Centre d’étude des crises et conflits internationaux

Genomics and international security

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Disclaimer

The following paper reflects the findings as of June 2019.

List of used acronyms

AIDS – Acquired immunodeficiency syndrome
CRISPR – (or CRIPR-Cas9) Clustered Regularly Interspaced Short Palindromic Repeats
DNA – Deoxyribonucleic Acid, self-replicating material present in nearly all living organisms, the carrier of genetic information.
GMO – Genetically Modified Organism

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1. Introduction

Genomics, an interdisciplinary scientific field studying the genome, has grown exponentially in the last few years. The newly discovered gene engineering biotechnique build around CRISPR, or *Clustered Regularly Interspaced Short Palindromic Repeats,* can alter the genes with unprecedented ease. The possibilities of this recent breakthrough inflamed not only hopes but also fears among many economic, social and military analysts. The present text highlights some of its implications in the field of international security.

Given the small number of academic sources concerning this subject, the text will be based mainly of the author's confrontation of classical and critical concepts of security studies with scientific papers and discoveries in the field of gene engineering. It will attempt to grasp the significance of CRISPR in the security domain. The first part presents an overview of the conceptual tools used in the analysis. Then, after briefly introducing the new technology, I propose an in-depth study of its positive and negative implications on security in economic, social, environmental and military domains based on the aforementioned concepts. My conclusion will show that as many security implications are still hypothetical, the exponential rate of breakthroughs as well as the growing investment in genetic research by many States gives evidence of the growing importance of CRISPR which in turn requires more in-depth research on the subject to provide a basis for an equitable legislation.

2. Views on security and the nature of threats

Traditionally, national security has been defined in terms of state's military and political might and its independence from foreign power to defend its own integrity[1]. Classical realism adopts a state-centric approach, assuming that states seek to defend their interests in a global competitive environment[2]. The competition among states might be perpetuated in military or territorial fields, as well as in the ones of economy, state stability (influence and power of its institutions) or prestige[3]. Inter-state competition can lead to weaponizing[4] civilian issues or technologies, enabling their dual-use and offensive capabilities[5]. The current "trade war"[6] or the "fake news campaign"[7] serve as an excellent example of how civilian sectors are enrolled in a power struggle among nations, in this case turning trade or information into weapons of power and influence.

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[1] Nicholas Spykman, *Geography of the Peace*, 1944, Yale: Institute of international studies, p.3

[2] Jonathan Kirshner, *The tragedy of offensive realism: Classical realism and the rise of China*, European Journal of International Relations vol.18, no.1, p.55

[3] Ibid., p.56

[4] Using something as a weapon of war. « *Weaponize* », Merriam-Webster, https://www.merriam-webster.com/dictionary/weaponize, access 11/10/18

[5] « Dual-use items are goods, software and technology that can be used for both civilian and military applications. » *Dual-use trade controls*, European Commission, 28/05/2018, http://ec.europa.eu/trade/import-and-export-rules/export-from-eu/dual-use-controls/index_en.htm, access 29/11/18

[6] *A quick guide to the US-China trade war*, BBC, 14/05/2019, https://www.bbc.com/news/business-45899310, access 30/05/19

[7] Mark Scott, *Half of European voters may have viewed Russian-backed 'fake news'*, Politico, 05/07/2019, https://www.politico.eu/article/european-parliament-russia-mcafee-safeguard-cyber/, access 30/05/19

As argued by liberal institutionalists, the international context can provide a favorable environment reducing the uncertainty of global anarchy and the probability of conflict through mutual agreements and international institutions[8]. This does not mean, however, that power struggle fades away, competition among states and allies remaining present[9]. If a given state feels threatened by the rise of a rival, it might increase its defense capabilities, causing others to react in the same way, thereby creating or intensifying a security dilemma[10]. Some issues such as biotechnology, combined with rivalry, destabilize international security, as all countries may suffer the consequences of a power strife.

A quick look at the critical theories of security studies broadens how do we identify and understand threats. Political scientist Arnold Wolfers distinguishes between their objective and subjective dimensions: objective threats represent the absence of threats to acquired values, and subjective threats refer to the absence of fear of threats to acquired values[11]. He also underlines the difference between actual threats and their perception, which might be under or overlined[12].

Barry Buzan's concept of securitization stands for transforming an issue into a matter of security, especially issues coming from sectors considered as "low politics", such as the environment, the economy or societal questions[13]. The act of securitization itself is a political act of language that can lead to a government or a decision maker adopting exceptional measures or policies reducing civic liberties to guarantee the population's security[14]. State security is, according to Buzan, a relational phenomenon with threats appearing mainly in relation to neighboring states. This rationale provides the backbone of his regional security complexes theory, which argues that states' safety preoccupations are interlinked to such an extent that they cannot be resolved independently from one another[15].

In parallel to these perceptual approaches, many scholars have broadened the definition of security from purely "hard" aspects to more "soft" and transnational ones[16]; such is the case with the concept of non-traditional or soft security[17]. The common security approach states that threats to international security are primarily emerging from "global problems shared by the entire international community: nuclear war, the heavy economic burden of militarism and war, disparities in living standards within and among nations, and global

[8] Robert O. Keohane, Lisa L. Martin, *The Promise of Institutionalist Theory*, International Security, Vol. 20, No. 1, 1995, p.50-51
[9] Ibid.
[10] John Herz, "Idealist Internationalism and the Security Dilemma", *World Politics* vol. 2, no. 2, 1950, p. 157
[11] Arnold Wolfers, "*National Security" as an Ambiguous Symbol'*, Political Science Quarterly, vol.67,1952, p. 485.
[12] David A. Baldwin, *The concept of security*, Review of International Studies, 1997, 23, vol5, no26, p.13-14
[13] Barry Buzan, op.cit., p.165
[14] Ibid.
[15] Michel Liégeois, *Stratégie et sécurité international*, Louvain-la-Neuve : DUC, 2018, p.36-37
[16] Barry Buzan (ed.), *Security: A New Framework for Analysis*, London, Lynne Rienner Publishers, 1997
[17] Niklas Swanström, T*raditional and Non-Traditional Security Threats in Central Asia: Connecting the New and the Old,* China and Eurasia Forum Quarterly, Volume 8, No. 2, 2010, p.35-36

environmental degradation"[18]. Threats are thus more transnational than solely attached to a particular state.

Similarly, the human security paradigm widens our understanding of security by emphasizing the security of individuals[19]. This is analyzed through seven variables : (1) *Food security*, access and availability of food ; (2) *Health security*, access to health care, or protection from diseases ; (3) *Environment security*, protection from natural disasters and from pollution ; (4) *Economic security*, employment opportunity, reducing inequalities and assured basic income ; (5) *Personal security*, protection from physical violence of the state, non-state groups or individuals ; (6) *Community security*, protection of ethnic or traditional groups ; (7) *Political security*, the ability to live in accordance to basic human rights and freedom of speech[20]. According to the concept of human security, security itself is not seen as an end but as a means to achieve human development[21].

Investigating this approach, the economist Samir Amin notes that the capitalist nature of the international system itself can cause under-development of the third world, harming the economic and the political security of the people[22]. Each state identity and rationale as well as the transnational nature of today's world may altogether present a danger to international security, especially if the status quo is destabilized by new emerging issues like new technologies, such as the artificial intelligence, or, as it will be developed, discoveries in the field of genomics[23].

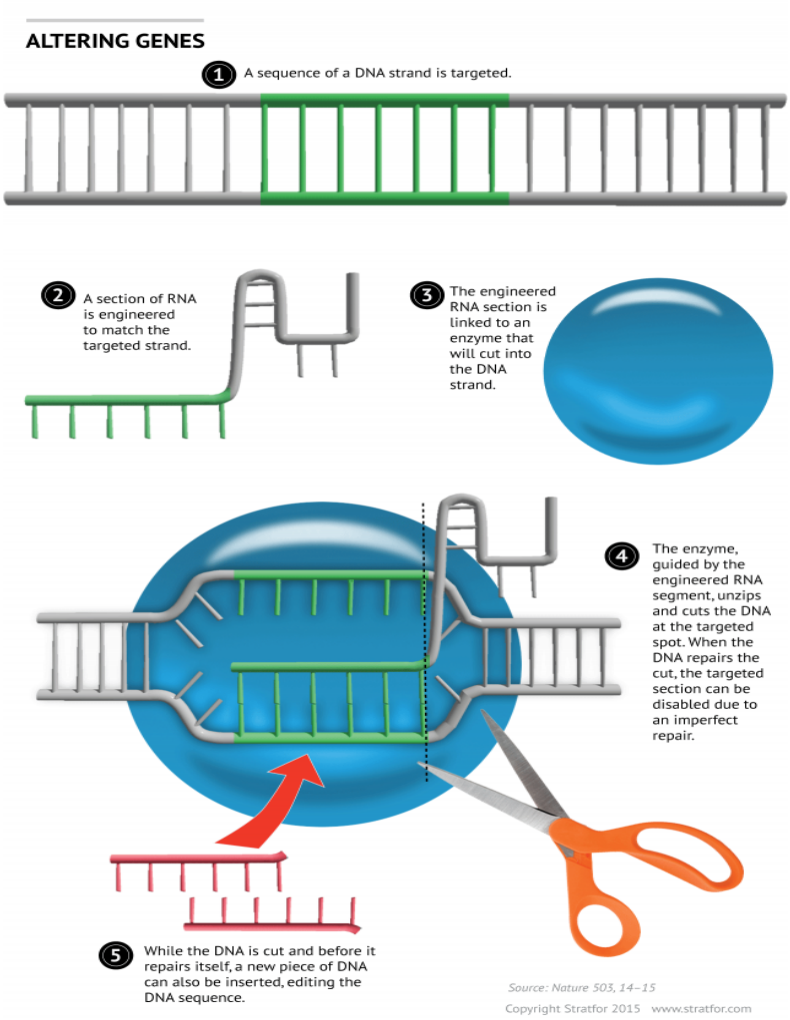
These concepts of security dilemma, perceptual perspectives on threats and securitization, traditional and human security are articulated to analyze security implications of CRISPR-Cas9 in the fields of economy, environment, society and military. The impact of this technology will be analyzed in terms of benefits and hindrances to the state security and to the individual human security paradigm.

3. Technological progress in genetic engineering

CRISPR constitutes the adaptive defense system in bacteria. Accompanied by Cas proteins, it provides genetic immunity and an overall expansion of the genome by "balancing tactical *acquisition* of beneficial material with strategic *loss* of extraneous and redundant genes[24]". Alike vaccinations that use deficient viruses to trigger immunity, CRISPR-Cas drives rapid

[18] Barry Buzan, Hansen Lene, *The evolution of international security studies*, Cambridge, New York, Cambridge University Press, 2009, p.137
[19] United Nations Development Programme (UNDP), *HUMAN DEVELOPMENT REPORT 1994*, New York : Oxford University Press, 1994, p.25
[20] Ibid. p.25-34
[21] Florence Basty, « *La sécurité humaine : Un renversement conceptuel pour les relations internationales* », Raisons politiques, vol. XXXII, no. 4, 2008, p.39
[22] Samir Amin, *Unequal Development: An Essay on the Social Formations of Peripheral Capitalism*, New York: Monthly Review Press, 1976
[23] Robert Gilpin, *The Richness of the Tradition of Political Realism*, International Organization, Vol. 38, No. 2, 1984, p.290
[24] Rodolphe Barrangou, *The roles of CRISPR–Cas systems in adaptive immunity and beyond*, Current Opinion in Immunology 2015, 32, p.36

immunization in the DNA code once targeted by an attenuated virus or a programmed restriction-modification (R-M) [25].



Recent studies have shared more light over other functions of CRISPR-Cas system, especially those enabling genome editing[26] using simply a cell's own repair mechanism[27] (thus without adding genetic material from an unrelated organism as was the case of transgenic GMOs[28]). « In this regard, CRISPR is used as a kind of GPS device to find its intended target on the DNA double helix where genetic editing is desired. Once it arrives at the precise position in the DNA, CRISPR cuts and splices the DNA with Cas9 enzyme in order to remove the sequence from the genome. The CRISPR system then incorporates a corrected sequence into the genome provided by scientists to "fix" the cut DNA sequence[29].»

The Cas9 protein can be programmed to engineer sequence insertions and removals at the gene scale with an unprecedented precision and ease[30] to tackle many pathogens and genetic deficiencies. It was applied to vegetal, animal as well as human cells and proved to be efficient, easy to use and inexpensive. Its effectiveness has been demonstrated by adjusting genes of mosquitos carrying malaria, the whole targeted population being altered

[25] Restriction-Modification System is the defense system of bacteria; Ibid.
[26] Xiao Yang, *Applications of CRISPR-Cas9 mediated genome engineering*, Mil Med Res., 2015, vol.2, no.11. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4433013/, access 11/10/18
[27] Eric E. Williams *GENE EDITING: BIOTECHNOLOGY BREAKTHROUGHS AND CHALLENGES*, Attorney Presentations, 02/07/18, p.3
[28] Costantini, F.; Lacy, E., I*ntroduction of a rabbit β-globin gene into the mouse germ line*, Nature, 1981, vol.294, p. 92–94.
[29] Eric E. Williams, op.cit., p.3
[30] Rodolphe Barrangou, op.cit., p.38

up to 99,6% in just one generation[31], which questions Mendel's traditional model of inheritance.

Although firstly used to target disease contamination and various plants pathogens[32], CRISPR-Cas9 biotechnology (known also as the Gene Drive) quickly raised many concerns, such as to what extent can the genome, or in fact nature itself, be altered. Some nations put liberal ethics aside and aimed at achieving technological high ground, enrolling other nations into a realist biotech-arms race with state and individual security at stake[33].

4. Economic issues

So far, the Gene Drive has mainly been used in the agricultural industry field to create improved plants and crops. Given the growing global population, stopping plant diseases could prove to be crucial to prevent mass migrations caused by food shortages, tackling one of today's most prominent issues. Chinese scientists have used CRISPR to create fungal-pathogen-free wheat[34]. American researchers have created tomatoes with prolonged life[35], and have successfully removed poison from tropical cassava crops, making it much easier to consume by humans[36].

As the world's most populated country, China identifies food security as one of its top priorities[37]. By investing in this new technology, Beijing seeks to avoid an overreliance on foreign food and energy imports[38]. The thirteenth five-year plan thus aims at creating up to 20 additional life-sciences parks and plans that biotechnology sector will exceed 4% of the gross domestic product by 2020[39].

But along its beneficial use for food security, lies the question of economic competition. Although a recent discovery, CRISPR is estimated to impact the market to some 6 billion

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[31] Andrew Hammond, et all., *A CRISPR-Cas9 gene drive system targeting female reproduction in the malaria mosquito vector Anopheles gambiae*, Nature Biotechnology, 2016 vol. 34, p. 78–83

[32] *Gene Editing: Tailoring the Future of Biotech*, Stratfor, 6/05/16, https://worldview.stratfor.com/article/gene-editing-tailoring-future-biotech, access 11/10/18

[33] *Battlefield Biotech: The Rising Competition Between China and the U.S.*, 26/06/18, Stratfor, https://worldview.stratfor.com/article/biotechnology-biotech-china-united-states-crispr-genome-agriculture-trade-war, access 11/10/18

[34] David Talbot, *Chinese Researchers Stop Wheat Disease with Gene Editing*, 21/04/14, MIT Technology Review, https://www.technologyreview.com/s/529181/chinese-researchers-stop-wheat-disease-with-gene-editing/, access 12/10/18

[35] Michael Specter, *The Gene Hackers*, 16/11/15, the New-Yorker, https://www.newyorker.com/magazine/2015/11/16/the-gene-hackers, access 12/10/18

[36] Ed Maixner, *Scientist edits poison out of cassava plant*, 06/06/18, AgriPulse, https://www.agri-pulse.com/articles/11061-scientist-edits-poison-out-of-cassava-plant, access 12/10/18

[37] Rebecca Keller, *How Technology Might Reshape China's Future*, 02/02/16, Stratfor, https://worldview.stratfor.com/article/how-technology-might-reshape-chinas-future, access 15/10/18

[38] Ibid.; Food imports coming mainly from US, France, Netherlands, Australia and Germany; in World Bank, WITS, China Food Products Imports By Country 2016, https://wits.worldbank.org/CountryProfile/en/Country/CHN/Year/LTST/TradeFlow/Import/Partner/by-country/Product/16-24_FoodProd

[39] Shannon Ellis, *Biotech booms in China*, 17/01/18, Nature, https://www.nature.com/articles/d41586-018-00542-3, access 15/10/18

dollars by 2022[40]. The three main players, the People's Republic of China (PRC), the United States, and the European Union, are engaged in a biotechnological race. As the top three CRISPR researchers, they contribute to 42%, 19% and 17% of total research respectively[41].

4.1. Economic espionage

According to American intelligence officials, in the Chinese case, the role of investment and cash incentives is also to enable researchers to expatriate and repatriate to PRC. This is the philosophy behind the Thousand Talents Plan that "offers full-time positions at prestigious universities and institutes, with larger than normal salaries and resources"[42] to foreign and Chinese scientists abroad[43]. Many Chinese researchers with PhD earned at Oxford are returning to China with their knowledge and expertise, contributing to Beijing's technological growth and sometimes to western brain drain[44]. American officials state that 44% of recruits are medicine, life or health sciences specialists[45].

The US perceives such activities as a threat in their 2018 National Intelligence Council report. The document states that this plan is aimed at facilitating the legal and illicit transfer of technology and intellectual property to China[46]. This can be done by employing "Western-trained returnees", by directly recruiting top academics, private entrepreneurs and government officials, or by investing in and acquiring American companies[47]. This soft version of the widely used Beijing's practice of industrial espionage[48] is not only an American problem as it may hamper European biotech industries pursuing advanced research in similar technologies.

Hurting the economies and creating an overreliance on foreign technological and biotechnological products is not only a state issue, as industry instability and lack of competitiveness can destabilize economic security, with severe consequences such as closing industries and diminished domestic employment opportunities. It is likely that an economic imbalance would favor China, as its legislation is less restrictive on research on modified mammals and crops or on technology plagiarism.

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[40] *Genome Editing/Genome Engineering Market worth 6.28 Billion USD by 2022*, MARKETSANDMARKETS, http://www.marketsandmarkets.com/PressReleases/genome-editingengineering.asp, access 12/10/18

[41] *Battlefield Biotech: The Rising Competition Between China and the U.S.*, op.cit.

[42] Philip Ball, *China's great leap forward in science*, 18/02/18, The Guardian, https://www.theguardian.com/science/2018/feb/18/china-great-leap-forward-science-research-innovation-investment-5g-genetics-quantum-internet, access 15/10/18

[43] Anthony Capaccio, *U.S. Faces 'Unprecedented Threat' From China on Tech Takeover*, 21/06/18, Bloomberg News, https://www.bloomberg.com/news/articles/2018-06-22/china-s-thousand-talents-called-key-in-seizing-u-s-expertise, accessed 15/10/18

[44] Which stands for the migration of qualified personnel in search of better life standards.

[45] Anthony Capaccio, op.cit.

[46] Ibid.

[47] Ibid.

[48] Ellen Nakashima, *In a first, a Chinese spy is extradited to the U.S. after stealing technology secrets, Justice Dept. Says,* 10/10/18, Washington Post, https://www.washingtonpost.com/world/national-security/chinese-spy-charged-with-stealing-us-military-secrets-and-extradited-for-prosecution/2018/10/10/b2a7325c-cc97-11e8-920f-dd52e1ae4570_story.html? noredirect=on&utm_term=.684bc095fd9f, access 15/10/18

These tendencies could lead to a perception of threat associated to the theft of technology. In turn, this perception could trigger a process of securitization in the field of science, which is already advised by American intelligence officials[49]. At a global scale, it may limit research exchange and international scientific cooperation, with implications spilling over outside the educational domain[50], creating scientific protectionism and blocking new breakthroughs.

4.2. The case of "lawfare"

Another issue raised by the Gene Drive is legislation. Canada, the US and Mercosur countries do not equate genetic engineering with genetic modification (GMO). The US does not have a federal legislation towards GMOs' review, and has overall favorable regulations[51]. In the EU however, all GMO must be extensively reviewed by the European Food Safety Authority, a process that can significantly delay a product's entry into the European market[52].

That is why the recent European Court decision backed by France on considering new editing techniques such as CRISPR as GMOs[53] can create more barriers between Western liberal democracies, especially when seen through a realist lens. Each new edited product will have to pass meticulous tests before entering the EU, which can result in blocking many edited foodstuffs imported from the US into the European continent, and thus further enflaming the trade competition[54] between both sides of the Atlantic.

The fact that different world regions have divergent policies concerning the Gene Drive makes it a case for studying it through the regional security complex theory. European Court's view of the issue creates specific securitization at the supranational European level, and thus more regional cooperation in the field of transnational legislation and regulation. Yet some European countries have different stances on gene-editing. For instance, France is firmly opposed to gene-edited crops, but Greece or the United Kingdom are much more open[55]. As the technology may evolve, so can the stance of some member states, putting EU's internal unity at stake.

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[49] American officials state that the « open society » gave the Chinese the opportunity to « the same technology and information that is crucial to the success of our future war-fighting capabilities ». The solution to the problem « must include strengthening American counterintelligence capabilities and elevating the private sector's focus on security » ; Anthony Capaccio, op.cit.

[50] Amol Rajan, *Techno-nationalism could determine the 21st Century*, BBC, 08/09/2018, https://www.bbc.com/news/technology-45370052, access 29/11/18

[51] Eric E. Williams, op.cit., p.10

[52] Eric E. Williams, op.cit., p.10

[53] *EU: A Ruling on Gene Editing Adds Another Wrinkle To Trade Talks*, 30/07/18, Stratfor, https://worldview.stratfor.com/article/eu-ruling-gene-editing-trade-talks-crispr-gmo-europe-america-agriculture

[54] With new gene editing research facilities open in France and in Germany, there lies the question of possible double standards of some regulations. In the UE, the main decision over the acceptance of edited food is still in the hands of individual states. See Kathleen M. Vogel, Crispr goes global: A snapshot of rules, policies, and attitudes, Bulletin of the Atomic Scientists, 05/06/2018, https://thebulletin.org/2018/06/crispr-goes-global-a-snapshot-of-rules-policies-and-attitudes/, access 29/11/18

[55] *How the EU's Stance on Gene Editing May Evolve*, 29/01/18, Stratfor, https://worldview.stratfor.com/article/how-eus-stance-gene-editing-may-evolve, access 16/10/18

The weaponization of law by creating neo-protectionist barriers can endanger the accessibility of genetically engineered agriculture to third world countries' soil. The EU is the largest single trading partner of Africa, receiving nearly $16 billion in agriculture and food imports[56]. European restrictions create barriers not only for US products but also for new emerging economies that could use this technology, blocking their commercial growth and thus hampering human development in those countries[57].

The normative power of the EU, being one of the main stakeholders in legislation concerning "new foods" (such as the Cartagena Protocol on Biosafety[58]), can significantly influence many Asian and African counterparts[59]. According to Buzan, a regional security complex of some states cannot emerge due to an overwhelming presence of a foreign power. African states cannot adapt regionally their policies on CRISPR to increase economic security because of strict regulations of a foreign power that will block their gene edited crops to enter its market. Even though they are primarily meant to protect the consumer, European barriers and norms may drive African leaders to lose interest in the technology, incapacitating a proactive food security insurance and perpetuating unequal development.

5. Environment

Gene-editing may have many beneficial impacts on the environment. Rising sea temperatures are threatening photosynthetic microbes called Symbiodinium that inhabit coral reefs and enable their survival by producing their food. Thanks to CRISPR, warmth resistant genes from rare strains of Symbiodinium can be injected to their less resistant counterparts, creating a way to save coral reefs[60]. Another example are wild tomato genes that need less light to grow; transplanted to commercial tomatoes, it reduces the energy needs of plantations[61].

But many questions are arising in relation to long term implications of CRISPR. The aforementioned mosquitos with the erased deficient gene almost never leaved the laboratory[62] as many scientists are underlining the uncertainty around CRISPR environmental impact. There is the danger of possible off-target gene modifications creating unwanted and nefarious alterations in other parts of the genetic code[63]. A team of American

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[56] Eric Niiler, *EUROPEAN RULING COULD SLOW AFRICA'S PUSH FOR CRISPR CROPS*, Wired, 25/07/2018, https://www.wired.com/story/european-ruling-could-slow-africas-push-for-crispr-crops/, access 28/11/18
[57] Ibid.
[58] Thomas P. Redick, *SYNGENTA CASE SETS BARRIERS & BOUNDARIES FOR GENETICALLY EDITED CROP & ANIMAL PIPELINES*, 9/08/2018., http://nationalaglawcenter.org/wp-content/uploads/2018/08/Genetic-Editing-of-Crops-and-Animals-Materials.pdf, access 15/10/18
[59] Ibid.
[60] India Bourke, *CRISPR: can gene-editing help nature cope with climate change?,* New Statesman, 05/10/2017, https://www.newstatesman.com/culture/nature/2017/10/crispr-can-gene-editing-help-nature-cope-climate-change, access 28/11/18
[61] Ibid.
[62] Andrew Hammond, op.cit.
[63] Xiao-HuiZhang, Louis Y Tee, Xiao-Gang Wang, Qun-Shan Huang, Shi-HuaYang, *Off-target Effects in CRISPR/Cas9-mediated Genome Engineering*, 14/12/16, Science Direct, https://www.sciencedirect.com/science/article/pii/S216225311630049X, 18/10/18

and European researchers found out that by limiting some viruses' genes, they might evolve more rapidly in a unpredicted manner increasing their resistance[64].

Another question is the permanent change of a targeted specie. The altered gene is inherited at a higher rate than a "wild" one[65], making the impact on biosafety[66] much greater in the case of an off-target modification, without the possibility of reversing it. Rare species could also disappear due to non-inheritance of their gene, endangering biodiversity. Moreover, as the creation of pathogen-resisting animals is facilitated with this new technology, so is the creation of pathogen-consenting ones, which would in turn have many environmental security implications[67].

To tackle possible transnational effects, a global, international level securitization may be needed in order to cope with the possible emerging threats[68]. Normative influence of supranational institutions like the United Nations can often put non-traditional issues, such as the climate change, on the agenda of decision makers and legislators[69]. A clear understanding of the full spectrum of the Gene Drive is needed, as the risk of sacrificing scientific research to subjectively perceived threats may be a side effect of ill-informed and politically driven national and international policy makers.

6. Social health and ethical implications

Although hypothetical, there are many possible scenarios as for the future possibilities and discoveries of this new technology. Much has been achieved as for today: alongside screening and detecting human cells responsible for cancer[70], new experiences on mice show that Cas9 engineering can cause a loss-of-function mutation of tumors[71], which could lead to finding a new treatment to various forms of cancer[72].

There are many beneficial examples: two baby girls with leukemia were treated in the UK with experimental CRISPR system therapy and did not show signs of cancer more than a

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[64] Kate Willis, *Attempts to CRISPR gene edited cassava plants to fight off viruses resulted in mutated viruses, study finds, raising concerns*, 26/04/2019, GLP, https://geneticliteracyproject.org/2019/04/26/attempts-to-crispr-gene-edited-cassava-plants-to-fight-off-viruses-resulted-in-mutated-viruses-study-finds-raising-concerns/, access 31/05/19

[65] Sonia Ben Ouagrham-Gormley, Kathleen M. Vogel, *Gene drives: The good, the bad, and the hype*, Bulletin of the Atomic Scientists, 14/10/2016, https://thebulletin.org/2016/10/gene-drives-the-good-the-bad-and-the-hype/, access 28/11/18

[66] « *The concept of biosafety encompasses a range of measures, policies and procedures for minimizing potential risks that biotechnology may pose to the environment and human health.* » In Biosafety and the environment: An introduction to the Cartagena Protocol on Biosafety, United Nations Environment Programme. p. 8

[67] Sonia Ben Ouagrham-Gormley, Kathleen M. Vogel, op.cit.

[68] *UNESCO panel of experts calls for ban on "editing" of human DNA to avoid unethical tampering with hereditary traits*, UNESCO, https://en.unesco.org/news/unesco-panel-experts-calls-ban-editing-human-dna-avoid-unethical-tampering-hereditary-traits, access 29/11/18

[69] Katie Peters, *Disasters, climate change, and securitisation: The United Nations Security Council and the United Kingdom's security policy*, Disasters in Conflict Areas, October 2018, Volume42, No2, pp.196-214

[70] Shalem O, Sanjana NE, Hartenian E, Shi X, Scott DA, Mikkelson T, Heckl D, Ebert BL, Root DE, Doench JG, Zhang F, *Genome-scale CRISPR-Cas9 knockout screening in human cells*, Science, vol.343, 03/01/14, p.84-87

[71] Platt RJ, Chen S, et all., *CRISPR-Cas9 knockin mice for genome editing and cancer modeling*, Cell, 09/10/14, vol.159, no.2, p.440-455.

[72] Christopher Wanjek, *How Close Are We, Really, to Curing Cancer with CRISPR ?* 29/07/18, Live Science, https://www.livescience.com/63192-curing-cancer-crispr.html, access 16/10/18

year later[73]. American scientists have discovered that "CRISPR-Cas9 system can eliminate the HIV-1 genome and prevent new HIV infection (…) [by] efficiently inactivating HIV-1 gene expression and replication."[74] As over 10,000 diseases are caused by defective genes[75], the Gene Drive could enhance health security for many individuals around the world. The Ischaemic heart disease for instance, is the first cause of death according to the WHO[76], being genetically inherited in 60% of cases[77].

6.1. The case of ethics

Chinese scientists went much further than their Western counterparts by being the first to conduct gene modifications in embryos to alter the gene responsible for a fatal blood disorder[78]. Seeing the growing potential and not willing to stay behind, researchers from the US[79] and the UK[80] followed their lead, raising questions about genetic engineering of humans[81]. As recently as November 2018, a Chinese scientist claimed to have altered the DNA of embryos of two twin girls for resistance to AIDS[82]. By the end of 2018, the US started human trials of CRISPR gene editing, with the technology being soon available in clinics[83].

Similarly, to the environmental impact, the long-term implications of use of the Gene Drive on human DNA is unknown. The risk of off-target modifications, accidentally altering other genes, may cause severe consequences on personal security of a person's health or life, but also on society as such. Todays' state of the technology does not yet allow advanced eugenics such as those depicted in Aldous Huxley's *Brave New World* or in Andrew Niccol's *GATTACA*, but amid new opportunities to address aging population, sickness and health problems, lies the issue of controversies in the field of ethics.

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[74] Xiao Yang, op.cit.

[75] *Genes and human diseases*, 2019, WHO, https://www.who.int/genomics/public/geneticdiseases/en/index2.html, access 31/05/19

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[80] Michael Le Page, *Why has a UK team genetically edited human embryos?,* 20/09/17, New Scientist, https://www.newscientist.com/article/2148057-why-has-a-uk-team-genetically-edited-human-embryos/, access 16/10/18

[81] Jessica Hamzelou, *Human genome editing shouldn't be used for enhancement – yet*, 14/02/17, New Scientist, https://www.newscientist.com/article/2121264-human-genome-editing-shouldnt-be-used-for-enhancement-yet/, access 16/10/18

[82] Suzanne Sataline, Ian Sample, *Scientist in China defends human embryo gene editing*, 28/11/18, the Guardian, https://www.theguardian.com/science/2018/nov/28/scientist-in-china-defends-human-embryo-gene-editing, access 28/11/18

[83] Rob Stein, *First U.S. Patients Treated With CRISPR As Human Gene-Editing Trials Get Underway*, NPR, 19/04/2019, https://www.npr.org/sections/health-shots/2019/04/16/712402435/first-u-s-patients-treated-with-crispr-as-gene-editing-human-trials-get-underway?t=1559211104340, access 31/05/19

Among many scientists, the use of CRISPR-Cas9 on humans is seen as disturbing and unethical[84]. Its spread may cause political backlash: seeing it as a threat to acquired values which societies are based upon, such as equality among individuals or religious beliefs against scientific alterations, decision makers may limit scientific research, fearing strong opposition from conservatist forces[85].

As early as 2004, Zbigniew Brzezinski warned about security implications of new gene editing technologies. A deeper divide between nations that own this biotech versus those who do not, unforeseen consequences for future "modified" populations, or the creation of a new anti-enhancement ideology born from resentment causing political action to limit scientific research or even representing a threat to democracies[86], are scenarios that should not be overlooked by policy makers.

If we consider the probability of a wider implementation of CRISPR-Cas9 in our societies, one needs to take into account the likelihood of a deeper social inequality in which people with considerable income could enhance their health, intelligence and even lengthen their life[87]. He Jiankui, responsible for altering the above-mentioned twins, has already received proposals from a fertility clinic in Dubai to "teach its clinicians CRISPR gene editing for Embryology Lab Application".[88] With each advancement in this field arises the question of consumer eugenics[89] that could further exacerbate economic and social divide.

This is where Brzezinski's ideology argument highlights another possible threat: terrorism. One can imagine religious fundamentalists organizing terror attacks against companies carrying out research or against future "modified" people, in a similar vein to the numerous cases of US extremists attacking abortion clinics[90].

The psychological process of dehumanization of the adversary would be very easy to grasp and to rally followers around. Applying the theory of professor Nick Haslam, proponents of the modification may be considered as amoral and lacking self-restraint, which can drive animalistic dehumanization[91]. Modified people themselves may be seen as technical "automats" lacking human nature, driving mechanistic dehumanization[92]. Social integrity or

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[84] Nina Frahm, *Are scientists' reactions to 'CRISPR babies' about ethics or self-governance*?, STAT, 28/01/2019, https://www.statnews.com/2019/01/28/scientists-reactions-crispr-babies-ethics-self-governance/, access 06/06/19

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[86] Zbigniew Brzezinski, *Le Vrai Choix*, Paris : Odile Jacob, 2004,p.278-280

[87] Ibid., p.278

[88] Sharon Begley, *Fertility clinics around the world asked 'CRISPR babies' scientist for how-to help*, STAT, 28/05/2019, https://www.statnews.com/2019/05/28/fertility-clinics-asked-crispr-babies-scientist-for-how-to-help/, access 06/06/19

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[91] Nick Haslam, *Dehumanization: An Integrative Review*, Personality and Social Psychology Review 2006, Vol. 10, No. 3, pp.252–264, p.257

[92] Ibid., p.260

the security of scientific community could be threatened. Again, the process of political securitization of those issues by power stakeholders may further polarize a given society between the pro and anti-enhancement blocs or hamper the state of research.

7. Military threats

Gene editing techniques also draw attention of the military. Research around CRISPR is already undertaken by Defense Advanced Research Projects Agency and by the People's Liberation Army[93]. In China, many gene editing research laboratories such as the Academy of Military Medical Sciences and the Third Military Medical University are army facilities, and many analysts warn about the possible dual-use of their research[94].

7.1. Lack of legislation

It is difficult to assess the actual scope of human enhancement due to the lack of transparency from the military sector as well as the lack of regulation on military research[95]. An overall lack of legislation from international bodies as to the limits of use of this technology is another problem. As it was previously said, there is some level of legislation concerning CRISPR, but it is not very advanced and covering few aspects. In the EU, there are no supranational restrictions as to human trials, and it is to the individual Member States to take a position on the matter[96]. From an international level, the Biological Weapons Convention lacks a way to ensure that all the states are compliant to its obligations[97]. National legislation is often imperfect and do not address the emerging risks[98].

7.2. A possible bio-weapon?

In this legal grey area, news about misuse of the Gene Drive by private scientists, the so-called bio-hacking[99], are worrisome. The technology's affordability is astonishing: 159$ for a basic tool-kit[100]. Non-state actors getting a grasp on and abusing the technology purposely or accidentally may cause serious hazard for civilian population and the environment, with biosafety at stake[101].

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[93] Robin Fears, *Assessing the Security Implications of Genome Editing Technology*, IAP, Herrenhaussen, 2017, p.14
[94] Brent M. Eastwood, *Gene-Editing in China: Beneficial Science or Emerging Military Threat?*, 13/07/17, Atlantic Council, http://www.atlanticcouncil.org/blogs/futuresource/gene-editing-in-china-beneficial-science-or-emerging-military-threat, access 18/10/18
[95] Robin Fears, op.cit., p.13
[96] *Human Genome Editing in the EU*, Report of a workshop held on 28th April 2016, French Academy of Medicine, https://www.interacademies.org/File.aspx?id=31273, p.8
[97] James Revill, *Could gene editing tools such as CRISPR be used as a biological weapon?*, 31/08/17, The Conversation, https://theconversation.com/could-gene-editing-tools-such-as-crispr-be-used-as-a-biological-weapon-82187, access 18/10/18
[98] Ibid.
[99] Sarah Zhang, *A Biohacker Regrets Publicly Injecting Himself With CRISPR*, the Atlantic, 20/02/18, HTTPS://WWW.THEATLANTIC.COM/SCIENCE/ARCHIVE/2018/02/BIOHACKING-STUNTS-CRISPR/553511/, ACCESS 18/10/18
[100] *DIY Bacterial Gene Engineering CRISPR Kit*, http://www.the-odin.com/diy-crispr-kit/, access 18/10/18
[101] Lucien Crowder, "Biohackers" conduct an unregulated arms race, Bulletin of the Atomic Scientists, 15/05/2018, https://thebulletin.org/2018/05/biohackers-conduct-an-unregulated-arms-race/, access 29/11/18

The possibility of a hypothetical CRISPR engineered biological weapon persists. The hypothesis of a rogue group releasing a biological weapon based on CRISPR aiming at humans may be unlikely due to the limitations of the technology as to its complicated transfer to other bodies[102], but a possible development of such weaponry by states aimed at enemy agriculture is much more likely[103]. Even if the technology is still being discovered, analysts worry that experiences may be conducted to create enhanced soldiers[104].

Similar to the Agent Orange released during the Vietnam War[105], environmental security is threatened with possible backlash on human security. Altered and enhanced pathogens designated to harm civilians by creating tumor cells[106] are possible by the same technology that can also attenuate and destroy them[107].

Another case of possible weaponization is individual DNA targeting. Today's computing power has lowered the costs of analysis of individual vegetal, animal and human DNA since its very first sequencing in 2003[108]. With our increasing understanding of the human genome thanks to projects like the National Geographic Genographic Project[109], many analysts warn about the possibility of clandestine manufacturing of ethnic bioweapons by state or non-state actors[110], which could jeopardize community security of specific ethnic groups. John Sotos, a chief scientist, points at the possibility of harming a single person (e.g. a famous politician or opposition leader) with a DNA targeted lethal or non-lethal weaponry[111], thereby threatening political security. In 2007 Russia has issued a ban on exports of human bio samples based on FSB report over possible manufacture of ethnic bioweapon against Russian citizens[112].

As in the case of the scenario of enhanced soldiers, little is known. Lack of knowledge by the decision makers themselves over the capabilities of other states may drive and increase threat perception and create a security dilemma with a new tech and arms race. Many long-

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[102] Sonia Ben Ouagrham-Gormley, Kathleen M. Vogel, op.cit.
[103] Ibid.
[104] Ibid.
[105] Agent Orange is a herbicidal chemical used during the Vietnam war to fight North-Vietnamese communist guerilla by destroying its crops. Aimed mainly at civilian plantations, it had many hazardous consequences on civilians as well as on US army personnel troops.
[106] Rath J., *Safety and Security Risks of CRISPR/Cas9*. In: Schroeder D., Cook J., Hirsch F., Fenet S., Muthuswamy V. (eds) *Ethics Dumping. SpringerBriefs in Research and Innovation Governance*, Springer, Cham, 2018, p.107-113
[107] Alex Hern, *'There are things worse than death': can a cancer cure lead to brutal bioweapons?*, 31/07/17, the Guardian, https://www.theguardian.com/science/2017/jul/31/bioweapons-cancer-moonshot-gene-editing, access 18/10/18
[108] Peter Apps, *Commentary: The next super weapon could be biological*, 19/04/17, Reuters, https://www.reuters.com/article/us-biological-weaons-commentary/commentary-the-next-super-weapon-could-be-biological-idUSKBN17L1SZ, access 18/10/18
[109] National Geographic Genographic Project is a private initiative to map historical human migration patterns by collecting and analyzing DNA samples from all over the world; *National Geographic Genogrphic Project official website*, https://genographic.nationalgeographic.com/, access 18/10/18
[110] Katherine Charlet, *The New Killer Pathogens: Countering the Coming Bioweapons Threat*, 17/04/18, Carnegie Endowment, https://carnegieendowment.org/2018/04/17/new-killer-pathogens-countering-coming-bioweapons-threat-pub-76009, access 18/10/18
[111] Alex Hern, op.cit.
[112] *Россия блюдет человеческий образец*, Коммерсантъ, 30/05/2007, https://www.kommersant.ru/doc/769777, access 07/06/19

standing opponents of any sort of genetical modifications are embracing research on the Gene Drive, such as Russia that has recently investing 1,7 billion dollars into its federal program[113]. Analysts are warning against a possible escalation, comparing the situation with the nuclear race, with critical political and security consequences such as a new cold war[114].

8. Conclusion and the way forward

The paper has demonstrated that CRISPR-Cas system arouses both hope and fear among analysts. Health improvement, economic weight, environmental and social impact and new military capabilities need to be closely scrutinized. Misperception about threats can drive over- or under-securitization of the field of gene editing. Overestimation could cause out-of-proportion legislation, in the process limiting scientific research. In turn this could slow the discovery of CRISPR potential, blocking its possible beneficial effects on food security and environment. On the other hand, too little regulation due to underestimating the security and ecological implications of this biotech, as it is currently the case, may enable the emergence of new threats from state and non-state actors.

So far, there is no need for urgent action, but the rapid evolution of the technology will require an accurate assessment and continuing attention of the implications of the Gene Drive by States, the main security providers for individuals and the population. As the paper has shown, weaponization of this technology may present a great danger to overall security and escalate an arms race at the international level.

As it was developed, there are few supranational legislative initiatives to tackle the grey area surrounding the Gene Drive. Little research reaching outside the sole field of its medical and commercial use has been undertaken so far, analyzing possible societal and environmental consequences, such as polarization, inequalities or ecological impact. A balance between *laissez-faire* and regulation as well as an open public debate including policy makers and academics is needed to fully embrace the new capabilities that may revolutionize biological research as well as the human kind.

[113] Olga Dobrovidova, *Russia joins in global gene-editing bonanza*, Nature, 14/05/2019, https://www.nature.com/articles/d41586-019-01519-6, access 07/06/19

[114] Zoltan Istvan, *Genetic Editing Could Cause the Next Cold War*, Vice, 13/12/2016, https://www.vice.com/en_us/article/ezp8me/genetic-editing-could-cause-the-next-cold-war, access 07/06/19

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L'analyse des éléments déclencheurs des conflits et des instruments de leur gestion - sanctions et incitants économiques comme moyens de politique étrangère; crises et interventions humanitaires; rôle de la mémoire dans un processus de réconciliation, par exemple - est combinée à l'étude empirique de différends internationaux et de processus de paix spécifiques.

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