can be to eradicate certain genes which produce unfavorable traits such as genetic diseases, which means, in theory, a child can be free of heritable disease such as hemophilia, color blindness, and cystic fibrosis. Another reason is to insert certain genes which produce favorable traits such as enhanced intelligence or a specific eye color. Designer babies are either created from an embryo selected by preimplantation genetic testing (PGT) or genetically modified through the CRISPR-Cas9 technique.

Fig. 4 Satirical Illustration about Designer Babies

4.1 Process Through PGT

Preimplantation genetic testing (PGT) refers to the assessment of embryos prior to implantation or pregnancy.

1. The process begins with in vitro fertilization (IVF) which involves extracting eggs from a woman's ovaries and fertilizing them with sperm in a laboratory setting, creating multiple embryos.
2. After the embryos are created through IVF and then cultured to develop, PGT can be performed to analyze the embryos for specific genetic traits.
3. Embryos that do not carry genes for hereditary diseases, or that carry desired traits are selected.
4. The selected embryos are transferred into the mother's uterus, and after the pregnancy, the child is born.

4.2 Role of CRISPR-Cas9

CRISPR-Cas9 works like molecular scissors, and can play a role in creating designer babies by directly editing genes in the DNA, including inserting, removing, or replacing genes, to eliminate undesirable traits or introduce desired traits.

"With this veritable biological scissors [CRISPR], [scientists] can now edit a genome as movie editors would a film clip" (Shirvington, 2022).

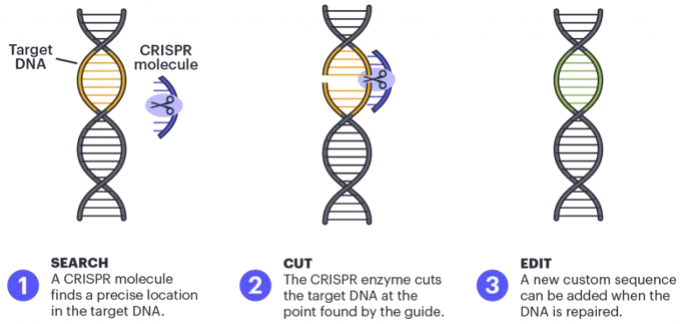

Fig. 5 Process using CRISPR-Cas9

4.3 Advantages of Designer Babies

The main advantage is that the health of babies can be improved by modifying their genetic make-up, as chances of genetic disorders can be reduced. Scientists also claim that it may be possible to install genes that offer lifelong protection against infection and even the effects of aging. If the population of these healthy designer babies increase, then in theory, the overall health of the population can be increased, including increased life spans and decreased prevalence of certain hereditary diseases. However, this currently remains largely theoretical or in the experimental stage.

4.4 Disadvantages of Designer Babies

The main disadvantage with babies who have been genetically enhanced is the disparity that could potentially be created between those who are genetically modified, and those who are not. Firstly, economically, there is the potential of the commercialization of designer babies, which can create an economic disparity between those who can afford enhancements and those who cannot. Additionally, in a work environment, genetically modified employees could be preferred, which could affect employment and further cause discrimination. Thus, the economic disparity can make the world even more unequal and prejudiced.

Another perspective of a disadvantage is that this is unnatural and could be considered as cheating. For instance, in the field of athletics, those who have been genetically enhanced to have increased athletic ability could be seen similar to those who use steroids, which is considered a form of cheating. This could widen the gap between those who are genetically modified and those who are not, which could further lead to discrimination.

4.5 Case Study: Lulu and Nana

In 2018, Chinese biophysicist Dr. He Jiankui stunned the world after he announced that he had created the world's first genetically modified humans (twins known by their pseudonyms Lulu and Nana) with modified genes to make the twins HIV immune. Dr. He conducted his experiment with couples in which the males were HIV carriers, and used CRISPR-Cas9 technology to disable the CCR5 gene which is involved in helping HIV enter healthy cells.

Dr. He was confronted with shock and outrage by other scientists and the media. He was condemned by the public and was ultimately found guilty of "illegal medical practices" including violating government bans on the clinical procedures of gene editing on a human embryo. Dr. He was sentenced to three years in prison. In the description of a video titled ""Designer Baby" is an Epithet" posted on Dr. He's YouTube channel "The He Lab," Dr. He writes "It is inhuman for [parents] not to protect their children if nature gives us the tools to do so." This shows his clear advocacy for this process, and he continues to defend his work.

As for his update, after Dr. He was released from prison, and in a National Public Radio (NPR) interview in 2023, he stated that the twins were living a "normal, peaceful, [undisturbed] life" however he declined to comment when interviewers pressed for more details about any negative effects on the twins, which may further contribute to the conspiracy and suspicion regarding the ethical and long-term health implications of his experiment, as well as the concept of designer babies overall.

5. The Ethical Dilemma

When we analyze biotechnology and the genetic modification of living organisms, it is important to consider the bioethical considerations. Do humans have the right to change the genetic material of living organisms? Does this cross ethical boundaries? What exactly are these boundaries? Some argue that humans do not have the right to manipulate the genetic material of living organisms, while others believe that we must use the tools available to us to improve our species. Our judgement is clouded by religion and personal beliefs and values, creating a mélange of contradicting perspectives on the situation. This gray area of ethics makes it challenging to determine what is ethical and what is not.

The main goal of genetic modification is enhancement and improvement. What if these improvements were available only to the richest people? This is likely, as the processes involved in genetic modification are very expensive. Thus, one of the primary issues is equity. If these processes are only available to the wealthy, it could create major disparities, and those who can afford these processes could gain unfair advantages, such as better employment in a workplace setting. This inequality could potentially foster a society where these genetic enhancements influence opportunity.

The process of genetically modifying living organisms is unpredictable and the safety and long-term effects are still unknown. Not only is consent an issue here, as children would not even have the chance to consent to being genetically modified, but another part of the issue is the experiments themselves and the risks that come along with them, including changing a child's way of life. Even in the ideal situation in which these processes are perfected and there is no need for experiments with unknown risks or consequences, the critical ethical questions still remain about whether humans have the right to change the genetic material of living organisms.

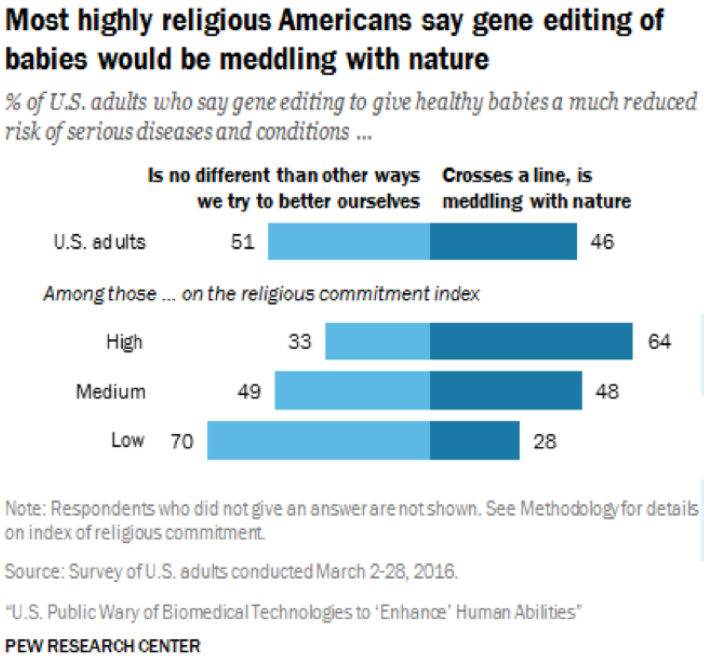

Fig. 6 Opinions of Religious Adults in the U.S. on the Genetic Editing of Babies

Furthermore, people from different cultural and religious backgrounds have different perspectives. Some strongly religious people believe that genetically modifying humans is sacrilegious, viewing it as an act of "playing God." Fig. 6 illustrates the results of a poll conducted in 2016 by the Pew Charitable Trust. It shows that in the United States, 64% of those with strong religious commitments, based on the religious commitment index, believe that gene editing to give babies a much reduced risk of serious diseases and conditions "crosses a line, [and] is meddling with nature." This number is only 28% for those who are low on the religious commitment index, and these differences in numbers show how religion can influence perspectives on the genetic editing of babies.

Moreover, once this technology becomes widely accessible, there is a high probability that it can be used with the wrong intentions and for the wrong reasons. Humans have often transformed once beneficial tools into means of harm. For example, drugs originally developed for medicinal purposes are now being abused. This further raises concerns about gene editing and the potential for it to be misused.

Some believe that we should take the chances to make improvements to our species, while others believe that it is not medically necessary. I believe that designer babies should be designed for the purpose of a healthier baby, and not for the purpose of enhancing a baby's "beauty" as *this* is medically unnecessary. As humans, we should celebrate our differences, as these differences are part of our identity, and I believe that we should not use science to change the physical appearances of babies based on the parents' aesthetic preferences, as doing so would take away the nuances and the inherent imperfections that make us human.

6. Conclusion

I believe that cloning can be very beneficial, especially to address the global shortage of organs, to preserve the population of species of animals, to address food insecurity, and to allow infertile parents to have biological children. Similarly, I believe that designer babies and the genetic modification of humans is beneficial for the purpose of removing genes that can cause genetic diseases, thereby improving the health of future generations in the long-term. The goal of medicine to reduce suffering, so if we have the technology and resources, then I believe we should continue developing it for the right reasons. As for the economic gap, perhaps once the technology is successful and society decides to proceed with it, costs can be reduced and this technology can become more accessible to more people. Yet at the same time, it is also crucial to look at the entire picture, and not just the benefits. As of now with the current progress of this technology, we still do not know the long-term consequences to genetically modifying organisms, and we must consider the potential for disparity and discrimination, as well as the affected lives of the genetically modified.

In the future, when the technology is developed enough, genetic modification can become very useful, therefore we should not impose a ban in this domain, as progress can only be made with more research and experimentation. However, we must proceed with caution. It is imperative to consider the pros and cons in all sectors of life, with emphasis on the ethical factors, before taking the genetic engineering of living organisms forward. We must foster a balance between innovation and our ethical responsibility to preserve human dignity while improving our species.

"Genetic engineering is a result of science advancement, so I don't think that in itself is bad. If used wisely, genetics can be beneficial, but they can be abused, too" – Hideo Kojima.

Funding Information

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration Of Conflict

I declare that I have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Are we ready for Designer Babies? (2024). In Nishith Desai Associates (pp. 5–17). https://www.nishithdesai.com/fileadmin/user_upload/pdfs/Research_Papers/Designer_Babies.pdf
2. Hardin, J. (2019, February 13). Genome Editing and the Christian. BioLogos. https://biologos.org/articles/genome-editing-and-the-christian
3. MedlinePlus. (2018, May 8). Cloning. Medlineplus.gov; National Library of Medicine. https://medlineplus.gov/cloning.html
4. National Geographic Society. (2022, May 20). Cloning. Education.nationalgeographic.org; National Geographic Society. https://education.nationalgeographic.org/resource/cloning/
5. National Museums Scotland. (2024). The story of Dolly the sheep. National Museums Scotland. https://www.nms.ac.uk/discover-catalogue/the-story-of-dolly-the-sheep
6. Raposo, V. L. (2019). The First Chinese Edited Babies: A Leap of Faith in Science. JBRA Assisted Reproduction, 23(3), 197–199. https://doi.org/10.5935/1518-0557.20190042
7. Regalado, A. (2015, March 5). Engineering the Perfect Baby. MIT Technology Review. https://www.technologyreview.com/2015/03/05/249167/engineering-the-perfect-baby/
8. Rugnetta, M. (2024). Cloning. In Encyclopædia Britannica. https://www.britannica.com/science/cloning
9. Ruwitch, J. (2023, June 8). His baby gene editing shocked ethicists. Now he's in the lab again. NPR. https://www.npr.org/2023/06/08/1178695152/china-scientist-he-jiankui-crispr-baby-gene-editing
10. Smith, M. (2024, October 27). Genetic Engineering | Talking Glossary of Genetic Terms | NHGRI. Genome.gov; National Human Genome Research Institute. https://www.genome.gov/genetics-glossary/Genetic-Engineering.

References for Images

1. Cowen, L. (2023). One and Done? How CRISPR Is Changing the Clinical Outlook for Multiple Diseases. Inside Precision Medicine, 10(3), 16–19. https://doi.org/10.1089/ipm.10.03.04
2. Grisé, C. (2019, May 13). Designer Babies. Upfront.scholastic.com. https://upfront.scholastic.com/issues/2018-19/051319/designer-babies.html?language=english
3. Shirvington, P. (2022, July 8). Designer Babies. Snipette. https://snipettemag.com/designer-babies/
4. What are Non-Transgenic Gene Editing techniques? (2021, October 22). CivilsDaily. https://www.civilsdaily.com/news/what-are-non-transgenic-gene-editing-techniques/
5. What is CRISPR? (n.d.). Innovative Genomics Institute (IGI). https://innovativegenomics.org/what-is-crispr/
6. Williams, E. (2023, February 24). What are genome editing and gene therapy? Genomics Education Programme. https://www.genomicseducation.hee.nhs.uk/blog/what-are-genome-editing-and-gene-therapy/.