이학석사 학위논문

크리스퍼, 자연성, 그리고 원탁회의

한국 생명과학자들의 생명윤리에 대한 시점의 변화 분석

CRISPR, Naturalness, and Roundtable

An Analysis of the Korean Bioscientists' Shifting Perspectives on Bioethics

2019 년 8 월

서울대학교 대학원

과학사과학철학협동과정

양 승 호

크리스퍼, 자연성, 그리고 원탁회의
한국 생명과학자들의 생명윤리에 대한 시점의 변화 분석

CRISPR, Naturalness, and Roundtable
An Analysis of the Korean Bioscientists' Shifting Perspectives on Bioethics

지도교수 이 두 갑

이 논문을 이학석사 학위논문으로 제출함

2019 년 5 월

서울대학교 대학원

과학사과학철학협동과정

양 승 호

양승호의 석사 학위논문을 인준함

2019 년 6 월

위 원 장 박 상 욱 (인)

부 위 원 장 John P. Dimoia (인)

위 원 이 두 갑 (인)

Abstract

양 승 호 (Seungho Yang)

과학사과학철학협동과정
(Program in History and Philosophy of Science)

The Graduate School
Seoul National University

The discovery of CRISPR-Cas9 and development of related technologies promised a much more accurate and easier to use method of genome editing. Amidst the research fervour prompted by this discovery, some Korean bioscientists are arguing that the Korean Bioethics and Safety Act imposes excessive limitations on gene therapy research. Calling for deregulation at the 112nd Roundtable Discussions, a policy discussion hosted by the Korean Academy of Science and Technology, three of these bioscientists presented their arguments. Interestingly, some arguments utilized naturalness as a moral value, which stands in contrast to the expected scepticism towards assigning value on naturalness. Following the line of thought presented by Daston and Vidal in *The Moral Authority of Nature*, this paper studies the naturalness-based arguments presented by scientists at the 112nd Roundtable not in their own but as a window to their other arguments, their position in relation to the debate, and what moral imperatives their position is based upon. Scientists at the Roundtable used their scientific expertise to argue for the naturalness of their proposed gene therapy, and argued that only science could provide proper answers to questions of naturalness, adopting a supposedly moral argument to support the imperative of scientific research. This paper argues that a "Q&A relationship" is being established by the scientists between themselves and the public, which I believe suggests a shift, but not a break, from a simplistic top-down relationship dictated by the deficit model.

Keywords: Gene Therapy, Naturalness, Roundtable Discussions, CRISPR

Student Number: 2016-20450

Table of Contents

1. Introduction: Biotech, Nature, and a Policy Discussion 5

2. About the Invocation and Abjuration of Naturalness 14

2.1. Existing literature on the relationship between bioscience and the public 14

2.2. A Brief History of Naturalness as a Source of Moral Authority 22

3. Naturalness and CRISPR: A Collection of Arguments 29

3.1. The naturalness of minimalist CRISPR interventions. 34

3.2. No "dangerous" insertions: a non-transgenic argument 42

3.3. Human enhancement and the "natural" human gene pool 50

3.4. Negative connotations of "mutation" and the public's irrationality 59

4. The Public and the Authority of Science 64

4.1. The positioning of the scientists' arguments and the "Q&A" relationship 64

4.2. History of the Korean Bioethics and Safety Act and the Legacy of Hwang ... 74

4.3. Appeal to the authority of the NAS report and Asilomar-in-Memory 83

5. Conclusion: Scientists of the Roundtable 93

References 98

1. Introduction: Biotech, Nature, and a Policy Discussion

Since its discovery and announcement by Jennifer Doudna in 2012, the applicability of CRISPR-Cas9 to genome editing has been hailed as one of the most important breakthroughs in the history of genome engineering. A family of DNA sequences that serve a role in the genetic "immune system" of certain species of prokaryotes, used for fighting off unwarranted changes in the genome by viruses, Cas9 (CRISPR-associated protein 9) is an enzyme incorporating CRISPR that uses the CRISPR sequence to identify and cleave invasive DNA; Doudna and her team discovered that Cas9 could be re-targeted by changing the sample sequence, which meant that any DNA sequence could be severed with Cas9 by simply reprogramming the enzyme.[1] Highlighting its ease of replication and its highly specific and programable targetability, scientists such as the discoverer Doudna herself have noted from early on the utility of CRISPR to biotech applications, including human gene therapy.[2]

While the scientific community hails the development of CRISPR and its ability to open doors, they are faced with detractors of genome engineering trying to fight its popularization, issuing warnings about the dangers both present and potential. The response of scientists to this opposition has primarily been to refrain from pursuing the most controversial directions of research while seeking government

[1] Martin Jinek, Krzysztof Chylinski, Ines Fonfara, Michael Hauer, Jennifer A. Doudna, and Emmanuelle Charpentier, "A Programmable Dual-RNA–Guided DNA Endonuclease in Adaptive Bacterial Immunity," *Science* 337, no. 6096 (2012), pp. 816-821.
[2] Martin Jinek, Alexandra East, Aaron Cheng, Steven Lin, Enbo Ma, and Jennifer Doudna, "RNA-Programmed Genome Editing in Human Cells." *elife* 2 (2013), e00471.
Jennifer Doudna, "Perspective: Embryo Editing Needs Scrutiny," *Nature* 528, no. 7580 (2015), p. S6.

approval for other, arguably safer subjects. The 2015 International Summit on Human Genome Editing, a meeting between leading bioscientists from around the globe organized by the US National Academy of Sciences, Engineering, and Medicine, was convened primarily to achieve consensus among the scientist community on what directions were dangerous and what were not.[3] The conclusions of the International Summit were then used to compile a set of policy recommendations for future governance of science.[4] In turn, scientists began directing their efforts towards directions green-lit by the Summit such as genome editing research on non-viable human embryos (those that cannot result in birth), expecting that their research will not be met with excessive controversy in light of the encouragement by international consensus.[5]

The 2015 Summit was not unique; there were other consensus-forming activities throughout the history of biotechnology, typically proceeded by a call to moratorium on research until questions on controversial topics can be answered. The earliest and archetypical of these was the 1975 Asilomar conference, which was convened in light of potential dangers that could arise from genetically modified bacteria created in labs, and produced a guideline on proper safety and containment

[3] National Academy of Sciences, Engineering, and Medicine, *International Summit on Human Gene Editing: A Global Discussion* (Washington, DC: The National Academies Press, 2016), https://doi.org/10.17226/21913.
[4] National Academy of Sciences, Engineering, and Medicine, *Human Genome Editing: Science, Ethics, and Governance* (Washington, DC: National Academies Press, 2017), doi: https://doi.org/10.17226/24623.
[5] Ewen Callaway, "Embryo-Editing Research Gathers Momentum: Scientists Proceed with Human-Genome-Editing Experiments as Ethical Debate Continues," *Nature* 532, no. 7599 (2016), pp. 289-291.

procedures in handling these engineered organisms.[6] As noted by historian of science Susan Wright in her work *Molecular Politics*, Asilomar is remembered by scientists as a landmark event that successfully met and answered the concerns of the public while providing scientists with time and means to learn more about genome modification, which led to the rational deregulation of biotechnology based on new knowledge regarding the safety of bioengineering. Due to the events following the Asilomar conference and later consensus emulating Asilomar, Genome Engineering is seen by scientists, government officials, and NGO activists as a scientific field that has a highly conscious relationship with public opinion.[7] Central to this relationship is the effort by scientists and government entities to communicate with and educate the public regarding bioscience, aimed at improving "Public Understanding of Science". Inherent in approach is the assumption that public resistance to new science is partially based on incomplete knowledge and thus can be mitigated with better information.[8]

One of these key points about which the scientists are directing their efforts to "better inform" the public is that of the *naturalness* of genome engineering. Accusations that genome engineering is *unnatural* and thus deplorable has been one of the most visible and widespread criticisms against the genetic modification of lifeforms. A prominent example of the naturalness argument being employed in

---

[6] Paul Berg, David Baltimore, Sydney Brenner, Richard O. Roblin, and Maxine F. Singer, "Asilomar Conference on Recombinant DNA Molecules," *Science* 188, no. 4192 (1975), pp. 991-994.
[7] Priska Gisler and Monika Kurath, "Paradise lost? 'Science' and 'the Public' after Asilomar," *Science, Technology, & Human Values* 36, no. 2 (2011), pp. 213-243.
[8] Monika Kurath and Priska Gisler, "Informing, Involving or Engaging? Science Communication, in the Ages of Atom-, Bio-and Nanotechnology," *Public Understanding of Science* 18, no. 5 (2009), pp. 559-573.

opposition to biotech can be found in the opinions of the US presidential committee on the ethics of human cloning authored during the latter Bush presidency; Christian minister and ethicist Leon Kass, who was an influential member of this committee and one of the most vocal, argued in his work *the Wisdom of* Repugnance that immediate negative response ("repugnance") to the unnaturalness of biotechnology is indicative of a deeper "wrongness" of the technology and thus is a sound reason for opposition.[9] Various surveys have also noticed the widespread presence and influence of concerns over unnaturalness in opinions against GMOs and other products of genetic engineering. A 2011 overview of surveys regarding attitudes of US citizens towards farm animal cloning found concerns of unnaturalness to be prominent among detractors of cloning, considering it to be more important than issues of safety.[10] A 2010 EU policy research report also features concerns of unnaturalness prominently as a metric of public resistance to animal cloning and genetically modified foodstuff.[11] Naturalness is indeed a oft discussed and highly influential topic when it comes to biotechnology.

The attitude of scientists towards naturalness is muted and more sceptical. A 2015 survey of various categories of literature by the UK-based policy research group

[9] Leon R. Kass, "The Wisdom of Repugnance: Why We Should Ban the Cloning of Humans," *Valparaiso University Law Review* 32 (1997), p.679.
[10] Kathleen R. Brooks and Jayson L. Lusk, "US Consumers Attitudes toward Farm Animal Cloning." *Appetite* 57, no. 2 (2011), pp. 483-492.
[11] George Gaskell, Sally Stares, Agnes Allansdottir, Nick Allum, and Paula Castro, *Europeans and Biotechnology in 2010: Winds of change? A report to the European Commission's Directorate-General for Research on the Eurobarometer 73.1 on Biotechnology, FP7 project 'Sensitive Technologies and European Public Ethics' (STEPE)* (Luxembourg: Publications Office of the European Union, 2010).

Nuffield Council summarizes the ways naturalness has been mentioned and discussed in literature by scientists, the press, members of parliament, and NGO activists for a period of 20 years.[12] In the report scientists stand out as the group where the survey found zero value-laden mentions of naturalness; the scientists instead preferred to stick to value-neutral treatment of naturalness (as a strictly technical term regarding the non-artificiality of certain objects and phenomena), and in some cases even argued that to assign inherent value to naturalness was a fallacy. Discussions on why such an assignment is a fallacy can be found in the 2017 NAS report *Human Genome Editing* that followed the 2015 International Summit.[13] The report argues that there is no single "natural" human genome, and that the argument that certain genes should be elevated and protected because it is natural "devolves to the view that the human genome should be treated with a sense of humility, and that humanity should recognize the limits of wisdom and science". Observing that naturalness of a gene is indicative of neither safety nor benefit, the NAS report concludes that to prefer natural genes over unnatural ones by reason of naturalness alone is unsound. *Human Genome Editing* proceeds to assert that the potential dangers of human intervention should be addressed with further research, not by forswearing intervention entirely.[14]

[12] Nuffield Council on Bioethics, *Ideas about Naturalness in Public and Political Debates about Science, Technology and Medicine* (2015), http://nuffieldbioethics.org/project/naturalness (retrieved 2018-07-09).
[13] National Academy of Sciences, *Human Genome Editing.*
[14] *ibid.*, pp. 124-125.

While naturalness as an argumentative point has been articulated for millennia and critiqued for centuries,[15] naturalness has not been particularly under study in the specific context of genome engineering, despite the widespread use of the concept in debates. One prominent and useful research was the aforementioned survey by the Nuffield Council, a UK-based policy research group regarding bioethics that seeks to "inform policy and public debate through timely consideration of the ethical questions raised by biological and medical research so that the benefits to society are realised in a way that is consistent with public values".[16] Their report *(Un)natural: ideas about naturalness in public and political debates about science, technology and medicine* details the findings of their wide-scope survey of the ways the tern "natural" and "unnatural" have been used in parliamentary debates, scientific research, media reports, and NGO publications in the United Kingdom for a period of twenty years.[17] The report indirectly suggests a number of reasons that naturalness has not been subject of as much research as it could have been. One reason may be that beliefs about naturalness are deeply personal beliefs and are usually not subject to argumentation – one either believes it is good, or not.[18] Another reason may be that, as a moral imperative that has been under scrutiny and criticism for several centuries (David Hume warned against the conflation of 'is' with 'ought', for instance), it has already been recognised

[15]Lorraine Daston and Fernando Vidal, eds., *The Moral Authority of Nature* (Chicago: University of Chicago Press, 2010). p.2
[16] Nuffield Council on Bioethics, "Our Aims and Values," http://nuffieldbioethics.org/about/aims-values (retrieved 2019-03-29).
[17] Nuffield Council on Bioethics, *Ideas about Naturalness.*
[18] *ibid*, p.17.

that distinguishing between natural and unnatural, and assigning positive or negative value to the categories, are not simple and the distinctions are for the most part unclear or not useful. Those familiar with the body of critique may even dismiss arguments based on naturalness out of hand; for instance, bioethicist John Harris is quoted as arguing the following:

> *"… The argument from what is or is not natural need not detain us long. Since the whole practice of medicine is unnatural (people naturally fall ill and die prematurely), if we were to accept an ethic which required us not to interfere with what was natural there would be little for medical practitioners and medical scientists to do."*[19][20]

The problems associated with the authority of nature does not mean that naturalness is not a suitable topic of research, however. In their edited work *Moral authority of nature*, historians of science Lorraine Daston and Fernando Vidal proposed a study not of the legitimacy of the authority of nature but rather of its jurisdictions and workings; research on how naturalness is invoked by participants of debates, how strong an influence nature wields in a particular context, and what other kinds authority naturalness is associated with.[21] Various chapters of the book deal with how the moral authority of nature is invoked in association with, or even in service to, other authorities and imperatives that the speaker has in mind. This paper is a case study in

[19] John Harris and Søren Holm, "The Future of Human Reproduction: Ethics, Choice, and Regulation," (Oxford: Oxford University Press, 1998). Recited from *ibid.*
[20] This dismissal is similar to that found in the NAS report *Human Genome Editing* regarding the folly of forgoing all intervention. National Academy of Sciences, *Human Genome Editing.*
[21] Lorraine Daston and Fernando Vidal, *op. cit.*, pp. 2-5.

this vein, focusing on the arguments set forth by Korean scientists at a "roundtable", attempting to contextualize and provide a possible explanation to the particular ways the scientists invoke naturalness.

This "roundtable" is the 112th Roundtable on "Suggestions regarding the Realization of Gene Therapy in the CRISPR Era" held in the summer of 2017, focused on the current state of Korean CRISPR research in relation to therapeutic purposes and a brief comparison between international regulatory regimes.[22] This event was a hybrid of panel discussion and press conference organized by the Korean Academy of Science and Technology (KAST), an originally independent but currently legally empowered body of esteemed Korean scholars in various scientific and technological fields that aims to promote the common interest of the sciences in Korea. The official aim of KAST is to "promote the basic sciences, and contribute to the advance of science and technology by recognizing and commending prominent scientists, and providing advice to the state".[23] A notable case of KAST intervening in affairs regarding public understanding of science is its 2012 defence of the theory of evolution being taught in school textbooks, where the organization moved decisively to uphold the authority of the scientific community and the importance of proper

[22] Korean Academy of Science and Technology, "112th KAST Roundtable Discussions: Directions for Legal and Regulatory Change Aimed at the Introduction and Utilization of Genome Editing Technology", 2017. 08. 03.

[23] Quoted and translated from the original Korean. "기초과학연구의 진흥기반을 조성하고, 우수한 과학기술인을 발굴, 활용함으로써 정책자문을 통해 과학기술 발전에 기여함을 목적으로 설립되었으며…"
Korean Academy of Science and Technology, "Purpose," https://kast.or.kr/kr/kast/purpose.php (retrieved 2019-03-24), translated from the Korean original.

(orthodox) scientific knowledge in education.[24] While the Roundtable was primarily a meeting between scientists and a small number of media representatives that were invited to promote the arguments of the scientists, it provides a valuable window from which to observe the opinions of Bioscience researchers in Korea about the current state of affairs, especially in regards to the Korean Bioethics and Safety Act in effect. KAST would later publish a policy advice pamphlet closely connected to this roundtable titled *Biomedical sciences and human rights*; this document is also under study in this paper.[25]

The topic of this paper pertains to the individual arguments employed by the scientists speaking at the roundtable in support of their overall position; in particular, this paper looks closely at the arguments which invoke naturalness or are referring to other arguments that invoked naturalness. This paper takes the position taken in *Moral Authority of Nature* that the authority of nature is seldom invoked alone, and seeks to connect these arguments based on naturalness to the rest of their arguments, aiming to construct a narrative that explains the way the scientists invoked nature. In doing so this paper seeks to provide a potential explanation as to what imperatives are driving the scientists to take their respective positions at the roundtable.

---

[24] Kyoutae Kim, "Evolution of Archaeopteryx and Horses to Remain in Textbooks(시조새-말 진화과정, 교과서 삭제 안될 듯)", *Dong-a Ilbo*, 2012. 06. 25, p.A12. http://news.donga.com/3/all/20120625/47262715/1

[25] Korean Academy of Science and Technology, *Medical-Life-Sciences and Human Rights (의생명과학과 인권)* (Seoul: Korean Academy of Science and Technology, 2018).

2. About the Invocation and Abjuration of Naturalness

2.1. Existing literature on the relationship between bioscience and the public

The Biotech industry has been an integral part of genome engineering research from its rise, and consequently a significant portion of prior research has scrutinised this context of commercialization of science. Much of this body of literature studies attempts by the aforementioned business interests to privatize bioscience "assets" such as isolated human genes of medical relevance, engineered lifeforms, or databases of gene distribution. Subsequent counter-efforts by numerous parties, mostly NGOs, to secure a more equal and just access to this "scientific commons" are studied as well. Myles W. Jackson's work on the commercialization of the *CCR5* gene identification,[26] Daniel J. Kevles' work on Oncomouse and the origin of the current patent-based Intellectual Property regime regarding biological "inventions",[27] Luigi Palombi's critique of the effects of the patent regime that allowed privatization of isolated but naturally occurring genes,[28] and Doogab Yi's work on private business ventures arising out of publicly funded research and the policy-informed legal ideas that shaped the birth of the Biotech industry are some notable examples.[29] These works detail the process through which a strong political impetus, arising from the American economic

[26] Myles W. Jackson, "How Gene Patents are Challenging Intellectual Property Law: The History of the CCR5 Gene Patent," *Perspectives on Science* 23, no. 1 (2015), pp. 80-105.
[27] Daniel J. Kevles, "Of Mice & Money: The Story of the World's First Animal Patent," *Daedalus* 131, no. 2 (2002), pp. 78-88.
[28] Luigi Palombi, *Gene Cartels: Biotech Patents in the Age of Free Trade* (Cheltenham: Edward Elgar Publishing, 2009).
[29] Doogab Yi, "Who Owns What? Private Ownership and the Public Interest in Recombinant DNA Technology in the 1970s," *Isis* 102, no. 3 (2011), pp. 446-474.

landscape of the 1970s that called for scientific funding to be justified through tangible, accessible results, lead to widespread privatization of scientific knowledge in the United States. This in turn would lead to shifts in the way scientific research was framed and conducted; most of the research cited above has been critical of this shift, claiming that privatization leads to "shoddy science" as claimed by Jackson, or scientific-industrial monopolies as described by Palombi.

The relationship between the scientific community and the public, in particular those dealing with the epistemological authority wielded by scientists and the influence afforded by this authority over ordinary citizens, has long been a subject of intensive study. This is especially so in the United Kingdom where the 1985 Royal Society report on the subject, the Bodmer report, spurred the government into action to improve the "scientific literacy" of British citizens. This in turn lead to the formation of Public Understanding of Science (PUS) as a scholarly field.[30] The 2000 House of Lords report *Science and Society*,[31] suggested that despite educational efforts by the PUS programme, the measured values of scientific literacy among the British public had remained constant throughout the activities of the Committee on Public Understanding of Science. This failure to cause measurable change prompted scholars to re-evaluate the situation.[32] This in turn led to the reconsideration, and eventual discrediting, of the

[30] The Royal Society, *The Public Understanding of Science* (London: The Royal Society, 1985); Walter Fred Bodmer, *The Public Understanding of Science* (London: Birkbeck College, 1986).
[31] House of Lords Select Committee on Science and Technology, Science and Society, *Third Report of the Session*
1999–2000 (London: HM Stationery Office, 2000).
[32] Steve Miller, "Public Understanding of Science at the Crossroads," *Public Understanding of Science* 10, no. 1 (2001), pp. 115-120.

theory that lack of scientific knowledge caused lack of enthusiasm for science, the so-called deficit model.[33] Science studies scholar Brian Wynne argued that the deficit model failed to account for the context of each citizen in their forming opinions regarding science, namely the level of involvement and knowledge of the political and social structure surrounding science and its governance. This context materializes as *trust*, which effects how much of and in what ways laypersons would "uptake (accept and adopt)" scientific explanations, and *locality*, which determines the compatibility of expert knowledge to the local context and thus affects the knowledge's practical utility and social legitimacy. Failure to take this into account is evidence of the continued assumption on part of the scientists of the objectivity and unparalleled epistemological supremacy of science, argues Wynne; the scientists are mis-framing the misunderstanding of the locals.[34]

Susan Wright's work *Molecular Politics* presents a detailed study into the social processes through which biosafety and bioethics governance was developed and practiced in the United States and the United Kingdom. Wright observes the existence of a "received understanding" among the scientists regarding the circumstances of these events, which tends to portray the deregulation process being driven primarily by technical issues and resolved primarily by the scientists' technical efforts. Wright

[33] Patrick Sturgis and Nick Allum, "Science in Society: Re-evaluating the Deficit Model of Public Attitudes," *Public Understanding of Science* 13, no. 1 (2004), pp. 55–74. doi:10.1177/0963662504042690.
[34] Brian Wynne, "Misunderstood Misunderstandings: Social Identities and Public Uptake of Science," Alan Irwin and Brian Wynne, eds., *Misunderstanding Science?: The Public Reconstruction of Science and Technology* (Cambridge: Cambridge University Press, 2003), pp. 19-46.

contrasts this understanding with the results of her analysis, which show that the social dimensions of the decision process were a crucial factor in the dismissal of the risk factors originally raised in concern. Wright argues that the various restricted-access scientific conferences that produced the supporting evidence for the deregulatory moves had been political gatherings aimed at pre-empting further regulations being imposed. For instance, in the immediate aftermath of the Asilomar conference, a key safety concern was the capacity of genetically modified bacteria becoming virulent and causing epidemics. In light of public controversies already brewing and those potentially on the horizon, the scientists imposed a voluntary moratorium on research until relevant questions of laboratory containment of genetic materials could be answered. Wright demonstrates that the process through which this concerns were dismissed, which happened at a rapid pace in the space of about two years, was shaped by closed-access meetings between scientists that actively sought out issues of potential concern, energetically investigated relevant topics, and disseminated their findings in a way that would preclude the concerns. This way, scientists were able to pre-empt government control of the lab safety issue and maintain freedom of scientific inquiry in the wake of the controversies regarding containment of engineered bacteria, all the while "addressing" the calls for reflexivity at the same time.[35]

This misremembering and the aforementioned misunderstanding may be connected, as further studies into the way the legacy of Asilomar and the beginning

[35] Susan Wright, *Molecular politics: Developing American and British Regulatory Policy for Genetic Engineering, 1972-1982* (Chicago: University of Chicago Press, 1994).

days of genetic engineering show. There exists a healthy body of literature that studies bioscience in its early formative days, centring on the debates surrounding Recombinant DNA technology and the rise of the Biotech industry that followed. The Asilomar Conference that convened to resolve the debates and provide science with a direction acceptable to the public has been heralded as a landmark decision by prominent scientists and has been a central topic of study to date.[36] The study by science studies scholars Priska Gisler and Monika Kurath *Paradise Lost* analyse the post-Asilomar science-Public relationship and the legacy of the 1975 conference.[37] Investigating how the conference was remembered and how this memory shaped the PUS policy efforts that followed, Gisler and Kurath discovers that the Asilomar Conference was being upheld as the ideal "other" upon which to contrast the disappointing present at which point science and the Public are seen to be constantly at odds. The authors describe the entire PUS effort as formulating and solidifying a division – akin to the "boundary works" as described by Gieryn demarcating the boundary between science and non-science[38] – between science and the Public by emphasizing the existence of a gap, either in understanding or opinion, that needs to be bridged. The persistence of this "gap" reasoning has been observed by Kurath and Gisler in multiple cases where "new" science was met with public opposition: for nuclear science, bioscience, and nanotechnology, scientists and the state both

[36] Gisler and Kurath, "Paradise lost?"
[37] *ibid.*
[38] Thomas F. Gieryn, "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review* (1983), pp. 781-795.

attempted to mitigate public concerns with educational efforts, evincing the understanding on the part of scientists that public opposition stems primarily from relative ignorance.[39] The authors argue that, while there has been changes to the deficit model over the years and recent efforts to depart from it,[40] the understanding of the "gap" that underlies the model has not been discarded.

In regard to the relationship between Korean bioscientists and the Korean public, much emphasis has been placed on ensuring the ethical behaviour of researchers in regard to the human rights of their test subjects and patients. That is the stated aim of the Korean Bioethics and Safety Act,[41] and is understood as the central point of Korean bioscience regulation by jurisprudence scholars as well, since the 2012 revision that removed the other stated goals of the law and left only the protection of "human dignity and values" in Article 1.[42] This particular focus of Korean law can be associated with the aftermath of stem cell researcher Hwang Woo-Suk's rise and downfall, as this case involved numerous breaches of human rights of

[39] Kurath and Gisler, "Informing, Involving or Engaging?"
[40] *ibid.*
[41] "Article 1 (Purpose): The purpose of this Act is to ensure bioethics and biosafety, thereby contributing to promoting citizens' health and improving their quality of life by *preventing the violation of human dignity and values* or the infliction of harm on human body in the course of researching on human beings and human materials or of handling embryos, genes, etc." Emphasis added. Bioethics and Safety Act. Korean National Assembly Act, 2017 (Republic of Korea), no. 14839. Retrieved from the website of the National Law Information Centre.
[42] Hong Suck Cho, "The System, Contents, and Problems on new Bioethics and Safety Act," *Public Law Journal* 13, no. 4 (2012), pp. 251-268.

patients who provided Hwang with genetic material (eggs) and were awaiting stem cell treatment that never materialized.[43]

An important and intriguing trait of the Hwang affair was that during the heyday of Hwang's popularity, and to a lesser extent even after the fraudulent nature of his research was revealed, Hwang and also later bioscientists enjoyed immense support from the state and the public. This popular support has been a topic of intense study by researchers. Sociologist Kim Jongyoung writes that this fervent support for Hwang especially after Hwang's downfall is linked to a widespread culture of mistrust of authority among Koreans in tandem with a strong nationalist, statist-patriotic value system linked with strong scientism that exhorted Hwang as a hero of the nation. As both the scientists themselves and the press reporting on them dipped into the well of nationalistic scientism for support, a strong narrative of heroic effort developed around Hwang's lab, which achievements brought the state great honour, and will bring the people immense health benefits and wealth some point in the future. Hwang doing everything in his power to serve the public and the state with science. In this narrative, the way Hwang's colleagues, and the state turned against Hwang as evidence emerged of his unethical conduct can be understood betrayal of a great man "after everything he has done for them". This shared nationalist-statist ethos, narrative of a

[43] Sang-Ik Hwang, "Bioethics in Korea – Past and Present," *Bio, Ethics and Policy* 1, no. 1 (2017), pp. 31-55.

scientist hero, and the subsequent sense of betrayal, Kim Jongyoung writes, are among the key factors behind the fervent Hwang support.[44]

The nationalist-statist arguments analysed by Kim Jongyoung is not limited to Hwang but seem to be common among later Korean bioscientists as well; the aforementioned connections of Korean research to international status and economic well-being of Korea as a country works in tandem with the more individualist arguments of biopolitics as described by Nikolas Rose.[45] According to an analysis by bioethicist Jun Bang-Ook, rhetoric of patriotism, economic development, and an exaltation of the "heroic" efforts of scientists for the betterment of public health serve as powerful arguments for support of bioscience in Korea.[46] Jun argues that such invocations of ethos and pathos are aimed at directing public gaze away from the concerns of the bioethicists, such as the ethical conduct of researchers and the ethical implications of the proposed technology. He blames the press of failing to separate these "emotional" arguments from ethical arguments, thus "exposing the public to the persuasive strategies of the scientists".

While similar arguments are in use by the scientists at the 112nd Roundtable Discussions as well, and thus Jun's analysis of scientist rhetoric still applies, the presence of naturalness-based arguments in the scientists' position escapes Jun's

---

[44] Jongyoung Kim, "Making Sense of Fervent Hwang Woo Suk Supporters – Culture of Conspiracy and the Politics of Accusation," *Korean Journal of Sociology* 41, no. 6 (2007), pp. 75-111.
[45] Nikolas Rose, "The Politics of Life Itself," *Theory, Culture & Society* 18, no. 6 (2001), pp. 1-30.
[46] Bang-Ook Jun, "Human Embryo Cloners' Rhetorical Strategies in Korean Media Reporting," *Journal of the Korean Bioethics Association* 6, no. 1 (2005), pp. 109-122.

analysis and deserves study. In particular where Jun argues that scientists use strategies of rhetoric to avoid handling ethical concerns, the scientists at the Roundtable instead seemed eager to claim that they too were concerned with the ethical issues, and their naturalness-based arguments can be understood as being their attempts at directly addressing some of those issues. After analysis of those arguments I believe that, while the argumentative positions of scientists may show little to no change, their approach to these concerns of outside parties may have changed.

2.2. A Brief History of Naturalness as a Source of Moral Authority

Naturalness, and its corollary *unnaturalness*, are states of being invoked by persons participating in debates regarding novel fields of science and technology, including but not limited to gene therapy. This is often done in a comparative, evaluative way, with "naturalness" being the presumed desirable state and everything "unnatural" being criticized, shunned, and warned against. This "value-laden" character of invocations of naturalness make them powerful points of argument in the relevant debates. While the invocations of naturalness often accompany more technical, more specific arguments regarding the focus of controversy, such as arguments on the safety (or lack thereof) of particular gene therapy methods,[47] the naturalness itself appears on its

[47] Hoongi Kim, *The Rights to Know and Choose in the Age of Bioengineering Consumption (생명공학 소비시대 알 권리 선택할 권리)* (Seoul: EASTASIA, 2013).

own without qualifications, and the inherent value is unexplained, presumably because it is supposed to be self-evident.[48]

When considering nature as a moral authority, it is important to keep in mind its protean character, how it has embodied *diverging* values throughout history. From divinely ordained hierarchy to unadulterated purity that serves as a modern aesthetic norm, "naturalness" meant many different things at different times. Nature and its dictates have hardly been monolithic, and what a particular invocation of naturalness, especially the oft-damning categorization of "unnatural", actually means in a given context varies heavily. The chapters of *Moral Authority of Nature* abound with examples of these various meanings of naturalness. Take for instance the invocations of nature in context of human sexuality. The allegories depicted in chapter 2 equate *is* fully with *ought* and the natural order refers to things as they are, i.e. as they were created. While creatures of God may deviate from the norm, they are still following their multiple, sometimes contradictory natures, and Lady Nature does not intervene. This contrasts with the autonomous nature as described in *Onanism*, where nature has given Man "natural urges" to procreate and severely punishes those who artificially go over the limits of the natural urges.[49] The precise intent of any given invocation of naturalness is also somewhat dependent on who is making the invocation, and thus a study of the

[48] Nuffield Council on Bioethics, *Ideas about Naturalness.* p.33.
[49] Katharine Park, "Nature in Person: Medieval and Renaissance Allegories and Emblems," Lorraine Daston and Fernando Vidal, eds., *The Moral Authority of Nature*, pp. 50-73; Fernando Vidal, "Onanism, Enlightenment Medicine, and the immanent justice of nature," *The Moral Authority of Nature*, pp. 254-281

history of naturalness as an argumentative concept includes a study of those who sought to speak on behalf of nature, the theologians, the scientists, the historians drawing out grand narratives.

Naturalness or the concept of the natural state of things has a long history of being invoked as a moral authority in history, ranging from medieval discussions of "Lady Nature" dressed in majestic robes as caretaker and arbiter of divine order to modern characterisation of natural wilderness as an undisturbed, pristine reservoir of vigour and spiritual healing. Invoked primarily through the negative – condemnations of things *unnatural* rather than exhortations of things natural – the moral authority of nature has held a continuous hold on societal norms, compelling human society to deem *what is* as *what ought to be*, although the actual amount of influence has waxed and waned depending on the time period, along with the themes generally associated with invocations of nature. *Moral Authority of Nature* serves as an excellent introduction to the varied ways nature has been invoked and the evolution of the ways nature was understood and obeyed, or defied.[50]

The beginnings of nature as a distinctly moral authority dictating right and wrong can be traced to the medieval age, where nature was considered a divine creation and thus an embodiment of divine will inherent within the design. Thus, nature (usually personified as a female character of regal bearing) became a vicar of

[50] *ibid.*

sorts to the authority of God, teachings beings to be as they were designated to be.[51] This primarily came to be invoked in arguments that condemned certain types of "abnormal" behaviour, especially non-standard sexual behaviours, which were announced to be crimes *contra naturam*, against nature. Although the authority of nature was rather limited in actual court proceedings – especially considering that in this mode nature had authority only in association to God, and thus nature stood in for and could always be supplanted by divine authority – it nevertheless formed an important part of the string of authorities that state actors could cite as justification for the use of its most extreme form of punishment, death. However, as jurisprudence became more professionalized and the Western legal tradition became more text-based, the vague, multifaceted character of nature as a moral source became problematic, and arguments based on nature slowly but surely died out from courts of law.[52]

This would change drastically in the age of Enlightenment when Nature, now fully as an abstract entity that embodied all that was natural as a whole, came to be considered the most important authority on human values and the source of all moral thinking. Where formally "her" authority derived from and could be entirely replaced by that of God, Nature that appears in Enlightenment moral debates is more direct, more authoritative. Nature is armed with punitive powers of her own such as diseases,

[51] Joan Cadden, "Trouble in Earthly Paradise: The Regime of Nature in Late Medieval Christian Culture," *The Moral Authority of Nature*, pp. 207-231.
[52] Helmut Puff, "Nature on Trial: Acts 'Against Nature' in the Law Courts of Early Modern Germany and Switzerland," *The Moral Authority of Nature*, pp. 232-253.

and actively visits harm and malady to those who trespass on her dictates. Nature was additionally endowed with new traits, such as objectivity and universality, that enhanced her moral authority over human society. Men of culture and learning were to deduce moral laws from laws of nature, its "unique and true source", and advise others accordingly. While still associated with divine will as her authority ultimately still derived from that of God, Nature nevertheless was fully capable of promulgating and enforcing its own dictates, further reinforcing the moral necessity of obeying it.[53]

The authority of nature is said to be derived from its capacity to grant means of categorizing things: categorizing animals into subcategories like humans, mammals, birds and reptiles; humans into sexes and age groups; sexual behaviours into reproductive and non-reproductive. Once successfully grounded in nature, such categories gained social, moral, and even ontological significance that granted the divisions an air of legitimacy and made the divisions more pronounced and permanent, although as historian Londa Schiebinger writes in her chapter, the divisions were not so distinct nor considered *physiologically* inherent before the changes of the 18th and 19th centuries. Where before there was assumed to be a general unity to all humans that allowed experimental findings in medicine to hold true for all humans, there came to be an increasing perception that differences, especially race, meant different medicinal requirements, as studies of these "natural categories" intensified. Whereas in the 18th century experimenters deemed medical experiments using negro slaves as being

[53] Fernando Vidal, "Onanism, Enlightenment Medicine, and the Immanent Justice of Nature," *The Moral Authority of Nature*, pp. 254-281.

medically relevant for Europeans, especially if their non-natural conditions, such as level of physical labour, were similar, the question had to be deliberately confronted and received intense scrutiny in the late 18th and the 19th centuries as theories of scientific racism developed.[54] Nature's authority not only established differences between categories but also similarities within categories; humans were to have "human nature" or humanness, men and women to have male and female characteristics, the races their each individual traits that were natural to them. To deviate from what these "natures" dictated was abnormal, dangerous, *wrong*.

This came to an abrupt shift in direction in the aftermath of World War II as Western civilization realized the extent to which innumerable horrors were committed in the name of race, the most politically pronounced of all natural divisions. In response, the 1950 UNESCO *Statement on Race* declared that race for all intents and purposes had zero scientific (and therefore, natural) basis, and was to be discarded as a scientific criterion. While this was obviously intended to undo the wrongs committed by human society in the name of nature and prevent future reoccurrences, this served as its own political influence that shaped human society in the name of nature in much the same way as did notions of race did in the late 19th century. In an ironic twist, in the two decades following the UNESCO *Statement* any finding of distinctions within the human species was considered unnatural and condemned as imagined spectres and remnants of a discredited view of human nature. This could have served as the political

[54] Londa Schiebinger, "Human Experimentation in the Eighteenth Century," *The Moral Authority of Nature*, pp. 384-408.

backdrop to the relative lateness in acceptance of the idea that there were various hominid species in contemporaneous existence in the course of human evolution. The same political-naturalist impetus could be argued to be behind the constant distinction of the modern human species from those earlier hominids, so that the "essential unity" of the human species is unmarred.[55] There may be many hominids, but there was and is only one human species.

Nature when invoked as a moral authority today in genome engineering debates still maintains many of the characteristics such invocations shared in the age of Enlightenment, where nature is seen to be universal, and capable of directly punishing those who disobey her dictates. The categorization *unnatural* still holds strong connotations of *unsafe* and *unsound*, and modern arguments are often based on the dual meaning. However, as the Nuffield Council study (2015) suggests and the NAS report *Human Genome Editing* exemplifies, scientists are often dismissive of invocations of naturalness and warn against confusing the natural with safety or benefit.[56] Similar dismissal of the sole use of naturalness can be found in criticisms of the Doctrine of Substantial Equivalence, a mainstay of current regulatory regimes of genetically engineered foods and drugs. Substantial Equivalence compares the chemical and physical characteristics between novel materials under scrutiny and a comparable sample found in nature; if the similarities are considered significant

[55] Robert N. Proctor, "Three Roots of Human Recency: Molecular Anthropology, the Refigured Acheulean, and the UNESCO Response to Auschwitz," *The Moral Authority of Nature*, pp. 466-490.
[56] Nuffield Council on Bioethics, *Ideas about Naturalness;* National Academy of Sciences, *Human Genome Editing.*

enough ("substantially equivalent") then the dangers associated with the novel material is assumed to be the same as the one found in nature and thus deemed "unproblematic", or more precisely, no more problematic than nature. Criticism of this concept often involve arguments that ending the investigation at the demonstration of "equivalence" rests on the *untested* assumption that *the natural* is tolerably safe.[57]

3. Naturalness and CRISPR: A Collection of Arguments

The advent of genetic manipulation technology with the capacity to limit edits to highly specific sites on the genome, called "site-directed nucleases"[58] or "genome editing"[59] by some, improved the accuracy and precision of genetic engineering sufficiently for a serious foray into its application to the human genome, the endeavour of human genetic therapy. By editing the genetic code of human beings, either in the foetus or in the developed human being, medical practitioners would be able to prevent the expression of deleterious hereditary traits, such as those serious enough to be seen as cause for genetic reproductive counselling. Even conditions not

[57] Hoongi Kim, *The Right to Know and Right to Choose.*
[58] Nancy Podevin, Howard V. Davies, Frank Hartung, Fabien Nogue, and Josep M. Casacuberta, "Site-Directed Nucleases: A Paradigm Shift in Predictable, Knowledge-Based Plant Breeding," *Trends in Biotechnology* 31, no. 6 (2013), pp. 375-383.
[59] Kim Jeong Hun, presentation at the 112th KAST Roundtable Discussions (2017).
Origin of the term is a terminology box in a ZFN article by Urnov et al., in Box 1, where the authors explain that they wanted to distinguish their work from previous research named 'gene targeting'. Fyodor D. Urnov, Edward J. Rebar, Michael C. Holmes, H. Steve Zhang, and Philip D. Gregory, "Genome Editing with Engineered Zinc Finger Nucleases," *Nature Reviews Genetics* 11, no. 9 (2010), p. 636.

directly tied to any specific gene are within the sphere of conditions that genetic therapy could potentially treat, as human metabolisms that enable those conditions could be changed to no longer facilitate the diseases. This is the case with the case of the therapy proposal by Kim Jeong Hun as showcased in our study. Kim seeks to treat Angiogenesis-Related Blindness, a family of eye conditions that share a common pathology of involving abnormal formation of superfluous blood vessels (angiogenesis) in the retina, by removing or disabling a gene associated with angiogenesis using CRISPR-Cas9. He aims to do this by delivering properly targeted CRISPR into the eye with very short-term vectors that will not survive long enough to escape the eye, thus containing the gene edit to the relevant organ.

CRISPR-Cas9 (hereafter simply referred to as CRISPR) is the latest in the series of the targeted genome editing tools, which includes earlier developments such as ZFN (Zinc-Finger Nucleases). While all genome editing tools share specifiability, i.e. the ability of the user to designate a specific target for the tool to work on, CRISPR is unique in that its target is selected by a sample DNA sequence that is directly compared to the target; if the sequences match, CRISPR cleaves the target. Whereas other side-directed nucleases involve formulating a custom-built nuclease for each different target, CRISPR requires merely swapping out the sample sequence with a new one to facilitate re-targeting. This simplicity of use is what led to the immense interest shortly after its discovery.

With the promise of new therapies in hand, scientists began to argue against the numerous regulations in place that prevented or restricted genetic engineering of humans, either its research or application. In the United States these protests were met with favourable responses from government-related entities, with the US National Academies of Science, Engineering, and Medicine releasing the report *Human Genome Editing: science, ethics, and governance* in 2017 that conditionally allowed ("yellow-lit") genetic engineering of the human germ-line that previously were restricted. Specifically, while the report reaffirmed the restriction on creating genetically engineered embryos for the purpose of creating an engineered human being, it argued that research involving embryos and other germline cells for the purposes of research could and should be allowed, in order for science to learn more, to promote developments elsewhere in the field.[60]

These new advances were met with resistance from those unfavourable to the expansion of genetic engineering, utilizing arguments both old and new. The aforementioned NAS report cites arguments such as those based on the imperfect safety record of genetic engineering thus far, the potential long-term effects of genetic changes that linger across generations (for germline edits), and the numerous questions of social justice that genetic therapy raises, ranging from broad questions on the righteousness of dividing human genetic traits into pathogenic and non-pathogenic categories, to acute questions regarding the human dignity of the disabled

[60] Prashant Nair, "QnAs with Alta Charo and George Church," *Proceedings of the National Academy of Sciences* 114, no. 23 (2017), pp. 5769-5771.

and disadvantaged.[61] A number of these arguments were reproduced at the KAST Roundtable by Kim Ok-Joo, as we shall see in detail below. These arguments questioned the wisdom, or the necessity, of altering the human genome, although some questioned the authority of scientists to act unilaterally upon the gene pool that is "the common interest of all humankind" and therefore subject to the collective will of the entire human race.[62]

Many of these arguments involve naturalness. Some of the arguments do so directly, pointing at the *unnaturalness* of interventive techniques themselves that are involved in gene therapy, such as the viral vectors that deliver nucleases to the human cell. Some do so indirectly, as in arguments regarding the selection of certain traits for therapeutic "correction": as these traits exist naturally in human beings, they are part of the overall human genetic pool that defines the human condition, and some opponents argue that any attempts to separately categorize these traits constitute discrimination.[63] Furthermore, as scientists at the Roundtable and the authors of *Human Genome Editing* point out, the human genome changes all the time – there exist

---

[61] These arguments are summarized in different sections spread across the NAS report. Notable sections that I'd like to highlight are the section on *A "Natural" Human Genome and the Appropriate Degree of Human Intervention* in pages 124-130, and the whole of chapter 6 "Enhancement". National Academy of Sciences, *Human Genome Editing*.

[62] "As a baseline, if we take human rights and democracy seriously, a decision to alter a fundamental characteristic in the definition of 'human' should not be made by any individual or corporation without wide discussion among all members of the affected population." George J. Annas, Lori B. Andrews, and Rosario M. Isasi, "Protecting the endangered human: Toward an international treaty prohibiting cloning and inheritable alterations," *American Journal of Law & Medicine* 28 (2002), p. 151.

[63] This argument is associated with the body of arguments against discrimination of the disabled communities, and have been raised against technologies such as prenatal screening to search for genetic "defects". The NAS report provides a short summary in pages 30-31 dealing with the UN Declaration of Human Rights, and pages 125-127 regarding the disability rights communities themselves. National Academy of Sciences, *Human Genome Editing*.

"natural" genetic changes that occur with or without human intervention. Arguments against genetic engineering therefore become arguments against artificial, or perhaps *unnatural*, changes in the genome; as such, all arguments against gene therapy specifically become arguments at least partially based on an objection against unnaturality.[64]

While naturalness may be invoked by arguments on both sides of the debate, not all naturalness arguments are the same. As analysed by previous research summarized in section 2, there are multiple types of meanings that can be assigned to naturalness.[65] When Kim Jeong Hun speaks about the naturalness of his proposed in-vivo genome editing, he is speaking of a different nature from that referenced by Kim Ok-Joo when she argues that there is no "normal" gene, only natural ones. Furthermore, as the various chapters of *Nature as a Moral Authority* illustrates, nature has a long history of being employed by various interests for widely differing goals, and the how and why of invocations of naturalness need investigation. As such, this study undertook an analysis of the various arguments wholly or partially based on naturalness employed at the Roundtable and beyond in related circumstances, in an effort to examine how the invocations were made, with what goal. This will allow us to construct a narrative that explains the set of arguments.

[64] Kim Jeong Hun, Kim Yon Soo, and Kim Jin-Soo, at the KAST Roundtable. Specific quotations follow below. Similar arguments, regarding the variability of "natural" genes and follies of certain possible categorizations, can also be found in the NAS report, at pages 124-130 and 138-139.
[65] Nuffield Council on Bioethics, *Ideas about Naturalness*.

3.1. The naturalness of minimalist CRISPR interventions.

Kim Jeong Hun, the presenter at the 112th KAST Roundtable Discussions, is an ophthalmologist.[66] He stresses that he is a practicing doctor, not a researcher; he deals with actual patients who suffer from blindness-causing conditions for which there is no cure commercially available. Foremost of these, he explains, is Angiogenesis-Related Blindness (ARB), which is a family of conditions that share a common pathology, that of abnormal angiogenesis (formation of new blood vessels) in the retina. The build-up of blood vessels progressively inhibits the function of sight cells until they cease to function, and the eye loses sight. For the blood vessels to form, a certain protein called Vascular Endothelial Growth Factor A (VEGF-A) must be present to act upon the cells of existing blood vessels. There exists a treatment that takes advantage of this common link, the cancer drug Bevacizumab (trade name Avastin) originally developed for colonary cancer that supresses VEGF-A. However, using Avastin to treat ARB has a serious drawback in that it requires monthly injections of the drug into the eye cavity in order for the medication to work. Worse, the drug may not work or stop working after a while, as warned by the US National Eye Institute.[67] Kim Jeong Hun argues that there is a need for a permanent, curative

[66] Kim Jeong Hun, MD, Ph.D. Fight against Angiogenesis-Related Blindness Laboratory, Seoul National University Department of Biomedical Sciences.
http://biomed.snu.ac.kr/main/tmpl_eng/sub_main.php?m_cd=35&m_id=0201&sp=2&wr_id=65

[67] "condition may progress even with treatment." National Eye Institute, "Facts about Age-related Macular Degeneration," https://nei.nih.gov/health/maculardegen/armd_facts (retrieved 2019-04-01)

procedure, and his team, Fight against ARB (FARB), is dedicated to finding that cure. His latest work is centred around using CRISPR to knock out the gene that controls VEGF-A function, thus preventing it from causing further angiogenesis in the eye. It is probably because of this direct connection to both CRISPR and a tangible medical need that Kim Jeong Hun was chosen to be the first to speak at the Roundtable.

As part of his presentation, Kim Jeong Hun defended the "naturalness" of his proposed gene therapy in two ways, based on the utilization of inherent repair mechanisms of the cell, and the lack of involvement of foreign genetic material, respectively. The most prominent of these was based on the strategy for knocking out the gene in question – the team intended to simply cut off the gene with a pair of Cas9-induced double-strand breaks, and then let the genome repair mechanisms *inherent* in the cell take over. A double-strand break (DSB) describes the cleaving of both helixes of the DNA sequence at a particular location; this prevents the usual repair mechanism for DNA damage from kicking in because there is no intact strand left to base the reconstruction of the other strand upon.

There are two possible outcomes for a DSB. One possibility is that the cell will restore the genome by cloning the sequence in the other, possibly non-pathological, copy of the genome stored within the nucleus (available in all sexually-reproducing eukaryotic cells, including those of humans) through a process called homology directed repair. The other possibility is that the cell will simply join whatever two severed ends that can be found into one, a process called non-homologous end-

joining. It is the latter which is the primary intended outcome for FARB; once the ends are joined the resulting sequence will simply not have the relevant gene, having been cropped out with CRISPR.

Since either of these processes are internal mechanisms of cell physiology for repairing DNA lesions, there is theoretically little intervention required to facilitate it, and despite present imperfections in practice, Kim Jeong Hun is confident that such technical challenges will be overcome in time; to quote, "as the technology develops and improves, off-target effects are inevitably reduced. Further research leading to betterment of technology will surely solve the off-target challenge in time, which is reason to push forward despite the current state of the art."[68] In any case, Kim Jeong Hun argues that, outside of the CRISPR-aided double-strand breaks, his method involves no phenomena that is *not native* to the human cell. For this reason, he described his intended cure as being "very natural" in its application, a form of "miniscule" therapy achieving *almost* entirely natural results with *almost* natural means.

The crux of Kim Jeong Hun's "minimalist" naturalness argument is of course the fact that the phenomena he relies on to achieve his goals are *inherent* to the cell. In emphasizing this, he is arguing against criticisms raised against former techniques used

[68] Translated by me from the original statement in Korean. "유전자 교정 기술이 개발되면 개발될수록 Off-target effect 라는건 줄어들 수밖에 없고요, 연구자가 더 유전자 교정을 연구해서 더 잘 만들면 당연히 Off-target effect 는 해결될 것이기 때문에 저희가 걱정하고 염려하지만 오히려 더 긍정적인 눈으로 바라볼 수 있는 부분이 아닌가 생각합니다." Kim Jeong Hun, presentation at the KAST Roundtable.

in genetic engineering, such as those regarding recombinant DNA technology that used viral vectors to introduce foreign genetic sequences into the human genome:

> *As you know, double-strand breaks occur constantly inside our bodies. Even though DNA strands regularly break, fortunately there exist internal repair mechanisms in the body that ceaselessly repair these damages. In that we're causing DSBs where we want in order to achieve our desired effect, "gene correction" is not so different from existing methods, except that instead of introducing novel material into the genome to achieve novel results, we are utilizing phenomena inherent to the cell. That the third generation genome editing (CRISPR) has advantages in its ease of synthesis and the capacity to run multiple edits at once over the 1st and 2nd generation tools (TALEN and ZFN) is well known. I am sure many of you are aware of this through various means.*[69]

Kim follows this up later with a statement on the "dangers" of some techniques:

> *Once a double-strand break occurs, there are largely three possible consequences. One is where the deleted portion is not restored [due to non-homologous end-joining], resulting in gene deletion. Another possibility is a miniscule change of one or a few [codons].*

[69] Translated by me from original statement in Korean. "여러분도 아시겠지만 여러분의 몸 안에서는 끊임없이 이중나선구조가 깨집니다. 우리 몸은 끊임없는 이중나선구조가 깨지지만, 다행히 우리 몸에선 이중나선구조 깨지는 것을 끊임없이 수리하는 시스템을 가지고 있고요. 기본적으로 이 유전자 교정 방법은 DSB 를 내가 원하는 곳에서 일으키고 그 일으킨 것을 통해서 내가 원하는 효과를 얻는다는 점에서 기존의 새로운 어떤 것을 도입해서 새로운 현상을 일으키기 보다는 원래 우리 몸에 있던 현상을 우리가 원하는 대로 프로그램 해서 적용한다는 것만 다르지, 기본적으로는 굉장히 효과적인 방법입니다. 실제로 1 세대 2 세대 유전자 교정 방법에 비해서 3 세대 유전자 교정 방법이 쉽게 만들 수 있고, 동시에 여러 개를 같이 할 수 있다는 장점은 이미 잘 알려져 있습니다. 이 부분은 이미 여러 차례 여러 자리 여러 경로를 통해서 들어서 여러분이 이미 알고 있을 거라고 생각합니다." Kim Jeong Hun, presentation at the KAST Roundtable.

These kinds of phenomena do not pose significant threats to the body. What we should be concerned about is when a foreign sequence is inserted in the place of the missing genes. This has been an issue with gene therapy: gene therapy [in the past] involved solving problems with existing genome by introducing foreign sequences to replace problematic functions. While our technique is not too different from previous gene therapy [in its effect], it is commonly misunderstood that we also insert foreign genes to the genome to achieve our therapeutic goals. My research, including my clinical trials is not about inserting foreign genetic material into the cell. We are researching options that are considered normal parts of the natural metabolism of the cell, such as gene deletion and substitution. In this regard I argue that we are technologically safer than previous genetic therapies. [70]

Why does Kim Jeong Hun emphasize the fact that his therapeutic strategy relies almost completely on inherent mechanisms? Seeing as the doctor is intervening in a situation where the human body has failed to fix itself (leading to blindness), shouldn't

[70] Translated by me from original statement in Korean. "DSB 가 일어났을 때, 그 다음에 일어나는 현상은 크게 3 가지로 생각해볼 수 있는데요, 한가지는 그냥 나선구조가 부서지고 나서 이 부위가 잘려지면서 그냥 deletion 되서 없어지는 거구요. 한가지는 한가지 정도의 아미노산 바뀌는 정도의 변화. 사실 이런 정도는 전혀 위험성이 없습니다. 거기에 비해 우리가 걱정해야 하는게 뭐냐면, 이런 deletion 을 만들어 놓고 그 안에 외부에서 무언가를 집어넣는다면 당연히 걱정할 점이 있는거죠. 사실 이 부분은 유전자 치료가 가지고 있는 문제입니다. 유전자 치료는 기존의 유전자의 문제를 해결하기 위해 외부의 유전자를 집어넣어서 이 문제 기능을 대신하게 하는 방법입니다. 사실 생각해보면 그거랑 큰 차이는 없는건데, 사실 우리는 어떤 오해를 하고있냐면, 유전자 교정이라 하면 유전자 치료와 같이 새로운 유전자 하나 집어넣어서 그런가보다, 라고 하지만, 앞서 말씀드린 많은 연구들, 그리고 제가 임상의사로서 제가 진행하고 있는 연구는 요 부위는 전혀 하고 있지 않습니다. 저희는 정상적으로 일어나는 현상 중 하나라고 생각할 수 있는 deletion, substitution 같은 굉장히 안전한 방향으로만 가고있고 김진수 교수님과 제가 하고 있는 연구는 요 방향만 하고 있습니다. 그게 일단 기술적으로 안전, 이라는 것이 첫번째 우리가 생각해야 할 부분이구요." Kim Jeong Hun, presentation at the KAST Roundtable.

he be emphasizing instead how the strategy does something the body can't do on its own? Interrupting this function could lead to problems, especially in the long-term as the promised benefits of evolutionary fine-tuning, called "nature's wisdom" by some, are unrealized; thus, it is imperative to obey its wisdom and not "unnaturally" "tamper" with its functions – hence his minimalist intervention being "safer" than more intrusive insertions of foreign materials.

However, if Kim Jeong Hun is conflating nature with safety, this raises a lot of questions. There's of course the obvious matter of Kim Jeong Hun employing an argument that is usually cited in *opposition* to the epistemological authority of doctors, however there are other inconsistencies closer at hand. The report *Human genome editing* by the US National Academy of sciences, which Kim Jeong Hun cites in his presentation, describes in the section on "natural" human genome how this very logic is one of the foundational arguments underscoring the public opposition to gene therapy, and presents some counter-arguments based on dislodging the authority of naturalness.[71] Kim Jin-Soo, a genome engineering scientist and one of Kim Jeong Hun's research partners who provided the CRISPR know-how (he also is one of the speakers in the panel debate that followed Kim Jeong Hun's presentation, more in section 3.3), quotes this very segment in adding that there is no single "natural" human

[71] National Academy of Sciences, *Human Genome Editing*, pp. 124-125.

genome shared by all humans, and that concerns for preserving the natural state should not disparage efforts of the medical profession to cure and help people.[72]

Furthermore, Kim Jeong Hun himself contradicts the natural wisdom argument with the very mission of his research. Early on in his presentation the presenter had explained how there already exists a medication that treats Angiogenesis-Related Blindness: Avastin (Bevacizumab). Kim Jeong Hun noted that a major problem with Avastin was that it required monthly medication via intravitreal injection (i.e. a needle in the eye) and could stop working even if this schedule were to be maintained. One major advantage of gene therapy over this medication was that it could target the genes associated with VEGF-A and disable it, thus permanently dealing with the disease. However, this would be a more drastic intervention in terms of going against nature's wisdom, as this therapy would render VEGF-A ineffectual in the eye permanently, unless another intervention of similar scope were to undo the change. This is unlike Avastin which is non-permanent and, more importantly to our investigation, is already proven to work. If one were to follow the invocation of nature as safety to its conclusion, one would have to foreswear gene therapy and continue to rely on monthly injections – contrary to what Kim Jeong Hun is seeking to achieve. If "minimal intervention" was to be a major selling point of the proposed gene therapy, Kim Jeong Hun is not presenting a very consistent case.

[72] Kim Jin-Soo's panel response at the panel debate portion of the Roundabout. Details below in section 3.3.

In light of the apparent incompatibility between the conflation of nature with safety and his aim to use gene therapy to cure a disease which is already treatable, I questioned why Kim Jeong Hun brought up the inherence of the DSB repair mechanisms. There are probably many possible explanations, but the one that I deem most likely in light of the other arguments brought forth at the panel debate and Kim Jeong Hun's close ties with Kim Jin-Soo, a specialist in the CRISPR field, is that this "minimalist" argument is not a general statement that compares his proposed treatment with Avastin. Instead, he was presenting a counter-argument to the notion that gene therapy in general is undesirable because genetic engineering is unnatural, using unnatural means to create unnatural beings. His argument is one in favour of CRISPR gene therapy in comparison to previous modes of genome engineering; it is aimed primarily at allaying the worries people have about the technology.

Why does this localized argument against particular naturalness-based opposition to gene therapy appear in Kim Jeong Hun's presentation? Why is this being mentioned in front of an audience of mostly retired scientists of the Korean Academy of Science and Technology? That I argue is closely connected to the stated goal of both the presentation and the 112th Roundtable Discussions. As suggested by the title of Kim Jeong Hun's presentation, "Proposal for the realization of clinical application of gene correction in the age of CRISPR: A toe in the door for clinical application of genome editing in the era of CRISPR", the argument is part of a proposal on

persuading people to push for deregulation of CRISPR research.[73] The argument is aimed first and foremost at the ultimate audience to whom scientists must "sell" their proposal, the public.

3.2. No "dangerous" insertions: a non-transgenic argument

As seen in the preceding section, Kim Jeong Hun eagerly advertises the *inherence* of the phenomena he utilizes to differentiate his technique with previous techniques, which according to his description involved *insertion* of *foreign* sequences. However, Kim Jeong Hun does not address in the presentation why he is asserting that insertions of foreign sequences are dangerous per se, nor does he advertise this difference in his publications where a deeper explanation may have been included if he had.

Digging for clues as to what danger he was referring to, one can after some searching find reference to the *regulatory* landscape (of the European Union, in fact) in one of the papers co-authored by Kim Jeong Hun's collaborator Kim Jin-Soo.[74] *Highly efficient RNA-guided genome editing in human cells via delivery of purified Cas9 ribonucleoproteins* cites several reasons why insertion of foreign sequences is relatively "problematic". The target genome may become contaminated with parts of the carrier genome that

[73] Kim Jeong Hun's presentation, KAST roundtable. "CRISPR 시대에 유전자교정 임상적용 실현을 위한 제언: A toe in the door for the clinical application of genome editing in the era of CRISPR"

[74] Sojun Kim, Daesik Kim, Seung Woo Cho, Jungeun Kim, and Jin-Soo Kim, "Highly Efficient RNA-Guided Genome Editing in Human Cells via Delivery of Purified Cas9 Ribonucleoproteins," Genome research 24, no. 6 (2014), pp. 1012-1019.

was not part of the intended insertion. Insufficient specificity of target location identification may result in the insertion of foreign sequences in unintended locations (something called *off-target indel*; this is actually one of the central features in the Roundtable presentations, as we shall see below) which are more difficult to anticipate than errors on the target location. Foreign material may cause an immune response from the host and may linger for some time before they dissipate or are removed.

Interestingly, *Highly efficient RNA-guided genome editing* also cites a couple of European Union policy research papers that summarize how much of the existing regulatory oversight of genetic engineering rely on the "dangers" associated with these foreign material insertions, or "transgenesis" to use the legal term.[75] These two papers, *Engineering nucleases for gene targeting: safety and regulatory considerations* (Pauwels et al.) and *Site-directed nucleases: a paradigm shift in predictable, knowledge-based plant breeding* (Podevin et al.), argue that, in light of the concern of government bodies with transgenesis, avoiding the category altogether by not involving *foreign* genes – "transgenes" – will save scientists considerable time and expense related to regulatory compliance. The method of doing so is through cisgenesis – utilization of genetic material native to the organism in question, perhaps the very same individual. Although not directly related,

[75] The two articles referenced by Kim Jin-Soo's paper deal primarily with the development of new commercial plant breeds, where the safety concern of the regulations is significantly lax compared to the oversight of gene therapy, as noticed by Pauwels on one of the two articles.
Katia Pauwels, Nancy Podevin, Didier Breyer, Dana Carroll, and Philippe Herman, "Engineering Nucleases for Gene Targeting: Safety and Regulatory Considerations," *New Biotechnology* 31, no. 1 (2014), pp. 18-27.
Nancy Podevin, Howard V. Davies, Frank Hartung, Fabien Nogue, and Josep M. Casacuberta, "Site-Directed Nucleases: A Paradigm Shift in Predictable, Knowledge-Based Plant Breeding," *Trends in Biotechnology* 31, no. 6 (2013), pp. 375-383.

there is evidence of such an argument already working in the case of agribusiness concerns trying to circumvent USDA definitions of GMOs: Noting that the current definition is dependent on transgenes, the United States Department of Agriculture had told researchers some time ago that it would not regulate newly developed cisgenic products on the grounds that they are not transgenic.[76] Could this legal context be the reason why Kim Jeong Hun differentiates between previous transgenetic techniques and his new, non-transgenic approach? I believe this is highly plausible, especially considering that he relied upon the non-transgenic argument for cisgenesis almost verbatim in his presentation as seen above. Later in his presentation while discussing the fine print of the Korean Bioethics and Safety Act, Kim Jeong Hun adds the following:

> *It may be that I am misreading this law, but as I understand the Korean Bioethics and Safety Act requires all research on gene therapy that seeks to deliver hereditary substances or cells containing such substances into the body must meet one of the two criteria presented therein. Insertion of genetic material needs to meet only either criteria 1 or 2. Our genome editing plan, despite being much safer than such insertions, must meet both criteria. If they demand that I justify my research on both grounds by the letter, I would need to stop my work immediately. As I mentioned previously before my description of CRISPR gene therapy, there already is a suppressor for VEGF-A.*

[76] Two Nature news articles by Emily Waltz illustrate the success of this argument in the United States succinctly.
Emily Waltz, "Tiptoeing around Transgenics," *Nature Biotechnology* 30, no. 3 (2012), pp. 215-217;
Emily Waltz, "Gene-edited CRISPR mushroom escapes US regulation," *Nature News* 532, no. 7599 (2016), p.293.

This means I do not meet the criteria set forth by the law; the law prevents me from studying anything other than the already available method, VEGF-A suppression.[77]

The two criteria that Kim Jeong Hun is referring to here are the two criteria defined in Article 47 Section 1 of the Korean Bioethics and Safety Act.[78] While Kim Jeong Hun's particular interpretation of the distinction between the two types of gene therapy (one that must meet both criteria and the other that only needs to meet one) may be questioned, what is more relevant to the question at hand is how he reacts to the distinction as he just defined it. He asserts that what distinguishes the two types is the transgenics criterion ("insertion of genetic material") – and implies that it is being applied backwards, i.e. non-transgenic procedures are "much safer". He does not go

---

[77] Translated by me from original statement in Korean. "제가 이 법을 잘못 이해하고 있는 걸지는 모르겠는데, 제가 이해하고 있기는 여기 보시면 유전 물질 유전 물질이 도입된 세포를 인체로 전달하는 일련 행위는 1,2 번 행위 중에 하나만 만족하면 된다입니다. 그래서 유전자 치료, 외부 유전자를 넣어주는 건 1,2 번 중 하나만 만족하면 되는 것 같은데요. 저희가 하는 유전, 제놈 에디팅은, 오히려 유전자 넣어주는 거 보다 오히려 앞의 두 방향으로 나아간다면 훨씬 안전한 방법인데도 이 두가지를 모두 만족할 때에만 할 수 있다고 합니다. 그럼 이 두가지 모두를 만족하려면 저희는 안과는 이 연구를 멈춰야 합니다. 제가 앞서 말씀드릴 때 유전자 교정을 말씀드리기 전에 눈에는 나쁜 혈관이 생기는 게 문제고 나쁜 혈관이 생기는 걸 막으려고 VEGF 억제제가 만들어졌다고 말씀드렸잖아요. 여기 보면 현재 이용 가능한 치료법이 있기 때문에 눈에서는 VEGF 억제제 이외에 유전자 교정법 연구를 하면 안됩니다." Kim Jeong Hun, presentation at the KAST Roundtable.

[78] *Article 47 (Gene Therapy) (1) Research on a gene therapy that falls into a series of procedures to alter genes in the body may be conducted in cases that meet both of the following conditions: <Amended by Act, no. 13651, Dec. 29, 2015>*

1. Research on a therapy for a hereditary disease, Acquired Immune Deficiency Syndrome (AIDS), or any other disease that threatens one's life or causes a severe disability;

2. Research on a therapy where there is no applicable therapy at present or the effect of a gene therapy is expected to be significantly better than other therapies.

(2) Research on a gene therapy that falls into a series of procedures to transfer hereditary substances or cells to which hereditary substances are introduced, to the body may be conducted only when falling under either paragraph (1) 1 or 2. <Newly Inserted by Act, no. 13651, Dec. 29, 2015>

Bioethics and Safety Act. Korean National Assembly Act, no. 14839 (2017). Retrieved from the website of the National Law Information Centre. Translation is by the National Law Information Centre. http://www.law.go.kr/LSW/eng/engLsSc.do?menuId=1&query=bioethics+and+safety&x=0&y=0#liBgcolor0

deeper into why the procedures are safer, but it seems evident by this point that Kim Jeong Hun is indeed employing the non-transgenic argument to promote his research.

The inconsistency of using the non-transgenic argument to promote gene therapy is that many of the concerns that birthed and developed the transgenic criterion were based on circumstances other than manipulation of the human genome. This is obvious when one considers where all the transgenesis-related regulations are found: in GMO regulations. A major consideration behind the precautions around transgenesis is that it is considered to be riskier than more "traditional" methods of inducing beneficial mutations, or "mutagenesis" to use the technical term, such as selective breeding or exposing plant genes to ionizing radiation.[79] As transgenesis imparts novel genes and therefore novel expressed traits to the target organism, and may result in a specimen that displays, unpredicted, unwanted and perhaps dangerous traits that would require its isolation, many government bodies thought it prudent to introduce specific controls for transgenic crop (and animal) development. One particular concern with the safety of old-school transgenesis is that while the sequence being introduced is under control, the insertion process itself is not, and the new sequence might land anywhere on the target genome, especially since being of foreign origin there is no specific place that the sequence belongs. In fact, another concern with transgenesis is that insertion usually involves extra bits of genetic material that

[79] Didier Breyer, Philippe Herman, Annick Brandenburger, Godelieve Gheysen, Erik Remaut, Patrice Soumillion, Jan Van Doorsselaere et al., "Commentary: Genetic Modification through Oligonucleotide-Mediated Mutagenesis. A GMO regulatory challenge?" *Environmental Biosafety Research* 8, no. 2 (2009), pp. 57-64; Podevin et al., *op. cit.*

are intended to allow the foreign sequence to successfully join with the target DNA despite the lack of a matching home, and these may not function as expected. Even contamination by sequences entirely outside the intended insertion package is possible, and is another problem that plagues the older method.

"Genome editing" refers to the new, site-specific methods of genome editing that do not rely on fortuitous insertion of genetic materials and instead cause mutations via double-strand breaks at precisely defined sites in the target genome, as explained regarding CRISPR in section 3.1. The term itself was devised by Urdnov et al., regarding zinc finger nucleases (ZFN), one of the earlier genome editing methods, to draw attention to the novel implications of the capability of these new techniques for site-directedness.[80]

The non-transgenic argument applies to products of the new "genome-editing" tools such as ZFN and CRISPR that do not involve insertion of genetic material to the target organism. As no new genetic material is introduced wholesale into the target genome, the range and scope of possible genetic changes fall within the scope of possibilities of the aforementioned "traditional" methods. The same is true of the process as well: as explained in the previous section, genome editing works by introducing a Double Strand Break at specific locations, which is also what happens with "natural" mutations or traditional means of mutagenesis such as radiation

[80] Urnov et al., (2010), "Genome Editing with Engineered Zinc Finger Nucleases." Box 1 explains the significance of the new term and why it isn't called gene targeting instead.

bombardment. This is why the non-transgenic argument is associated with deregulation: there are no grounds for subjecting genome editing to "extra" oversight like that for transgenesis, as they are just like old methods, results-wise. The same old rules for traditional methods should suffice.

In contrast, there is *no traditional method of gene therapy*. There is no "baseline" set of laws that the Korean Bioethics and Safety Law should revert to in response to the non-transgenic argument, because there was no (openly practiced) genetic manipulation of human beings in the first place. Thus, any genetic therapy is *novel* and therefore potentially dangerous, no amount of non-transgenic arguments can lower the perceived risk. The only relevant questions are the most basic ones: just how safe is CRISPR gene therapy? Even though targeted mutagenesis has little chance of causing widely unexpected mutations in the target organism, isn't *any* non-ordinary change potentially dangerous and entirely non-acceptable for in-vivo human gene therapy? [81] Of course, both Kim Jeong Hun's presentation and Kim Jin-Soo's discussion of the topic include arguments aimed at answering the relevant questions – for instance, Kim Jeong Hun's mention of the occurrence of off-target indels in CRISPR-empowered genome editing and his efforts to reduce them, or Kim Jin-Soo's

[81] "For NBGT applications where the enrolment of the recipient organisms in such elaborate screening and selection programs is less feasible or even not acceptable (e.g. gene therapy), the identification and molecular characterization of intended and potential off-target cleavage sites remain important aspects for the assessment and anticipation of potential unintended and adverse effects." Pauwels et al., (2014), "Engineering Nucleases for Gene Targeting: Safety and Regulatory Considerations," p. 24.

answer to Kim Ok-Joo's concerns regarding social justice – but the non-transgenic argument remains irrelevant.

Then why was the transgenic argument employed in the first place? It may be that Kim Jeong Hun, being an ophthalmologist, was unaware of the precise context of the non-transgenic argument and referenced it as a mistake, but seeing as he made almost the exact same presentation almost a year later at the Korean Federation of science and Technology Societies Annual Meeting, collaborating once again with Kim Jin-Soo, I see little reason to suspect that the presentation was poorly planned or inadequately researched. Kim Jin-Soo in particular is a veteran of promoting gene therapy in the media, having participated in the 2015 International Summit on Human Gene Editing, and would be well-versed in the intricacies of the non-transgenic argument and how it relates to various bodies of regulation on biotechnology. Kim Jeong Hun reports that he has coordinated with Kim Jin-Soo regarding the presentation's contents and sometimes quotes Kim Jin-Soo directly;[82] if there was something problematic about Kim Jeong Hun's employment of the non-transgenetic argument, then Kim Jin-Soo would have probably advised his collaborator against it.

The explanation that I think fits best is that, once again, they are answering an argument about the unnaturalness of gene therapy, one that was not present at the roundtable itself but rather originates with the public. While the transgenics criterion

[82] "When I first started work on genome editing with Kim Jin-Soo, I first asked him to confirm for me two things…" "Kim Jin-Soo constantly assured me of the safety of CRISPR…" "…I believe this explanation by Kim Jin-Soo illustrates the situation best…" Excerpts from Kim Jeong Hun's presentation, KAST roundtable.

is arguably irrelevant to human genome editing, it nevertheless is a very high-profile topic, being at the heart of most currently active GMO regulatory schemes. It is transgenics that gives GMOs the moniker "frankenfoods", and by disassociating their gene therapy with the controversy surrounding GMOs perhaps the two Kims sought to avoid a similar opposition regarding their gene therapy plans. As the two Kims describe it, there's nothing eerily unnatural about gene therapy; it deals not with Frankenstein's monsters but rather deals with utilizing natural phenomena to rearrange natural genes in novel ways.

3.3. Human enhancement and the "natural" human gene pool

Kim Jin-Soo is a scientist whose career straddles both the academia and the industry, having been a Samsung researcher before he opened his own company, Toolgen, which he continues to run to this day. Toolgen makes biomedical tools for use in both research and industrial applications, and *digenome-seq*, an in-vitro whole-genome sequencer for determining the off-target ratio in a Cas9-digested genome,[83] is Toolgen's most prolific product. Digenome-seq is seen in use in Kim Jeong Hun's research into using CRISPR to knock out the VEGF gene to determine the improvement in off-target indel minimalization, for instance. Kim Jin-Soo maintains his simultaneous position as head of Toolgen and as an academic at Seoul National

[83] Daesik Kim, Sangsu Bae, Jeongbin Park, Eunji Kim, Seokjoong Kim, Hye Ryeong Yu, Jinha Hwang, Jong-Il Kim, and Jin-Soo Kim, "Digenome-seq: genome-wide profiling of CRISPR-Cas9 off-target effects in human cells," *Nature Methods* 12, no. 3 (2015), p. 237.

University. He is active in the media, being a vocal proponent of the entrepreneurial mindset among academics and the deregulation of gene therapy research. He is often found lamenting about how Korea is committing industrial self-harm by restricting research in his interviews.[84]

The way presenters, especially Kim Jin-Soo, invoke naturalness can be described as reactionary, as they are answering commonly raised arguments against genomic engineering in general. This aspect is most directly evident in the words being used to promote the proposed cure for ARB and responds to arguments raised against the promotion. As noted numerous times, Kim Jeong Hun's description of his research project is keen to label his therapy as "genome correction", as opposed to just "gene therapy". One aspect of this distinction was its minimalist nature, as his CRISPR scissors will be able to achieve the therapeutic goal with only minimal interventions, utilizing natural phenomena inherent in the cell. Another aspect of this distinction was the technique's non-transgenic, non-alien nature, introducing no foreign material into the genome and leaving no traces in the cell after the correction is complete. The last aspect of the distinction highlights the naturalness of the objective of the technique: the distinction between Gene Therapy and Genome

[84] Tae-Il Kim, "Kim Jin-Soo 'changing the world with gene therapy'," *Haemophilia Life(헤모필리아 라이프)*, 2016. 02. 11.
Hoe-Sup Won, "Director Kim Jin-Soo says 'Korean Regulation Stifles Technological Advancement in the Midst of Genome Editing Patent Wars'," *Maeil Business*, 2016. 05. 18.
Seong-Ho Cho, "Chosun Monthly Interviews Kim Jin-Soo 'Suspected of Patent Commandeering'," *Chosun Monthly*, 2018. 09. 10.

correction is, according to Kim Jeong Hun, that correction only seeks to restore the "errors" in the patient genome into the "healthy" or "normal" state.[85]

This "restoration" distinction can be explained as follows. As described above in section 3.1, there are two possible results from the initial Double-Strand Break. One is non-homologous end joining (NHEJ), where the cut ends of the DNA strand are simply put back together. This can be utilized to delete a section of the genome by cutting at two points in such a way that NHEJ would put the two farther points together, instead of the actually cut points. Another is homology directed repair, where the repair mechanisms of the cell try to restore the lost gene by reconstructing a new sequence based on the other set of genes stored within the cell. As long as this other copy of the gene is not of the pathological form, the one that causes abnormally high rate of blood vessel formation through pathological activation of VEGF-A, the restoration of this gene would result in a successful cure of ARB.

The wording of the label "genome correction", as explained by Kim Jin-Soo, refers to this "restoration of the non-pathological state" that is the intended goal of

[85] Genome correction is my translation for the Korean term in use by the two Kims, 유전자 교정. The term for the most part is treated by the presenters, especially Kim Jeong Hun, as being a straight translation of Urdnov et al.'s "Genome Editing," as can be seen in the way Kim Jeong Hun describes three generations of "gene correction" and how foreign research teams are going forward with its human applications. In light of the numerous differences in which the presenters use the term to distinguish their research from previous gene therapy proposals, however – especially the particularly normative argument studied in section 3.3. – I believe that the term should be considered distinct from the original as used by Urdnov et al., To this end I maintain the wording "correction" when referring to the arguments put forth by Kim Jeong Hun and Kim Jin-Soo.

FARB's method.[86] This "corrective" direction is what he considers to qualify the planned method as being truly "therapeutic", as opposed to other possible forms of human genetic engineering which may instead lead to *human enhancement*, a particular topic of human genetic engineering that is a major focus of opposition to deregulation of gene therapy.[87] To quote him, genome correction does not produce super-humans, it only produces normal ones.[88]

A significant portion of opposition to human genetic engineering, especially heritable edits to the germline, rests on the argument against human enhancement, which predicts that proliferation of genetic engineering of humans would lead to the technology being utilized to push individuals beyond the current range of human genetic expression, resulting in a hereditary group of "super-humans" that are advantaged in relation to the non-enhanced population.[89] As gene therapy is expected to be expensive and limited to only a small portion of the human race, the group of people enhanced in such a way could not only introduce a new source of inequality but do so in a way that closely follows and exacerbates the current divisions of wealth

[86] While Kim Jeong Hun never makes the normative distinction of "correction" explicit in his presentation, he does call his intended tactic "substitution", which he mentions is safer and more "normal" compared to "insertion" of transgenesis.
[87] This topic was raised by another of the panel debaters, Medical Historian Dr Kim Ok-Joo. "Deregulation and proliferation of gene therapy could lead to changes in social opinions and regulatory impulses that would allow genetic engineering to change patient genomes beyond what can be understood as being therapeutic, into levels that could grant advantages to the patient."
[88] "Those who had followed my research closely, those able to read into the details, would realize the truth of [what I am arguing right now] on their own. Human enhancement is made more difficult, not easier, by refocusing efforts on *genome correction*." Emphasis is mine. Kim Jin-Soo's panel discussion, KAST roundtable.
[89] *Human Genome Editing*. pp. 137-161.

and social class.[90] Even though gene therapy may be introduced and initially utilized in ways that do not venture into enhancement, the resulting social "acclimatization" to human genetic engineering and maturation of the technology may eventually evolve society to the point where human enhancement occurs; this argument is called the "slippery slope" argument.[91]

Concerns of potential social justice issues are not limited to the slippery slope. In direct opposition to this "Restoring the Normal" argument, historian of medicine Kim Ok-Joo (the only non-scientist in the panel) in her panel discussion pointed out that the very concept of "normal" in regard to the human genome was problematic and was embroiled in a social justice debate of its own. The debate can be summarized into the assertion that there is no "ideal state" to which the "normal" or the "medically sound" can be boiled down into; instead, there is always a wide variety of genes found in the human gene pool, and they are all "natural", "human" genes. The human genome runs a wide range of expressive traits, and the "benefits" and "disadvantages" of individual phenotypes are dependent on the particular context within which the trait is expressed. Furthermore, even considering this, some traits that are usually considered "unquestionably" disadvantageous can nevertheless be considered normal, even essential, for some individuals. For instance, for the inherently blind, their blindness may not be an immense disability but simply an everyday part of life – for

[90] Dr Kim Ok-Joo's discussion, KAST Roundtable.
[91] *Human Genome Editing*. pp. 128-130.

them, the sense of sight does not even exist.[92] While this radically contingent nature of the question of normalcy is highlighted in the case of heritable genetic disabilities, it is not limited to such communities. The very attempt to define and use the term normal in regard to humans raises questions of who has the right to define it, and what happens to those who fall outside it.

Problems of the concept of the normal state become more acutely visible when one considers the legacy, both direct and indirect, of eugenics within discussions of genetic therapy. As Kevles (1995) points out in *In the Name of Eugenics*, "the definition of defect might become once again a hereditarian cloak for social prejudice."[93] The eugenic impulses to "improve" the human gene pool and remove "pathologic" genes and phenotypes from existence are still detectable in modern genetics, and it is because of this shadow that the modern world, or at least the United States where eugenics "was always associated with racism", is as of yet still wary of human genome editing. This general aversion to genetic improvement and enhancement is also noted in the NAS report, which briefly discusses its history while noting that the same arguments were presented, discussed, and ultimately abandoned in regard to prenatal genetic screening. The report continues that genetic screening, while an ongoing source of tension within and around the disabilities community, did not lead to the numerous social problems that its widespread use was feared to herald;

[92] This particular example is quoted directly from the 2017 NAS report.
[93] Daniel J. Kevles, *In the Name of Eugenics: Genetics and the Uses of Human Heredity* (Cambridge: Harvard University Press, 1995).

the report observes, for instance, that the time period in which the screening technology became more widely used was also the period in which public acceptance of disabilities increased markedly. However, in the end the NAS report concedes that the issue is very unlikely to become closed in the near future and will merit continuous deliberation.[94] As further developments in the field of genetic engineering ever increasingly empowers humankind's ability to rewrite its own biological basis, the fear that a more terrible form of eugenics might be birthed from the ashes of the old one continues.

Kim Jin-Soo was also careful to note that continuous communication between the various parties was necessary, but interestingly enough, the participants in the conversation he was envisioning was not the scientists and the public but rather the scientists and the ethicists. Noting that the NAS report from which he was quoting liberally was written by a committee chaired by a professor of law and bioethics, Alta Charo, Kim Jin-Soo remarked "surely there are ethicists in Korea who can come up with a similar text" and promised that if any ethicists were just willing to come knocking on his door, he would be ready to explain to them everything they'd like to learn about genome correction.[95] While he asserted this conversation will be two-way

---

[94] *Human Genome Editing*. pp. 125-127.

[95] Translated from the original statement in Korean. "결국에는 이런 유전자가위 연구자들과 생명윤리학자들 사이에 정보 공유와 소통이 정말 중요 하다는 것이죠. 그래서 저는 생명윤리학자들이 기술에 대해 우려를 갖고 있고, 염려하시는 분이 있다면 언제든지 절 불러주시면, 제가 만사를 제치고 달려가서, 가서 정말 정확히 말씀드리고, 우려하시는 부분이 어떤 것인지 밤을 세서라도 듣고 싶습니다. 어떤 부분은 기술적으로 해결할 수 있을 것이고, 어떠한 우려는 그냥 기우일 수도 있는 것이고, 생각을 통해서 해결할 수도 있을 것이고, 서로 소통한다면, 연구자들도 발전할 수 있을 것이고, 생명윤리학자들도 오히려 건설적으로

and that both parties will have something to learn from the other, the fact that he has already established the NAS report as the desired goal of any such collaboration between scientists and ethicists seems to indicate that this conversation is still aimed at formulating a united, better informed alliance aimed at persuading the public of the ultimate acceptability of gene therapy.

Another indication of how he was approaching the concerns of human enhancement can be found in how Kim Jin-Soo answered Kim Ok-Joo's claim that all human genes are natural. He agreed that the human genome runs a very wide spectrum and there is no narrowly definable "standard state" that human genetic variety can be measured against; to quote the NAS report, "there is no single human genome shared by all of humanity."[96] However instead of concluding that there is nothing to correct towards, Kim Jin-Soo instead argued that the lack of a standard that there is no precise definition to distinguish between treatment and enhancement.[97] A similar point was raised in the NAS report that I believe may shed light to his statement: as there is no standard state, all measurements of genetic health

---

발전할 수 있을 것이라고 생각합니다. 예를 들어서 미국 National Academy of Sciences 가 올 2 월에 보고서를 냈죠. 인간 베아 연구를 어디까지 허용할 것인가에 관해서. 여기를 보시면, 연구를 허용하는 것은 당연한 거고, 심지어 임상적용도 이러이러한 케이스는 허용할 수 있다, 라고 돼있습니다. 그 보고서를 쓴 분이 Charo 박사님인데, 생명윤리학자입니다. 한국의 생명윤리학자도 이 수준의 보고서를 충분히 쓸 수 있다고 생각합니다. 서로 돕고, 공부를 하고, 논의를 하고, 그래서 연구자와 생명윤리학자와 철학자들이 팀워크를, 머릴 맞대서 해결해야 하는 문제가 아닌가 생각하고… 예, 말씀 들어주셔서 고맙습니다." Closing remarks, Kim Jin-Soo's panel discussion, KAST roundtable.

[96] *Human Genome Editing*. p.124.

[97] "On the topic of enhancement and treatment, while those are of different concepts, to distinguish between the two categories in practice is difficult and is never clear-cut." Kim Jin-Soo's panel discussion, KAST roundtable.

will be context-specific, and whether a particular case of human genome editing will turn out to be enhancement or treatment will depend on the circumstances. The report further observes that this distinction may need to be blurred in light of the evolving role of the physician from intervening in diseases already occurring to anticipating and preventing future diseases; preventive medicine can be categorized as both treatment and enhancement.[98] In any case, as the particular strategy being pursued by the FARB team involves homology directed repair using a copy of the gene already in the cell and not anything designed by the physician, Kim Jin-Soo seems confident in his position that whatever he plans to do is not enhancement.

Compared to the two arguments earlier in the roundtable presented by Kim Jeong Hun, Kim Jin-Soo's positions on the treatment/enhancement dichotomy are dismissive of the authority of naturalness. His alternative standard of "the normal/healthy state" is rather traditional for a scientist and stands in opposition to Kim Ok-Joo's claim of universal naturality of all human genomes, a statement that he did not seek to argue against. He even goes as far as to say that what the current generation perceives as enhancement, and even the very notion that enhancement is bad, is not guaranteed to continue to hold for future generations, and that the standard may shift over time. Here he adopts a value-neutral approach to naturalness in that he concedes that all human genomes are natural, but in doing so he has made the criterion irrelevant to what genomes should be cured and what should be left as is. Worded

[98] "Drawing lines: therapy versus enhancement." *Human Genome Editing*. pp. 145-146.

differently, he merely seeks to replace natural but harmful genes with also natural genes that happen to be harmless.

For a point non-technical, naturalness is discussed rather often and at length by the medical scientists gathered at the KAST Roundtable; Kim Jeong Hun constantly returns to it, and it takes up nearly half of Kim Jin-Soo's discussion as well. Kim Yon Soo, another of the panel speakers, also had something to say about naturalness, despite his discussion mostly dealing with the Korean Bioethics and Safety Law and its provisions for government-public oversight of scientist activity. A more in-depth look into his statement reveals that he is talking not of his views on naturalness but rather the views of the public.

3.4. Negative connotations of "mutation" and the public's irrationality

Kim Yon Soo is a biomedical researcher at Chungnam National University's Graduate School of New Drug Discovery and Development. Like Kim Jin-Soo, Kim Yon Soo is prolific in the media and a strong proponent of obtaining and maintaining a technological lead on gene therapy; to this end, he also argues for deregulation of research. As can be seen below, he brought the boldest deregulatory argument among the panel speakers at the KAST Roundtable.

Most of Kim Yon Soo's discussion at the panel debate was centred around promoting a regulatory body composed of technical experts (i.e. bioscientists) to

control gene therapy, as opposed to a mixed or even non-technical body as currently provided for by the Korean Bioethics and Safety Act.[99] As such, naturalness was not an explicit topic of his discussion; however, an indirect treatment of naturalness figured into his explanation of the opposition against gene therapy. Kim Yonsoo expressed his belief that the resistance of the general public against gene therapy was a result of either a misunderstanding or an unfounded fear, and naturalness, or more precisely "normalness" was part of that misunderstanding:

> *…Another aspect of the [Korean Bioethics and Safety Act] that should be discussed is how it pivots on the term 'mutation'. Most people when they see the word mutation would think of mutant traits. Of course, mutations are often positive, in some cases making cures possible. For instance, the gene therapy treatment of AIDS involves inducing a mutation on a 'normal' CCR5 gene so that it malfunctions. Science used 'gene correction' to turn a normal gene into an abnormal state to achieve a cure for AIDS. The term mutation seems very negative at first glance, but [as just mentioned] actually has a lot of positive aspects. Whether a particular mutation is something safe and worthy enough to undergo clinical trial is something that a panel of experts can*

[99] Ethical oversight of bioscience research as required by the Korean Bioethics and Safety Act occurs at two levels, with a central National Bioethics Committee deliberating on matters of bioethics and safety, and Institutional Bioethics Committees in charge of oversight of actual research occurring in their respective institutions. Both are mixed bodies; the National Committee is composed of public servants, scientists, and *"representatives of religions, ethics circles, judicial circles, non-government organizations or women"*, while the Institutional Committees are mostly composed of members of the scientific institution itself but must include at least one member with *"sufficient experience and knowledge to evaluate social and ethical validity"* and at least one member from outside the institution.
Korean Bioethics and Safety Act. Korean National Assembly Act, no. 14839 (2017). Retrieved from the website of the National Law Information Centre.
http://www.law.go.kr/LSW/eng/engLsSc.do?menuId=1&query=bioethics+and+safety&x=0&y=0#liBgcolor0

and do adequately judge. However, there are many in the public who are beholden by this 'public fear', civilians with negative impressions of genome engineering. I believe the use of words such as mutation in the law may be one of the causes of this fear, and thus, this word, along with the entire category, must be deleted from the law. […] Concerns regarding research are already sufficiently considered by relevant committees in charge of overviewing clinical trials, and they will disallow dangerous trials from going ahead. Regulations such as Article 47 are thus redundant, in addition to causing public fear, and are therefore undesirable.[100]

Kim Yon Soo presents that one of the basis of public resistance against gene therapy is the public's understanding that gene therapy involves "abnormal" mutations, which while abnormal are still beneficial. The word "normal" used by Kim Yon Soo in this context should probably be understood as additionally meaning "natural" as in "naturally occurring in the human genome", as can be seen from how he describes the

[100] Translated from the original statement in Korean. "또한 법의 문구에 변이[라는 표현이 사용되는데] 이 변이라는 것이 많은 사람들에게는 돌연변이를 의미합니다. 돌연변이라는 것은 어떤 측면에서 보면 굉장히 좋은 것인데, 인간에게 치료할 수 있는 좋은 것입니다. 첫번째 유전자 치료기술을 이용해서 사람한테 적용한, 에이즈 환자가 에이즈 바이러스가 T 세포를 감염시키지 못하도록 정상적인 CCR5 유전자를 망가뜨리는 겁니다. 인위적으로 유전자편집기술을 써서 변이를 일으킨거죠, 정상이 아닌 비정상으로. 그렇게 치료를 하고 있는 겁니다. 변이라는 말은 우리가 대단히 부정적으로 들리지만 사실 양적(positive) 측면이 많이 있는거고 이것이 [임상적으로 시험할 만한 것인지는] 위원회의 전문가들을 통해서 충분히 볼 수 있는 것이기 때문에.. 대중에게, *퍼블릭 피어(Public Fear)*라고 우리가 보통 부르죠, 유전자치료에 대하여 대단히 부정적인 견해를 담고있는 퍼블릭(대중), 일반인들이 많은데 변이라는 부정적 용어가 우리의 인식을 일으키는 원인이 아닐까 생각합니다. 용어가 문제가 아니라 사실 이 항목 전체가 없어져야 되는 것이고. 제가 주장하고 싶은것은 토론 말미에도 나와있지만 사실은 얼마 전에 국무총리실에서 규제와 관한 의견을 내달라고 그래서 저는 모든 항목을 없에라, 실제 사람에게 적용하는 것은 많은 주의가 필요하고 많은 논의가 필요하지만 1,2 항은 없에는 것이 타당하다. 충분히 우리가 임상실험 인가 커미티(Committee)에서 충분히 논의해서 결정할 수 있는 과학적 근거가 쌓여있고, 논의를 할 수 있는 능력이 있기 때문에..." Kim Yon Soo's panel discussion, KAST Roundtable.

CCR5 gene prior to gene therapy as "normal". CCR5 refers to a chemokine receptor on human white blood cells that is used by many forms of the Human Immunodeficiency Virus to infect the cells, thus leading to AIDS.[101] Recent developments in gene therapy are targeting the *CCR5* in an effort to achieve a curative (permanent) treatment of AIDS;[102] Sangamo Therapeutics' ZFN gene therapy treatment SB-728-T is currently undergoing open label Phase 2 clinical study.[103] This development is what Kim Yon Soo is referring to when he mentions deliberately turning normal *CCR5* genes 'abnormal', which indicates that Kim Yon Soo was using "normalness" as a semi-synonym for "natural abundance". While there do exist a naturally occurring, HIV-resistant version of the CCR5 receptor known as $CCR5^{\Delta 32/\Delta 32}$, this is extremely rare especially outside of the European population groups.[104] Seeing as a number of CCR5-centred gene therapy strategies – some of them undergoing

[101] The connection between AIDS and the *CCR5* gene has led to commercial interests rapidly capitalizing on its value, and eventually led to intriguing developments in intellectual property rights on human gene sequences. For a succinct summary of the history of the *CCR5* gene and its commercialization see Jackson, M. W. (2015). How Gene Patents are Challenging Intellectual Property Law: The History of the CCR5 Gene Patent. *Perspectives on science*, 23(1), 80-105.

[102] Anjie Zhen and Scott Kitchen, "Stem-Cell-Based Gene Therapy for HIV Infection," *Viruses* 6, no. 1 (2014), pp. 1-12.
A review of their special pertinence in light of recent developments in antiviral medicine strategy can be found in:
Stefan HE Kaufmann, Anca Dorhoi, Richard S. Hotchkiss, and Ralf Bartenschlager, "Host-Directed Therapies for Bacterial and Viral Infections." *Nature Reviews Drug Discovery* 17, no. 1 (2018), p.35.

[103] Sangamo Therapeutics, "Pipeline,' https://www.sangamo.com/pipeline (retrieved 2019-04-01)
Pablo Tebas, David Stein, Winson W. Tang, Ian Frank, Shelley Q. Wang, Gary Lee, S. Kaye Spratt et al., "Gene Editing of CCR5 in Autologous CD4 T-Cells of Persons Infected with HIV." *New England Journal of Medicine* 370, no. 10 (2014), pp. 901-910.

[104] Zhen & Kitchen, *op. cit.* p.3.

clinical trials[105] – involve disrupting the expression entirely, Kim Yon Soo's "abnormal" in this sense includes non-naturally-occurring forms as well.

What Kim Yon Soo is arguing in the above statement therefore can be understood as the assertion that naturalness is not equated with safety or desirability; in fact, desirable forms of some genes are desirable precisely because they are not natural. While this seems at conflict with Kim Jeong Hun's invocation of naturalness at first, in light of how Kim Jeong Hun is painting a picture of a natural gene therapy, perhaps there is no contradiction. Kim Yon Soo's argument is posed directly in opposition to the expectation that natural evolution has granted humanity with very good and efficient genes. This is the so-called "nature's wisdom" argument, and Kim Yon Soo's dismissal has some aspects that resonate with the dismissals by bioethicists quoted in the 2015 Nuffield Council report.[106] Kim Jeong Hun's argument is that his proposed gene therapy involves no insertion of foreign genetic material and minimal involvement of mechanisms not native to the human cell. As seen here, Kim Jeong Hun's argument shares nothing with the nature's wisdom argument that Kim Yon Soo attacks.

What's interesting about the naturalness arguments being employed at the Roundtable is not in their differences but rather what they *do* have in common: that the concerns are being answered with technical solutions and clarifications, i.e. with

[105] Ibid. p.4.
[106] Nuffield Council on Bioethics, *Ideas about Naturalness.* p.17.

science. Moreover, the scientists argue that more data, produced with further experiments, can only yield better science, and thus better answers for the questions currently being asked about biotechnology. Their arguments collectively paint the picture that all these concerns would not have been raised or could be soothed with proper, directed research. Scientists are eager to hear the concerns, they claim, and even more eager to look for relevant scientific findings so that they may answer those concerns. They merely want to be permitted to do so.

4. The Public and the Authority of Science

4.1. The positioning of the scientists' arguments and the "Q&A" relationship

A common element throughout the various arguments of naturalness brought forth by scientists at the KAST Roundtable is that they are all directed *outwards*; they are aimed at opposing viewpoints originating from outside the scientist community. These viewpoints are commonly held by the public, who were absent from the Roundtable itself – while historian of medicine Kim Ok-Joo was at the panel and raised issues of social justice, human dignity, and other ethical concerns, she raised no arguments dependent on naturalness itself, other than to point out that there is no single natural human genome (and thus no real way to easily discern "unnatural" human genes), which was the same point brought up by Kim Jin-Soo in the following panel discussion. These arguments from outside that the scientists were arguing against had been present in the wider genome engineering debate for some time; some of them

were those addressed by the international bodies being quoted by the scientists, such as the 2015 International Summit on Human Gene Editing,[107] and some were those raised by critics of genetic engineering in books and political arguments.[108] The reason there was practically no discussion occurring within the panel debate itself was because many of the arguments of the scientists were not aimed at Kim Ok-Joo; they were mostly speaking *to* or *about* the public that wasn't there.

While the scientists make no specific mention of the arguments they had in mind when they presented their counter-arguments, I believe the following list more-or-less represents the external arguments that correspond to each respective naturalness-based argument present at the roundtable:

"Wisdom of Nature" – arguing that humans should not intervene in natural processes that are the result of millions of years of evolutionary tweaking or divine design[109] – corresponds to Kim Jeong Hun's claim that his minimalist approach to gene therapy should be more attuned to natural phenomena.

"Purity of the Human Genome" – arguing that inserting foreign genetic material to the human genome insults human dignity, invades the sanctity of humanness, or raises unnecessary questions on what defines a human (and thus

---

[107] National Academy of Sciences, *International Summit on Human Gene Editing.*
National Academy of Sciences, *Human Genome Editing.*
[108] Hoongi Kim, *The Right to Know and Right to Choose.*
[109] Nick Bostrom and Anders Sandberg, "The Wisdom of Nature: An Evolutionary Heuristic for Human Enhancement," in Julian Savulescu and Nick Bostrom, eds., *Human Enhancement* (Oxford University Press on Demand, 2009).

defines eligibility for protection of human rights)[110] – corresponds to Kim Jeong Hun's "non-transgenic," or cisgenic, argument that his gene therapy involves no foreign genes.

"Anti-Enhancement Argument" – arguing that editing the human genome will lead to, or at the least allow the eventual proliferation of, human enhancement – corresponds to Kim Jin-Soo's explanation that his gene therapy technique involves restoring the genome to a state already existent in the gene pool and therefore will not lead to "enhancement." The human enhancement concern is a complex topic; bioethicists warn that enhancing the capabilities of some human beings beyond what is currently possible within the human gene pool may lead to either the rise of super-humans as a separate class, or a shift in what is perceived as proper parental care. Existence of super-humans may create a new class struggle, which may exacerbate existing social divisions especially considering such technology may be beyond the reach of the economically underprivileged, and thus the genetically enhanced will also be economically better-off. Also, if enhancement were to become normalized, enhancement of some traits may become prevalent enough to be considered socially proper and thus individuals lacking those enhancement, such as those with inherited disabilities, may become ostracised.[111]

---

[110] National Academy of Sciences, *Human Genome Editing*. p.124; Roberto Andorno, "Human Dignity and Human Rights as a Common Ground for a Global Bioethics," *Journal of Medicine and Philosophy* 34, no. 3 (2009), pp. 223-240.

[111] National Academy of Sciences, "Enhancement," *Human Genome Editing*, pp. 137-162.

"Wisdom of Repugnance" – arguing that genetically modified beings cause reactions of disgust among humans which in and of itself is sufficient moral grounds for opposition – corresponds to Kim Yon Soo's arguments regarding the public fear of mutations, and may also correspond to Kim Jin-Soo's argument that their therapy seeks to restore "normal" genes. The phrase "wisdom of repugnance" comes from Leon Kass, a physician and political activist who was chairman of the US President's Council on Bioethics from 2001 to 2005.[112]

Due to this outwards focus of the panel arguments, the 112th Roundtable feels less like a policy discussion and more like a briefing on the current state of the debate delivered by active scientists to an audience of senior or retired scientists gathered there to check on the process – a briefing on what "they" are saying against "us", and what arguments "we" have prepared to disarm those of the opposition. The outward directionality can be detected in the way the scientists describe their opposition, and the tone with which they present their own counterarguments. For instance, Kim Jeong Hun when describing how his gene therapy differs from previous ones, labels public impressions of previous techniques as "common misunderstanding," as can be seen in the following quote:

> *This has been an issue with gene therapy: gene therapy [in the past] involved solving problems with existing genome by introducing foreign sequences to replace problematic functions. While our technique is not too different from previous gene therapy [in its*

[112] Leon R. Kass, *op. cit.*

effect], it is ***commonly misunderstood*** *that we also insert foreign genes to the genome to achieve our therapeutic goals. My research, including my clinical trials is not about inserting foreign genetic material into the cell. We are researching options that are considered normal parts of the natural metabolism of the cell, such as gene deletion and substitution. In this regard I argue that we are technologically safer than previous genetic therapies.*[113]

Kim Yon Soo describes public opposition to the concept of mutations as "public fear":

However, there are many in the public who are beholden by this 'public fear', civilians with negative impressions of genome engineering. I believe the use of words such as mutation in the law may be one of the causes of this fear, and thus, this word, along with the entire category, must be deleted from the law.[114]

---

113 "사실 이 부분은 유전자 치료가 가지고 있는 문제입니다. 유전자 치료는 기존의 유전자의 문제를 해결하기 위해 외부의 유전자를 집어넣어서 이 문제 기능을 대신하게 하는 방법입니다. 사실 생각해보면 그거랑 [유전자 교정 사이에] 큰 차이는 없는건데, *사실 우리는 어떤 오해를 하고있냐면*, 유전자 교정이라 하면 유전자 치료와 같이 하 새로운 유전자 하나 집어넣어서 그런가보다, 라고 하지만, 앞서 말씀드린 많은 연구들, 그리고 제가 임상의사로서 제가 진행하고 있는 연구는 요 부위는 전혀 하고 있지 않습니다. 저희는 정상적으로 일어나는 현상 중 하나라고 생각할 수 있는 deletion, substitution 같은 굉장히 안전한 방향으로만 가고있고 김진수 교수님과 제가 하고 있는 연구는 요 방향만 하고 있습니다. 그게 일단 기술적으로 안전, 이라는 것이 첫번째 우리가 생각해야 할 부분이구요." The "we" in the phrase *우리는 어떤 오해를 하고 있냐면(What we are misunderstanding)* should be understood as referring to the Korean nation or society in the sense of the uninitiated public, as Kim Jeong Hun himself obviously understands the distinction between transgenics (insertion of foreign genetic materials) and cisgenics (use of native genetic materials). The phrase may also refer to non-specialist scientists, but in this case the sense of being uninitiated still holds true. Kim Jeong Hun, presentation at the KAST Roundtable.

114 "대중에게, 퍼블릭 피어(Public Fear)라고 우리가 보통 부르죠, 유전자치료에 대하여 대단히 부정적인 견해를 담고있는 퍼블릭(대중), 일반인들이 많은데 변이라는 부정적 용어가 우리의 인식을 일으키는 원인이 아닐까 생각합니다. […] 유전자치료에 대한 정의를, 변이라는 표현을 대체해서 식약청의 유전자 치료에 대한 정의를 새롭게 냄으로서 충분히 일반인들이 가지고 있는 막연한 공포는 없어질 것이라고 생각합니다." Kim Yon Soo's panel discussion, KAST Roundtable.

Such labels accompany the descriptions of opposing views, while "multitude of data (factual evidence)"[115] and "communicative efforts (by experts)"[116] are cited as means to combat those views. This characteristic positioning of the scientists is telling: the scientists are depicted as fighting against "misconceptions", "assumptions" and "generalizations" that are invalided by scientific knowledge, especially the latest discoveries.

One could argue that there is nothing new with this mode of argumentation by scientists, relying upon their epistemological authority to persuade others, as this is in line with previous descriptions of the deficit model. I assert however that the authority of the expert society is not all that can be observed at work in these arguments, as the scientists are not arguing that they are already *right* per se, but rather that research is the only right way to gain valid information that in turn is necessary to make the right decisions, and thus research should always be allowed to proceed. While many scientists claim their acceptance of the public's authority to decide the direction forward, as evinced Kim Jeong Hun's statement that "the prevailing opinion

115 "그럼 왜 선진국들이 이렇게 우리나라보다 이렇게 이러한 새로운 기술에 대한 임상실험이라던지에 대해서 더 보수적이지 않고 진보적인 입장을 취하느냐. 저는 그것이 신뢰 기반의 사회에다가 히스토리를 중시[하기 때문이다라고] 생각합니다. 즉, 많은 실험실에서의 데이터, 또 많은 임상시험을 통한 데이터가 있고, 그 데이터를 기반으로 해서 전문가들이 모여서 아, 이 연구는 할 가치가 있다, 해볼만하다, 리스크가 비교적 없는 제품을 통해서 들여다볼 필요가 있다 라고, 전문가들이 충분히 합의하면, 그것을 갔다가 실행할 수 있게 하는 것이야 말로 선진국인 것입니다." *ibid.*

116 "결국에는 이런 유전자가위 연구자들과 생명윤리학자들 사이에 정보 공유와 소통이 정말 중요 하다는 것이죠. […] 어떤 부분은 기술적으로 해결할 수 있을 것이고, 어떠한 우려는 그냥 기우일 수도 있는 것이고, 생각을 통해서 해결할 수도 있을 것이고..." Kim Jin-Soo's panel discussion, KAST Roundtable.

among scientists is that we should proceed with care until there is public consensus for the technology to move forward,"[117] they are still insistent that proper decisions must be based on facts, facts that only science can provide. Even Kim Yon Soo, who argues that scientists are the only ones qualified to make decisions on what research is acceptable and what is not, grants that medical applications should be done "after careful consideration and discussion"; it is only research that should not be restricted by redundant oversight.[118] It is in this vein that the scientists criticize the Korean Bioethics and Safety Act: it governs not only the practice of medicine but also research, hereby prohibiting scientists from obtaining critical data that can support more learned decisions regarding genome engineering.

That the moral valuation of nature was not questioned at the Roundtable is an interesting aspect of the scientists' arguments. Outside of Kim Jin Soo briefly discussing the applicability of the word "natural" to the human genome, the scientists have not questioned the use of naturalness as a source of value; this is despite the usually observed trend of scientists being wary of giving the moral authority of nature too much credit, exemplified with Kim Yon Soo pointing out that naturalness itself

---

[117] Translated from original Korean. "사회적인 consensus 가 있기 전까지는 조심스럽게 하는게 좋겠다, 라는게 현재까지의 동의입니다. 저도 거기에 동의합니다. 다만, 여기서 말하는건 임상의 적용이구요, 연구는 할 수 있어야 하지 않나, 가 제 생각입니다." Kim Jeong Hun, presentation at the KAST Roundtable.

[118] Translated from original Korean. "제가 주장하고 싶은 것은 토론 말미에도 나와있지만 사실은 얼마 전에 국무총리실에서 규제와 관한 의견을 내달라고 그래서 저는 모든 항목을 없애라, 실제 사람에게 적용하는 것은 많은 주의가 필요하고 많은 논의가 필요하지만 1,2 항은 없애는 것이 타당하다. 충분히 우리가 임상실험 인가 커미티(Committee)에서 충분히 논의해서 결정할 수 있는 과학적 근거가 쌓여 있고, 논의를 할 수 있는 능력이 있기 때문에…" Kim Yon Soo's panel discussion, KAST Roundtable.

has no inherent medical value in and of itself.[119] The aforementioned 2015 survey report by the science policy research organization Nuffield Council is a quantification study showing a similar leaning on the part of UK scientists. The council's report analysed the ways in which "naturalness" was utilized in arguments regarding genetic research in British publications for a period of 20 years up to the date of publication.[120] While categorizing the arguments by persons utilizing them, the Nuffield Council report found that the scientists under study made no value-laden mentions of naturalness, and instead showed an outspoken scepticism about there being a sound reason to assign right or wrong to naturalness (0 value-laden, 1% borderline).[121] This is in marked contrast to value-laden usage of naturalness in other fields, such as in media articles (10% value-laden, 11% borderline), parliamentary discussions (12% value-laden, 7% borderline), and civil organization publications (6% value-laden, 11% borderline).

Comments from scientists as quoted in the Nuffield Council report suggest that the scientists become vocal about their avoidance of assigning value to naturalness when they encounter such value-laden conceptions being held by non-scientists. A 2014 report published by the UK organization Sense About science on the topic of naturalness, for instance, posits that "in terms of chemical safety, 'industrial', 'synthetic', 'artificial', and 'man-made' do not necessarily mean damaging and 'natural'

[119] Aforementioned CCR5 argument by Kim Yon Soo, analysed in section 3.4. Kim Yon Soo's panel discussion, KAST Roundtable.
[120] Nuffield Council on Bioethics, Ideas about Naturalness.
[121] *ibid.* pp. 41-45.

does not necessarily mean better."[122] Similar sentiment can be found in publications by US-based bodies as well: in a discussion document made for the National science Foundation, the authors pointed out that "…The natural-versus-artificial distinction, as a way to identify human enhancements, may prove difficult to defend given the vagueness of the term 'natural'."[123] A relatively extended discussion of the topic and its place in the overall debate around genetic engineering can be found in the NAS report *Human Genome Editing*, where a similar sentiment is evident: "The word 'natural' has similarly taken on a positive connotation reflecting a common view that nature produces things that are healthier and generally better than anything artificial – this despite evidence demonstrating that 'natural' things can either be safe or intrinsically dangerous."[124] These arguments implore healthy scepticism against assigning value to naturalness itself.

Why is it, then, that the scientists gathered at the KAST Roundtable are making use of naturalness-based arguments? Why are they silent on the validity of the criterion of naturalness in the evaluation of the merits of gene therapy? Even if the public is worried about naturalness, shouldn't scientists instead be concentrating their efforts into fighting the fallacies in imbuing value to nature, seeing as they are not the relevant questions? I believe this is because the scientists at the KAST roundtable are

[122] Sense About science, *Making Sense of Chemical Stories* (2014) available at: http://www.senseaboutscience.org/pages/making-sense-of-chemical-stories.html
[123] Fritz Allhoff, Patrick Lin, James Moor, and John Weckert. "Ethics of Human Enhancement: 25 Questions & Answers," *Studies in Ethics, Law, and Technology* 4, no. 1 (2010).
[124] National Academy of Sciences, *Human Genome Editing.* p.138.

accepting of the role of the public as ultimate decision-makers in the acceptance of gene therapy: as long as the concern is indeed being raised, it is not the place of scientists to question the validity of the concern. The scientists acknowledge the *social* validity of the concerns themselves, i.e. the related questions have been asked and many people are basing their decision-making on them, and so they can be persuaded by the scientists with successful and relevant answers. Kim Jin-Soo acknowledges that the public has concerns about the creation of babies endowed with "enhanced" traits, and promises that the gene therapy that he envisions has even less of a chance of such unnatural progeny. Kim Jeong Hun actively proclaims the naturalness of his gene knockout strategy in order to answer what he perceives to be common concerns in the public regarding the naturalness (and thus acceptability) of his new gene therapy. While Kim Yon-Soo warns against assigning value to naturalness itself, arguing that "unnaturalness" is not a valid ground for caution, he still grants that any medical application of the technology must follow thorough discussion and social consensus.[125]

These answers that scientists provide, along with their claim that further research must be allowed by the law to enable the discovery of further answers, present a relationship between science and the public that is different from, although not separate from, the traditionally understood relationship that underpins the deficit model. The deficit model directly correlates public resistance to science with public

[125] Translated from original statement in Korean. "실제 사람에게 적용하는 것은 많은 주의가 필요하고 많은 논의가 필요하지만…" Kim Yon Soo's panel discussion, KAST Roundtable.

ignorance of science and seeks to remedy it with dissemination of knowledge on the contents and methods of science, with scientists deciding both the questions to be asked and the answers to them. In contrast, the relationship that the scientists at the KAST Roundtable imply is more akin to that of a Q&A session, with questions asked by the public which are then answered by the scientists. While the capacity to provide answers – their intellectual authority – is still closely guarded by the scientists, it is the public that decides what questions the public is concerned about. Even though the public was absent from the Roundtable itself, by directing their efforts to answering what they perceived as public concerns the scientists interacted with public opinion, albeit in an admittedly long-winded and roundabout way. Rather than telling the public what they should understand, science asks the public what it wishes to know.

The aforementioned positioning explains to the audience *why* it is worthwhile to support the work of the scientists, but what form should that support take? *How* do the scientists want to be supported? The scientists were clear in their demands: they want deregulation.

4.2. History of the Korean Bioethics and Safety Act and the Legacy of Hwang

As can be seen in the title of the 112th Roundtable Discussions, the overall focus of the scientists' collective arguments was that the current Korean Bioethics and Safety Act must be made less restrictive of research. Describing the current regulations with

adjectives such as "counter-productive,"[126] "most conservative,"[127] "backwards," and "misunderstanding,"[128] the scientists argued that there was little justification for the level of restriction placed on gene therapy research.

The scientists' arguments of deregulation are not themselves the focus of this paper and will not be analysed in detail here. However, the legal and social context in which the current deregulatory push is placed are of interest, especially regarding the changing narratives with which the scientists' role within society has been framed in the understanding of the Korean public. The "Q&A" posture taken by the scientists in regard to naturalness-based arguments, and the eagerness on part of the scientists to present themselves as good listeners that this posture represents, should be understood in relation to the increasing "public distrust" that scientists perceive within Korean society.

The Korean Bioethics and Safety Act, and legal governance of bioscience and biotechnology in general, has been characterised by a tug-of-war between the two positions of "promotion of Korean biotechnology" and "protection of human values", each championed by bioscientists and bioethicists respectively. In the network analysis of various actors and the interactions between them in the original 2005 legislation of the Korean Bioethics and Safety Act, Science and Technology Studies scholar Song

[126] Scientists argue that the new law protects neither the welfare nor the rights of citizens.
[127] Kim Yon-Soo claims that the Korean law is based on some of the most conservative laws regarding gene therapy in the world, for instance that of Japan.
[128] The "non-transgenic" argument of Kim Jeong-Hun asserts that the legislature lack understanding of the distinction between previous genome engineering techniques such as recombinant DNA technology and the current CRISPR-aided gene knockout strategy pursued by his team.

Sung-Soo explains that the non-government actors can largely be divided into the science community and the citizen advocacy groups, each arguing for promotion of biotechnology and protection of human values, respectively. The deliberations surrounding Bioethics and Safety Act in the early 2000s were characterized by the constant and unresolved stand-off between these two positions. This stand-off caused constant delays in the legislative process, and the proposal went through numerous revisions while the positions of the bioscientists and the NGOs remained unchanged throughout the time period. Legislation was achieved only after the non-government actors were deprived of their access to the legislative process and the divisions within the government were temporarily set aside in favour of not delaying the legislation any further. The resulting law reflected mostly the views that favoured the promotion of biotechnology.[129]

In his book *Biotechnology and Politics* bioscience journalist Kim Hoongi analyse the actors and concerns that were involved in the earliest formulative stages of the Bioethics and Safety Act, between the late 90s and its first legislation in 2005. The main actors in the Korean legislative process are the Standing Committees of the National Assembly, which dominate the legislative process within the legislature, and the relevant Ministries of the executive branch of the Korean government. In the case of the Bioethics and Safety Act the actors are the Science, ICT, Broadcasting, and Communications Committee of the National Assembly (hereafter referred to as the

[129] Sungsoo Song, "Policy Network Analysis on the Legislation Process of Bioethics in Korea, 1997~2003," *Journal of Korea Technology Innovation Society* 8, no. 2 (2005), pp. 702-731.

Science Committee), the Ministry of Science and Technology (underwent numerous reorganizations in recent history, currently the Ministry of Science and ICT), and the Ministry of Health and Welfare. Kim Hoongi reports that the Science Committee favoured the statist arguments for the promotion of biotechnology over the moralist arguments for the protection of human values, which were championed mostly by citizen advocacy groups, who did not have direct access to the Committee. The Ministry of Science and Technology followed suit for the most part and worked to represent the opinions of the Korean science community. The Ministry of Health and Welfare, although representing the arguments of the human values advocacy groups at first, realized quickly that any legislative proposal that ran contrary to the opinions of the science community was unlikely to be approved by the Science Committee, and shifted their position to be more in-line with the rest of the main actors. Kim Hoongi observes that while both ministries were eagerly pushing for new legislation that would govern bioethics and biosafety (a push encouraged in part by the Cartagena Protocol on Biosafety), neither had "specific vision" on what form the new law should take, which is why the ministries were quick to fall in line with the view of the Science Committee.[130]

This changed drastically in the 2012 revision of the Bioethics and Safety Act, which more-or-less completely overhauled the law and reoriented it away from the promotion of biotechnology and towards the protection of human values. Legal

[130] Hoongi Kim, *Biotechnology and Politics* (Seoul: Whistler, 2005).

scholar Cho Hong Suck writes in his analysis of the 2012 revision of the Korean Bioethics and Safety Act that the deletion of "establishing circumstances that would promote [biotechnology]" from the mission statement of the Bioethics and Safety Act (Article 1), thus leaving only "preventing the harming of human bodies and the violation of human dignity and values", is crucial and reflects the overall theme of the 2012 revision. In addition, the revised law postulates that all subsequent laws that govern matters of bioethics and biosafety must obey the principles and regulations set forth in the Bioethics and Safety Act, which affirms that the law's new focus on the promotion of human values is comprehensive and must be observed by everyone at all cases within Korean jurisdiction. This shift in focus was accompanied by a much stronger system of oversight on research activities, with the oversight committees now mandating the inclusion of "experts on bioethics".[131]

It is this revised form of 2012 that is under discussion at the 112th Roundtable Discussions. Article 47 is of particular interest, as it governs gene therapy specifically. As explained briefly in section 3.2 while discussing Kim Jeong Hun's arguments, Article 47 prohibits all gene therapy activity unless the particular activity meets the two criteria set forth within the article. The first criterion is the "disease criterion", allowing gene therapy for genetic diseases, cancer, AIDS and other such critical, life-threatening diseases. The second criterion is the "method criterion", allowing gene therapy for diseases where no other methods of treatment exist, or gene therapy is

[131] Hong Suck Cho, *op. cit.*

expected to be substantially superior to all existing methods. For in-vivo therapy, both criteria have to be met, while for ex-vivo only one of the two criteria need to be met. In its 2005 original form the Korean Bioethics and Safety Act originally required only one of the two criteria be met for gene therapy to be allowed; this was changed in the 2012 overhaul to require both criteria be met in response to calls for stronger regulation, but then partially deregulated for ex-vivo therapy in 2015 in consideration of the "international deregulatory trend".[132]

Throughout this period the constant tug-of-war between the two positions of promotion of biotechnology and protection of human values is evident within the law itself, even after the deletion of the former position from the mission statement in the 2012 revision. The 2015 revision, for instance, list "improving national competence in the gene testing field" as one of the reasons for the deregulatory revision.[133] This shows that the position of the scientists at the Roundtable, that the Bioethics and Safety Act should promote biotechnological advancement despite the contrary stated mission of the law, is not unique to the scientists and enjoy, or at least have enjoyed in 2015, considerable support within the government.

A turning point in this tug-of-war was the Hwang Woo Suk scandal that rocked Korea in 2005. Science historian Song Sang-Yong analysed the Hwang scandal

[132] Dae-Woong Park and Hwa-Shin Ryoo, "Regulatory Framework for Gene Therapy on Human Embryos in Response to CRISPR-Cas9," *Journal of the Bioethics Association* 17, no. 1 (2016), pp. 35-52.
[133] Original text is in Korean, translation is mine. Bioethics and Safety Act. Korean National Assembly Act, 2015 (Republic of Korea), no. 13651. Retrieved from the website of the National Law Information Centre.

as one of the largest crises in the history of Korean science, and a turning point in the struggle between scientism powered by an "ideology of development", which would correspond to the call for promotion of biotechnology, and the concern over protection of human values. Hwang Woo Suk is a Korean veterinary scientist who first gained fame in 1999 for his claim of cloning two cows, dairy cow Yeongrong-I and Korean cow Jin-i. His alleged claim of creating an embryonic stem cell in 2004 gained him international notoriety, and he became the greatest, most celebrated hero of Korean science. When his 2004 and 2005 publications were proved to be the results of academic fraud, and that he had achieved practically none of the things he had claimed to have achieved, shocked the nation, but defence of Hwang's research and reputation continued for some time and still remain active to some extent. Noting that celebration and defence of Hwang Woo Suk transcended politico-ideological divides and social categories, Song Sang-Yong argued that Hwang's popularity was a symptom of widespread belief in scientism that permeated the whole of Korean society. While the fall of Hwang provided an opportunity for Korean society to re-evaluate scientism and its development-focused outlook, Song writes that scientism still reigns strong in Korea and its effects are constantly felt.[134]

Hwang had been linked with the Korean Bioethics and Safety Act from its early legislation. As Kim Hoongi notes, the concern that regulation of genome engineering research could hamper Hwang's research efforts was one of the strong

[134] Sang-Yong Song, "The Hwang Woo Suk case: A Critical Review," *Korean Association of Science and Technology Studies Conference* 2015.12 (2015), pp. 1-11.

factors influencing the legislative process.[135] His fall from grace, in turn, created a strong social impetus for increased outside oversight on bioscience research, which is noted as one of the reasons for the 2012 revision of the Bioethics and Safety Act, and numerous other laws covering similar issues of bioethics.[136] Hwang remains the most remembered case of the excesses of Korean scientism, and a prototype of what future science governance should avoid.

Constant references to "distrust" of scientific authority on part of the Korean public alluded to by the scientists of the 112th Roundtable thus should be understood in reference to the legacy of Hwang. The scientists' appeals to statist-scientist arguments such as national scientific competence belies the continued influence of "development ideology" and scientism among Korean bioscientists, as noted by Song Sang-Yong. From this point of view, the 2012 revision represents an "over-reaction" of Korean society (of which the state is considered a representative agent) towards the scientific community over the peculiar wrongdoings of a single scientist, who has already been disenfranchised and cast out.

Furthermore, evidence suggests that scientists understand the legacy of Hwang to be primarily about his research fraud, and show less interest in the accusations of bioethical nature, such as regarding the morality of Hwang's harvesting of eggs from his junior scientists and economically unprivileged patients, and the

---

[135] Hoongi Kim, *Biotechnology and Politics*, section 3, pp. 96-167.
[136] In-Young Li, "Legal Policy for Genetechnology – Promotion, Biosafety, Bioethics," *Hallym Law Forum* 18 (2007), pp. 157-197.

matter of whether sufficiently informed consent was given. Kim Yon Soo's argument that the peer-review process is sufficient and the lack of scientific expertise on part of outside panels makes them unfit to understand and judge research, also stand on the assumption that most activities of the review board will centre around inquiries of technical nature, not moral.[137] Kim Jeong Hun's comments regarding the applicability of the Bioethics and Safety Act to him, when he claimed that he's "not doing this to publish 'good' papers", also may be alluding to the Hwang scandal as it relates to the Bioethics and Safety Act. While explaining that his research cannot meet both criteria for allowed research as set forth in Article 47 of the Bioethics and Safety Act, Kim Jeong Hun remarks, "I am not a basic researcher, I do clinical studies and applied research to bring new technologies to my patients. This law prohibits my research, but I'm not doing this to write good papers or anything like that." By differentiating himself from 'pursuit of academic accolades', Kim Jeong Hun is arguing that he is not someone that the law should be aiming to regulate.[138]

The use of naturalness arguments by scientists at the Roundtable Discussions represents a shift away from this focus on the *science vs. ethics* dichotomy that characterised previous stand-offs between "promotion of biotechnology" and "protection of human values". Whereas the two concerns had been understood to be in constant conflict with each other, scientists' attempts at answering naturalness-

[137] "Concerns regarding research are already sufficiently considered by relevant committees in charge of overviewing clinical trials, and they will disallow dangerous trials from going ahead." Kim Yon Soo's panel discussion, KAST Roundtable.
[138] Kim Jeong Hun, presentation at the KAST Roundtable.

based concerns with scientific counter-points and the resulting "repositioning" of the utility of science in regards to societal concerns represents a marriage of the two positions into a single narrative, where promotion of biotechnology (technically, bioscientific research) *is* protection of human values. While this still stays firmly within the overarching ideology of scientism, this new posture deviates from simplistic characterisation of ethics "getting in the way of progress" and thus could be a sign of more conversational approaches in the future.

4.3. Appeal to the authority of the NAS report and Asilomar-in-Memory

Most, if not all, of the arguments scientists presented in regard to naturalness concerns at the Roundtable were adopted from the arguments analysed and set forth in the NAS report *Human Genome Editing*. There are also multiple other similarities that can be drawn between the positioning of the scientists at the KAST roundtable and the emphasis on the need to allow research to proceed presented by the 2017 NAS report.[139] First of all, the scientists at the roundtable constantly cite both the report and the 2015 International Summit that ultimately led to it as sources of authority to boost the persuasiveness of their claims for deregulation. There are numerous points in the Roundtable where the scientists bring up the Summit on the report as evidence of international consensus among scientists that some avenues of genetic research are

[139] National Academy of Sciences, *Human Genome Editing*.

safe enough to pursue, as shall be seen in more detail below. In addition, the Summit is taken up as proof that scientists are aware of the concerns of the public and are actively discussing and addressing the concerns, especially with Kim Jin-Soo who was present at the 2015 Summit and participated in the deliberations. This is especially visible with the arguments of Kim Yon Soo who pushes for more autonomy and self-regulation for scientists when it comes to research.

There's also a rather intriguing connection that can be found in the way scientists in the KAST roundtable and the NAS argue for the importance of continuing research. In addition to the above arguments that research is safe and that scientists can be trusted, a third argument regarding why research should be done is presented that is in line with the aforementioned "answering of questions". The more interactive relationship between science and the public that I described above centres around a re-positioned claim for science's sole capacity to provide meaningful answers. The claim that science is the sole source of verifiable (or at the least, intellectually valuable) answers is defended by the assertion that valid decisions are those based on facts, the traditional demesne of science. Kim Jeong Hun argues that research of gene therapy techniques should be allowed regardless of current regulatory status of their medical application, as the decision to deregulate or not would itself have to rely on the answers that science will find.[140] While he does not directly weight in on the need

[140] Translated from original Korean. "다만, 여기서 말하는 건 임상의 적용이구요, 연구는 할 수 있어야 하지 않나, 가 제 생각입니다. 연구를 해야 그 다음에 필요성을 알 텐데…" Kim Jeong Hun, presentation at the KAST Roundtable.

for science to be allowed to find answers, Kim Jin-Soo emphasizes the importance of bioethicists to interface directly with scientists so that their concerns may be thoroughly discussed, understood, and answered using relevant scientific knowledge – which implies the importance of finding that knowledge.[141] This emphasis on allowing research bears intriguing similarities with prior research regarding the way scientists remember the recent past of bioscience.

The aforementioned assertion of the need for fact-based decision-making and the supremacy of science as the source of facts are in line with a certain worldview common among scientists, which is called the "received understanding" by Susan Wright in *Molecular Politics* and "Asilomar-in-memory" by J. Benjamin Hurlbut in *Remembering the Future. Molecular* Politics reports that the history of deregulation of recombinant DNA technology is remembered and understood by scientists as being primarily a result of educational and persuasive efforts by scientists, fighting misunderstandings based on incomplete knowledge. Wright reports that a biased view of the history of Bioscience was at work among scientists, the aforementioned received understanding;[142] in this version of history, the deregulation of biotech after initial public resistance is depicted as being the result of successful efforts by scientists to persuade non-scientists of the lack of merit of previous concerns. Hurlbut links this

[141] Translated from original Korean. "결국에는 이런 유전자가위 연구자들과 생명윤리학자들 사이에 정보 공유와 소통이 정말 중요 하다는 것이죠. […] 서로 돕고, 공부를 하고, 논의를 하고, 그래서 연구자와 생명윤리학자와 철학자들이 팀워크를, 머릴 맞대서 해결해야 하는 문제가 아닌가 생각하고…" Kim Jin-Soo's panel discussion, KAST roundtable.
[142] Wright, *op. cit.* p.7.

view of Asilomar with the 1995 US Congressional hearings on cloning technology and 2010 Presidential Commission on Bioethics, arguing that Asilomar as remembered by scientists and key persons in governance served as a model for both cases, prescribing what form proper governance takes, involving a fixed relationship between science, government, and the public. A new ideology was in place, providing instructions for building a better future.

The received understanding of Asilomar as analysed by Wright goes as follows. The arguments for opposing genetic engineering that were key to the guidelines imposed in the aftermath of Asilomar were then found by scientists to be based either on lack of knowledge on the subject or on faulty, subjective reasoning. Concerted education using newest research findings filled in the gaps in the public understanding, or at the least persuaded policy makers to listen to reason instead of fear. In this way, deregulation was not spawned from negotiation but was the cumulative result of cooler heads eventually prevailing; it was society, not science, that was the primary source of risk. Wright's book demonstrates in detail just how much negotiations and changing of circumstances were involved in the actual process of deregulation; nevertheless, the received understanding continues to dominate scientists' perception of past events, including the Asilomar conference itself.

This "received understanding" can be better understood in relation to the long-held narrative of "Public Understanding of science", which centres around attempting to bridge a gap in understanding and perspective between "science", as

understood as a unified body of specialists, and "the Public", imagined as a mass of laypersons with no expert knowledge. Much of the efforts by scientists and government bodies in bringing the public into science governance, including efforts for increased public participation, has been handled under the umbrella of that narrative. Monika Kurath and Priska Gisler in their work *Informing, involving or engaging? science communication, in the ages of atom-, bio- and nanotechnology* offers a critique of this narrative and efforts associated with it, pointing out that this simplistic opposition between two imagined, antagonistic bodies of thoughts is what drives the ineffectiveness of the efforts in the first place. Analysing the various technological controversies in the late 20th and the current centuries, Kurath and Gisler note that, even as the narrative of Public Understanding constantly shifted towards a "more democratic form of participation" by the public in scientific governance, the essential epistemological divide between an expert scientific community and a relatively underinformed "lay" public was maintained, which perpetuated the one-directional "deficit" model of knowledge dissemination.[143] Key to this continued survival of the deficit model in some shape or form would be the collective memory of Asilomar that various relevant groups hold. Gisler and Kurath noted that, while the specific contents were different, state officials, scientists, and NGO activists alike remembered the Asilomar conference fondly as an example of responsible governance and

[143] Kurath & Gisler, "Informing, Involving or Engaging?"

participation; a "paradise lost".[144] All subsequent interactions between science and the public were understood in relation to the first "model" case.

J. Benjamin Hurlbut in *Remembering the Future* explains that such a perceived understanding of the context and achievements of Asilomar, "Asilomar-in-memory", prescribed both a proper form of responsible governance of emerging technologies and proper levels of agency to the Scientific Community, the State, and the Public.[145] Utilizing Jasanoff's theorization of Sociotechnical Imaginaries that are fleshed out in the same book, Hurlbut describes that not only is Asilomar-in-memory an imagined ideal past but a powerful prescription for handling all emerging technologies, representing a success story that is to be emulated in order to ensure the continuous ushering in of productive futures, brought about by the new technology. Analysing the 1997 Congressional hearings on cloning and the deliberations of the 2010 report of the Presidential Commission for the Study of Bioethical Issues, Hurlbut explains in succinct detail how Asilomar-in-memory was crystalized into a stable system: in it, science is an autonomous, self-governing and unified body that is solely competent to "read" and foretell the future. Law is understood as necessarily reactive to the changes brought about by science due to its lack of expertise; thus, law should patiently wait while science produces the knowledge necessary to understand what possible futures exist. In turn, science is to responsibly practice its autonomy and serve society by

[144] Gisler & Kurath, "Paradise Lost?"
[145] J. Benjamin Hurlbut, "Remembering the Future: Science, Law, and the Legacy of Asilomar," Sheilla Jasanoff and Sang-Hyun Kim, eds., *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (Chicago: University of Chicago Press, 2015), pp. 126-151.

carefully measuring the risks and benefits of expanding technology: the Asilomar moratorium as initiated by the Berg Letter[146] is hailed as the exemplar of such responsible action. Notably, the public is imagined as an unruly entity prone to acting prematurely; it must be carefully managed so that discussions on how to proceed can occur only after science produces its predictions of possible futures. The role of government is to act as the crucial bridge between the concerns of the public and the knowledge of science; to relay the worries of the public to science, to support and allow science to find answers, and to manage the public so that its concerns do not boil over into rash action. This tripartite division of labour is designed to ensure that the public's sometimes overreactive, potentially destructive imaginations do not result in harm to the whole. Asilomar-in-memory is a shining success story of this particular form of governance, and by re-enacting it, society perpetuates the set roles prescribed by the memory to the three primary actors.

There are similarities that can be drawn between the model prescribed by Asilomar-in-memory and the argumentative positions took by the scientists at the KAST Roundtable. While none of them invoke the image of Asilomar directly, they constantly remind the audience that the key tenets of good governance are to seek the right answers. Kim Jeong Hun argued that allowing research to proceed can only lead

[146] Paul Berg, David Baltimore, Herbert W. Boyer, Stanley N. Cohen, Ronald W. Davis, David S. Hogness, Daniel Nathans et al., "Potential Biohazards of Recombinant DNA Molecules," *Science* 185, no. 4148 (1974), p.303.

to better tools and better answers.[147] Kim Jin-Soo points out that bioethicists (in the governance position) should reach out to scientists and communicate the concerns that they and the public have so that scientists can properly answer them.[148] Kim Yon Soo emphasizes the role and prominence of the expert committees charged with policing research in the US, and the trust that government has placed in the scientists.[149]

---

147 Translated from original statements in Korean. "다만, 여기서 말하는건 임상의 적용이구요, 연구는 할 수 있어야 하지 않나, 가 제 생각입니다. 연구를 해야 그 다음에 필요성을 알텐데 제가 알기론 미국이나 스웨덴의 연구팀에선 연구는 허용된 걸로 압니다." Kim Jeong Hun, presentation at the KAST Roundtable.
"다시 말해서, 유전자 교정 기술이 개발되면 개발될수록 Off-target effect 라는건 줄어들 수밖에 없고요, 연구자가 더 유전자 교정을 연구해서 더 잘 만들면 당연히 Off-target effect 는 (줄어들 거기 때문에) 저희가 걱정하고 유려하지만, 오히려 조금 더 긍정적인 눈으로 바라볼 수 있는 부분이 아닌가 생각합니다." *ibid.*
"지금 현재 진행하고 있는 실험도 그렇고 원숭이 실험도 그렇고. 그런데 제가 한가지 걱정하는 것은 저희가 이런 연구를 하는 데에 있어서 물론 무조건 무조건 해야 됩니다, 뭐 안전합니다 라고 강조하고 싶은 게 아니고요, 이런 연구가 잘 적용될 수 있도록 저희가 지금 front 에 가 있다고 생각하면, 더 front 로 앞서나갈 수 있도록, 이 연구가 발전할 수 있는 계기가 되기를 정말 염원하구요. 이 토론에서 제가 도움을 받을 수 있는 많은 말씀을 들을 수 있기를 기원하겠습니다. 이상입니다." *ibid.*
148 Analysed earlier in section, and also in section 3.3. Kim Jin-Soo's panel discussion, KAST roundtable.
149 Translated from original statement in Korean. "마지막으로 말씀드리고 싶은 것은 [일반 신약개발에 대한 허가는 식약청(FDA)에서 하지만] 유전자 치료 기술에 대해서는 NIH 에서 민간 위원회를 통해서 허가합니다. RAC(Recombinant DNA Advisory Committee)이라고 해서 25 명 내외의 민간 전문요원들이 심의를 합니다. 20 년 가까이의 히스토리, 심의 역사를 통해서 "아 이거는 우리가 심의를 안해도 임상 연구 할 수 있어"싶은 항목에 대해서는 심의도 안하고 바로 허가를 내줍니다. 하지만 새로운 유전자 기술, CRISPR 기술과 같은 것이 오면, "아 이건 우리가 한번 들여다봐야해" 하고 들여다보고 심의를 해서 "아 이건 할 수 있겠어" 하면 바로 허가해주고 식약청은 자기네가 가진 기준을 가지고 자료를 요구해서 심의한 다음 허가를 해 줍니다. 그 특징중의 하나는 NIH 에서 유전자치료에 대해서 심의하는 전문요원들은 25 명 모두가 실명이 공개가 되고 거기서 토론하는, "이 심의대상 연구를 허가할 것인가 추가 데이터를 요구할 것인가" 토론하는 내용이 카메라로 모두 recording 되서 모든 사람이 볼 수가 있습니다. 그래서 신뢰, 전문성과 신뢰성을 확보한 상태에서 하고 있죠. 따라서 식약청이 따라갈 수가 없는 새로운 기술에 대한 판단은 NIH 에서 전문가를 통해서 임상시험을 허가를 해줍니다. [미국에] 우리나라 생명윤리법에 있는 1,2 항과 같은 조항은 없습니다. 다만 있는것은 베아, 생식세포에 대한 것은 제한하지만 그것도 연방펀드를 가진

Further connection between Asilomar-in-memory and the arguments at the KAST Roundtable can be found through the constant references to the 2015 International Summit and the NAS report *Human Genome Editing*.[150] Kim Jeong Hun and Kim Jin-Soo invoke the authority of the International Summit (in which Kim Jin-Soo took part) and the resulting *Human Genome Editing* report as evidence of the existence of broad, authoritative consensus among scientists about what kind of research should be allowed to proceed. Seeing as the International Summit is in many ways a successor to the spirit of the Asilomar Conference, having been summoned by a similar call for moratorium, the 2015 Baltimore letter, written by many of the same people, including Paul Berg,[151] the scientists of the KAST roundtable can be said to be invoking a modern re-enactment of the Asilomar conference, in an attempt to re-establish the proper form of science governance as prescribed by the received understanding. Kim Jin-Soo's glowing reference to bioethicist Alta Charo, one of the key persons involved in the 2010 Presidential Commission that Hurlbut studies, may also be understood in line of these connections. Charo is one of the co-authors and a spokesperson for the conclusions of the 2017 report, as seen in a Proceedings of the NAS interview.[152] In his praise, Kim Jin-Soo laments that there hasn't yet been

연구만 제한되지 민간 펀드를 사용한 연구는 제한되지 않습니다." Kim Yon Soo's panel discussion, KAST Roundtable.

[150] National Academy of Sciences, *International Summit on Human Gene Editing.*
National Academy of Sciences, *Human Genome Editing.*

[151] David Baltimore, Paul Berg, Michael Botchan, Dana Carroll, R. Alta Charo, George Church, Jacob E. Corn et al., "A Prudent Path Forward for Genomic Engineering and Germline Gene Modification," *Science* 348, no. 6230 (2015), pp. 36-38.

[152] Prashant Nair, *op. cit.*

someone like Charo in Korea, who would defend the importance of continuing research in the name of finding answers – an argument that Charo herself had done by invoking Asilomar-in-Memory.

Kim Jeong Hun in his presentation emphasizes that the International Summit, while voluntarily committing to David Baltimore's proposed moratorium on germline editing,[153] gave the green light on somatic cell edits, which he claimed was supportive of his argument for deregulation in Korea. Kim Yon-Soo explicitly claims that scientists are already empowered to govern themselves, and that further regulatory oversight without scientist input is redundant and harmful to society. They stress that the inhibition of science, caused by the premature intervention of Law, will come back and lead to great losses by the public. Instead, they argue, research itself must continue, even if the public ultimately decides to not implement gene therapy in practice; if that comes to pass, at the least it will be a learned decision, informed by the results of scientific research. This argument echoes that of Asilomar-in-memory: as Alta Charo told the US Senate Subcommittee on Labour and Human Resources in 1997, "these kinds of … discussions about the scientific advances that are at risk if we were to ban all such forms of research could be more important than any kind of legislation you ultimately come up with, because it will help us to understand what it is we are balancing and make a reasoned choice."[154]

[153] David Baltimore et al., *op. cit.*
[154] Re-cited from J. Benjamin Hurlbut, *op. cit.* p.139.

In this vein, the opposition of the scientists at the Roundtable to the Korean Bioethics and Safety Act gains a new dimension. The scientists argue that the law has been "imposed" on an unwilling scientific community, without its consent or input, and that this imposition is harmful.[155] In reference to Asilomar-in-memory, such an imposition would be a grave trespass, as not only has law acted prematurely, without having all the answers in hand, but it has also prohibited science from providing further knowledge. In order for science to readily serve its rightful role, research must be deregulated as in accordance with the consensus of the 2015 International Summit, the newest incarnation of Asilomar. Any further concerns of the public would then be answered by this new research; only after the answers have been provided should law act.

5. Conclusion: Scientists of the Roundtable

The scientists gathered at the 112th KAST Roundtable Discussions argued many things on gene therapy's behalf. Analysing their naturalness-based arguments in particular, I noticed how the arguments, while not fully developed, still engaged properly with naturalness-based concerns of the public. This was despite a noted

[155] Translated from original text in Korean. "그러나 이러한 제도화는 '추격형(fast follower), 하향식(top-down)' 방식의 특징을 보이며 한계를 드러내고 있음. 우리나라의 제도는 외국에서 수십년에 걸쳐 논의되고 발전한 소위 '선진'제도를 빠르게 수입하여 따라잡고자 하였다는 점에서 추격형이며, 관련 연구자와 학문 공동체는 대체로 제도 도입에 소극적, 방어적이었던 반면 정부가 주도하여 제도의 도입이 추진되었다는 측면에서 하향식임." Korean Academy of Science and Technology, *Medical-Life-Sciences and Human Rights*.

tendency on part of scientists to be reluctant to invoke naturalness or express scepticism over its moral value, perhaps in knowledge of the various pitfalls that naturalness as a moral authority is associated with. While the scientists did not agree among themselves regarding the precise valuation of nature and sometimes contradicted their other points in the same discussion, naturalness nevertheless occupied a significant place in their overall statements. Scientists were eager to answer the concerns of the public, to clear any misunderstanding that may exist, and to learn what more they could do to assuage their worries.

This positioning of the scientists at the roundtable, something that I have called a "Q&A" posture, is different from, if not separate from, the magisterial position of scientists as understood through the deficit model. Whereas in the deficit model scientists deem ignorance of science itself as the cause of public opposition to new science and seek to remedy this ignorance with scientific education, the scientists at the 112th Roundtable instead sought to answer whatever questions people might ask of them, regardless of whether those questions had any technical, scientific merit. Kim Jin-Soo went as far as to profess his willingness to spend sleepless nights fully discussing any and all concerns bioethicists may have about bioscience, until all questions are answered.[156]

[156] This particular statement however is not new, and Korean scientists have been accused of promising to do so and then failing to deliver. Bang-Ook Jun, *op. cit.* p. 114.

This eager ear of the scientists goes hand-in-hand with the deregulatory arguments: the Korean Bioethics and Safety Act is badly written primarily because it hinders the ability of science to answer questions, to acquire new knowledge that may be important in future decision-making. Whereas traditionally Korean scientists have accused bioethics of getting in the way of necessary progress that would benefit the state and nation, this new positioning instead argues that regulatory oversight is getting in the way of *ethics*, here represented by the naturalness concerns. By connecting "ethical" questions with scientific answers, scientists at the 112th Roundtable are attempting to bring bioethics into the aegis of scientific inquiry, so that ethical concerns would become cause for more research, not less.

The argument that regulation of research is counterproductive gains a new dimension in light of the prescriptions of Asilomar-in-memory, an idealized understanding of the Asilomar conference of 1975 and its immediate aftermath, where proper cooperation between scientists and the government resulted in what is understood to be a very successful management of the public's concerns. In order for the newly re-positioned role of science as the answerer of questions to work, its capability to find answers must not be hindered. Even if it turns out that the ultimate decision of the public is to not adopt the new technology, until that decision can be made, science must be allowed to do everything in its power to find relevant answers.

This capacity to answer questions is uniquely reserved to the scientists and functions as a new pillar that supports the intellectual authority of science. As such,

even while science has yielded to the public the capacity to decide what questions are important, science is indispensable to the decision-making process, as without it decisions will have to be made blind. Scientists of the 112th roundtable accentuate this claim by referring to the 2015 International Summit and the subsequent 2017 NAS report *Human Genome Editing* as evidence of international recognizance of this essential role of science. The tripartite division of labour between answer-seeking science, concern-filled but curious public, and a mediating government must be maintained to ensure a fully functioning and progressive society. Because the Bioethics and Safety Act instead seeks to unilaterally control science, effectively shackling science in the name of the public, the Korean state will only end up preventing science from serving the public. Thus, the repositioning of the scientists in regard to naturalness-based concerns represent another attempt at rallying Korea under scientism.

On the other hand, this new positioning represents a shift away from the traditional dichotomy between the promotion of bioscience and biotechnology and the protection of human values. The legislative history surrounding the Bioethics and Safety Act is dominated by the permanent stand-off between these two concerns, which reconciliation was deemed impossible and legal proposals either struck a middle ground or discarded one concern in favour of the other. However, by attempting to answer naturalness-based concerns with scientific arguments (or ordinary arguments supported by the intellectual authority of the scientific community), the scientists at the 112th Roundtable Discussions can be said to have attempted to unite the two

positions into one, dominated by the authority of the scientists but still linked into a single narrative where scientific inquiry could satisfy both concerns.

The symbolic meaning of the Round Table in its original, Arthurian form is that there is no head in a round table, and thus all who sit at it are of equal standing. While the new positioning of the scientists in regard to naturalness-based arguments does not imply acknowledging moral authorities as being equal to scientific authorities, it still comes far from the previous mode of argumentation, which can be visualized as scientists and ethicists sitting at two separate tables facing each other. By adopting naturalness, a supposedly moral and non-scientific concern, as part of their collective argument for gene therapy research, the scientists have presented a way to frame the debate concerning gene therapy in a singular, unified imperative, instead of a conflict between two opposing positions. If this shift could be identified and acknowledged as such and nurtured into a new direction in debates regarding gene therapy in Korea, then I believe the 112th Roundtable could very well be the first step towards establishing a true Round Table for scientific and moral concerns.

References

Allhoff, Fritz, Patrick Lin, James Moor, and John Weckert, "Ethics of Human Enhancement: 25 Questions & Answers," *Studies in Ethics, Law, and Technology* 4, no. 1 (2010).

Andorno, Roberto, "Human Dignity and Human Rights as a Common Ground for a Global Bioethics," *Journal of Medicine and Philosophy* 34, no. 3 (2009), pp. 223-240.

Annas, George J., Lori B. Andrews, and Rosario M. Isasi, "Protecting the Endangered Human: Toward an International Treaty Prohibiting Cloning and Inheritable Alterations," *American Journal of Law & Medicine* 28 (2002), p. 151.

Baltimore, David, Paul Berg, Michael Botchan, Dana Carroll, R. Alta Charo, George Church, Jacob E. Corn et al., "A Prudent Path Forward for Genomic Engineering and Germline Gene Modification," *Science* 348, no. 6230 (2015), pp. 36-38.

Berg, Paul, David Baltimore, Herbert W. Boyer, Stanley N. Cohen, Ronald W. Davis, David S. Hogness, Daniel Nathans et al., "Potential Biohazards of Recombinant DNA Molecules," *Science* 185, no. 4148 (1974), p.303.

Berg, Paul, David Baltimore, Sydney Brenner, Richard O. Roblin, and Maxine F. Singer, "Asilomar Conference on Recombinant DNA Molecules," *Science* 188, no. 4192 (1975), pp.991-994.

Bodmer, Walter Fred, *The Public Understanding of Science* (London: Birkbeck College, 1986).

Bostrom, Nick, and Anders Sandberg, "The Wisdom of Nature: An Evolutionary Heuristic for Human Enhancement," in Julian Savulescu and Nick Bostrom, eds., *Human Enhancement* (Oxford University Press on Demand, 2009).

Breyer, Didier, Philippe Herman, Annick Brandenburger, Godelieve Gheysen, Erik Remaut, Patrice Soumillion, Jan Van Doorsselaere et al., "Commentary: Genetic Modification Through Oligonucleotide-Mediated Mutagenesis. A GMO Regulatory Challenge? " *Environmental Biosafety Research* 8, no. 2 (2009), pp.57-64.

Brooks, Kathleen R., and Jayson L. Lusk, "US Consumers Attitudes Toward Farm Animal Cloning," *Appetite* 57, no. 2 (2011), pp.483-492.

Callaway, Ewen, "Embryo-Editing Research Gathers Momentum: Scientists Proceed with Human-Genome-Editing Experiments as Ethical Debate Continues," *Nature* 532, no. 7599 (2016), pp.289-291.

Cho, Seong-Ho, "Chosun Monthly Interviews Kim Jin-Soo 'Suspected of Patent Commandeering'," *Chosun Monthly*, 2018. 09. 10.

Cho, Hong Suck, "The System, Contents, and Problems on New Bioethics and Safety Act," *Public Law Journal* 13, no. 4 (2012), pp. 251-268.

Daston, Lorraine, and Fernando Vidal, eds., *The Moral Authority of Nature* (Chicago: University of Chicago Press, 2010).

Doudna, Jennifer, "Perspective: Embryo Editing Needs Scrutiny," *Nature* 528, no. 7580 (2015), p. S6.

Gaskell, George, Sally Stares, Agnes Allansdottir, Nick Allum, and Paula Castro, *Europeans and Biotechnology in 2010: Winds of change? A report to the European Commission's Directorate-General for Research on the Eurobarometer 73.1 on Biotechnology, FP7 project 'Sensitive Technologies and European Public Ethics'(STEPE)*, (Luxembourg: Publications Office of the European Union, 2010).

Gieryn, Thomas F., "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review* (1983) pp. 781-795.

Gisler, Priska, and Monika Kurath, "Paradise Lost? 'Science' and 'the Public' after Asilomar," *Science, Technology, & Human Values* 36, no. 2 (2011), pp.213-243.

Harris, John, and Søren Holm, "The Future of Human Reproduction: Ethics, Choice, and Regulation," (Oxford: Oxford University Press, 1998).

House of Lords Select Committee on Science and Technology, Science and Society, *Third Report of the Session*
1999–2000 (London: HM Stationery Office, 2000).

Hurlbut, J. Benjamin, "Remembering the Future: Science, Law, and the Legacy of Asilomar," *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (2015), pp.126-151.

Hwang, Sang-Ik, "Bioethics in Korea – Past and Present," *Bio, Ethics and Policy* 1, no. 1 (2017), pp. 31-55.

Jackson, Myles W., "How Gene Patents are Challenging Intellectual Property Law: The History of the CCR5 Gene Patent," *Perspectives on Science* 23, no. 1 (2015), pp. 80-105.

Jinek, Martin, Krzysztof Chylinski, Ines Fonfara, Michael Hauer, Jennifer A. Doudna, and Emmanuelle Charpentier, "A Programmable Dual-RNA–Guided DNA Endonuclease in Adaptive Bacterial Immunity," *Science* 337, no. 6096 (2012), pp. 816-821.

Jinek, Martin, Alexandra East, Aaron Cheng, Steven Lin, Enbo Ma, and Jennifer Doudna, "RNA-programmed genome editing in human cells." *elife* 2 (2013), e00471.

Jun, Bang-Ook, "Human Embryo Cloners' Rhetorical Strategies in Korean Media Reporting," *Journal of the Korean Bioethics Association* 6, no. 1 (2005), pp. 109-122.

Kass, Leon R., "The Wisdom of Repugnance: Why We Should Ban the Cloning of Humans," Valparaiso University Law Review 32 (1997), p.679.

Kaufmann, Stefan HE, Anca Dorhoi, Richard S. Hotchkiss, and Ralf Bartenschlager, "Host-Directed Therapies for Bacterial and Viral Infections." *Nature Reviews Drug Discovery* 17, no. 1 (2018), p.35.

Kevles, Daniel J., *In the Name of Eugenics: Genetics and the Uses of Human Heredity* (Cambridge: Harvard University Press, 1995).

Kevles, Daniel J., "Of Mice & Money: The Story of the World's First Animal Patent," *Daedalus* 131, no. 2 (2002), pp. 78-88.

Kim, Daesik, Sangsu Bae, Jeongbin Park, Eunji Kim, Seokjoong Kim, Hye Ryeong Yu, Jinha Hwang, Jong-Il Kim, and Jin-Soo Kim. "Digenome-seq: genome-wide profiling of CRISPR-Cas9 off-target effects in human cells." *Nature methods* 12, no. 3 (2015), p. 237.

Kim, Hoongi, *The Rights to Know and Choose in the Age of Bioengineering Consumption* (Seoul: EASTASIA, 2013).

Kim, Hoongi, *Biotechnology and Politics*, (Seoul: Whistler, 2005).

Kim, Jongyoung, "Making Sense of Fervent Hwang Woo Suk Supporters – Culture of Conspiracy and the Politics of Accusation," *Korean Journal of Sociology* 41, no. 6 (2007), pp. 75-111.

Kim, Kyoutae, "Evolution of Archaeopteryx and Horses to Remain in Textbooks", *Dong-a Ilbo*, 2012. 06. 25, p.A12.

Kim, Sojun, Daesik Kim, Seung Woo Cho, Jungeun Kim, and Jin-Soo Kim, "Highly Efficient RNA-Guided Genome Editing in Human Cells via Delivery of Purified Cas9 Ribonucleoproteins," Genome Research 24, no. 6 (2014), pp. 1012-1019.

Kim, Tae-Il, "Kim Jin-Soo 'Changing the World with Gene Therapy'," *Haemophilia Life(헤모필리아 라이프)*, 2016. 02. 11.

Korean Academy of Science and Technology, "112th KAST Roundtable Discussions: Directions for Legal and Regulatory Change Aimed at the Introduction and Utilization of Genome Editing Technology", 2017. 08. 03.

Korean Academy of Science and Technology, "Purpose," https://kast.or.kr/kr/kast/purpose.php (retrieved 2019-03-24).

Kurath, Monika, and Priska Gisler, "Informing, Involving or Engaging? Science Communication, in the Ages of Atom-, Bio-and Nanotechnology," *Public Understanding of Science* 18, no. 5 (2009), pp.559-573.

Li, In-Young, "Legal Policy for Genetechnology – Promotion, Biosafety, Bioethics," *Hallym Law Forum* 18 (2007), pp. 157-197.

Miller, Steve, "Public Understanding of Science at the Crossroads." *Public Understanding of Science* 10, no. 1 (2001), pp.115-120.

Nair, Prashant, "QnAs with Alta Charo and George Church," Proceedings of the National Academy of Sciences 114, no. 23 (2017), pp.5769-5771.

National Academy of Sciences, Engineering, and Medicine, *International Summit on Human Gene Editing: A Global Discussion* (Washington, DC: The National Academies Press, 2016), doi: https://doi.org/10.17226/21913.

National Academy of Sciences, Engineering, and Medicine, *Human Genome Editing: Science, Ethics, and Governance* (Washington, DC: National Academies Press, 2017), doi: https://doi.org/10.17226/24623.

Nuffield Council on Bioethics, *Ideas about Naturalness in Public and Political Debates about Science, Technology and Medicine* (2015), http://nuffieldbioethics.org/project/naturalness (retrieved 2018-07-09).

Palombi, Luigi, *Gene Cartels: Biotech Patents in the Age of Free Trade* (Cheltenham: Edward Elgar Publishing, 2009).

Park, Dae-Woong, and Hwa-Shin Ryoo, "Regulatory Framework for Gene Therapy on Human Embryos in Response to CRISPR-Cas9," *Journal of the Bioethics Association* 17, no. 1 (2016), pp. 35-52.

Pauwels, Katia, Nancy Podevin, Didier Breyer, Dana Carroll, and Philippe Herman, "Engineering Nucleases for Gene Targeting: Safety and Regulatory Considerations," *New Biotechnology* 31, no. 1 (2014), pp. 18-27.

Podevin, Nancy, Howard V. Davies, Frank Hartung, Fabien Nogue, and Josep M. Casacuberta, "Site-Directed Nucleases: A Paradigm Shift in Predictable, Knowledge-Based Plant Breeding," *Trends in Biotechnology* 31, no. 6 (2013), pp. 375-383.

Rose, Nikolas, "The Politics of Life Itself," *Theory, Culture & Society* 18, no. 6 (2001), pp.1-30.

Royal Society, the, *The Public Understanding of Science* (London: The Royal Society, 1985).

Sangamo Therapeutics, "Pipeline,' https://www.sangamo.com/pipeline (retrieved 2019-04-01)

Song, Sang-Yong, "The Hwang Woo Suk Case: A Critical Review," *Korean Association of Science and Technology Studies Conference* 2015.12 (2015), pp. 1-11.

Song, Sungsoo, "Policy Network Analysis on the Legislation Process of Bioethics in Korea, 1997~2003," *Journal of Korea Technology Innovation Society* 8, no. 2 (2005), pp. 702-731.

Sturgis, Patrick, and Nick Allum, "Science in Society: Re-evaluating the Deficit Model of Public Attitudes," *Public Understanding of Science* 13, no. 1 (2004), pp.55–74. doi:10.1177/0963662504042690.

Tebas, Pablo, David Stein, Winson W. Tang, Ian Frank, Shelley Q. Wang, Gary Lee, S. Kaye Spratt et al., "Gene Editing of CCR5 in Autologous CD4 T-Cells of Persons Infected with HIV," *New England Journal of Medicine* 370, no. 10 (2014), pp. 901-910.

Urnov, Fyodor D., Edward J. Rebar, Michael C. Holmes, H. Steve Zhang, and Philip D. Gregory, "Genome Editing with Engineered Zinc Finger Nucleases." *Nature Reviews Genetics* 11, no. 9 (2010), pp. 636.

Waltz, Emily, "Tiptoeing Around Transgenics," *Nature Biotechnology* 30, no. 3 (2012), pp.215-217.

Waltz, Emily, "Gene-Edited CRISPR Mushroom Escapes US Regulation," *Nature News*, 532, no. 7599 (2016), p. 293.

Won, Hoe-Sup, "Director Kim Jin-Soo says 'Korean Regulation Stifles Technological Advancement in the Midst of Genome Editing Patent Wars'," *Maeil Business*, 2016. 05. 18.

Wright, Susan, *Molecular Politics: Developing American and British Regulatory Policy for Genetic Engineering, 1972-1982* (Chicago: University of Chicago Press, 1994).

Wynne, Brian, "Misunderstood Misunderstandings: Social Identities and Public Uptake of Science," Irwin, Alan, and Brian Wynne, eds., *Misunderstanding Science?: The Public Reconstruction of Science and Technology* (Cambridge: Cambridge University Press, 2003), pp. 19-46.

Yi, Doogab, "Who Owns What? Private Ownership and the Public Interest in Recombinant DNA Technology in the 1970s," *Isis* 102, no. 3 (2011), pp. 446-474.

Zhen, Anjie, and Scott Kitchen, "Stem-Cell-Based Gene Therapy for HIV Infection," *Viruses* 6, no. 1 (2014), pp. 1-12.

Bioethics and Safety Act. Korean National Assembly Act, 2015 (Republic of Korea), no. 13651. Retrieved from the website of the National Law Information Centre. http://www.law.go.kr/LSW/lsInfoP.do?lsiSeq=178132&efYd=20151229#0000

Bioethics and Safety Act. Korean National Assembly Act, 2017 (Republic of Korea), no. 14839. Retrieved from the website of the National Law Information Centre. http://www.law.go.kr/LSW/eng/engLsSc.do?menuId=1&query=bioethics+and+safety&x=0&y=0#liBgcolor0

Sense About science, *Making Sense of Chemical Stories* (2014) available at: http://www.senseaboutscience.org/pages/making-sense-of-chemical-stories.html

국문 초록

유전자치료는 인간 유전자 조작의 당위성과 다양한 신체적, 사회적 부작용에 대한 논란 속에서 찬반 입장 간의 첨예한 대립으로 둘러쌓여있다. 이전의 수단 보다 훨씬 사용이 용이하고 정확한 3 세대 유전자가위 “CRISPR-Cas9”의 발견과 관련 기술 개발에 힘입어 세계 곳곳에서 유전자치료 연구가 진행 중인 오늘날 현행 생명윤리안전법이 과도한 규제라고 판단한 한국의 일부 과학자들은 2017 년 8 월 제 112 회 한림원탁토론회에서 법의 완화를 주장하였다. 이들 과학자들이 자신의 주장을 뒷받침하기 위해 내세운 주장 중에는 자연성에 기반한 논리도 포함되어 있었는데, 본 연구는 대스턴(Lorraine Daston)과 비달(Fernando Vidal) 편저 “자연의 윤리적 권위의 역사(Moral Authority of Nature)”의 해석에 동의하여 과학자들의 자연성 기반 논리를 그 자체로 받아들이기 보다 관련된 다른 당위성과 논리적 주장을 파헤칠 열쇠로 받아들였다. 본 논문은 과학자들의 주장 속에서 한국 과학자들이 이해하고 있는 과학계와 일반 대중의 관계가 단순 부족모델 (deficit model)로 국한되지 않은 일종의 “문답형”의 관계라고 볼 근거가 있다고 주장한다.

키워드: 유전자치료, 자연성, 한림원탁토론회, 크리스퍼

학번: 2016-20450