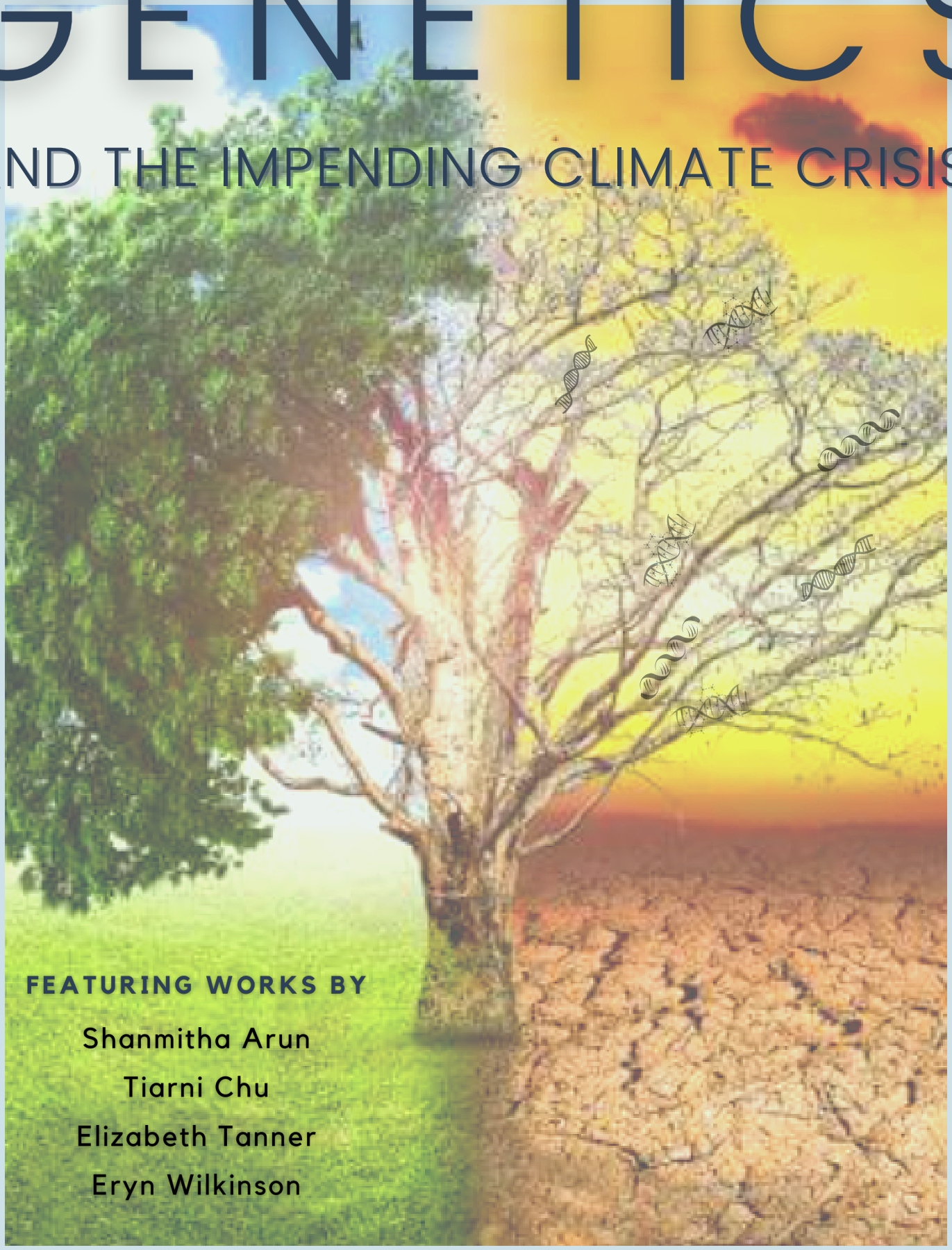
GENETICS

AND THE IMPENDING CLIMATE CRISIS



FEATURING WORKS BY

Shanmitha Arun

Tiarni Chu

Elizabeth Tanner

Eryn Wilkinson

TABLE OF CONTENTS

Notes from the Authors 3

Background 4

Climate Change 5

Climate Change and Reproduction Crossword 8

CRISPR 9

Case Study: HIV resistance through CRISPR 11

IVF 14

Adaptation: friend or foe 15

The 4 S's of genetic editing: 16

Safety

Significance of harm to be averted

Case Studies: Zika virus, Malaria, and Heat 18

Succeeding Generations

Social Consequences

Ethical + Legal Discussion 21

Ethical and Legal Concerns of CRISPR Usage 22

Mary Windham: Interview 25

Climate Change Adaptation 26

Environmental Reproductive Justice 27

IVF Legal Battle: Health Insurance Coverage 29

Drawing the line: A Legal Nightmare 30

Implications on Society 31

IVF: Socioeconomic classism 32

Indigenous Peoples 33

Developing Nations 34

Stephanie Kiesow: Interview 35

Crossword: Revisited 37

Gender 38

5 ways IVF has changed the world 39

Looking Forward 41

Alternate Solutions 42

Conclusion 44

References 45

Notes from the Authors

With the climate crisis becoming more imminent, and the chance for milder solutions passing quickly, technologies such as CRISPR-Cas9 and IVF have been proposed to ensure the survival of the human race. Yet, these solutions require further evaluation of past, current, and potential future perspectives from marginalized communities so that the world that survives is an equitable one.

When looking at the intersections between climate change and reproductive choice, our approach centered around the ways that different groups are disproportionately impacted, primarily medically and politically, by the combined negative effects of climate change and systemic oppression. One main focus of the project was the idea of Environmental Reproductive Justice, which highlights the way the environment impacts individuals, especially those who identify as women, indigenous peoples, disabled peoples, and other minority groups, and further contributes to disparities in reproductive health. Not everyone has the resources and money required to obtain this luxury as CRISPR-Cas9 and IVF are costly solutions. While there are other alternate solutions, which are cheaper, we have been trying for years to mitigate the effects of climate change and humankind is simply still not doing enough. We also aimed to look at the societal impact that our project can entail, as we understand and aim to see further into how these global, biological conflicts are intertwined with societal implications.

We do acknowledge that reproductive technology can be seen as a "downstream" solution, whereas directly addressing climate change via eliminating greenhouse gases would more of an "upstream solution." However, despite global efforts to reduce the carbon footprint made by mankind, global warming and climate change are still pressing issues that need to be addressed. It is unfortunate and sad that we have gotten to this point, but turning to the advantages of new reproductive biotechnologies may be the only way going forward.

BACKGROUND

1 *Climate Change*

CRISPR 2

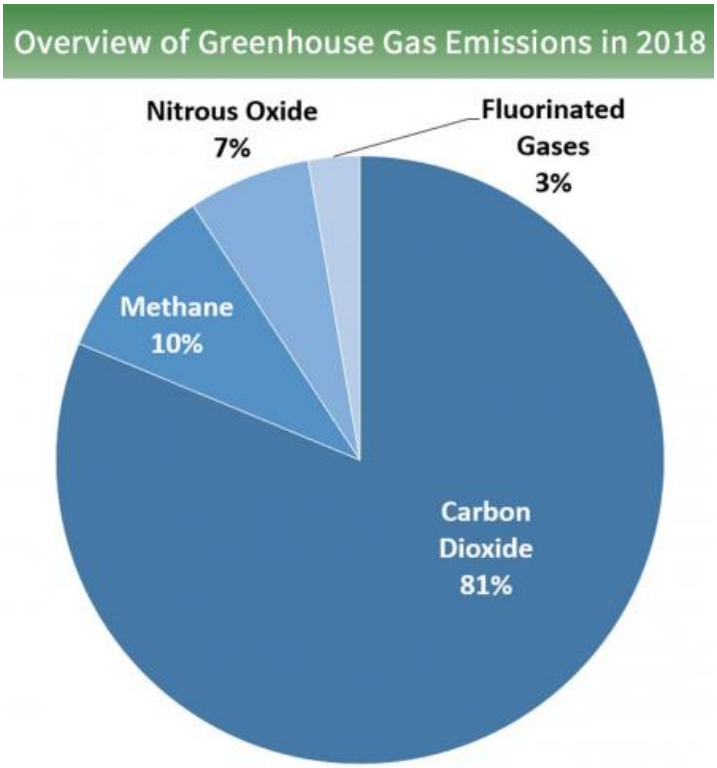
3 *IVF*

Climate Change

by Elizabeth Tanner

Climate Change refers to the shifting of the Earth's climates at an increasingly quick rate, largely due to human activities. Climates are the overall weather of a region over a period of multiple years. Climates generally shift throughout history, however, this transition is usually exceedingly slow, occurring over thousands of years. In the past 50 years, substantial changes in global climates have been noticed, at rates much too high to be due to natural causes. Scientists have determined that this increase in changes to climates can be attributed to several key human actions.

The main greenhouse gas contributors are Carbon Dioxide, Methane, Nitrous Oxide, and Fluorinated Gases.



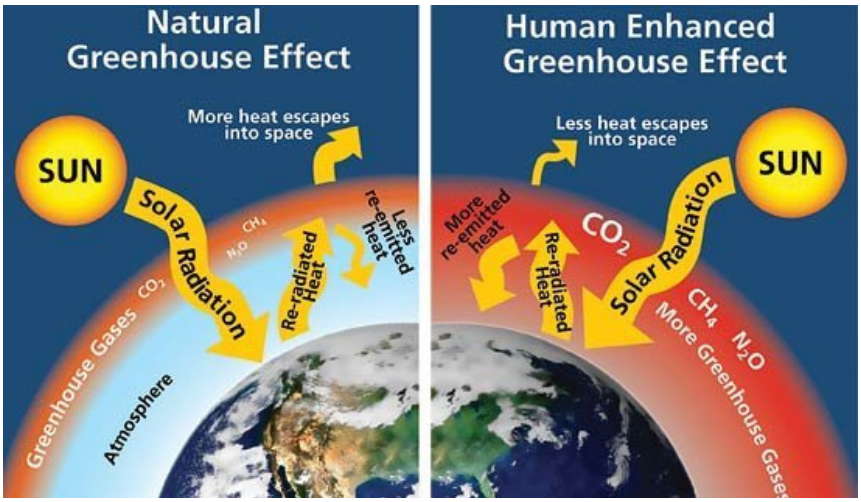
Fossil Fuel Usage

Since the industrial revolution, humans have been fueling energy sources through burning fossil fuels like coal. However, the process of burning these fossil fuels releases several toxic pollutants called Greenhouse Gases into the atmosphere.

The largest contributors to greenhouse gases entering the Earth's atmosphere are electricity, transportation, and industry.

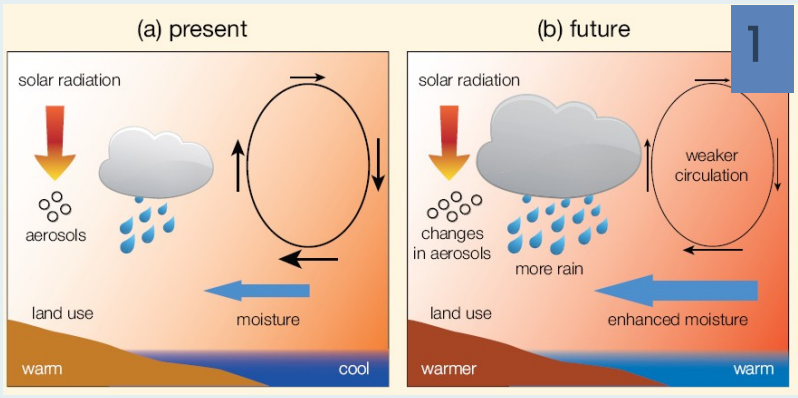
Greenhouse Effect

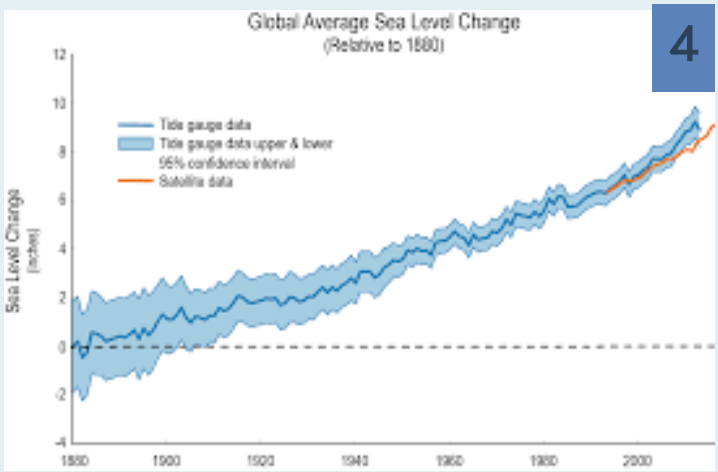
The Greenhouse gas effect is when greenhouse gases are reflected back to Earth from the Earth's atmosphere instead of escaping. The trapped gases lead to more heat getting stuck in the Earth's atmosphere, slowly contributing to global warming. As a result, environments experience more extreme weather events and temperatures.

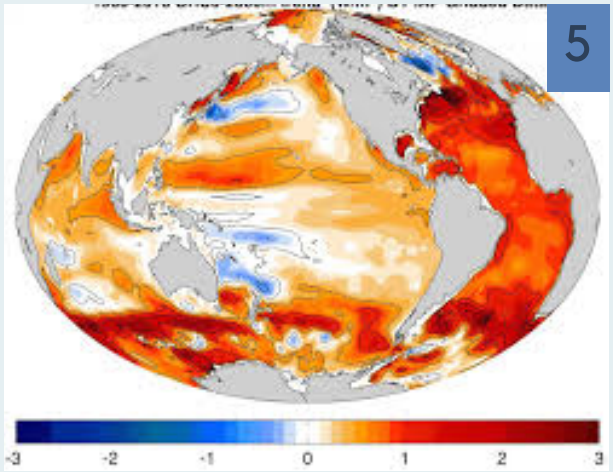


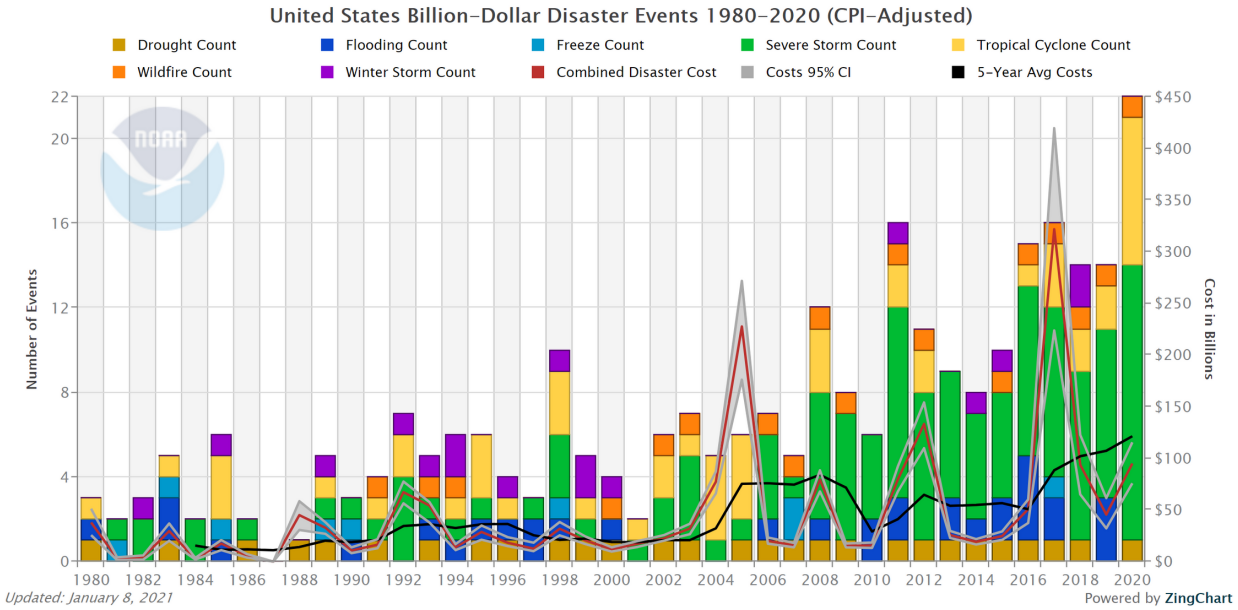
The 5 Major Environmental Effects

(1) Global water cycle shifts
(2) Declining glaciers and snowpack
(3) Ocean acidification
(4) Sea level rise
(5) Warming of temperatures and oceans









Graphic from: NCDC NOAA Time Series

<u>*Social Consequences*</u>
As the Earth's climates continue to shift and extreme weather increases in frequency, these impacts will affect daily human society in a multitude of ways. Scientists expect the following seven main societal effects of Climate Change.

Heat-related illness
Temperature changes will lead to increased frequency and severity of heat-related illnesses, like heat shock and heat stroke, especially as basic resources become less accessible.

Habitat degradation and fragmentation
Changes in climates will shift livable habitats, causing massive species migrations and decreases in available resources.

Cardiopulmonary illness
High temperatures act as a catalyst for heart failure, heart attacks, and strokes.

Food shortages
Food production will be altered by extreme weather and habitat changes. These changes will cause crop yields to decrease without modification or habitat changes to adapt to the new climate.

Water shortages
Weather changes will lead to irregular water conditions such as droughts, heavy snowfall, and groundwater availability.

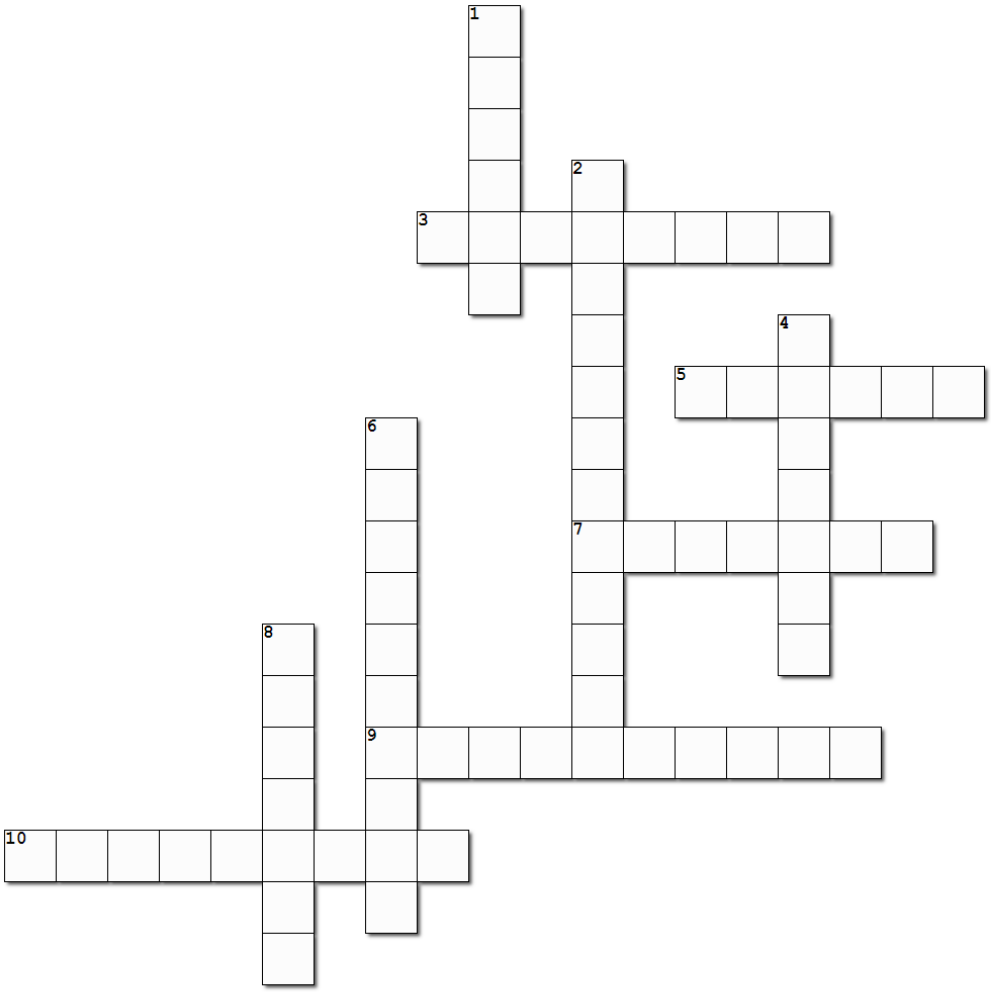
Food, Water, and Zoonotic Illnesses
Exposure to new ecosystems will also expose humans to illnesses that we do not have built resistance to, which making novel diseases a more frequent occurrence.

Mental Health consequences
Climate anxiety and mental health concerns from increased stress to have access to basic needs will increase mental health pressures.

What can we do?
Mitigation: decreasing current releases of greenhouse gases and actively working to decrease the current amount because the crisis gets worse
Adaptation: reduce the effect of these changes by adjusting human society and health to better survive in these new environments
Resilience: prepare, anticipate, and respond to threats as they arise to minimize the impact on the Three E's of Sustainability.

Climate Change and Reproduction Technology

CROSSWORD



Created using the Crossword Maker on TheTeachersCorner.net

Across

3. The study of heredity and genes
5. Technology used by He Jiankui
7. The global weather patterns
9. Mechanical, electronic, medical, communications
10. Changes over time

Down

1. A range of identities
2. Making a copy of something (or someone)
4. Vaccinations can prevent some of these
6. Opposable thumbs
8. Opposite of In Vivo

Did you know?

Global temperatures have increased by about 1° Celsius in the past century.

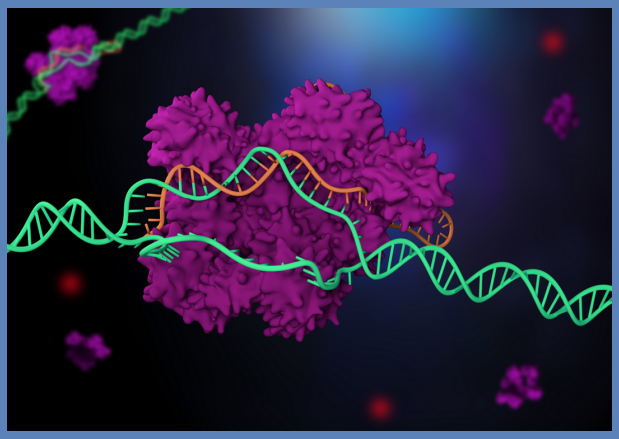
Rainforest destruction is a major cause of carbon dioxide release.

In the U.S., costs of gestational surrogacy vary widely, from $1000 to $100,000 (depending on carrier's fee, program, legal, and medical expenses). In other countries, such as India, the cost ranges from $15,000 to $30,000.

CRISPR

by Tiarni Chu

Precision genome editing technology is largely sought out, for it has potential to benefit food production, disease treatment, and other medical advancements by altering DNA sequences. DNA is built of nucleotides, the building blocks of life, and these strings of nucleotides that make up DNA can be changed so that the organism gets altered. The CRISPR-Cas9 system is a genome editing tool based on bacterial immunity; it uses a certain kind of DNA, clusters of regularly interspaced short palindromic repeats (CRISPRs), and a specialized protein, Cas9, to edit and target genes within a genome (American Association for the Advancement of Science).



Bacteria use this molecular mechanism to recognize foreign invader DNA and adapt to it, allowing them to survive for longer. The bacterial immunity function was first noticed in yogurt in 2007 and was developed into a genome editing tool in 2012 (Vidyasagar, 2018). CRISPR utilities guide RNAs (gRNAs), which bring the Cas9 protein to a target sequence within the genome to cut. Research first started experimenting on human cells in 2013 and has mainly been focused on disease cures like "correcting genetic defects" (Vidyasagar, 2018).

CRISPR

by Tiarni Chu

However, CRISPR does not have a one-hundred percent efficiency. There are off-target effects of genome editing, as mechanistic mistakes can be made on genes that were not targeted by the CRISPR system (Banan, 2020). Off-target effects cause mutations--this is what current research is focused on, as scientists are attempting to improve the efficiency of the CRISPR-Cas9 system so that they can successfully cure and treat human diseases.

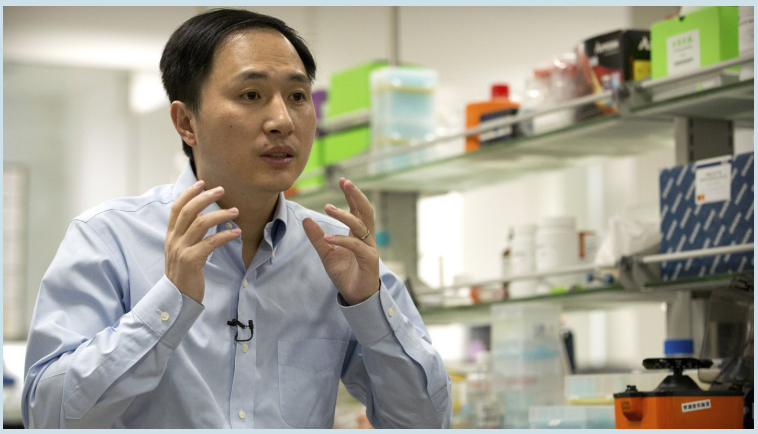
Essentially, this genome editing tool is acting "like a pair of molecular scissors."

(Vidyasargar, 2018)

For example, breast cancer mutations can be created in cells using CRISPR and these cells can be treated with different kinds of chemotherapy; this will shed light on how different kinds of breast cancers can be appropriately treated and how current treatment can be improved (Dekkers, 2020). There is lively debate about whether or not CRISPR should be utilized as a germline editing technology, as there are many ethical considerations to account for before investing in this kind of research.

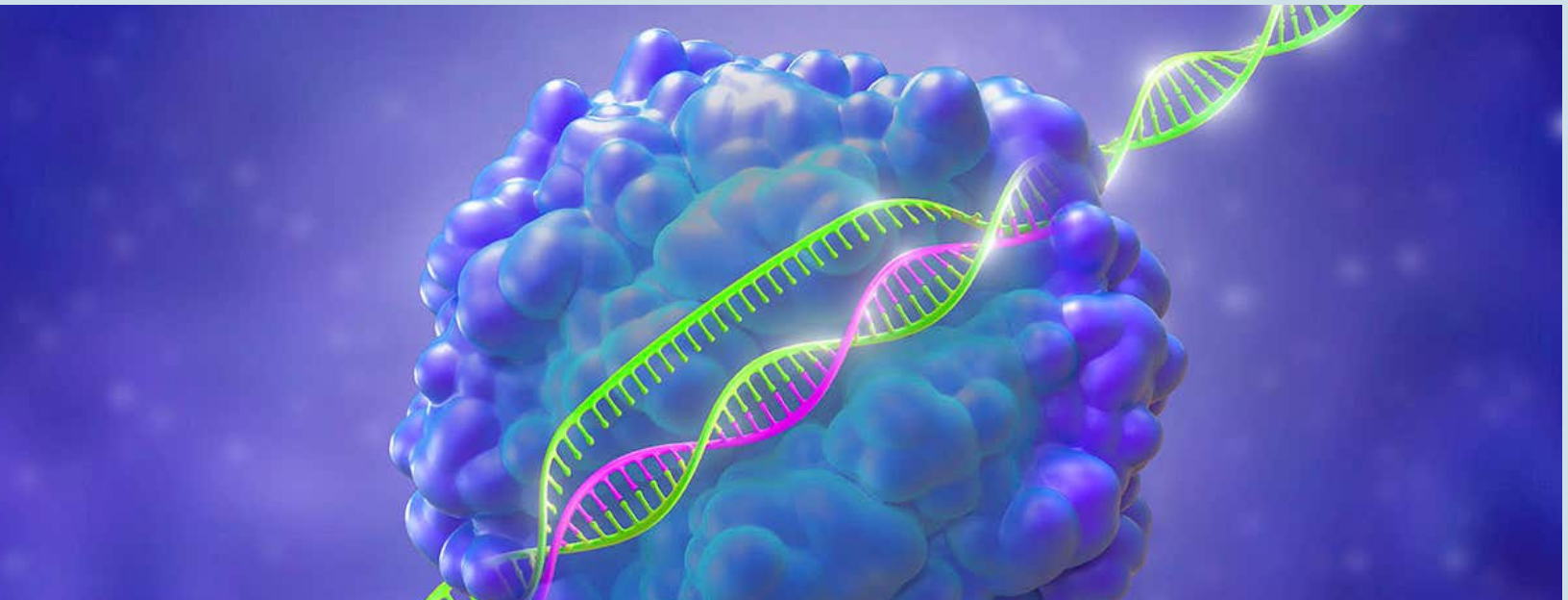
Case Study: Using CRISPR to increase HIV resistance

by Elizabeth Tanner and Tiarni Chu



The first time that a baby was born using CRISPR technology was late 2018. Dr. He Jiankui announced that two twin girls were born whom he genetically modified using CRISPR, but he "flouted established norms for safety and human protections" while doing so (Cyranoski, 2019). Dr. He genetically modified their germline cells, meaning the changes he made to their germline will affect all their cells and ultimately be passed on to their subsequent children. He attempted to alter the CCR5 gene so that these two girls cannot contract AIDS, however, the experiment did not turn out the way Dr. He expected it to.

Instead of having the CCR5 deleted from all cells via CRISPR, CRISPR only acted on some cells so that the girls have cells with a mutated version of CCR5--in fact, this mutation Dr. He made has never been observed in humans before. There is very little public information on the experiment rather than the brief statements given by Dr. He himself, and the scientific community outside of China does not know if the Chinese government provided Dr. He with funding. There are no public statements of the parents and what information was given to them prior to the birth of their twins. Dr. He is now serving years in prison for his rogue research.



Case Study: Using CRISPR to increase HIV resistance

by Elizabeth Tanner and Tiarni Chu

While this study is widely unapproved of by the scientific community because of the ethical and legal regulations that He Jiankui did not abide by, this research shows just one potential impact that CRISPR is capable of having on human adaptation. While HIV has been studied for decades and treatments have been discovered, no cures have been found. However, if He Jiankui's research was successful, it suggests it would be possible to avoid anyone from obtaining HIV, and diseases similar to it in the first place.

This possibility has huge implications for the future of genetic editing as it could mean that countless life-threatening or painful diseases could be outright avoided. This includes novel diseases from new exposures to habitats, plants, or animals from climate change effects, or long present diseases within human populations.

"Approaching this document, I was hoping to see a reflective and mindful approach to gene editing in human embryos. Unfortunately, it reads more like an experiment in search of a purpose, an attempt to find a defensible reason to use CRISPR/Cas9 technology in human embryos at all costs, rather than a conscientious, carefully thought through, stepwise approach to editing the human genome for generations to come."
- Rita Vassena (Eugin Group Scientific Director)

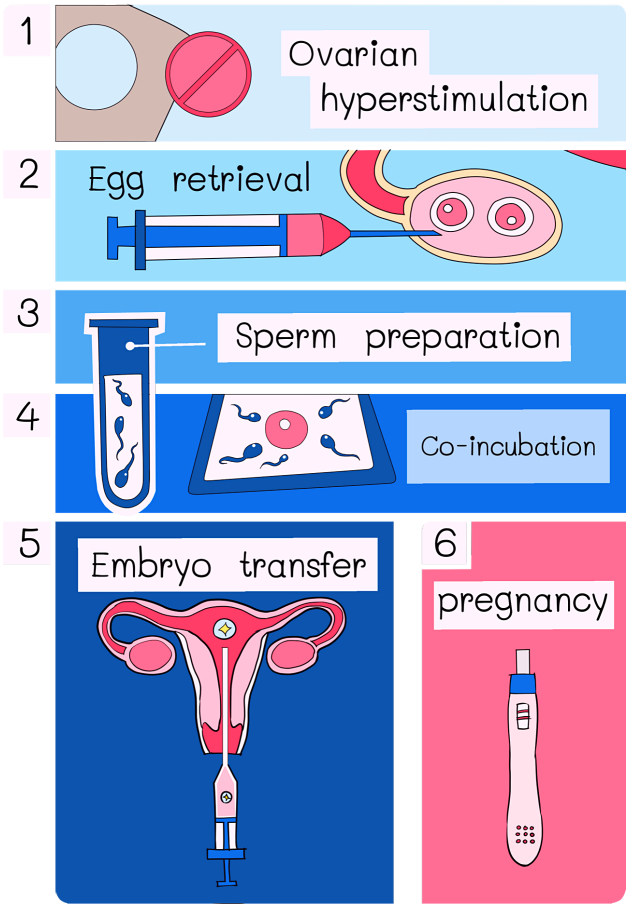
However, this study also emphasizes the importance of having definitive legal regulations for what research parameters exist regarding genetic editing. There are genuine fears about eugenics or gross misappropriation of CRISPR if not tightly regulated by the ethical and scientific community, and He Jiankui's research confirms that there will always be individuals willing to go outside the law for scientific purposes or their own goals, so having ways to regulate and reinforce rules about what use of CRISPR is deemed morally and legally permissible is essential.

IVF by Shanmitha Arun

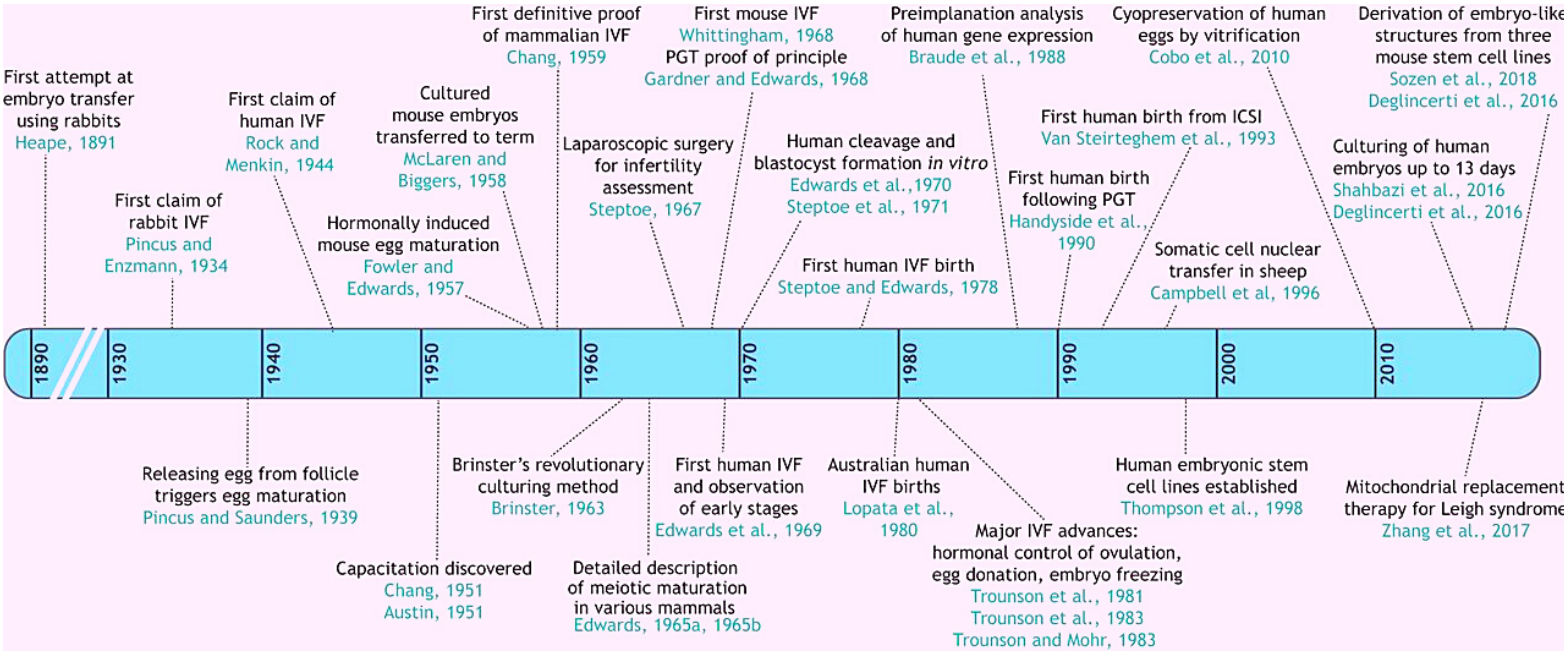
In-vitro fertilization, or IVF, is one of the most effective forms of assisted reproductive technology. It involves a series of procedures, including egg retrieval, fertilization, and embryo transfer.

IVF may be offered as a treatment for a variety of reasons: fallopian tube damage, ovulation disorders, endometriosis, impaired sperm production, or a genetic disorder ("In Vitro Fertilization (IVF)", 2019).

IVF has greatly advanced embryo research and while there are other similar assisted reproductive technologies (ART) such as gamete intrafallopian transfer (GIFT) and zygote intrafallopian transfer (ZIFT), IVF is the most popular (Zhu, 2009). While this reproductive technology is greatly promising and gives hope to many, it is important to acknowledge the risks involved. Risks of IVF include: multiple births, premature delivery, miscarriage, birth defects, and stress ("In Vitro Fertilization (IVF)", 2019). It is also a lengthy, complicated, and costly process.



History of IVF:



My menstrual cup changed my life. Period.

ADAPTATION: friend or foe?

1. *The 4 S's of Genetic Editing*
2. *Safety*
3. *Significance of harm to be averted*
4. *Succeeding Generations*
5. *Social Consequences*

Adaptation: Friend or Foe?

by Elizabeth Tanner

As climate change impacts continue to increase in severity, human risk factors are multiplying at tremendous rates. In order to survive in these new conditions, humans will need to address concerns regarding the three E's of sustainability: economic, environmental, and equality. However, dealing with issues as they arise is only a feasible response for so long, and humans are rapidly reaching a point where the widespread climate change environmental effects will be too frequent and too severe for the current reactionary methodology to be effective. Current impacts disproportionately affect the most vulnerable members of society, emphasizing humanity's current failures in protecting equality. Without rapid action, it will be too late to protect not just the highest risk among us, but large populations of human societies. Ocean level increases and changes in temperature will lead to shifts in viable habitats for all plants and animals. Food sources and ecosystem interactions will be disrupted, putting humans at higher risks for zoonotic diseases and decreasing food production successes.

Thus, a careful analysis of the viability of using genetic editing on humans to adapt to environmental impacts through analyzing the

four S framework of Safety, Significance of harm to be averted, Succeeding Generations, and Social Consequences should be applied to determine when, and if, genetic editing is a viable solution to the climate issues humanity now faces.

Safety
Current genetic editing technologies carry several safety risks. Firstly, there are concerns regarding off-target gene effects. Current scientific understanding of the human genome and its interactions between genes is not fully known, and thus, editing one aspect of a genome can not yet be assured to not have an impact on other aspects of that individual's genome. This is a substantial risk and is one of the main scientific aspects holding back a wider list of potential applications for CRISPR technology. However, similar to all scientific advancements, scientific progress is not possible without continuing to research determine the risks and rewards of the topic.

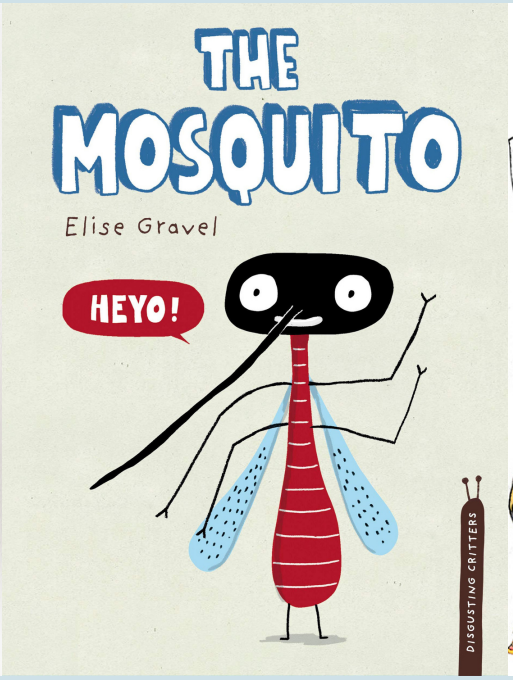
Additionally, adaptions arise in human genomes from natural variation. This existence of these mutations make it impossible to assure that the human genome would not simply mutate to its original state or mutate again to have a different effect at some point in the future. These changes could affect both the patient themselves and even future potential offspring.

Significance of harm to be averted
This factor is highly dependent on the specific use of CRISPR that is being considered, however, medical therapeutic uses of CRISPR arguably hold the most potential for diminishing risks. Specifically, life-threatening diseases, both those currently present or theoretically in the future, inherently result in a large amount of harm. Genetic editing that is able to remove harm from these diseases by increasing resistance or decreasing the severity of the disease could result a net increase in human health. Some current examples of diseases where using CRISPR editing technology could yield substantial decreases in harm include Zika, Malaria, and HIV. However, diseases are not the only harm that genetic editing could mitigate.

Climate change factors are also shifting living habitats for humans, plants, and animals. These shifts are inherently going to-and already are-changing human diets.

Climate Change Health Outcomes: Who is at Risk?

by Elizabeth Tanner
and Eryn Wilkinson



Zika

A study completed in 2019 using CRISPR identified insights into the human neural cells that are responsible for Zika virus resistance (Yun, 2019). Zika virus is a has a harmful to the health of embryos if the mother obtains the virus while pregnant.

With this development, the scientific community believes it may be possible to determine what genes to target with CRISPR in order to increase women's resistance to Zika virus.

While understanding of the cells that genetic editing would need to target is not comprehensive and requires more research, this breakthrough is an exciting first step to creating the possibility of making the use of CRISPR to increase Zika virus resistance a scientific possibility.

"Future therapeutic strategies exploring these shared host factors may confer broad neural protection."
- Yun, et.al., 2019

Malaria

Vector-borne diseases such as malaria are increasing in prevalence due to climate change. With temperatures rising and the tropical ecosystems of mosquitos expanding, malaria will present a new challenge in areas of the world where it has previously been absent (Semenza, 2009).

"The decision to use CRISPR/Cas9 to fight malaria, or genome editing in general, does not belong solely to science, but also requires public engagement, especially from the African communities living in malaria-endemic areas."
- Patrão Neves, 2017

The potential use of CRISPR-Cas9 to edit the mosquito genome to eradicate malaria has been offered as a potential solution to this symptom of climate change, but to do so without the consideration of the disadvantaged communities who have been affected by malaria throughout history would be unethical (Patrão Neves, 2017).

Heat

Increased temperatures due to climate change have also had a direct impact on health outcomes across the globe.

Research now suggests that weather with days where the temperature passes 80 °F is linked to decreased gestational length during pregnancy, which is associated with premature births, lower birth weight, and other effects on fetal development (Barreca, 2019). As climate change continues to increase the global temperature, more days will fall into the above 80 °F temperature range, slowly decreasing the human global population.

This harmful effect of climate change directly and disproportionately effects different areas of the world, furthering disparities in reproductive health.

If CRISPR could be utilized to edit the human genome in such a way that temperature effects would be less harmful, the ethical considerations of equitable access to this technology would need to be evaluated.

As diets change, gut microbiomes, which are part of the human immune system also shift. Furthermore, a balanced diet is an essential part of a healthy life, and this is jeopardized by shifting temperatures and habitats. Using CRISPR technology to enhance the viability of plants to survive or produce yields in changing environments could mean that individuals are able to provide for themselves and their families. This usage, especially since it would not be directly on humans, is much more widely accepted in the medical community even today, and in fact, several common crops, such as corn and rice, already have several genetically modified strains that are widely available. However, using CRISPR to genetically edit human gut microbiomes to increase immune systems or increase microbiome diversity is much more widely debated. In these situations, the risks that humans face are much harder to quantify because there are no assurances that humans will face extreme pain or altercations in life expectancy without the use of genetic editing (unlike usage for severe medical diseases). Thus, these cases should be carefully considered as more information becomes available regarding technological knowledge of how gut microbiomes react to changes in climate or diet.

Thirdly, as climate changes yield more extreme weather and temperatures continue to increase, there is the potential to locate the genes responsible for humans' ability to withstand temperature ranges, with could allow humans to increase the range and extremes of temperatures that they can survive in. The Earth has been steadily trending upward in average temperature for over 50 years, and the current legal regulations have not shown tremendous promise in changing this trajectory. While the genes responsible have not yet been researched, allowing genetic modification for this and similar purposes of increasing human resistance to extreme weather-related effects could be extremely beneficial to allowing human populations to effectively adapt and survive as climate changes continue to alter the landscape and ecosystems that humans currently reside in.

There are also several situations where the usage of CRISPR should not be considered. The existence of these topics exists because of the medical and ethical concerns that CRISPR rises. CRISPR is not a cheap resource and thus is not equally accessible to all. Therefore, allowing CRISPR for nonextreme medical purposes could lead to ethical dilemmas about unequal access to this technology. Additionally, there is a valid fear that cosmetic uses of CRISPR could result in a new eugenics movement, allowing individuals to pick certain traits to be prioritized. These fears are justified, and thus the harm that

individuals will face without CRISPR must outweigh these concerns in order to fulfill this second qualification.

Succeeding Generations

CRISPR has the ability to edit genes of an individual that could be inherited by their offspring. This poses several ethical dilemmas about both autonomy and unexpected consequences for their future potential children. However, both of these concerns can be addressed by creating parameters for the uses of CRISPR that would be considered to be acceptable. Firstly, by establishing that CRISPR would be used only in extreme medical circumstances, such as life-threatening diseases or extreme adaptations to climate change, then any future offspring likely would not survive without the existence of their parent's decision to undergo genetic editing, and thus there would be no offspring's autonomy to jeopardize without the use of CRISPR. In these situations, the benefits of CRISPR outweigh the concerns for succeeding generations, and it would be a morally permissible option.

Social Consequences

Lastly, it is important to consider the social consequences of legalizing CRISPR, including the pricing and availability of this technology. Many effects of climate change are already disproportionally affecting the most vulnerable individuals and communities, and thus precautions would need to be taken to ensure that this issue is not simply exacerbated. CRISPR technology must be used in a way that does not just allow the most privileged members of society to continue to take actions that harm the planet without consequences while the environmental and social effects all compile on the most vulnerable.

In order to make sure that social consequences are upheld, equitable distribution of CRISPR technology, pricing, and healthcare systems would need to be established. Without these precautions, there is fear that those who are responsible for more than a proportional aspect of climate change would not feel motivated to change their actions to benefit others and protect the plant and their communities because they would be able to use CRISPR as a way to avoid accountability for their actions. Thus, CRISPR technology should continue to be studyed, but should not become accessible to all until the social aspect of the technology has been addressed.

Reference:
https://www.gao.gov/products/GAO-20-478SP

ETHICAL + LEGAL

1 CRISPR and Its Loose Ends

2 Interview with Mary Windham

3 Climate Change Adaptation

4 Environmental Reproductive Justice

5 IVF Legal Battle: Health Insurance Coverage

6 Drawing the Line: A Legal Nightmare

CRISPR: Is This Right?

By Tiarni Chu

Advanced genome editing technology undoubtedly comes with ethical questions. Should we as the human race be utilizing this kind of technology? Editing a germline of one individual also means that all subsequent generations from that individual will be altered, as changes within the germline are inherited by the next generation. Many people are worried that germline editing will have long-lasting, negative effects.

Currently, the general public approves of somatic gene editing for disease eradication. Somatic cells are those that do not get inherited from parent to child. For example, Dr. Carroll and his team at the Western Washington University in Bellingham are doing research on mice to further investigate Huntington's disease. Huntington's disease is an inherited, degenerative neurological disorder in which a person's cognitive and psychiatric functions decline.

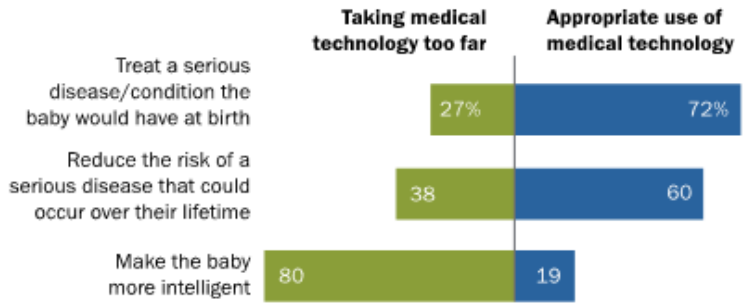
They are concerned with whether preimplantation genetic diagnosis (PGD) and in vitro fertilization (IVF) can be successfully used to eradicate this disease from the human germline by screening embryos before conceiving.

By choosing to implant embryos that do not have the disease mutation, the resulting child would not have the gene for Huntington's disease. This method of using biotechnology would be extremely beneficial to those affected by this disease.

Taken from the Pew Research Center in 2018, this shows a survey of how American adults see human genome editing (Funk and Hefferon, 2018):

A majority of U.S. adults say changing a baby's genes to treat a serious congenital disease is appropriate

% of U.S. adults who say changing a baby's genetic characteristics for each of the following reasons is ...



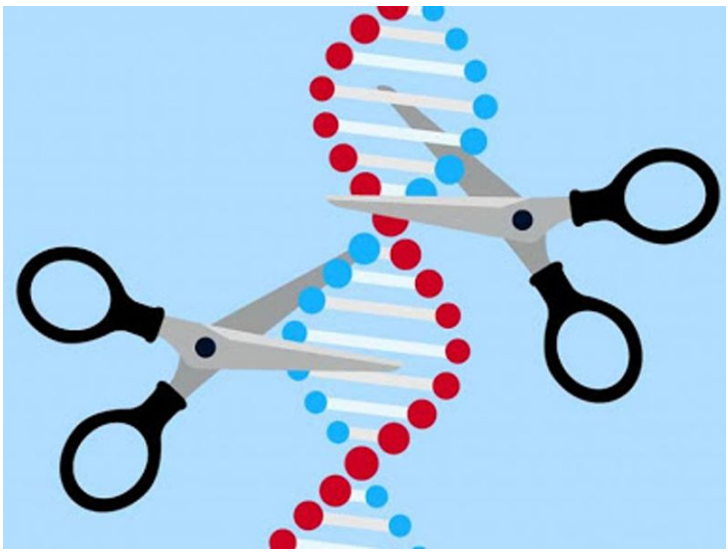
Note: Respondents who did not give an answer are not shown.
Source: Survey conducted April 23-May 6, 2018.
"Public Views of Gene Editing for Babies Depend on How It Would Be Used"

PEW RESEARCH CENTER

When a disease can be eliminated, much of the general public feels that biotechnology should be used for this. In fact, Dr. Bailey of the Johns Hopkins Bloomberg School of Health stated,

> "It may well be unethical for us ***not*** to use CRISPR to treat genetic diseases."

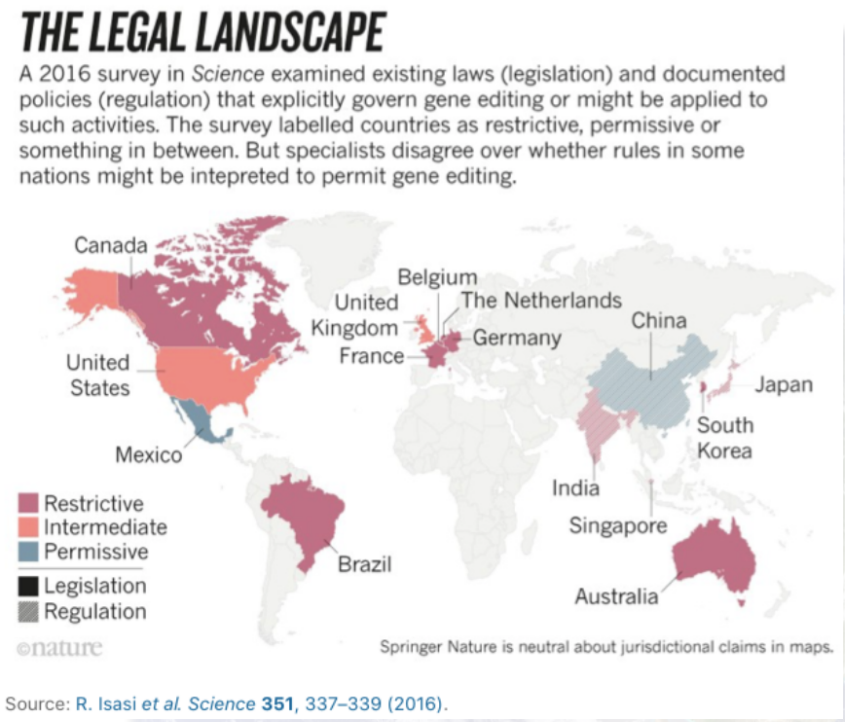
However, CRISPR is not as well studied compared to PGD or IVF and is much more intensive, as it is editing the genomic code of an individual. Human germline editing via CRISPR, compared to using other biotechnology for disease eradication, is not a widely accepted biotechnology. Scientists around the world have announced their disapproval of the 2018 scandal in which Chinese scientist Dr. He unethically developed two babies using CRISPR. The American Society of Human Genetics developed a statement in 2017 on their position of human germline editing. They worked together with different groups of lawyers, bioethicists, genetic counselors, and health service researchers to get a broader understanding of the societal and scientific ramifications of genome editing. ASHG said that "given the nature and number of unanswered scientific, ethical, and policy questions, it is inappropriate to perform germline gene editing that culminates in human pregnancy" (Ormond, 2017). Other global organizations like the Asia Pacific Society of Human Genetics, British Society for Genetic Medicine, Human Genetics Society of Australasia, and Southern African Society for Human Genetics verbalized their support of this.



It is vital to understand how researchers can continue moving forward with CRISPR research while being cognizant of the global socio-ethical perspectives. It's worth noting that there is worry that if gene editing becomes widespread, those who do not have access to such technology may feel ostracized. These global implications of accessibility of science are a part of a larger ethical discussion but should always be taken into consideration when learning about new biotechnologies. It should be thoroughly discussed about how a technology can be best implemented and regulated to benefit all, not just the wealthy that would have easiest access. This begs the question of accessibility of genome editing as a whole.

Human Embryos: International Policy

by Tiarni Chu



Source: R. Isasi *et al. Science* **351**, 337–339 (2016).

There is still much debate about embryonic stem cell research. In the United States, there are restrictions on how embryos can be used in research. The National Institutes of Health (NIH) is the largest funder for biomedical research with an annual budget of $40 billion (Matthews, 2020), and the NIH is not allowed to provide federal funding to any research projects that involve the "manipulation or destruction of human embryos for research purposes" (Kearl, 2018). This means that, technically, CRISPR research on embryoscould be done but it must be funded through means outside the government. The Food and Drug Administration (FDA) does not approve research for drugsor biological products involving the manipulation or destruction of human genomes (Cohen & Adashi, 2016).

These regulations are quite important for this discussion, as how researchers can obtain funding for embryonic research will drive the conversation about how reproduction can be shaped by climate change. To complicate it further, each country has different policies regarding embryonic research and there is no international agreement; for example, out of the 22 top investing countries in research and development, 12 countries have a 14-day limit on how old the embryo of research interest is, 1 has a 7-day limit, five has prohibitions, four do not have any national guidelines (Matthews, 2020). This calls for more international collaboration to be done before intense research presumes in the direction of human embryonic research.

Interview with Mary Windham

by Elizabeth Tanner

I got the chance to speak with Mary Windham, a bioethics professor and medical professional, to discuss what ethical barriers and legal policies would need to be addressed in order for scientists and politicians alike to consider the expansion of genetic editing technology usage. Professor Windham established that "ethics should have a certain measure of coherence and stability to it," however, it "is not like math, it's not like two plus two equals four. You will never get that certainty, so don't look for it." Thus, the best way to determine the social and moral obligation dilemmas that arise from contemplating the use of genetic editing technologies is to create standards to mitigate risk factors that are inherently present with all scientific progress.

In technology advancement, "There is a subtle but significant driver to go towards a standard of perfectionism and thus Professor Windham believes discussions regarding gene editing always have the "slippery slope" fear.

"Every single ethical decision I make is not made in a vacuum, it is made through picking up as many pieces of evidence as I can and thinking through it."
- Mary Windham

The fears of the slippery slope must be avoided by creating guidelines to regulate use. However, these guidelines must as be accompanied by careful consideration on a case-by-case level. Professor Windham says that "every single ethical decision I make is not made in a vacuum, it is made through picking up as many pieces of evidence as I can and thinking through it," and thus these regulations must allow flexibility depending on the context. However, it is first important to make overall general regulations for the most straightforward cases.

More specifically, a regulation that this paper argues has the strongest moral basis is genetic editing for the purpose of Professor Windham stated that "therapies that advance the eradication of known diseases would be apparently... an upside for humanity," suggesting that these specific scenarios could be within the criteria for when the potential benefits of CRISPR would be capable of overpowering the potential harms- depending on the status of the technology. However, treatments that are purely cosmetic or for personal enhancement would not be morally permissible and could lead to extremely hazardous repercussions similar to the Eugenics movement.

Climate Change Adaptation: Evolution v. CRISPR-Cas9

by Eryn Wilkinson

Climate Change and CRISPR-Cas9

In November 2018, the world's first genetically edited babies were born, causing scientific uproar and a complete halt in all CRISPR research aimed toward genetically-editing humans (Begley et. al, 2018).

This was the first ever use of CRISPR to edit the human genome, and the twins Nana and Lulu had their genomes genetically modified to block HIV infection. However, this was highly controversial, as the research had not been approved by an ethical board, and the use of CRISPR on humans was still extremely risky (Cohen et. al, 2019).

While it will take time to evaluate the full effects of using CRISPR on the twins, the imminent climate crisis has led to the reopening of the discussion of using CRISPR to edit the human genome (Lehmann, 2021).

According to the American Medical Association Journal of Ethics, researchers have been able to successfully pinpoint specific mutations associated with disease that can be edited using CRISPR-Cas9 technology (Lehmann, 2021).

This has led others to speculate as to the potential of using the same technology to improve our ability to adapt to climate change. With increased disease resistance and protection from increasing temperatures, humans could increase survival rates and implement much quicker and more accessible solutions.

Climate Change and Evolution

Plants and animals, including humans, have adapted to environmental pressures and changes throughout history, resulting in the evolution of species as discovered by Charles Darwin in 1859. Changes in the environment, as well as a complete change in lifestyle has caused humans to evolve a decreased average body temperature over time, most likely because of decreased metabolic rates (Lee, 2020).

Humans may also be able to adapt to increasing global temperatures eventually, although the current rate of climate change is occurring much faster than the typical rate of evolution. While the use of CRISPR-Cas9 is a tempting solution, the process of evolution is so complex that to genetically alter the human genome could interfere with the natural process of evolution in conflicting and potentially dangerous ways (Almeida et. al, 2019).

A Discussion of Environmental Reproductive Justice

by Eryn Wilkinson

Environmental conditions disproportionately impact the reproductive health of women, minorities, and other marginalized groups in our society

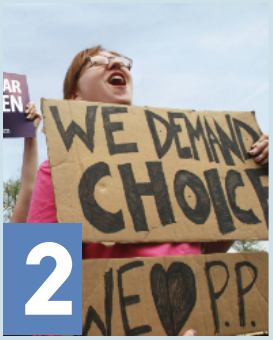
1 The Sierra Club has a history of exclusion, racism, and xenophobia that has interfered with access to environmental reproductive justice for many groups (Hopkins, 2018).

2-3 Women fight for their right to (not) have children, to parent with dignity, and to reproduce regardless of class, race, gender, sexuality, or disability (Lappé et. al, 2019).

4-6 Birth-strikers refuse to reproduce until action is taken around climate change; this is one extreme way in which climate change activists fight for change (Barratt, 2019).

7 Indigenous groups have lead the way for thinking about environmental and reproductive justice as a single rather than separate movements (Lappé et. al, 2019).


1



2

3

4

5

6

7

"It would require a shift in the kind of value structure that we currently operate commerce and industry on."

"Is there a human right to a healthy environment for conception and development?"

"I am an eternal optimist."

- Dr. Hannah Landecker, University of California of Los Angeles, Institute of Society and Genetics

PREGNANCY and CLIMATE CHANGE

The PROBLEM

Climate change worsens air pollution and extreme weather which can have severe impacts on health during and after pregnancy including:

- PRETERM BIRTH
- LOW BIRTHWEIGHT
- STILL BIRTH
- EFFECTS ON BRAIN DEVELOPMENT

What WE CAN DO

Advocate for public policies that lead to:

- GLOBAL REDUCTION IN AIR POLLUTION EMISSIONS
- STEADY DIVESTMENT FROM FOSSIL FUELS
- REDUCING TOXIC EXPOSURES

> *"The health impacts of our global climate crisis on maternal and child health can no longer be ignored."*
>
> *International Federation of Gynecology and Obstetrics (FIGO)*

FIGO International Federation of Gynecology and Obstetrics

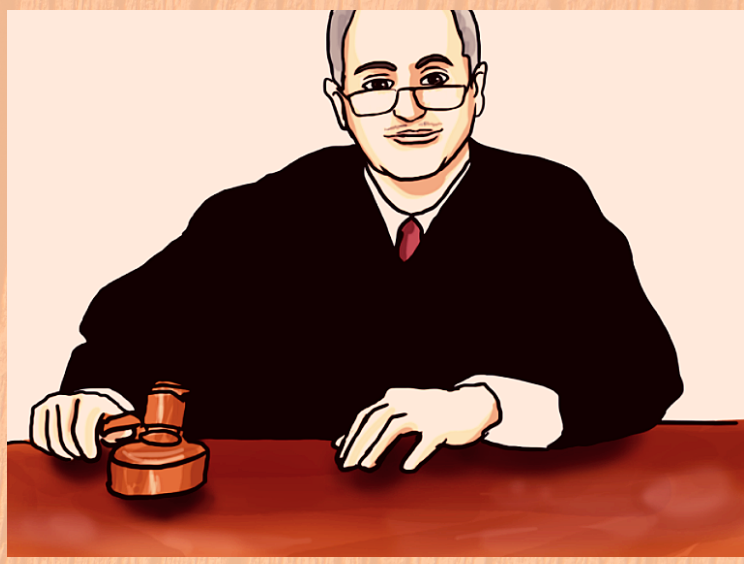
HEAL HEALTH AND ENVIRONMENT ALLIANCE

UCSF Program on Reproductive Health and the Environment

IVF Legal Battle: Health Insurance Coverage

by Shanmitha Arun

KNIGHT V. HAYWARD UNIFIED SCHOOL DISTRICT

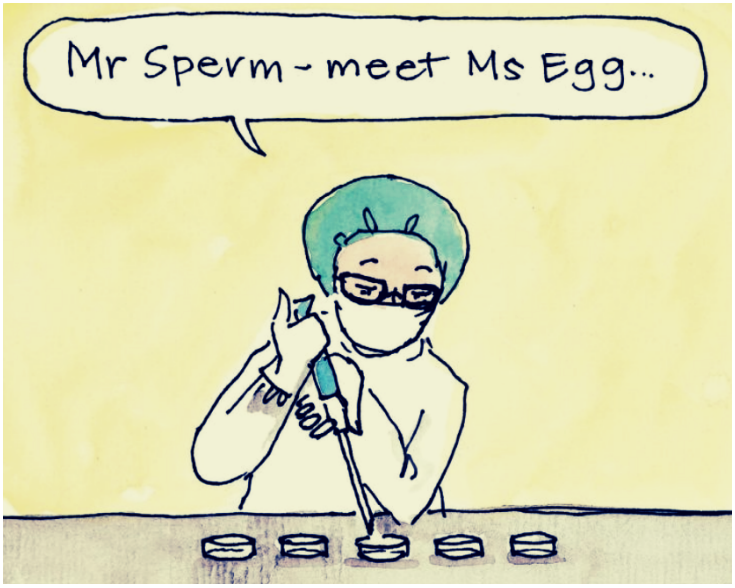


A teacher's claim arose from the fact that the group health insurance policy provided by the district to its employees did not cover in vitro fertilization (IVF) treatment, which the teacher and his wife were obliged to obtain at their own expense. The discrimination at issue was only suffered by individuals, like the teacher and his wife, who experienced types of infertility not responsive to forms of treatment covered by the plan, and were treatable only through IVF. However, because everyone participating in the plan received the same coverage for infertility treatment, the plan was not a disability-based distinction.

This court case brings up the issue of health insurance policies specifically not covering IVF. Without health insurance coverage, IVF is not an accessible treatment for many. The average cost of an IVF cycle in the U.S. is about $12,400 (Sifferlin, 2017). Even an appointment with a fertility specialist can cost anywhere from $200-400. Not only is IVF an extremely costly option, it is also not accessible to many women in the United States as 18 million women live in an area where there are no ART clinics (Sifferlin, 2017). In order for IVF to be a viable option as the reproduction of the future, health insurance coverage policies must change and the costs overall must be reduced.

Drawing the Line: A Legal Nightmare

by Shanmitha Arun



WRONGFUL BIRTH CLAIMS

B.F. v Reproductive Medicine Assoc. of N.Y.

This court case from 2015 talks about a wrongful birth claim based on inadequate genetic screening of an egg donor for an in vitro fertilization procedure. The parents were seeking financial compensation for raising an "impaired" child. This case brings up the idea of "Where do we draw the line? Should genetic testing be done to prevent certain syndromes? If so, which ones?"

LAWS AND REGULATIONS

Global Scale

Climate change is a global problem that requires a global solution; however, across-border regulations are hard to achieve. It is important to understand the differences between different countries and what is deterring an overall global understanding. A survey of more than 100 countries looking at the rules and regulations relating to assisted conception, particularly IVF, found that some countries have higher numbers of multiple pregnancy because of the number of embryos they transfer during assisted conception (Mashta, 2010). A number of countries only have professional guidance and about a third have no regulations at all. To move forward, global regulations and policies must be required to protect IVF patients.

Societal implications

1 *IVF: Socioeconomic Classism*

Developing Nations 2

3 *Birthing Process*

Impact on the Gender Spectrum 4

IVF: Socioeconomic Classism

by Shanmitha Arun

While it is monumental that scientific treatments such as In-Vitro Fertilization (IVF) have been created to help those unable to bear children, it is essential to understand issues like commodification of the womb as they intersect with infertility biotechnology. This imagined world of using IVF and CRISPR to protect babies against the changing climate may only be accessible to people of higher socioeconomic status. Unless the costs of these technologies are drastically reduced and it becomes accessible to all individuals, our world will become more unjust and inequitable.

"New mental health issues may arise, or preexisting mental health issues may become more severe or worsen during IVF treatment. Emotional support and open and honest dialogue about the stressors of infertility should be established. "
-Dr. Aaron Styer

"We sign the contract but nobody reads it to us. And if there's a literate person in the room, they ask them to wait outside. They (clinic) say if you don't want to sign then we'll find somebody else. But I am majboor (compelled by my situation)."
-Surrogate from India

WHO IS INVOLVED?

Doctors, clinics, regulatory agencies, insurance companies, governments, donors, potential surrogates, intended parents, and intended children

It is important to think about all the parties involved and what role they play.

WHO GETS TREATMENT?

- People who can afford it
- Depending on the country, only heterosexual couples and non-single individuals

BIOETHICAL PRINCIPLES

JUSTICE: regulatory differences exist between countries where assisted reproduction is/is not permitted for single women or same-sex couples; cost makes it hard for lower socioeconomic status couples to get the treatment

BENEFICENCE + NONMALEFICENCE: ownership of stored gametes and embryos; surrogates have medical complications; mental and physical health effects of hormones

AUTONOMY: informed consent; international surrogates get taken advantage of

Indigenous Peoples: Legal Frameworks and Cultural Tradition

by Eryn Wilkinson

Indigenous Peoples are defined by the United Nations as sectors of society determined to preserve, develop, and transmit to future generations their ancestral territories, and their ethnic identity, as the basis of their continued existence as peoples, in accordance with their own cultural patterns, social institutions, and legal systems (Hymowitz et. al, 2003). Indigenous tribes have sovereignty, meaning that they have the right to choose their own political and legal organization.

However, there are still legal barriers that prevent indigenous peoples from having full authority over their tribal territory, and contribute to the continued injustice experienced by indigenous tribes (Norton-Smith et.al, 2016).

"For [indigenous people] climate justice, multispecies environmental awareness, and reproductive advocacy are not, and have not been, separate domains." - Lappe et. al, 2019

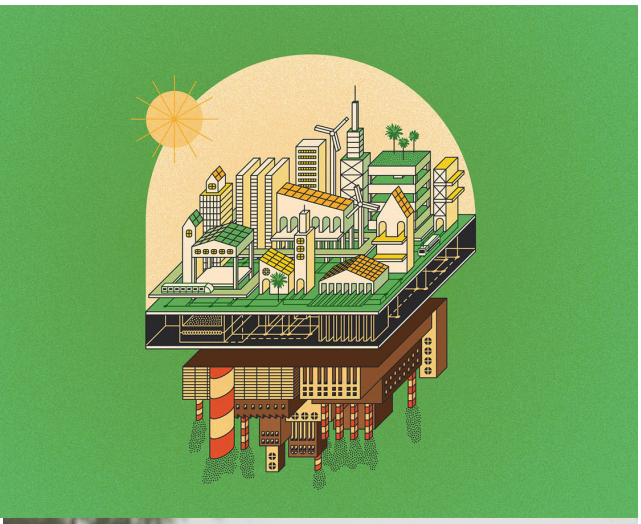
Climate-change adaptation within indigenous communities has been severely limited by Federal policies that restrict indigenous tribes' access to culturally important resources and options for conservation (Hoover et. al, 2012).

According to the National Congress of American Indians, indigenous communities are also disproportionately affected by negative health impacts caused by climate change, especially those societies in coastal and river flood plains who are more dependent on climate-sensitive resources (*"Climate Change"*, 2021).

Yet, tribal wisdom and cultural practices that have been acquired over centuries offer an invaluable resource to climate-scientists, and indigenous perspectives should be taken into consideration by policy makers addressing the current global crisis.

Developing Nations: Global Policies

by Eryn Wilkinson



Historically, developing countries have contributed little to carbon emissions, but require greater energy demands to reduce poverty and support growing populations ("*What's the Role*", 2019). The Paris Agreement has obtained commitments from both developed and developing nations who have self-identified ways to reduce carbon emissions, but the inequalities that disadvantage developing countries' abilities to transition to low-carbon development must also be considered ("What's the Role", 2019).

One proposal to address climate change responsibility is the Green New Deal in the United States, which places the U.S. in a leading role for reducing emissions as a result of its high level of technological advancement and disproportionate amount of greenhouse gas emissions (Dsouza, 2020).

Yet, policies fostering climate change action have been met with resistance due to the expensive cost of implementation and intense political gridlock. As time passes, global warming continues to increase temperatures, extreme weather events increase in frequency, and developing nations continue to experience disproportionate harms of climate change (source).

One of these impacts is decreased crop yield due to extreme temperatures, which, in countries with rapidly growing populations, only contributes to the problem of malnutrition (Moses, 2019).

Agricultural scientists have previously posited the use of genetically modified crops using CRISPR-Cas9 and other genetic editing technologies in order to increase the quality and amount of food grown in these developing countries; however, according the the Genetic Literacy Project, these innovations have been blocked by Western environmentalist groups promoting organic agriculture (Moses, 2019).

With the proposal for the genetic editing of crops resurfacing in the face of climate change, the ethical implications of now using CRISPR in developed nations becomes a concern.

Why the future is ours to mold: The Birthing Process

AN INTERVIEW WITH STEPHANIE KIESOW
BY SHANMITHA ARUN

-How has the birthing process shifted from home births to hospitals? What impact has this had on society and women, in particular?

In the United States during the early 20th century there was a transition away from home births towards birthing in the hospital. By shifting the environment into the hospital setting, birth became more "medicalized", operative interventions increased, and new technologies were introduced. Through the use of these new medical technologies, doctors and patients began to depend on the data they were receiving to monitor both mother and child, ultimately placing the birthing experience even more in the hands of the hospital staff. It could also be said that this shift may have decreased the "intuitive knowing" women hold of their pregnancy and labor.

Additionally, the environment in the hospital is different compared to that at home. For example, hospitals often have very bright lights which are not conducive to labor and women are often instructed to push in positions that may not feel intuitive (such as on their backs) in order for the doctor to be able to see more clearly.

As a doula, what do you feel are the most important parts of the birthing process and what is important to preserve?

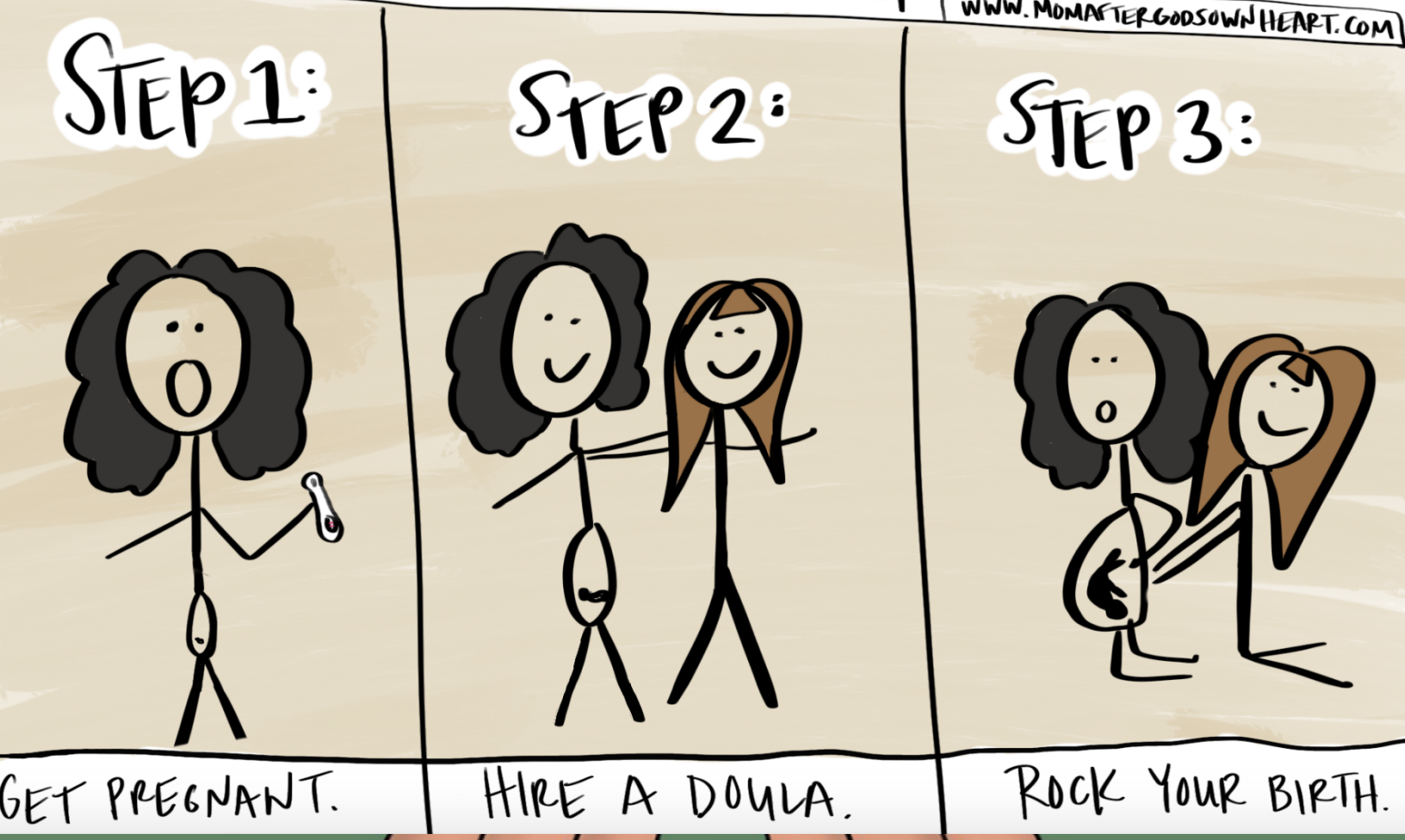
I believe that one of the most important parts of the birthing process is to have the pregnant person feel empowered in their decisions and supported by their team during labor.

How would this reimagined world with IVF and CRISPR shift the birthing process further? Will it become more medicalized and do you see this being a potential problem?

In this reimagined world, it will be important to provide equal access and care to the pregnant person regardless of who received IVF/CRISPR in order to avoid widening the gap of maternal and child health disparities. Perhaps, those who received this treatment will be under more specialized care with enhanced scrutinization through the use of new medical technologies. This, in turn, could possibly lead to a cascade of interventions (where one intervention causes a result which then requires another intervention to take place).

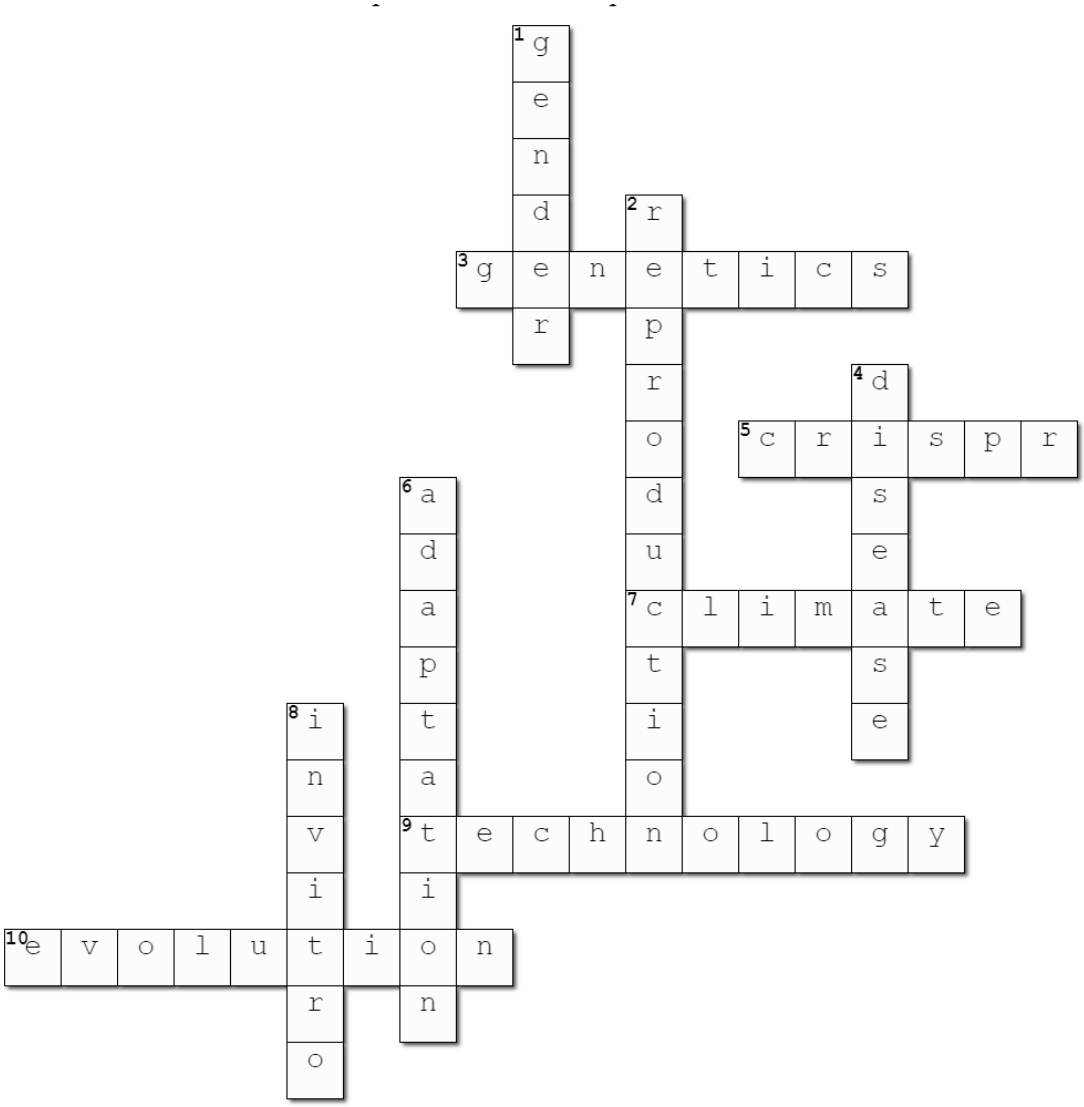
Three steps to an empowered birth

WWW.MOMAFTERGODSOWNHEART.COM



Climate Change and Reproduction Technology

CROSSWORD ANSWERS



Created using the Crossword Maker on TheTeachersCorner.net

Across

3. The study of heredity and genes (**genetics**)
5. Technology used by He Jiankui (**crispr**)
7. The global weather patterns (**climate**)
9. Mechanical, electronic, medical, communications (**technology**)
10. Changes over time (**evolution**)

Down

1. A range of identities (**gender**)
2. Making a copy of something (or someone) (**reproduction**)
4. Vaccinations can prevent some of these (**disease**)
6. Opposable thumbs (**adaptation**)
8. Opposite of In Vivo (**invitro**)

Gender Spectrum, Not a Binary

By Tiarni Chu

With climate change becoming a pressing issue, we look towards reproductive biotechnologies. However, these technologies have large implications on how future generations identify themselves, as there are many questions regarding the extent to which we can use these methods ethically. Gender and sex are related but cannot equate one another. The concept of gender has evolved overtime:

Gender is "undergoing seas of change-- people aren't one or the other, but perhaps neither, or maybe both."
- Steinmetz

There was a pre-existing assumption that gender and sex are the same thing and the maleness or femaleness of an individual was based on their genitalia. However, this two-toned perspective can be restraining and harmful to those who fall outside of the binary. Now, gender is better understood and more widely accepted as a spectrum instead of a binary. It can be especially dangerous when a society perpetuates gender roles or expectations onto those who fall within it, as there is societal pressure to behave in a certain manner regardless of how anyone personally feels about gender.

Family balancing is the medical practice of couples choosing the sex of their pregnancy before implantation via IVF. Yet, the practice of family balancing can enforce heteronormativity (which is believing that only two sexes exist, male and female, these sexes coordinate with two genders of man and woman, and the genders are associated with predetermined behaviors and attitudes). Heteronormativity is then considered dangerous, as it "delegitamizes people who do not conform to [it], that is, intersex people, trans-people, gender-fluid people, non-binary people, and all people with non-normative sexualities. Using biotechnologies to alter future generations can undermind the complexity of gender.

Heteronormativity endangers people passively through processes of ignoring or failing to recognize, but more often actively, via erasure and silencing, and employing shaming and violence as punishment for non-compliance" (Shahvisi, 2018). Parental preference for having a child of a certain sex and the medical practice of choosing the sex of a child may not directly harm anyone, but it places a value on gender and enforces gender roles, which can be harmful. Family balancing is toying the more than just sex selection but the understanding and treatment of gender.


Photo Credit Anna Parini

5 ways IVF has changed the world

by Shanmitha Arun

1. Normalizing conception in a petri dish
2. Opened the gateway to the field of embryo research
3. Sparked debate on moral status of embryo
4. Paved the way for stem cell research
5. Forced us to think about genetic screening

Looking Forward

1 *Alternate Solutions*

Conclusion 2

Alternate Solutions

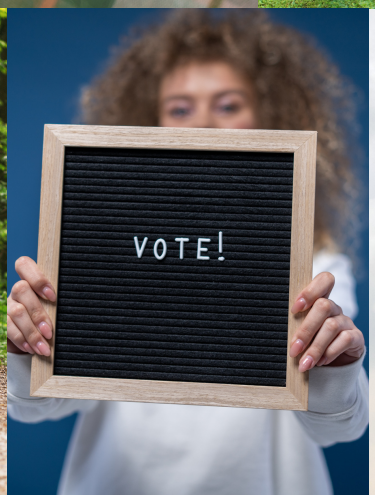
By Elizabeth Tanner

Investing in genetic modification as a solution to the world's climate change problems is not the only option remaining, and we still have time to take dramatic action to reverse the effects of climate change. Individuals and corporations both hold power and the ability to take action to mitigate the effects of Climate change.

Individual Impacts

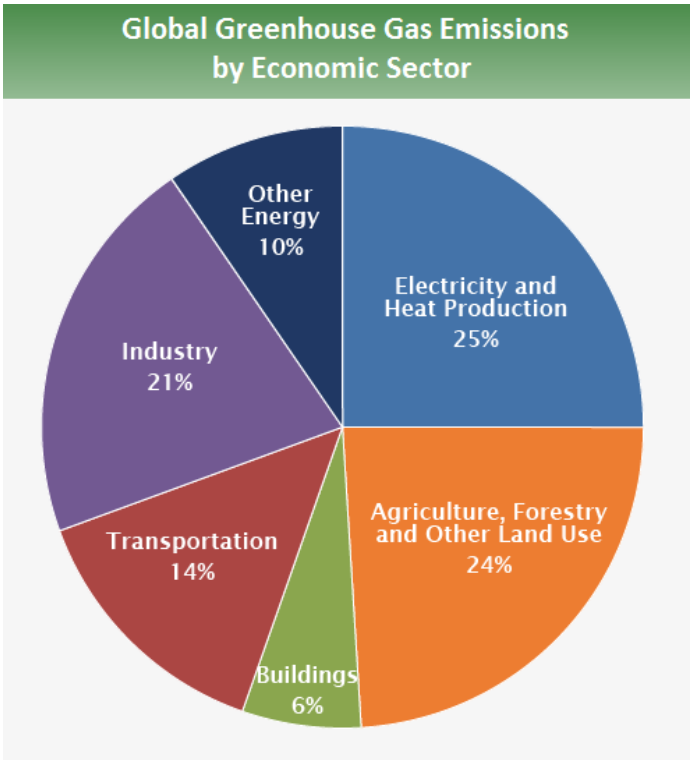
While many greenhouse emissions and climate change intensifiers are predominately caused by corporations, there are several types of ways that individuals can directly decrease their own climate impact.

Some of these ways include:
(1) Transitioning to a plant-rich diet
(2) Reducing your food waste by shopping only for what you will eat or creating a compost bin for food and yard waste scraps
(3) Opting for sustainable transportation options
(4) Advocacy and supporting local/sustainable businesses
(5) Supporting transitions from fossil fuels and nonrenewable energy sources in your communities and corporations



Governmental and Corporation Impacts

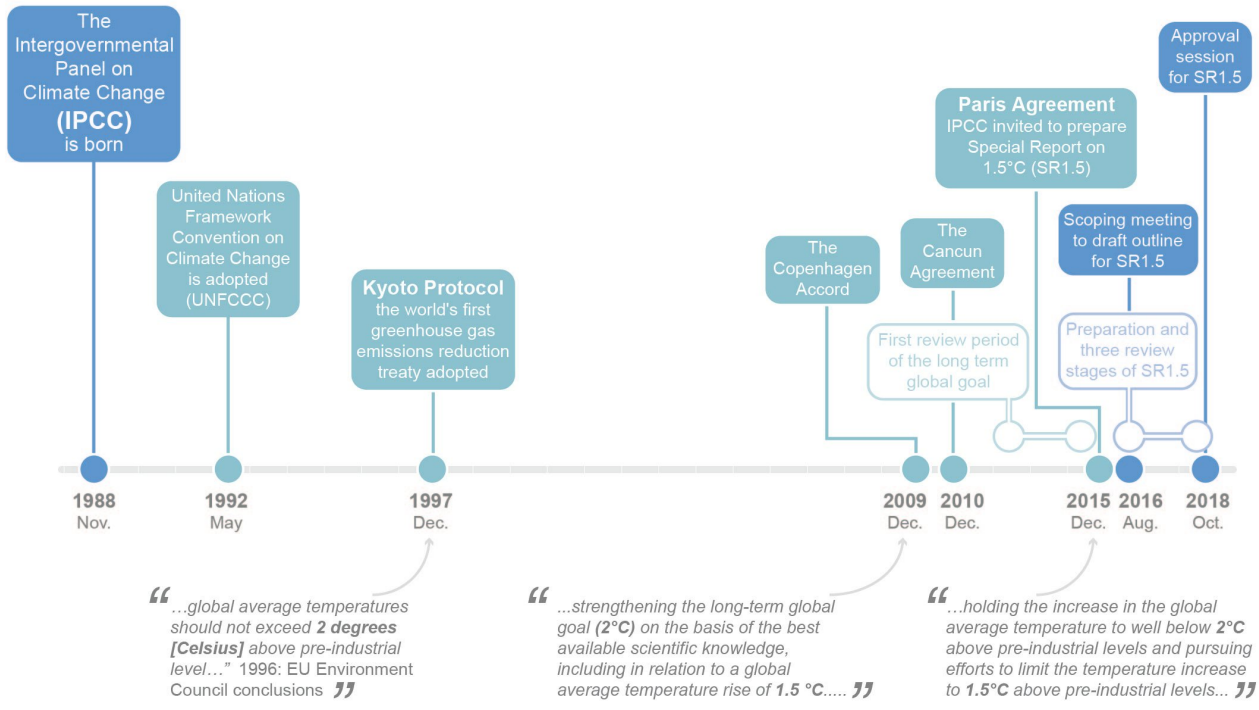
While individual actions can make a difference, a large proportion of Global Greenhouse emissions are not due to individual actions, but actions of governments or corporations. Thus, it is important to ensure that those responsible for these emissions are accurately held responsible for their actions.



Mitigation

The state of the Earth's climate continues to worsen, however, it is not too late to address these issues. Thus, before genetic editing should be considered, it is important to discuss the ways in which current climate issues could be mitigated through legal or social actions.

The Paris Agreement, signed in 2015 by 195 countries, imposes standards of action and for these countries in order to limit greenhouse gas emissions. This treaty aims to reduce emissions in a way that will not harm the economy or equity while helping the environment and country's agreements vary based on their specific conditions. Unfortunately, 6 years have passed since the Paris Agreement was created and many countries are not on track to reach their goal, suggesting humans may face irreversible damage to our climate that would make genetic editing the best remaining option to adapt to the effects of climate change.



Reference: https://www.ipcc.ch/sr15/faq/faq-chapter-1/

Conclusion

"You cannot get through a single day without having an impact on the world around you. What you do makes a difference and you have to decide what kind of a difference you want to make."
- Jane Goodall

Where do we go from here?

In a 2019 volume of the Journal of Law and Biosciences, Henry Greely dissected how the scientific community can possibly move forward with human embryonic research after Dr. He Jiankui used genetic alteration on babies without proper, ethical practice. Greely proposed "scientific snitching bodies" that are the official organizations to act on reports of suspicious behavior on scientists and have the power to intervene during potential problematic research projects (2019). Our group proposes the development of these official organizations, such these undoubtedly have the potential to prevent projects similar to Dr. He's from going as far as it did. A "scientific snitching body" will intergrate a system of regulation surrounding ethical dilemmas in research. The idea of having an official organization or group of people to report concerning behavior of scientists could provide a lot of security to the public about new, upcoming biotechnologies, knowing that there are more regulations put in place after what happened with Dr. He's research.

There should be ample room for inclusive societal debate before research moves forward. There needs to be international legislation and agreement about how far research is allowed to go, as sometimes new biotechnologies turn into a national weapon in the international scope. In reality, we should be looking forward to advancing the human race as a whole instead of considering different nations as different forces. As a scientific community, we should be considering broadly about societal and ethical implications when discussing the future of human germline editing. With extensive consideration as to how certain research can affect our modern day society, we hope our project provides insightful evidence as to how human germline editing can bring benefits to the world.

References: Background

Center for Climate Change and Health. "Climate Change 101-: Climate Science Basics." A Physician's Guide to Climate Change, Health and Equity, Sept. 2016, https://climatehealthconnect.org/wp-content/uploads/2016/09/Climate101.pdf.

Hannah, Lee. Climate Change Biology. Second ed., Elsevier Academic Press, 2015, Science Direct, www.sciencedirect.com/book/9780124202184/climate-change-biology?via=ihub=.

NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2021). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73

Short, Erica E, et al. "Climate Change Contribution to the Emergence or Re-Emergence of Parasitic Diseases." Infectious Diseases: Research and Treatment, vol. 10, 1 Jan. 2017, doi:10.1177/1178633617732296.

Vidyasagar, Aparna. "What is CRISPR?" LiveScience, 21 April, 2018, https://www.livescience.com/58790-crispr-explained.html.

American Association for the Advancement of Science. CRISPR-Cas9: Engineering a Revolution in Gene Editing. American Association for the Advancement of Science
Custom Publishing Office, 2014.

Banan M. "Recent advances in CRISPR/Cas9-mediated knock-ins in mammalian cells."

Journal of Biotechnology, vol. 308, 20 Jan. 2020, pp. 1-9. ScienceDirect, https://doi.org/10.1016/j.jbiotec.2019.11.010. Accessed 28 Jan. 2021.

Dekkers, J., et al. "Modeling Breast Cancer Using CRISPR-Cas9-Mediated Engineering of Human Breast Organoids."Journal of the National Cancer Institute vol. 112, no. 5, pp. 540-544. 1 May 2020, doi: 10.1093/jnci/djz196.

Cyranoski, David. "The CRISPR-baby scandal: what's next for human gene-editing." Nature vol. 566, 28 Feb. 2019. Doi: 10.1038/d41586-019-00673-1.

"Assisted Reproductive Technology: The Fast Facts." Adoptive Families, 30 Aug. 2019, www.adoptivefamilies.com/how-to-adopt/assisted-reproductive-technology-fast-facts/.

American Association for the Advancement of Science. CRISPR-Cas9: Engineering a Revolution in Gene Editing. American Association for the Advancement of Science
Custom Publishing Office, 2014.

"In Vitro Fertilization (IVF)." Mayo Clinic, Mayo Foundation for Medical Education and Research, 22 June 2019, www.mayoclinic.org/tests-procedures/in-vitro-fertilization/about/pac-20384716.

Johnson, Martin. "Human in Vitro Fertilisation and Developmental Biology: a Mutually Influential History." Development, vol. 146, no. 17, 5 Sept. 2019, doi:10.1242/dev.183145.

Banan M. "Recent advances in CRISPR/Cas9-mediated knock-ins in mammalian cells."
Journal of Biotechnology, vol. 308, 20 Jan. 2020, pp. 1-9. ScienceDirect, https://doi.org/10.1016/j.jbiotec.2019.11.010. Accessed 28 Jan. 2021.

Dekkers, J., et al. "Modeling Breast Cancer Using CRISPR-Cas9-Mediated Engineering of Human Breast Organoids." Journal of the National Cancer Institute vol. 112, no. 5, pp. 540-544. 1 May 2020, doi: 10.1093/jnci/djz196.

Cyranoski, David. "The CRISPR-baby scandal: what's next for human gene-editing." Nature vol. 566, 28 Feb. 2019. Doi: 10.1038/d41586-019-00673-1.

Vidyasagar, Aparna. "What is CRISPR?" LiveScience, 21 April, 2018, https://www.livescience.com/58790-crispr-explained.html.

Zhu, Tian. "The Embryo Project Encyclopedia." In Vitro Fertilization | The Embryo Project Encyclopedia, 22 July 2009, embryo.asu.edu/handle/10776/1665.

References: Adaptation

Barreca, Alan, et al. "Maybe Next Month? Temperature Shocks, Climate Change, and Dynamic Adjustments in Birth Rates." National Bureau of Economic Research, Oct. 2015, doi:10.3386/w21681.

Berrang-Ford, Lea, et al. "Are We Adapting to Climate Change?" Global Environmental Change, vol. 21, no. 1, Feb. 2011, pp. 25–33., doi:https://doi.org/10.1016/j.gloenvcha.2010.09.012.

Climate Action Network. "Social Impacts." Climate Action Network, 2020, climateactionnetwork.ca/issues/impacts-and-adaptation/learning-cente/global-impacts/social-impacts/#:~:text=The%20health%20of%20human%20beings,cause%20death%2C%20disability%20and%20suffering.

Fawzy, Samer, et al. "Strategies for Mitigation of Climate Change: a Review." Environmental Chemistry Letters, vol. 18, no. 6, 30 July 2020, pp. 2069–2094., doi:https://doi.org/10.1007/s10311-020-01059-w.

Lehmann, Lisa. "Is Editing the Genome for Climate Change Adaptation Ethically Justifiable?" AMA Journal of Ethics, vol. 19, no. 12, 2017, pp. 1186–1192., doi:10.1001/journalofethics.2017.19.12.stas1-1712.

Lehmann, Lisa. "Using the 4-S Framework to Guide Conversations With Patients About CRISPR." AMA Journal of Ethics, vol. 21, no. 12, 2019, doi:10.1001/amajethics.2019.1029.

Li, Yun, et al. "Genome-Wide CRISPR Screen for Zika Virus Resistance in Human Neural Cells." Proceedings of the National Academy of Sciences, vol. 116, no. 19, 2019, pp. 9527–9532., doi:10.1073/pnas.1900867116.

Patrão Neves, Maria, and Christiane Druml. "Ethical Implications of Fighting Malaria with CRISPR/Cas9." BMJ Global Health, vol. 2, no. 3, Aug. 2017, p. e000396. DOI.org (Crossref), doi:10.1136/bmjgh-2017-000396.

Regalado, Antonio. "China's CRISPR Babies: Read Exclusive Excerpts from the Unseen Original Research." MIT Technology Review, MIT Technology Review, 2 Apr. 2020, www.technologyreview.com/2019/12/03/131752/chinas-crispr-babies-read-exclusive-excerpts-he-jiankui-paper/.

Semenza, Jan C., and Bettina Menne. "Climate Change and Infectious Diseases in Europe." The Lancet Infectious Diseases, vol. 9, no. 6, June 2009, pp. 365–75. ScienceDirect, doi:10.1016/S1473-3099(09)70104-5.

Solomon, Scott. "Climate Change Could Affect Human Evolution. Here's How." NBC News Mach, 2018, www.nbcnews.com/mach/science/climate-change-could-affect-human-evolution-here-s-how-ncna907276.

Slenning, B. D. "Global Climate Change and Implications for Disease Emergence." Veterinary Pathology, vol. 47, no. 1, 1 Jan. 2010, pp. 28–33., doi:https://doi.org/10.1177/0300985809354465.

References: Ethical + Legal

Climate Action Network. "Social Impacts." Climate Action Network, 2020, climateactionnetwork.ca/issues/impacts-and-adaptation/learning-cente/global-impacts/social-impacts/#:~:text=The%20health%20of%20human%20beings,cause%20death%2C%20disability%20and%20suffering.

Climate Justice Resilience Fund. "Indigenous Communities Are at the Forefront of Climate Resilience." Climate Change News, www.climatechangenews.com/2019/11/28/indigenous-communities-forefront-climate-resilience/.

Dunne, Daisy. "Mapped: How Climate Change Disproportionately Affects Women's Health." Carbon Brief Clear on Climate, www.carbonbrief.org/mapped-how-climate-change-disproportionately-affects-womens-health.

Ormond, K., et al. "Human Germline Genome Editing." American journal of human genetics vol. 101, 2 (2017): 167-176. doi:10.1016/j.ajhg.2017.06.012

Funk, C. & Hefferon, M. "Public Views of Gene Editing for Babies Depend on How It Would Be Used." Pew Research Center, 26 July 2018. https://www.pewresearch.org/science/2018/07/26/public-views-of-gene-editing-for-babies-depend-on-how-it-would-be-used/.

Ledford, H. "CRISPR babes: when will the world be ready?" Springer Nature, 19 July 2019. https://www.nature.com/articles/d41586-019-01906-z.

Olson, E., Terry, S., Topol, E., et. al. "Should CRISPR be used to edit human genes to treat genetic diseases?" Hopkins Bloomberg: Public Health, Johns Hopkins School of Public Health, March 2019, https://magazine.jhsph.edu/2019/should-crispr-be-used-edit-human-genes-treat-Genetic-diseases.

Bailey, S. "Open Source: Should CRISPR be used to edit human genes to treat genetic diseases?" Hopkins Bloomberg Public Health, 13 February 2019. https://magazine.jhsph.edu/2019/should-crispr-be-used-edit-human-genes-treat-genetic-diseases

Matthews, K. "National human embryo and embryoid research policies: a survey of 22 top research-intensive countries." Regenerative Medicine, vol. 15, no.7 (17 August 2020). Doi: https://doi.org/10.2217/rme-2019-0138

Kearl, Megan. "Dickey-Wicker Amendment, 1996." The Embryo Project Encyclopedia, Arizona Board of Regents, 4 July 2018, embryo.asu.edu/pages/dickey-wicker-amendment-1996.

Cohen, I. and Adashi, D. "The FDA is prohibited from going germline." Science, vol. 353, 6299 (5 Aug 2016): 545-546. doi: 10.1126/science.aag2960.

Callaway, E. (2016). UK scientists gain licence to edit genes in human embryos. Nature News, 530(7588), 18. doi:10.1038/nature.2016.19270

B.F. v Reproductive Medicine Assoc. of N.Y., LLP, 136 A.D.3d 73, 22 N.Y.S.3d 190, 2015 N.Y. App. Div. LEXIS 9367, 2015 NY Slip Op 09370 (Supreme Court of New York, Appellate Division, First DepartmentDecember 17, 2015, Entered). advance.lexis.com/api/document?collection=cases&id=urn:contentItem:5HMJ-XY91-F04J-70XS-00000-00&context=1516831.

Knight v. Hayward Unified School Dist., 132 Cal. App. 4th 121, 33 Cal. Rptr. 3d 287, 2005 Cal. App. LEXIS 1339, 2005 Cal. Daily Op. Service 7691, 2005 Daily Journal DAR 10375, 17 Am. Disabilities Cas. (BNA) 17, 2 Accom. Disabilities Dec. (CCH) 12-034 (Court of Appeal of California, First Appellate District, Division TwoAugust 24, 2005, Filed). advance.lexis.com/api/document?collection=cases&id=urn:contentItem:4GY9-P8B0-0039-44NJ-00000-00&context=1516831.

Sifferlin, Alexandra. "Millions of Women Don't Have Access to Fertility Treatments." Time, Time, 14 Mar. 2017, time.com/4701023/fertility-treatments-ivf/.

Asplund, Kjell. "Use of in vitro fertilization—ethical issues" Upsala Journal of Medical Sciences, 125:2, Nov. 2019, pp. 192-199, DOI: 10.1080/03009734.2019.1684405Sinha,

Vaishali and Rebecca Haimowitz, directors. Made in India, Chicken&Egg Pictures, 2010, madeinindiamovie.com/.

Begley, Sharon, et al. "'CRISPR Babies' Scientist He Jiankui Rose from Obscurity to Stun the World." STAT, 17 Dec. 2018, https://www.statnews.com/2018/12/17/crispr-shocker-genome-editing-scientist-he-jiankui/.

Cohen, Jon, et al. "Did CRISPR Help—or Harm—the First-Ever Gene-Edited Babies?" Science | AAAS, 1 Aug. 2019, https://www.sciencemag.org/news/2019/08/did-crispr-help-or-harm-first-ever-gene-edited-babies.

Hopkins, Hop. "How the Sierra Club's History With Immigrant Rights Is Shaping Our Future." Sierra Club, 2 Nov. 2018, https://www.sierraclub.org/articles/2018/11/how-sierra-club-s-history-immigrant-rights-shaping-our-future.

Lappé, Martine, et al. "Environmental Politics of Reproduction." Annual Review of Anthropology, vol. 48, Oct. 2019, pp. 133–50. PubMed Central, doi:10.1146/annurev-anthro-102218-011346.Lee, Jack J. "Human Body Temperature Has Decreased in United States, Study Finds." Stanford News Center, Stanford University, Jan. 2020, med.stanford.edu/news/all-news/2020/01/human-body-temperature-has-decreased-in-united-states.html.

Lehmann, Lisa Soleymani. "Is Editing the Genome for Climate Change Adaptation Ethically Justifiable?" AMA Journal of Ethics, vol. 19, no. 12, American Medical Association, Dec. 2017, pp. 1186–92. journalofethics.ama-assn.org, doi:10.1001/journalofethics.2017.19.12.stas1-1712.

Almeida, Mara, and Rui Diogo. "Human Enhancement: Genetic Engineering and Evolution." Evolution, Medicine, and Public Health, vol. 2019, no. 1, Jan. 2019, pp. 183–89. Silverchair, doi:10.1093/emph/eoz026.

Barratt, Sarah. "Birth Strikers: The Women Refusing To Have Children Because Of Climate Change." ELLE, 26 Apr. 2019, https://www.elle.com/uk/life-and-culture/a27162032/birth-strikers-women-children-climate-change/.

References: Implications on Society

Steinmetz, K. "Beyond 'He' or 'She': The Changing Meaning of Gender and Sexuality. Time Magazine, vol. 189, no. 11 (27 March 2017): https://time.com/magazine/us/4703292/march-27th-2017-vol-189-no-11-u-s/.

Hopkins, S. & Richardson, L. "Gender Identity: From Biological Essentialism Binaries to a Non-binary Gender Spectrum." Gender Equality, 14 August 2020. DOI: https://doi.org/10.1007/978-3-319-70060-1_87-1

Shahvisi, A. "Engendering harm: a critique of sex selection for family balancing." Journal of Bioethical Inquiry, vol. 15 no. 1, 24 Jan. 2018, pp. 123-137, National Center for Biotechnology Information, doi: 10.1007/s11673-017-9835-4

Franklin, Sarah. "Conception through a looking glass: the paradox of IVF." Reproductive biomedicine online vol. 27,6 (2013): 747-55. doi:10.1016/j.rbmo.2013.08.010

Waldby, Catherine. The Oocyte Economy: The Changing Meaning of Human Eggs. Duke University Press, 2019. JSTOR, www.jstor.org/stable/j.ctv1168bt8.

Ball, Philip. "Seven Ways IVF Changed the World – from Louise Brown to Stem-Cell Research." The Guardian, Guardian News and Media, 8 July 2018, www.theguardian.com/society/2018/jul/08/ivf-in-vitro-fertilisation-louise-brown-born.

Slenning, B. D. "Global Climate Change and Implications for Disease Emergence." Veterinary Pathology, vol. 47, no. 1, 1 Jan. 2010, pp. 28–33., doi:https://doi.org/10.1177/0300985809354465.

Solomon, Scott. "Climate Change Could Affect Human Evolution. Here's How." NBC News Mach, 2018, www.nbcnews.com/mach/science/climate-change-could-affect-human-evolution-here-s-how-ncna907276.

"Climate Change." NCAI, W.K. Kellogg Foundation, 2021, www.ncai.org/policy-issues/land-natural-resources/climate-change.

Dsouza, Deborah. "The Green New Deal Explained." Investopedia, 08 Oct. 2020, www.investopedia.com/the-green-new-deal-explained-4588463.

Hoover Elizabeth, et al. "Indigenous Peoples of North America: Environmental Exposures and Reproductive Justice." Environmental Health Perspectives, vol. 120, no. 12, Environmental Health Perspectives, Dec. 2012, pp. 1645–49. ehp.niehs.nih.gov (Atypon), doi:10.1289/ehp.1205422.

Hymowitz, Sarah, et al. The Rights of Indigenous Peoples, University of Minnesota, 2003, hrlibrary.umn.edu/edumat/studyguides/indigenous.html.

Lappé, Martine, et al. "Environmental Politics of Reproduction." Annual Review of Anthropology, vol. 48, Oct. 2019, pp. 133–50. PubMed Central, doi:10.1146/annurev-anthro-102218-011346.

Moses, Uchechi. "Viewpoint: Developing Countries Need GMO, Gene-Edited Crops to Solve Food Security Challenges." Genetic Literacy Project, 31 Oct. 2019, https://geneticliteracyproject.org/2019/10/31/viewpoint-developing-countries-need-gmo-gene-edited-crops-to-solve-food-security-challenges/.

Norton-Smith, Kathryn, et al. Climate Change and Indigenous Peoples: A Synthesis of Current Impacts and Experiences. PNW-GTR-944, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 2016, p. PNW-GTR-944. DOI.org (Crossref), doi:10.2737/PNW-GTR-944.

References: Looking Forward

Greely, Henry T. “CRISPR'd babies: human germline genome editing in the 'He Jiankui affair'.” Journal of law and the biosciences vol. 6, no. 1, pp. 111-183. 13 Aug. 2019, doi:10.1093/jlb/lsz010.

Fawzy, Samer, et al. “Strategies for Mitigation of Climate Change: a Review.” Environmental Chemistry Letters, vol. 18, no. 6, 30 July 2020, pp. 2069–2094., doi:https://doi.org/10.1007/s10311-020-01059-w.

Paris Agreement to the United Nations Framework Convention on Climate Change, Dec. 12, 2015, T.I.A.S. No. 16-1104.

United States, Congress, Recognizing the Duty of the Federal Government to Create a Green New Deal. 2019.