1 2 90

UNIVERSIDADE Ð COIMBRA

Bela Irina Passos Natário de Castro

WHAT IS A GENETICALLY MODIFIED SEED?
A STUDY OF THE ONTOLOGICAL POLITICS OF BIOTECHNOLOGICAL INNOVATION

VOLUME 1

Tese no âmbito do Programa de Doutoramento em 'Governação, Conhecimento e Inovação', no ramo 'Impactes Sociais da Ciência e Tecnologia', orientada pelo Professor Doutor João Carlos Freitas Arriscado Nunes, pela Doutora Rita Maria Assunção Serra, e pelo Professor Doutor Raúl José García-Barrios e apresentada à Faculdade de Economia da Universidade de Coimbra.

Dezembro 2021

FACULDADE DE ECONOMIA
UNIVERSIDADE DE COIMBRA

What is a genetically modified seed? A study of the ontological politics of biotechnological innovation

Bela Irina Passos Natário de Castro

Tese no âmbito do Programa de Doutoramento em 'Governação, Conhecimento e Inovação', no ramo 'Impactes Sociais da Ciência e Tecnologia', orientada pelo Professor Doutor João Carlos Freitas Arriscado Nunes, pela Doutora Rita Maria Assunção Serra, e pelo Professor Doutor Raúl José García-Barrios e apresentada à Faculdade de Economia da Universidade de Coimbra.

Dezembro 2021

UNIVERSIDADE DE COIMBRA

This page intentionally left blank

Acknowledgment

Writing a dissertation teaches us to be unhappy more intelligently, and if anyone tells it differently, they lie. A Ph.D. is a violent relationship that we managed to get out of thanks to the support of so many people. To them, my most profound and humble thanks.

In this process, not everyone is an ally. Too many people will try to kill you along the way. They sure did. Yet, with the help of the family that I chose and those that choose me every day, I persisted. I am not sorry for letting those that hurt me go.

This was an 8-year process. In 8 years, I have gained much, but I also lost enormously. António Alves Vieira and Peter Taylor, you left my side without going. I can still touch you, smell you, and learn with you from the books you have left. Thank you for teaching me that "stars do move".

By the end of this path, I feel like a shapeshifter. I not only learned with too many people; I have absorbed them. I now laugh like Emma León and Patrícia Ferreira. I use flowery dresses like Mayrén Vargas. I sing to every word I hear because of Rita Pais and blame Raúl García-Barrios for me singing. I wrinkle my nose like Tatiana Moura and swear like João Carlos. I make mushroom soup like Rita Serra, tzatziki like Ann Blum, and set the table like Pedro Alípio. I leave glasses around the house like Catarina Príncipe. Yet, I still sneeze as always.

By the end of this path, it is impossible to name everyone and every moment that has found a way into this dissertation. Still, it matters to acknowledge some of them.

Mostly obviously, my gratitude goes to my supervisors. João Arriscado, Rita Serra, and Raúl García-Barrios. Thank you above all for giving me freedom. The biggest lesson I learned from you was how to think freely. I broke chains in my thought thanks to you, and I promise not to let this freedom rot in hell. "I do swear on my honour, and on the faith of the brotherhood of knights, to use the Force only for good, denying, turning always from the Dark Side; to dedicate my life to the cause of freedom, and justice. If I should fail of this vow, my life shall be forfeit, here and hereafter."

To Patrícia Moreira Ferreira, for helping write this story and for creating understanding in the moments when my supervisors and I weren't able, and for so many more things.

I’m also thankful to those that opened up their lives so I could make this dissertation and to those that in so many different ways made this path possible: Elena Álvarez-Buylla, Angelika Hilbeck, Bernadette Oehen, Diana Romo Rios, Brian Wynne, Christian Vélot, Adriana Garay-Arroyo, Berenice Garcia, María Paz Jiménez Sánchez, Alma Piñeyro-Nelson, Rafter Ferguson, Nicolas Defarge, Emmanuel González Ortega, Andrés Barreda Marín, Julio Muñoz Rubio, Arnaud Apoteker, Joël Spiroux de Vendômois, Sérgio Pedro, Rosário Lago, Hannes Lammler, Marcelo Firpo de Souza Porto, Jorge Veraza, Ignacio Chapela, Jason Delborne, Helen Wallace, Tamara Lebrecht, Doug Gurian-Sherman, Lucas Wirl, Diederick Sprangers, Jack Heinemann, Andreas Dietschi, Ulrich Loening, Christine von Weizsäcker, Sanjay Kumar, David Gee, Damian Verzeñassi, and of course Anthony Jackson for always believing in my abilities, YNWA.

To all at the Centro Regional de Investigaciones Multidisciplinarias - UNAM, Laboratorio de Genética Molecular, Epigenética, Desarrollo y Evolución de Planta-UNAM, Comité de Recherche et D'Information Indépendantes sur le Génie Génétique, Institut für Integrative Biologie – ETZ Zürich, Unión De Científicos Comprometidos con la Sociedad, European Network of Scientists for Social and Environmental Responsibility, GeneWatch UK, and International Monsanto Tribunal, my biggest thanks.

To all at the Plataforma Transgénicos Fora, thank you for the constant possibility of debate. Special thanks to Margarida Silva and Lanka Horstink.

To all of you at the Faculty of Economics, University of Coimbra, but specially those at the Escola de Estudos Avançados, Alexandra Sousa e José Almeida.

To my family at the Centre for Social Studies, a special hug to my colleagues and friends at GAGEP. João Neto, Hélia Santos, Alexandra Cordeiro, Rita Pais, João Paulo Dias, Catarina Fernandes, Jéssica Santos, Rita Kacia, and André Caiado. Thank you for embracing all my tears and panic attacks.

To my team in the project JUSTFOOD, Irina Velicu (and for all the clever comments to some of my drafts), Stefania Barca, Rita Calvário, Lúcia Fernandes, Andreea Ogrezeanu, Sérgio Pedro, Anastasia Oprea and Hestia Delibas. Thank you for always making me present even in my absence.

To the North/South Library, Maria José Carvalho, Acácio Machado, and Inês Lima. To GAFIN, Isabel Fernandes, Mónica Baltazar, Célia Viseu, António Casca and Viviana Ribeiro. To GTI, Pedro Abreu, Alberto Pereira, André Pena and André Queda, for making the fantastic logo for this project. To GAP and GECI, Pedro Dias da Silva, Alexandra Pereira, Inês Costa, Ana Caldeira, Ana sofia Veloso, Joaquim Veríssimo, and Alina Timóteo. Thank you for always having my back in my delays and more.

To Dona Fernanda, Dona Elvira, Helena, and Isabel, thank you for always making sure I didn't get lost in the chaos of my mail and desk.

To António Carvalho for challenging me to continue exploring the violent character of these monsters.

To all of you at CES, thank you so much.

To Maeve Soudain and Victor Ferreira for the several proofreadings of this work. All issues with the English are my sole responsibility. Thank you Merlin, for the final reading.

To all the doctors and physiotherapists who put up with me in emergency rooms and "urgent" appointments Ph.D. related during these years. A special thank you to Ana Eustáquio.

To my family in Coimbra, thank you for defying the laws of physics every day and being the force that keeps the light in this black hole city. Thank you Tatiana Moura, Barbára Ranito, Linda Cerdeira, Daniela Martins, Susana Baptista, Silvia Ferreira, Tiago Rolino, Miguel Côrte-Real, Hugo Padilha, Gabriela Moura e Sara Araújo. A special acknowledgment to Lurdes Marques for the peace you bring to my home every month.

To my comrade Jonas Van Vossole, you know that my conclusion would never be possible if it weren't for you,

To all my friends and comrades of the struggle, José Soeiro, Fernando Mariano, Tiago Braga, Pedro Ferreira, Marta Gomes, Marcela Uchôa, Mónica Soares, João Moreira, Gabino Martínez, Santiago Gorostiza, João Pedro Ferreira, Javier Fernández, Tor Krever, German Sandoval, Ricardo Cabral Fernandes, Silvia Frankelin, my communist friend Neide Areia, and Izaura Solipa "The expropriator of the empire". To the good old days, Alfredo Campos, Vania Moreira, Sónia Pimenta, Nuno Teles, Ana Oliveira, Tiago Ribeiro, and all that never left a chair cool down at Tropical.

A special thanks to Major Mário Tomé, for the intense debates about technology and socialism, for the constant exchange of ideas and challenges, for all the support during several moments of my life, and above all, for the 25^{th} of April.

To all of you that every day make revolutions, thank you.

To Sérgio Arguello, Ya nos cayó el chahuistle!

George Souvlis, SEE? I DID IT!

Thank you for the critical bibliographical references and fruitful debates to Sebastian Budgen and everyone at Historical Materialism London Conferences.

To my sister Maria Cristina Barbosa for showing me that sisterhood can be stronger than blood. We are now a bigger sisterhood with Jimena Garcia, Sabina León and Margarida Ferreira Campos,

To my mother Sofia Alexandra a reminder: this PhD is in Sociology (she always forgets).

To my father José Damião, Lightning then the thunder,

To my brothers Pedro and Hugo and all my grandmothers Maria's,

To those that in this life I have named mother, brother, sister, niece, godson, and grandmother,

To my only grandfather Damião, I will tell you all about in my dreams,

To my Permanent family, Sérgio Vitorino, João Mineiro, Mariana Gomes, Vera Palos, Nuno Moniz, Dalila Teixeira, Alex Gomes, Mamadou Ba, Isabel Louçã, Mi, Pedro Rodrigues, Carla Leal, Carlos Carujo, José Viana. You make my life a place where I want to be.

To João Carlos Louça for making utopias a concrete practice.

To Merlin Valton, my electric dream, let us go hunting storms.

Catarina Princípe, you were the lighthouse in these black waters. Along this path, I learned with you more than is possible to write in this dissertation. Thank you for never letting me perish.

Mayrén Alavez-Vargas, I know it was you who ate the chocolate! Aiñ!

NO FALTAM 43! AYOTZINAPA

This work was funded by the Portuguese State through FCT - Foundation for Science and Technology within the scope of the PhD Studentships SFRH/BD/117707/2016.

Fundação para a Ciência e a Tecnologia

Part of the work was conducted within the activities of the project "JUSTFOOD - From Alternative Food Networks to Environmental Justice" (2018-2021), coordinated at the Centre for Social Studies by Irina Velicu and Stefania Barca, and funded by FEDER - European Fund for Regional Development funds through the COMPETE 2020 - Operational Programme for Competitiveness and Internationalisation (POCI), and by Portuguese funds through FCT - Foundation for Science and Technology in the framework of the project PTDC/GES-AMB/29355/2017. Reference: POCI-01-0145-FEDER-029355.

Cofinanciado por:

COMPETE 2020 PORTUGAL 2020 UNIÃO EUROPEIA Fundo de Coesão

Part of the dissertation uses reflections promoted under the activities of the project "BIOSENSE - Science Engaging Society: Life Sciences, Social Sciences and Publics" (2010-2013), coordinated at the Centre for Social Studies by João Arriscado Nunes, and funded by FCT - Foundation for Science and Technology in the framework of the project PTDC/CS-ECS/108011/2008.

Fundação para a Ciência e a Tecnologia

This page intentionally left blank

Resumo

Nos últimos quarenta anos, a existência e o impacto dos organismos geneticamente modificados (OGMs), especialmente as plantas, tem sido objeto de um intenso debate global. Considerando as diversas controvérsias a seu respeito, e lembrando que os OGMs são produzidos por um complexo sistema de interações que precisam dar conta de suas possibilidades técnicas e teóricas em relação com a sua economia política e estruturas institucionais, dentro e fora dos laboratórios e no terreno, esta pesquisa doutoral tem como objetivo explicar o que aconteceu (e ainda acontece) no seio de um dos atores mais importantes para a existência de organismos geneticamente modificados, a ciência. Por que encontramos cientistas dos dois lados da controvérsia? Que modelos e ideias sobre a ciência estão em conflito? Que fatores estão em suas raízes? Quais são as consequências desse conflito para o que hoje entendemos como ciência? E diante da controvérsia, o que é, afinal, uma semente geneticamente modificada?

A busca por respostas a essas questões seguirá o caminho dos estudos sobre dissidência científica e estudos de laboratório em conjunto com a análise do processo de subsunção da ciência ao capitalismo. Esse caminho foi escolhido por dois motivos. Por um lado, para complementar uma já ampla variedade de abordagens críticas ao problema dos OGMs e, por outro, como estratégia para compreender a incomensurabilidade da polêmica no âmbito da ciência.

No entanto, se durante esse curso me mantive aberta às possibilidades de emancipação associadas aos OGMs, a minha proposta inicial acabou sendo derrotada. Nesse sentido, mais do que buscar possíveis usos para os OGMs, devemos olhar para as utopias concretas que se desenvolvem no campo da dissidência. Utopias que prometem uma prática científica responsável e justa e, portanto, exigem a rejeição destes seres.

Palavras-chave: organismos geneticamente modificados; estudos dissidentes de ciência e tecnologia; subsunção da ciência ao capitalismo; utopias concretas.

This page intentionally left blank

Abstract

In the last forty years, the existence and impact of genetically engineered organisms (GEOs), especially plants, have been the subject of an intense global debate. Considering several controversies regarding them and remembering that GEOs are produced by a complex system of interactions that need to account for both its technical and theoretical possibilities with its political economy and institutional structures, inside and outside the laboratories and the fields, this doctoral research aims to explain what happened (still happens) within one of the most important actors for the existence of genetically engineered organisms, science. Why do we find scientists on both sides of the controversy? What models and ideas about science are in conflict? What factors lay at its roots? What are the consequences of this conflict for what we understand today as science? And considering the controversy, what is, after all, a genetically modified seed?

The search for answers to these questions will follow the path of studies on scientific dissent and laboratory studies in conjunction with the analysis of the process of subsumption of science under capitalism. This path was chosen for two reasons. On the one hand, to complement an already wide variety of critical approaches to the problem of GEOs, and on the other hand, as a strategy to understand the incommensurability of the controversy within the realm of science.

If I remained open to the possibilities of emancipation associated with GEOs during this course, my initial proposal would be defeated in the end. In this sense, rather than looking for possible uses for GEOs, we must look to the concrete utopias developing in the field of dissidence. Utopias that promise a responsible and fair science practice and therefore require the rejection of these beings.

Keywords: genetically engineered organisms; dissent studies of science and technology; subsumption of science under capitalism; concrete utopias.

This page intentionally left blank

Acronyms

CIMMYT - International Maize and Wheat Improvement Center

CONACyT - Consejo Nacional de Ciencia y Tecnología, México

CRIIGEN – Comité de Recherche et d'Information Indépendantes sur le Génie Génétique

CRISPR - Clustered Regularly Interspaced Short Palindromic Repeats

CRISPR/Cas9 - CRISPR associated protein 9, formerly called Cas5, Csn1, or Csx12

CSS - Critical Scientists Switzerland

ENSSER - European Network of Scientists for Social and Environmental Responsibility

EZLN - Zapatista Army of National Liberation

FAO - Food and Agriculture Organization of the United Nations

GEO – Genetically engineered organisms

GMO – Genetically modified organisms

IMT – International Monsanto Tribunal

NAFTA - North American Free Trade Agreement

NPET - New Plant Engineering Techniques

R&D – Research and Development

STS - Science and technology studies

TINA - There Is No Alternative

UCCS – Unión de Científicos Comprometidos con la Sociedad

UCCSNAL - Unión de Científicos Comprometidos con la Sociedad y la Naturaleza de América Latina

UCS - Union of Concerned Scientists

UNAM – Universidad Nacional Autonoma de México

This page intentionally left blank

Index

All social life is essentially practical. All mysteries which lead theory to mysticism find their rational solution in human practice and in the comprehension of this practice. (Karl Marx in Theses on Feuerbach, Theses VIII, 1845).

This page intentionally left blank

Introduction

In the last forty years, the existence and impact of genetically engineered organisms (GEOs), also referred to as genetically modified organisms (GMOs), have been the subject of an intense global debate in all areas of their application. Usually framed as a matter of acceptance or rejection, on both sides of the barricade that frames this global debate are activists for health, environment, and food, movement of producers, business associations, foundations, political parties, consumers, as well as scientists and R&D institutions.

Despite the global controversies surrounding all forms of genetically engineered organisms, no debate has been more vehement and bitter than those applied to agriculture, the so-called green biotechnology. There are several reasons, described by abundant literature from ecology and political economy, that explain why genetically engineered organisms associated with agriculture, embodied in the figure of the seeds (hybrid or transgenic), have attracted so much attention and have been so controversial (Myers, 2001; Charles, 2002; Bowring, 2003; Nunes *et al.*, 2003; Kloppenburg, 2004; Herring, 2007; Kinchy, 2012; Álvarez-Buylla & Piñeyro-Nelson, 2013).

Although there is a global consensus that seeds are a fundamental element of history and a common heritage of peoples, faithful companions of human physical and cultural evolution since their early domestication, the arrival of the green biotechnologies has radically transformed the character of their cultural contribution to our human societies (Kloppenburg, 2004). On the side of those that we can frame as pro-GEO/GMO, the dominant voices not only accept that seeds have been true companions of societies' physical and cultural evolution, but they also frame such relations within a context of constant 'war' between humans and nature. When they are not arguing that we require GEOs/GMOs due to the climate and environmental challenges that we face, they argue that GEOs/GMOs are necessary to correct the imperfections and limitations of nature. These assumptions, however, are contested by the anti-GEO/GMO movements, that despite also embracing seeds contributions to human societies, frame the relationship between humans and nature on the basis of care, kin, and communal practices. For them, millennial practices of improving crops are the result of a relationship that goes beyond what is materially given and is involved in relationships of affection, community[1], culture, and a balanced relationship between human needs and nature conservation and its limitations. It is, therefore, not a surprise that the anti-GEO/GMO movement would oppose the emergence of genetically engineered organisms. Organisms created by a class of workers [scientists], whose labour has been progressively subsumed under capitalism, and for this reason, they see GEOs as 'technomarketideology' products (Garcia, 2011), produced under assumptions that considered irrelevant all form of knowledge over nature that are not built within the circuits of capitalism varieties (Hall & Soskice, 2001). 'Molecular neoliberalism', Brian Wynne (2013) has argued, renders obsolete all forms of life that are not produced under the capitalist command.

Considering the above-described controversy and remembering that GEOs/GMOs are produced by a complex system of interactions that need to account for both its technical and theoretical possibilities with its political economy and institutional structures, inside and outside the laboratories and the fields, this doctoral dissertation aims to attempt to understand what happened, and still happens, within one of the most important actors for the existence of genetically engineered organisms, science. Why do we find scientists on both sides of the controversy? What models and ideas about science are in conflict? What factors lay at its roots? What are the consequences of this conflict for what we understand today as science? And considering the controversy, what is, after all, a genetically modified seed?

[1] Community is here understood as a structure that allows the virtuous development of its members while producing common goods. Thus, distinguishes from community built on consumption. (see Klein, 2000)

A tale of two sciences

Utopias are collective futures filled with the desire for social justice and committed to overcoming the inequalities that the capitalist system sustains (Louçã, 2021). For this reason, utopias are not just aspirations and dreams but practices of hope that organize collectives around the construction of another world. As João Louçã (2021) suggests, utopias pervade our history and the present practices that seek to survive the hegemony of capitalism. All utopia, therefore, implies a critical look at the present that overshadows concrete collective practices of hope. Some collectives even go beyond this definition, building ways of life that are also self-reflexive. According to Pietro Daniel Omodeo "self-reflexivity is the presupposition for conscious deliberation which magnifies the subject in his/her power to freely determine himself/herself under specific historical conditions." (2019, p. 2). Likewise, it is from the concrete practice of utopia that new methods of analysing reality are born. In these utopias, 'critical thinking arises in the face of the capitalist hydra' (EZLN, 2017).

In May 2015, the EZLN (Zapatista Army of National Liberation) organized a week of seminars entitled "El pensamiento crítico frente a la hidra capitalista" (Critical thinking in the face of the capitalist hydra).[2] During these days, they once again united the Zapatista practice and theory with the rebellion by which they live. Between the confrontation with the crisis of capitalism and their account of the genealogy of the Zapatista *praxis* [3], they promoted dialogues with other forms of resistance to capitalism, among which, those framed within our modern scientific system. It was a clear demonstration that utopias are not isolated entities, they can dialogue, and the heterogeneity of forms seeking to overcome capitalism is not the problem. The problem is the forms of common suffering imposed by the capitalist system; such is the case of Ayotzinapa. [4]

---

[2] The seminar "Critical thinking in the face of the capitalist hydra", organized by the Zapatista community of the Caracol de Oventik took place between May 3 and 9, 2015. That same year, Mexican legislative and municipal elections took place in June. The full program and audio recordings, as well as the transcripts can be accessed via the link: https://radiozapatista.org/?page_id=13233

[3] Praxis is understood in this dissertation as "sense to the free, universal, creative and self-creative activity through which humans create (make, produce) and change (shape) historical, human world and the self; an activity specific to humans, through which people basically differentiated from all other beings" (Petrović, 1991a, p, 435)

[4] Ayotzinapa that's how the Iguala massacre is referred to in Mexico. The Iguala massacre took place on September 26, 2014, when 43 students from the Raúl Isidro Burgos Rural Normal School in Ayotzinapa disappeared. Only 9 bodies have been found to date. It is suspected that the young students were kidnapped by state militias and killed by members of the drug-trafficking cartel called "Guerreros Unidos".

Among the many who engaged in dialogue with the Zapatist community at the ‘Caracol de Overtek’ was Maria Elena Álvarez-Buylla Roces (figure 1), a prominent Mexican biologist specializing in evolutionary ecology and a known voice against GEOs/GMOs and pesticides, in particular those based on glyphosate.[5]

Born in the late 1950s in Mexico City, Elena Álvarez-Buylla's interest in science was influenced by her family upbringing. As the daughter of a neurophysiologist father and a biologist mother and granddaughter of Arturo Álvarez-Buylla Godino, shot by Francoist forces, and Wenceslao Roces Suárez, historian and translator of *Das Kapital*, Álvarez-Buylla inherited both the achievements of the modern Mexican scientific system and Spanish revolutionary republicanism. From an early age, she developed a particular interest in plants.

She told me that when she was around seven years old one of her grandparents granted her part of the family garden. There, Álvarez-Buylla developed a heightened capacity for reflection regarding how we can understand plants. By the end of the 70s, Álvarez-Buylla went to the National Autonomous University of Mexico (UNAM), where, in 1982, she obtained her diploma in biology and a master’s degree in 1985. During her time as a university student at UNAM, she engaged in various forms of activism. With other colleagues, she struggled to create a nature reserve within the university campus, known today as San Angel Ecology Reserve (Reserva Ecológia del Pedregal de San Ángel) (García-Barrios, 2014).

This collective social experience, in which her studies in biology supported her political action, would be a decisive factor in the construction of a scientific *ethos* that does not deny the importance of the rational inquiry of science but that also engages with social and political needs for the transformation of the prevalent historical state of affairs.

By the end of the 80s, and encouraged by close friends to pursue doctoral studies, Álvarez-Buylla went to the United States of America. She developed her skills in Developmental Biology in combination with Evolutionary Ecology at the University of Berkley, California. During that time, she becomes a mother. Of all existing plants, it was maize that captured Álvarez-Buylla's attention and her scientific interest.

Maize is the type of plant that allows both to inquire into molecular and evolutionary biology and the type of plant with a commercial use associated with several historical episodes that transformed the world.

[5] The biography of Elena Álvarez-Buylla presented here is the result of several interviews conducted in depth with the scientist during my fieldwork. The fieldwork took place in Mexico from January to July 2018. The biography is complemented with secondary sources.

Moreover, in Mexico, maize has a historical and cultural centrality, unlike any other country in the world. Therefore, in maize, Elena Álvarez-Buylla finds the most significant possibility of uniting 'basic science' and the agroecological processes entangled with peasant communities and their territorial resistance and autonomy legacies. In other words, she connected theory with practice, moving beyond the realm of the practice of science into society. This scientific approach would shape her scientific career as interdisciplinary, pervaded by a critical stance committed to social processes while holding on to scientific rigour.

Being present at the Zapatista meeting as a scientist, mother, daughter, sister, and woman, she shared her vision regarding the controversy of GEOs/GMOs and the problems involving maize, one of the principal crops, historically (re)produced by indigenous people communities in Mexico.

In her conversation "La hidra capitalista disfrazada de "ciencia y maíz"" (The capitalist hydra disguised as "science and maíz") Elena Álvarez-Buylla expressed not only arguments for her opposition to GEOs/GMOs, but she also placed GEOs/GMOs as products of a system of knowledge production that is founded on futile, and violent means and objectives. It is not the first time that a notion of violence has been associated with a debate about GEOs/GMOs. Rarely does this not happen.[6] The existence of GEOs/GMOs is so imbued with violence that it is hard not to talk about them without referring to violence. However, although violence is an important subject when we try to fully understand the GEO/GMO controversy, Elena Álvarez-Buylla's speech focused on distinguishing two systems of knowledge production: *science* and *Science*.

science, in lowercase she explains, is what the majority of the world addresses as scientific knowledge. It is the hegemonic position of a system of knowledge production that Álvarez-Buylla criticises as subsumed by the interests of the capitalist ways of production and its ultimate goal, profit. The other, *Science*, capitalized, is what she stated to be a truly scientific system, a system of knowledge production whose means-ends are not hijacked by private profit interests. Whose means-ends are hyphenized organically

---

[6] Several reports of violence promoted by transgenics can be consulted on the International Monsanto Tribunal website: https://www.monsanto-tribunal.org/

The International Monsanto Tribunal took place in 2016-2017 in The Hague. Five judges delivered a legal opinion and concluded that Monsanto's (now, Bayer's) activities have a negative impact on basic human rights. Better regulations are needed to protect the victims of multinational corporations. International law should be improved for better protection of the environment and include the crime of ecocide.

A further analysis of the International Monsanto tribunal has been co-developed with my good friend and colleague Sérgio Martín Arguello. The analysis was published in 2016, in the May edition of Le Monde Diplomatique – Edição Portuguesa (pages 14-15). A copy of the article is included in the annex to this dissertation.

and entangled with the community values for autonomy, justice, and wellbeing. Where knowledge of nature and society can support relations of kin and care.

Despite Álvarez-Buylla 's critique of *science* and her utopian project of *Science* being of extreme relevance, they are not a novelty that comes with her. A careful look at the past of *science*, and its community (our community) reminds us of important socio-scientific movements that sought to radicalize the critique of science subsumed under capitalism. Had they originated in labour relations (such as the Luddites) (Robins & Webster, 1983; Garcia *et al*., 2018, McNally, 2012, pp. 85-88) or the revolutionary vanguard (such as the Russian revolutionary scientific movement) (Bukharin *et al.*, 1971; Borges, 2021) or even born from the articulation of social movements and scientists (such as the movement Science for the People, and the feminist movements of the 70s), the critique of *science* and the attempts for its reconceptualization into *Science*, it's a heterogeneous practice of concrete utopias, who sometimes followed more institutional paths (Taylor & Patzke, 2021).

In 2015 Álvarez-Buylla's speech was heard but partially ignored by the scientific community. Three elements may help explain why there was no uproar or support regarding her statements at the time (and so many other times). The first explanation for the silent treatment is that Álvarez-Buylla's speech was addressed, in the view of the hegemonic voices, to a minority. In this sense, all criticism by Elena Álvarez-Buylla of GEOs/GMOs and *science*, in general, could be easily overlooked, as it did not represent a threat to the established hegemony of *science*. To ignore a scientist's position is a common feature of the hegemony when it believes that the subject under discussion has nothing to be reviewed. The second and third explanations are found in Brian Martin's (1992) works. According to the author, silence seems to be the norm, particularly when it could concern any kind of support to a scientist's controversial statement. On the one hand, this silence is due to a general feeling of fear that scientists have when they may challenge powerful interests (Martin, 1992). On the other hand, silence is produced by internal mechanisms of suppression that impose a type of self-censorship (Martin, 1997).

Still, on June 13, 2018, during the Mexican presidential campaign, candidate Andrés Manuel López Obrador announced as part of his strategy for the Mexican Science and Technology system the appointment of Elena Álvarez-Buylla as the next president of CONACyT, the National Council of Science and Technology.[7] It did not take long for the voices of hegemony to rise against this announcement. From this moment on, Álvarez-

[7] CONACyT is the Mexico's entity in charge of the promotion of scientific and technological policy and activities. Its Portuguese equivalent is the Foundation for Science and Technology (FCT). Under Elena's direction, CONACyT tried to integrate the humanities in its name, but the proposal has not yet been adopted, being the target of intense debate in the Mexican academy.

Buylla's criticisms and her *Science* utopia became the center of attack for those who saw their hegemonic position and privileges threatened. The attacks escalated when Lopez Obrador was elected president of Mexico on July 1, 2018, and Álvarez-Buylla was confirmed as the next CONACyT director.

But the attacks, and the attacker for that matter, were also not new for Elena Álvarez-Buylla. As an example, for many years, the attempts to suppress Álvarez-Buylla went through the association of her with Stalin's communism (or referred to any negative imagery that exists about communism and socialism, for that matter). In particular, she has been associated with the Russian scientist Trofím Lysenko, commonly presented as a negationist of Mendelian genetics or an antihero of *science*. Antiheroes are primarily used as standard models for a comparison with the contemporary deviations of 'contrarian science'[8], allowing to characterize scientific narratives that oppose modern hegemonic paradigms as guided by non-epistemic factors (Brante & Eizinga, 1990). In this way, Elena Álvarez-Buylla's detractors try to associate her with figures that are markers in the history of *science* as fallacies, corrupts, and models of anti-scientists. Hear about 'Dr. Lysenko', the 'new Lysenko' or even 'Elena Lysénkova Álvarez-Buylla' was, and still is, very common on social networks (figure 2), and serves the purpose of discrediting Álvarez-Buylla 's positions as a scientifically competent scientist by promoting an erroneous connection between those that oppose GEOs/GMOs with the Stalinist policy for agriculture, taking advantage of the contemporaneous anti-communist hegemonic imaginary.

Allegedly, this adjective was coined by Mauricio-José Schwarz, a journalist and writer born in Mexico, currently based in Spain. In his multiple public interventions on *science* we found several attempts to discredit Álvarez-Buylla 's scientificity and persona. But if it is impossible to impute Schwarz's responsibility for 'Elena's Lynsekist adjective', the same cannot be said for the emergence of another,'Dr. Chulel', whose responsibility is entirely Schwarz's. On July 19, 2018, Schwarz launched on its YouTube channel another one of his 'science communication episodes', this time with the title "Why should the nomination announced for the direction of CONACyT be reconsidered".[9] The video, whose title already announces the content of its monologue, dedicates its 24 minutes to the attempt of discrediting Elena Álvarez-Buylla's project for the future of *Science* in Mexico. In this video, Schwarz uses Álvarez-Buylla 's dialogue in the Zapatista meetings

---

[8] According to Jason Delborne, contrarian science is the "first spark of dissent, in which some scientists begin to question facts, theories, and assumptions of promotional science", while promotional science is the authors terms "the dominant discourse of mainstream science" (Delborne, 2005 p.8).

[9] Mauricio Schwarz video "Why should the nomination announced for the direction of CONACyT be reconsidered" can be accessed in this link: https://www.youtube.com/watch?v=apo2sWg-waU&t=452s

of 2015, focusing on particular moments of her dialogue, including the moment when she mentions “El chulel” or the “essence” of maize.

> True science shows that transgenic maize is not the same in its essence, in its soul, like ours, the criollo, **it has lost its ‘chulel’**, as the centrals say and has also become poisonous to itself and to all the maize brothers with which will interact. (Elena Álvarez-Buylla talk at the Zapatista seminar on the 5th of May, 2015. Transcription and translation by the author. Author's emphasis)[10]

‘El chulel’ is used in this context by Álvarez-Buylla to address a ‘chamula’ concept of soul being.[11] For the purpose of this dissertation ‘chulel’ has been translated to ‘essence’. Although such translation is not free from debate, ‘essence’ is here defined as the most important quality of maize that give it its general character, the ability of becoming (-with) (Deleuze & Guattari, 1987; Haraway, 2008).

According to Elena Álvarez-Buylla's talk, genetically engineered maize is a type of maize that does not have ‘chulel’, does not have a soul, it has lost its “essence” of becoming. This description of a GEOs provides a powerful mental image that describes the standpoint, not just of the social and environmental anti-GEO/GMO movement, but also of the scientific movement that has challenged the need, concepts, and applications of genetically engineered organisms for decades.

Either by the devastation that GEOs cause to the natural populations of maize, by contaminating non-GEOs fields, or by the toxicity they impose on the land, due to their dependence on the use of pesticides, such as glyphosate, for decades, the anti-GEO/GMO movement has been denouncing the devastating impacts of GEOs/GMOs and how these altered organisms destroy the social-practices of mutual constitution that for millennia have allowed human communities and maize varieties to co-evolve.

Moreover, Álvarez-Buylla’s dialogue also provides a socio-cultural-scientific definition of what a genetically engineered organism is, which I will attempt to inscribe into our collective imaginary as a zombie. For Elena Álvarez-Buylla, saying that maize lost its ‘essence’, is a historical-cultural translation of how she, as a scientist working under *science*, describes the consequences of a knowledge practice subsumed under capitalism. In other words, her definition explains how a genetically engineered organism results from a series of complex processes that, under capitalism, constitute the practice of modern science and serve the private interest of the big capitalists predominantly. Her detractors, on their hand, have a very different perspective on the matter:

---

[10] Elena Álvarez-Buylla’s talk can be listened to by accessing https://radiozapatista.org/?p=12977

[11] ‘El Chulel’, has been explained to me - by several sources during my fieldwork is Mexico - to refer to the spirit, the soul of all beings. However, other explanations may also be provided such as the one found on Wikipedia, that regards the variation of Chuleles, which are the souls of some people who have the power to manifest in animal forms. Wikipedia link for ‘Chuleles’: https://es.wikipedia.org/wiki/Chuleles

> Obviously, science cannot prove that a maíze has a different soul from the soul of another, it cannot say that it is poisonous, simply because it is not, because it is a lie. [but] The objective of saying this, before a group of people who are precisely the heirs of centuries of marginalization, where they have not been allowed access to knowledge, where they have not been allowed to access technology, where they have been kept living as the 17th century. What is the reaction you are trying to get? fear, visceral rejection, absolute. "A scientist came to tell us that it is not like that, so what reasons do we have to help?" And since they do not have them, thanks to the effective demagoguery, a generalized rejection has been achieved. Telling people half-truths is immoral. Elena Álvarez Buylla affirms that true science is practiced, which is peasant science and that it is very different from transgenic science, botarga science, Western science, the science of hydra, has a very malevolent name for all science, which is only science, the search for knowledge. Knowledge is obtained by following the scientific method, a farmer, someone from the city, someone from Saint Petersburg, someone indigenous, someone in Buenos Aires, or someone in Alaska. There is no true science of false science, and that is a hoax again to pass it on to other people. (Mauricio Schwarz, in this YouTube video of July 19, 2018. Transcription and translation by the author.)

Why Elena Álvarez-Buylla said that maize has an 'essence' and that such 'essence' is absent from a genetically engineered organism, and why the voices of the hegemony attacked her so vehemently for this, to the point of creating satires around her (figure 3), is a core question of this dissertation, that aspires to understand what a genetically modified seed is.

However, returning, in the form of a doctoral dissertation, an understanding of this episode implies questioning the current practices and history of *science* and how we understand it today in its relations with capitalism. This *science* inquiry will thus allow understanding the reasons that support Álvarez-Buylla's critique of *science* and her utopian *Science* project, as well as it will enable understanding of the reasons why hegemony gives the answers it does, whether expressed by silence or suppression. In the end, the explanation presented in this dissertation, about this episode, aims to clarify its consequences for maize. In other words, it will try to explain what happens to maize when hegemony refuses to accept utopias and attacks them violently.

Considering the above, this dissertation formulates three hypotheses. The first refers to the use of the idea of 'essence'. What experiences? knowledge? what history? led Elena Álvarez-Buylla to use the concept of 'chulel'? and why transgenic maize has no 'chulel'? The hypothesis presented here formulates that we are facing two notions of maize resulting from different modes of socio-technical organization of maize production. Using the vocabulary of social studies of science and technology (STS), the concept that comes closest to this idea of two notions of a socio-technological being is sociotechnical imaginary, proposed by the STS scholar Sheila Jasanoff and Sang-Hyun Kim (Jasanoff & Kim, 2015).[12]

On the one hand, both notions indicate what is desirable through the use of technology. On the other hand, their technologies are co-productions, considering that they are inseparable from the ways by which each community chooses to live (Jasanoff, 2004). However, both Jasanoff and Kim's concept of 'sociotechnical imaginary' and Jasanoff's concept of 'co-production' (2004) are not enough to explain the existence of both notions since they did not consider the conflicting relationship with capitalism in the formulation of their proposals. In this sense, this dissertation will also try to fill this gap by approaching the existence of the two notions as entangled in a conflict with the capitalist ways of producing life. In a manner, the first chapter of this dissertation will explain the modes of organization of production that are at the base and produce the absence of the maize's 'chulel'.

Moreover, in Chapter 1 "Two notions of maize" I seek to frame both maize and the genetically engineered events of maize as an epistemic object co-constructed in a complex symbiotic history with the history of capitalism (Knorr-Cetina, 1999; Nunes, 2004; Rheinberger, 2010; Tutino, 2018). To this end, the chapter assumes maize as a product of social collectives, or, using the common language of STS, as a technoscientific organism, inscribing, in this way, this chapter in the traditional STS way of thinking about the social and technological history of scientific *things* (Haraway, 1991, 1997; Franklin, 2007; Saraiva, 2016). The chapter begins with one of the founding myths of maize. The choice to begin the chapter this way is justified because this myth is a living myth. By way of explanation, it is a myth that continues to be delivered and communicated within the narratives of resistance of peasants and indigenous peoples, particularly in Mexico, where a part of the fieldwork that informs this dissertation was carried out and have a strong influence on Álvarez-Buylla's perspective on the 'essence' of maize.

For the same reason, the two notions of maize that I will explore will be informed by two maize pathways with contrasting stories. On the one hand, is the history of Mexico, told through the history of maize, to explain the 'essence' of maize for communities such as the Zapatistas. This was a choice that best suited the narratives I was confronted with during my fieldwork. Yet, and considering my previous proposal to fill the existent gap on the necessity to account for the conflicting relationship with capitalism, the story I will tell explores how maize was central to the emergence of Mexican capitalism since the time of the silver economy that dominated global trade from

[12] For a genealogy on science and technology studies see Roque & Nunes (2008) introduction (pp.13-35).

the 16th to the 19th centuries. This world economy gave rise to a system that John Tutino (2018) describes as ‘symbiotic exploitation’, and in which maize had a central role.

On the other hand, the chapter points to the absence of ‘chulel’ in genetically engineered maize. For this, I will follow the path of maize commodification in the circuits of global trade, starting by accounting how maize was crucial to the Portuguese and Spanish imperial projects and how it has been, in fact, central to many of the socio-economic projects whose result is the intensification of forms of dehumanization, oppression, and exploitation of labour and nature. Although these themes are not studied in-depth under this chapter, they are of particular relevance to this work, since under my current hypothesis, they seem to inform the modern shape of maize and its relationship with the construction of an ideological project of modernity in which transgenics appear both as products and as soulless guides.

The second hypothesis of this dissertation seeks to formulate an explanation of why academic hegemony rejects Elena Álvarez-Buylla's vision, explicitly her utopian vision of *Science* and the possibility of talking about the ‘essence’ of things. What does hegemony lack to understand her? The hypothesis presented here says that the process of subsumption of science under capital resulted in a total process of alienation of scientists (Marx, 2015). Trapped in a fetishism resulting from the products of their work, the scientists who constitute the voices of hegemony are here framed as imprisoned workers, amputated intellectuals, constant victims of the contradictions of the capitalist production system with huge impacts on the ways *science* has, and can, progress (Robins & Webster, 1985; Marx, 2017a; Harvey, 2003). In this sense, Chapter 2 “Biology under the influence” will explore the critiques promoted by Richard Levins and Richard Lewontin, as well as the tradition that they left behind, of what can be named as the subsumption process of biology under capitalism (Lewontin, 1998; Lewontin & Levins, 2007; Levins & Lewontin, 2009).

Likewise, I will try to highlight that neoliberal politics have heightened this subsumption process since the 80s, which further divides the practices of science from its theories. Under neoliberalism, practices are accounted as the technologies and their markets, fostered by private initiatives, while theories are the labour and reproductive forces sustained by public funding.

Moreover, neoliberal approaches to scientific practices and labour reinforce the unprecedented gap between scientific culture and other forms of culture, a tendency that André Gorz has been observing since the 1970s (Gorz, 1976). Besides, the increasing neoliberalization of science and the progressive division of labour that answer the command of capitalism gave rise to a new form of organization of scientific labour that

García-Barrios, Hernández and Appendini (2008) have named 'strategical cooperation'. By drawing on their proposal, I suggest that this form indicates that new scientific sub-specialties, such as those that allow for the creation of GEOs, are the result of the command of capitalism rationality and only useful if they integrate the larger culture of the corporate culture. This will give force to several other accounts that consider that the neoliberalization process of science is not merely a problem of knowledge commodification (Lave *et al.*, 2010), but an ideologically driven process. For this matter, I will explore the connections between ideologies of the capitalist system with science, concluding that there is no way to escape such connections and that it is also not desirable to deny the ideological imprints in scientific practices. Rather than denying the ideological assumptions of *science*, we should invest in a collective reflexivity effort over them and their entanglements with our scientific praxis to open the path to a scientific process of emancipation mediated by class struggles. This proposal follows Daniel Omodeo's (2019) recent suggestion for the construction of political epistemology.

However, this hypothesis also requires the formulation of the condition by which we can overcome the capitalist disorder. In this sense Chapter 2 will also seek to address the forms of resistance that are generated within instances of capitalism-scientific struggles. This exercise, informed by fieldwork that crosses laboratory studies with the work of sociologists such as Brian Martin and Jason Delborne on dissent studies (Martin, 1999; Delborne, 2008, 2016), seeks in the analysis of case studies the paths that shape new scientific practices and new forms of organization of the scientific labour, in order to inform an emancipatory praxis of science, a new *Science* utopia.

Chapter 3, on the other hand, will look at the violent aspects of this controversy to shed some light on the structural character of the violence that constitutes GEOs' existence. The undeniably violent character of the history of maize, of science subsumed under capitalism, and of the forms of suppression, that act on the construction of alternatives thus justify a reflection on violence. This chapter will explore the hypotheses that the violence reported in the fields is deeply connected with the coercive forces that subsume science under capitalism while also allowing the possibility of new conceptions of science. This chapter will account for the several reports made during the International Monsanto Tribunal and other fieldwork contexts.

The dissertation ends with chapter 4, "Zombie *mea p*.". By way of conclusion, this chapter attempts to offer an answer to the question "What is a genetically modified seed?". As the chapter title suggests, the pursuing path considered the metaphor of a zombie. Following Dimitris Papadopoulos (2010a, 2010b, 2014) and the fact that all technoscientific artifacts are political phenomena, the zombie ontology is here defined as one ontology that allows locating genetically engineered organisms as beings of a scientific project built to conspire against itself and suppress alternatives in practice.[13]

In sum, the present work argues that while it is true that the binding of private transnational biotechnology companies to scientific progress has promoted the rapid development of scientific knowledge in fields such as genetic engineering, at the same time, it has also promoted a sea of "epistemic" destruction, with consequences to the way we make and govern science. Therefore, this dissertation tries to refocus the scientist as an important social actor in the construction of reality; thus, it pays attention to the social character of the science promoted by the dissidents. Nevertheless, this dissertation carries an extraordinary historical weight. If, on the one hand, it tries to account for the richness of social theory that emerges from current scientific conflicts, it, too, is informed by thinkers and theories who shaped sociological theory in moments of history marked by social conflict and economic and scientific revolutions.

[13] The concept of ontological politics present in the title of this dissertation follows the simplest definitions proposed by Papadopoulos (2014). In this sense the term ontological politics is “used to describe politics in technoscience; it refers to the existence of a multiplicity of possible organisational possibilities and engagements in a specific socio-material arrangement, in an existing ontology.” (p.71).

Notes of the fieldwork

This dissertation is informed by two laboratory studies, knowledgeable by previous works such as those conducted by Bruno Latour and Steve Woolgar (1986), laboratory ethnography. In this sense, the ethnographic work in the laboratory did not intend to promote a visual description of experiments conducted within the laboratory. Nor tried to justify the laboratory work based on the coherence between theoretical assumptions and conducted experiments (Knorr-Cetina, 1995). Instead, it has focused on the cultural activity of the scientists of these laboratories. Life within the laboratory is then engaged in the symbolic and political networks of knowledge construction (1995). In other words, it not only looks at what is visible but also at what is invisible and silenced (Star & Strauss, 1999). It combines both the sociology of discovery and experiments with the sociology of scientific and technical organization, eliminating the separation between the social world and science practices. In this sense, laboratory studies allow the understanding of how knowledge is mobilized by practice and how this space of practice is built on the limits of what science is - or is not. For these reasons, laboratory studies do not obey one single methodological approach. As Knorr-Cetina stated, the study of laboratory life entangles methodologies such as Latour's and Woolgar's actor-network theory, Michael Lynch's ethnomethodology, Traweek's symbolic anthropology, and even her constructivist-oriented approach (Knorr-Cetina, 1995, 1999). [14]

The first laboratory, where I conducted a 6-month ethnography in 2018, was the Molecular Genetics, Plant Development and Evolution Laboratory of the Department of Functional Ecology of the National Autonomous University of Mexico (UNAM). Elena Álvarez-Buylla coordinates the laboratory. She is a well-known voice that has for decades opposed GEOs/GMOs in Mexico and worldwide. Álvarez-Buylla is also a founding member, in 2004, of the UCCS (Unión de Científicos Comprometidos con la Sociedad), a collective of critical scientists dedicated to the construction and practice of

[14] For Graeme Gooday (2008), laboratory studies lost their centrality with the rise of the technocratic materialism of the Reagan-Thatcher era. The rise of neoliberalism during the 1980s has demanded from the sociologist an approach that would follow the pathways of the material life of the laboratory into the non-material world of science communications, ethics, and public understanding of science, deviating the sociologists' attention to the external expressions of science in the world, such in the museums, exhibitions, science cafes, etc. Moreover, it is possible that, as Gooday (2008) pointed out, the world of the laboratory outside of the laboratory becomes more attractive for social scientists than the practices inside. Within our practices, we have crystallized the idea that science is only useful when it encounters social life, and that science is mostly understood when it confronts the structures that give them social legitimation.

the concept of responsible science. UCCS similar organizations are UCS - Union of Concerned Scientists (USA, 1969), ENSSER - European Network of Scientists for Social and Environmental Responsibility (2009), CSS - Critical Scientists Switzerland (2015), UCCSNAL - Unión de Científicos Comprometidos con la Sociedad y la Naturaleza de América Latina (2015), among other.

In Mexico, fifteen individual conversations were held, of which nine were formal interviews, one of them in-depth with several sessions. Everyone was asked to explain what made them pursue a scientific career, the contradictions they find within science through their practices, what motivated them to organize, or not, into groups of critical scientists, and their scientific position about the conflicts over genetically engineered organisms. In the case of women, a reflection was also requested on what it means to be a woman in science, what this implies, its barriers, and challenges. Given the character of the topic under investigation, and since all informants were guaranteed anonymity, a characterization of the sample will not be presented, as this would easily reveal the identity of the interviewees. The ethnographic work also considered observation within the laboratory and field trips and observation of team meetings. To better understand the theoretical framework mobilized by these researchers in their critique of GEOs, I attended the UNAM *Molecular Biology and Plant Development* optional curricular unit. These classes allowed me to review some of the fundamental aspects of the biology and ecology of plants, particularly of maize. It also sought an update on my knowledge regarding the theoretical backgrounds and state-of-the-art of genetic transcription and the influence of genes in the development and evolution of plants.

This ethnographic work was further complemented by participation in three public events, namely: i) the presentation of the publication “Treinta años de transgénicos en México”, a research conducted by the Centre for Studies of Change in the Mexican Field, that took place in Mexico City on the 15th of February 2018, ii) the presentation of the book “Transgénicos: Grandes beneficios, ausencia de daños y mitos”, held by promoters and advocates of transgenics, that took place at Colegio Nacional in the 22nd of February 2018, and iii) the round tables “Los alimentos transgénicos a debate”, that took place at UNAM between the 11th and 13th of April 2018, and that brought the two conflicting views together in a public debate.

During my stay in Mexico, I also attended classes on *Microeconomics and Macroeconomics,* which allowed me to complement my studies on Institutional

Economics, providing access to new analytical tools for the understanding of the economic impacts of biotechnological innovation, as well as classes on *Political Economy* and the course in Complex socioecological processes, held in San Cristobal de las Casa, Colegio de la Frontera Sur, in the state of Chiapas.

The second ethnographic period, between the autumn of 2018 and the spring of 2019, involved the Comité de Recherche et d'Information sur le génie Independantes Génétique (CRIIGEN). The CRIIGEN is an independent center for research and counter-expertise in the risk assessment of genetically engineered organisms. Its researchers are persistently engaged in scientific controversies and legal disputes, Gilles-Eric Séralini being the most recognized figure in the collective. However, due to the character of CRIIGEN, it was not possible to replicate the approach followed for the Mexican case. The study on CRIIGEN involved several trips between France, Switzerland, and Germany, and in one case, the ethnography was interrupted for family reasons. Even so, it was possible to carry out five interviews that were complemented with several conversations with critical European scientists who belong to or are in the orbit of the networks of critical knowledge where CRIIGEN is included.

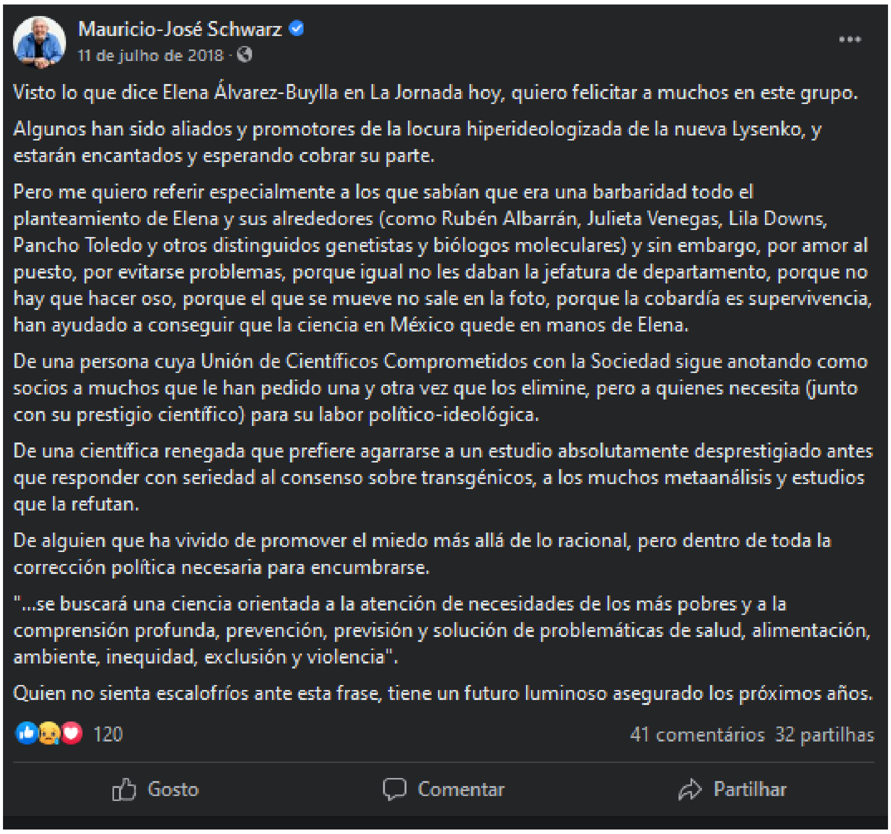
The ethnographic work also encompassed my participation as a member of ENSSER - European Network of Scientists for Social and Environmental Responsibility, namely the presence in public events such as i) the conference on “Agriculture and Health: the need for greening Europe – an opportunity for Greece”, that took place between 22-24 of November 2017 in Athens, ii) the public event “Bound to fail – The flawed scientific foundations of genetic engineering” held in Berlin on the 5^{th} of September 2018, iii) the “9^{th} GMO- Free Europe Conference” that was held between the 6^{th} and 7^{th} of September 2018 in Berlin, and iv) the “Gene Drive symposium”, that took place in Bern on the 24^{th} of May 2019.

Despite the difficulties encountered with the European case, the experience as an activist in the organization of the International Monsanto Tribunal, held in October 2016 in The Hague, was also included in the research. This means that a part of the methodological work is also autobiographical.

Both laboratories were chosen due to the character of research they carry out – counter-expertise – which enables the exploration of a 'becoming of science'. According to Sezin Topçu (2008), counter-expertise can be defined as "[…] a set of mechanisms and activities aiming to check, counterbalance, and complement a given system of expertise" (p.243). Also, according to Topçu, "counter-expert" is a role that scientists have been adopted when their practices allow the creation of new frontiers between science and society. When the aims of the claims of "counter-experts" do not end on matters of proof, instead they launch questions "based on which scientific certainties are constructed" (2008, p.238).

Content analysis was used to treat information – mainly interviews - both as variables. That is, it sought to identify consistencies and relationships and as a resource to frame concepts and other elements of the theoretical apparatus mobilized in the dissertation. Each chapter thus emerges from this practical work. Contrary to what would be currently expected, the coding and treatment of interviews and bibliography did not use qualitative data analysis software. The decision not to use the software did not follow any opposition to its use, but a matter of personal style, which still prefers and finds pleasure in the traditional way of analysis, that is, printing, cutting, and using brightly coloured pens to carry out the analysis. This style of analysis rested on grounded theory, where codes are built from reading and thinking about the data and only stop when saturation is reached. However, abductive reasoning was associated with grounded theory methodology, and in this sense, episodes such as the ones narrated above have guided the hypothesis that frames this work (Star, 2007; Timmermans & Tavory, 2012).

Figure 1 - María Elena Álvarez-Buylla received the National Science Award of 2017 for her contributions to the molecular genetics of plants. In the photography, Álvarez-Buylla offers former Mexican president Enrique Peña Nieto her 2013 book "El maíz en peligro ante los transgénicos: un análisis integral sobre el caso de México". (Source: Mexican Federal Government, retreived from the newspaper Reforma website).



Mauricio-José Schwarz
11 de julho de 2018

Visto lo que dice Elena Álvarez-Buylla en La Jornada hoy, quiero felicitar a muchos en este grupo.

Algunos han sido aliados y promotores de la locura hiperideologizada de la nueva Lysenko, y estarán encantados y esperando cobrar su parte.

Pero me quiero referir especialmente a los que sabían que era una barbaridad todo el planteamiento de Elena y sus alrededores (como Rubén Albarrán, Julieta Venegas, Lila Downs, Pancho Toledo y otros distinguidos genetistas y biólogos moleculares) y sin embargo, por amor al puesto, por evitarse problemas, porque igual no les daban la jefatura de departamento, porque no hay que hacer oso, porque el que se mueve no sale en la foto, porque la cobardía es supervivencia, han ayudado a conseguir que la ciencia en México quede en manos de Elena.

De una persona cuya Unión de Científicos Comprometidos con la Sociedad sigue anotando como socios a muchos que le han pedido una y otra vez que los elimine, pero a quienes necesita (junto con su prestigio científico) para su labor político-ideológica.

De una científica renegada que prefiere agarrarse a un estudio absolutamente desprestigiado antes que responder con seriedad al consenso sobre transgénicos, a los muchos metaanálisis y estudios que la refutan.

De alguien que ha vivido de promover el miedo más allá de lo racional, pero dentro de toda la corrección política necesaria para encumbrarse.

"...se buscará una ciencia orientada a la atención de necesidades de los más pobres y a la comprensión profunda, prevención, previsión y solución de problemáticas de salud, alimentación, ambiente, inequidad, exclusión y violencia".

Quien no sienta escalofríos ante esta frase, tiene un futuro luminoso asegurado los próximos años.

120 · 41 comentários · 32 partilhas

Gosto · Comentar · Partilhar

Figure 2 - Example of a Facebook post by Mauricio-José Schwarz captured by the author in the public group "No a la pseudociencia en la UNAM".

Figure 3 - On the left, a caricature that appeared on Twitter in 2018 after Elena Álvarez-Buylla was nominated for director of CONACyT. On the right, a caricature appeared on the Facebook profile of @ObreroFuturista, on August 15, 2019.

Use of terms

Genetically engineered organisms (GEO) – A genetically engineered organism is defined here as an organism that has been improved inside the modern apparatus of biotechnology R&D. The use of the GEOs term in this dissertation entangles both the definition of hybrid seed and a transgenic seed.

Hybrid – a hybrid is a plant that results from combining the qualities of two organisms of different breeds or varieties through sexual reproduction. Hybrid plant varieties were first introduced in the United States of America in 1935. According to Kloppenburg, hybrids, which were a key actor on the "Green Revolution" "played a crucial role in galvanizing not just substantial yield increases, but a wide range of negative primary and secondary social and environmental impacts as well. (2014, p. 6). Hybrid plants are a technology that introduces a new way of saving labour force in the crop and new forms of consumption within the productive system through the use of large machinery and new forms of agricultural management. Hybrids inaugurated the first form of property over seeds, which resulted in the promotion of the new legality under which organisms became homologous by international law.

Transgenics – under this dissertation, a transgenic is understood as a genetically modified plant produced by genetic recombination and editing. A transgenic plant is the product of modern genetic engineering techniques (e.g., zinc finger nucleases, TALENs, CRISPR/Cas9). Some of today's modern genetic editing techniques allow the researcher in the laboratory to alter, destroy, or introduce foreign genetic material into host cells, manipulating in this way the genetic code of living organisms to express in the form desired by its creator. Today, it is possible to eliminate, or horizontally transfer, any gene from an organism's DNA to another, regardless of the species of origin and sexual compatibility. However, it is also important to acknowledge that transgenic organisms only exist in the presence of the market and its commodity form (e.g., Herbicide-resistant (HR) crops, Golden rice, Flavr Savr tomato, Amflora potato, AquAdvantage salmon). Transgenics are products of out-farm practices, namely laboratories and R&D private and public institutions, produced within a corporate culture that resorts to venture capital.

Genetically modified organism (GMO) – The term "genetically modified organism" is often used as a synonym for transgenic or hybrids. However, under this dissertation, I will explore a different definition. Here, genetically modified organisms can be considered an organism whose “traditional” breeding plant techniques have improved. Meaning, it is the result of a system of plant improvement that exists outside the apparatus of modern technology and capitalism. This distinction is made to avoid the false idea that genetically engineered techniques are extensions of “traditional” breeding techniques. Promoters of hybrid and transgenic plants often use this analogy, but the social movement contests it, and, above all, farmers and peasants that have kept, managed, and improved the varieties of vegetable variety for millennia, reject it. However, and because most people still associate GMOs with genetically engineered organisms (GEO), whenever the GEO acronym is used, it will also be associated with the GMO acronym.

Criollo maize or Criollo seed – is here referred to as a species of crop that has been improved outside the modern apparatus of biotechnology R&D. Criollo maize should be understood for this dissertation as a product of farmers' practices, both as individuals and associations, of improvement of plants based on the natural legalities of those plants (e.g., sexual compatibility). This means they are subjected to the rules of biological laws and can be produced both in and outside the farm.

Promotional science - is the concept used by Jason Delborne (2005) to describe the dominant discourse of mainstream science in agro-biotechnology.

Contrarian science – according to Delborne (2005), contrarian science is the first action against mainstream ideas over genetically engineered organisms. It is a questioning of the facts, theories, and assumptions of promotional science (p. 23)

As a final introductory note, I would like to clarify that this dissertation limits Elena Álvarez-Buylla to the period before her position as director of CONACyT. In this sense, her proposal must be seen in this temporal framework. The achievements, successes, challenges, barriers, and contradictions faced by Elena Álvarez-Buylla as president of CONACyT will have to be the object of a study other than this one.

Chapter 1 — Two notions of maize

This page intentionally left blank

1.1 – Introduction of chapter 1

This chapter attempts to answer the research questions that regard Elena Álvarez-Buylla's scientific and personal paths to the use of the concept of ‘chulel’. What historical accounts led her to claim that genetically engineered maize does not have ‘chulel’? What knowledge underlies this statement? Answering these questions will highlight the reasons that allow affirming that criollo maize has an ‘essence’ while genetically engineered maize has lost it. Moreover, I formulate the hypothesis that we face ‘two notions of maize’ resulting from different maize modes of socio-technical organization of its production. In this sense, this first chapter dedicates its effort to exploring the technosocial-historical modes of maize production from pre-colonial times to modern maize. To this end, the chapter assumes maize as a product of ‘social collectives’ and therefore starts with one of its founding myths. ‘Social collectives’ is understood here as the social relations of human groups that influence the form of maize and are influenced by it. In this respect, the narrative of the chapter offers a passage through labour and maize socio-technological relations in different periods to make tangible the connection between this plant and its material and immaterial cultural heritage.

Furthermore, and because this dissertation regards scientific controversies, I highlight scientific debates that tried to determine the biological starting point of maize and how the lack of an interdisciplinary perspective has led to a delay of centuries in understanding the biological roots of maize.

Moreover, the ‘two notions of maize’ are informed by ‘two maize historical pathways’ with contrasting stories. On the one hand, Mexico's history is told through the history of maize, which, I argue, helps explain the ‘essence’ of maize for communities such as the Zapatistas. An explanation that nevertheless cannot ignore the tensions and contradictions of history, namely, maize context of ‘symbiotic exploitation’ and its importance both for sustaining and resisting capitalism (Tutino, 2018). On the other hand, is the path of maize commodification in the circuits of global trade. From the colonial ships to the financialization of agriculture in modern times, maize has been a transformed witness of all. However, this narrative division does not mean that the paths are independent of each other. Both historical accounts are interconnected and are mutually dependent. The final part of the chapter will approach the ‘two notions of maize’ at conflict in its current socio-technological apparatus and how they are framed within two agricultural systems.

1.2 - The history of Maize from pre-colonial times to modern maize

1.2.1 - The myth of how maize came to be

According to the Aztec legend Quetzalcóatl is the god[15] responsible for giving maize to humankind. How it happened depends on the book you read or the person that tells you the story. For this reason, there are several versions of this Mesoamerican mythological event, but it is possible to summarize it as follows.[16]

> The maize existed apart from human communities. Guarded by helpers of the God Tláloc in Tonacatepetl, the "Mountain of the Sustenance", maize existed inaccessible, but not unknown, to the human communities. After being asked by the humans to help them obtain access to the food hidden in the mountain, Quetzalcóatl turns into a red ant, carrying a golden kernel of maize in its back, and asks if the ant could help in finding such a precious thing. Reluctant, the red ant decided to point the path. To follow such a path Quetzalcóatl transforms his figure. Transmuted into a black ant, Quetzalcóatl trails the complex underground galleries built by the colony. Once emerged in the valley of the Tonacatepetl, Quetzalcóatl steals a kernel and brings it back to Tamoanchan [17] where the gods taste it and decide to put it in the mouth of humans. (Story produced by the author).

The myth of how maize came into being with humans does not end here. Quetzalcóatl's quest fails in providing humans direct access to the food in the mountain. It is then that Oxomoco and Cipactonal[18] announced that only Nanahuatzin — the god that sacrificed himself in the fire to become the sun — can break the mountain. With the help of the blue, white, red, and yellow rain gods, Nanahuatzin breaks Tonacatepetl, allowing all the colourful kernels of maize to spring from it. With the opening of Tonacatepetl, not only maize became available. Beans, *huauhtli* (Amaranth), and chia are also now in the hands of humans to be cultivated.

---

[15] The name of Quetzalcóatl comes from the Nahuatl languages and it means the "Feathered Serpent". The gender of this entity is unclear. Although often referred to as a male, some texts suggest that Quetzalcóatl holds both the male and female genders. It can, therefore, be understood as a dual or genderless entity. Also, Quetzalcóatl is an Aztec god, and must not be confused with his Maya equivalent Kukulkan.

[16] The myth presented here results from the readings of the works of Alfredo López (2006, pp. 306−307); David Carrasco (2000, p. 100); Carmen Aguilera (2001, pp. 233−234); and Eduardo Matos (2018a, pp. 32−33, 2018b, p. 34).

[17] Mystical place where gods created the humans.

[18] Oxomoco and Cipactonal are Aztec deities responsible for astrology and the calendar. They are considered the first and only Aztec deity couple.

The myth behind Quetzalcóatl and the origin of maize is probably one of the most important myths for the construction of the pre-Hispanic communities of Mesoamerica, particularly those from Mexico. It is a myth that persists until today and tells us about how maize, which is more than just food, became part of the cultural identity of the Mexican population. For people who, in their own words, "are made of maize", this plant symbolizes their history, culture, language, flesh, and resistances.

At the entrance of the Government Palace of Tlaxcala — today one of the 31 states of Mexico that in pre-Hispanic times was the territory of the Tlaxcalans[19] —, it is written:

> The primitive man, the nomad, and the hunter discovered the teosinte, the divine maize, and after cultivating it for millennia, turned it into our maize. Maize (*centli* in Nahuatl language), year after year, marvellously covers the entire surface of our land from unbelievable times. Maize, the source of our strength that was cultivated with *coa*,[20] was the creator of our great pre-Columbian cultures. Sun of maize, a cob of gold, which, in its multiple and rich forms, was and continues to be the main food of our autonomous communities every day. And that the ancients Teochichimecas-Texcaltecas, lords of the Texcales became great corn growers, giving their homeland the name Tlaxcallan, which is as much as to say the land of the Tlaxcalllis or also the land of corn or cornbread. (Text collected during ethnographic work in Tlaxcala, 2018, and translated by the author).

In the myth of Quetzalcóatl and the origin of maize, we are not just told a story of the relationships between gods and humans. The myth describes the ways and modes of maize production, transmitted from generation to generation in the form of a tale.

According to Jonathan Z. Smith *et al.*, (2020) entrance in the online British Encyclopaedia "Britannica", a myth functions as an explanation of facts.

> Obviously, a myth such as this one functions as an explanation, but the narrative form distinguishes it from a straightforward answer to an intellectual question about causes. The function of explanation and the narrative form go together, since the imaginative power of the myth lends credibility to the explanation and crystallizes it into a memorable and enduring form. Hence myths play an important part in many traditional systems of education (Smith *et al*., 2020).

In this sense, myths serve today as a roadmap into the world in which ancient communities dwell, their modes of production, and social reproduction[21]. In addition, myths provide researchers today with insights into the past of agricultural species and their relationships with civilizations. To some extent, the Quetzalcóatl myth allows for an

---

[19] The pre-Hispanic Tlaxcala state was independent from the Aztec Empire.

[20] The *coa* refers to the agricultural technique of using pointed stick for sowing seeds.

[21] Myths, legends, and folk tales are recurrently mobilized in disciplines such as archaeology and ethnobotanics.

insight into the ancient practices of Mesoamerican agriculture. Even though the myth does not provide any inquiry into the cause of things, it is a narrative about origins and, in this sense, serves as a validation of practices and societies (Smith *et al.*, 2020). Considering the several myths regarding maize, including those present in the Popol Vuh, we may assume that each myth represents each society's relationship with the species and serves as an explanation of its system of production. Accordingly, there is no such thing as a sole founding myth of maize. Each myth provides insights into each society's relation with maize, and we should expect to find different myths regarding each society's distinct view of this plant, associated with each form of the social organization of production.

Common to all is the fact that, and regardless of how production is socially organized, all the myths consider human labour. Labour is here understood in its simplest definition; it is a permanent interaction between people and people with the natural world. Thus, labour is a condition common to all forms of human societies. However, to understand how necessary labour appears in each society and is present in each myth, we must also account for its socio-technological relations.

As described by Raúl García-Barrios, Luís García-Barrios and Elena Álvarez-Buylla (1991, pp. 133−135), maize producers face several ecological factors with varying persistence and control possibilities. When facing such a diversity of environments, human producers need to choose among different technical options available and known to them, which should favour their production. Each technological option, in turn, requires a form of social organization. Consequently, the workers produced diversified productive landscapes for growing maize, and therefore different explanations for them. For example, the *Chinampas* are the social-technological pre-Hispanic form of maize production that seems to arise in the myth. Primarily located in the valley of Mexico City, the *chinampas* are a technological option for plant production that requires several labour performances, including sophisticated engineering labour to maintain the drainage system. Like the ants that build complex galleries, humans producing under this social-technological regime constructed a complex mesh, staking out a rectangular enclosure into the marshy lakebed (figure 4). The *chinampas* were intensive in human labour.

Also intensive in human labour are the *cajetes*. The *cajete* technique, more common to what is known today as the state of Oaxaca, is a method of maize production in wet soils. This technique requires soil drilling to a depth of 30−40 cm. In each hole, a seed of maize is dropped, so a plantation of maize requires at least a dozen persons whose labour articulates in the process of *cajeteo* (figure 5). All these forms of maize cultivation belonged to traditional indigenous institutions supported by collective action and types of labour cooperation. In the pre-Hispanic communities of Mexico, the social organization of such labour cooperation resulted from a technical constraint, whose form of organization anchored a social organization that produced several consensuses among the constituted classes.

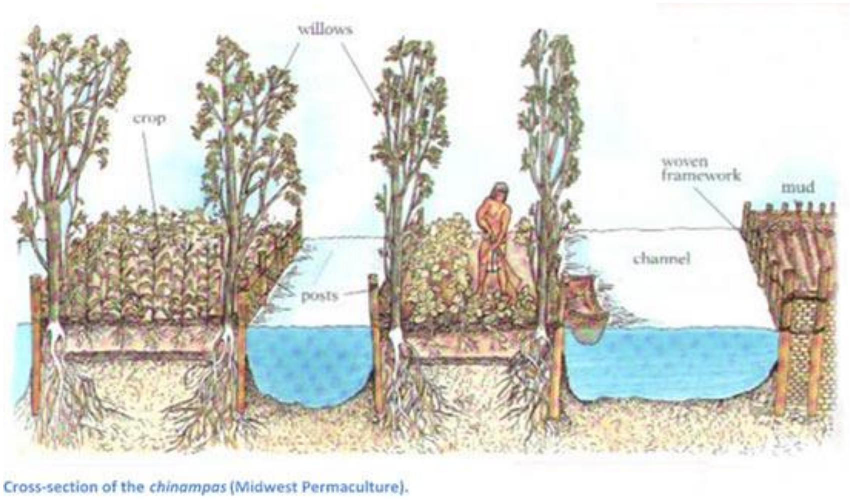


Figure 4 — An unidentified author's representation of a Chinampa. Source: Robles *et al.* (2018, p. 118).

Figure 5 — Representation of *cajete* at the Florentine Codex. Source: Bernardino de Sahagún, Wikipédia (2020).

The dominant class, for example, exploited the labour of the majority of the community members, providing protection and security in turn. Besides the fact that this class held the land or controlled the access to common lands, their moral power was sustained by the constitution of negotiation mechanisms, such as the ritualist ones, and labour norms, such as those based on familiar or reciprocal ties between members of the classes (García Barrios *et al.*, 1991, pp. 27–28).

Alongside the necessity of labour division and labour cooperation for maize plantation, Mesoamerican indigenous communities have also created a system of agricultural production where maize plantations were associated with other species. As mentioned in the myth of maize, when Nanahuatzin breaks Tonacatepetl, there is an overflow of maize, beans, *huauhtli* (amaranth), and chia, among other species, which represent the polyculture known as *milpa*.

Milpa is a Mesoamerican agricultural system from pre-Hispanic times that gathers together different crops within the same space, providing the necessary food for the communities. *Milpa* crops are nutritionally complementary. For example, maize lacks digestible niacin, while beans are rich (Mann, 2006).[22] From the ecological point of view, *milpa* is a way to provide maize with the nitrogen required for its growth. Nitrogen is supplied to maize by legumes plants that establish symbiotic relationships with some bacteria present in the soil. In this way, the ecological relationships built by this species avoid using modern chemicals, rationalized by the contemporary capitalist forms of agricultural systems.

Moreover, *milpa* is more than a system of agricultural production; it is a socio-cultural historical production. According to Charles C. Mann:

> Based on the Gulf Coast side of Mexico's waist, on the other side of a range of low mountains from Oaxaca, the Olmec clearly understood the profound changes wreaked by maize—indeed, they fêted them in their art. Like the stained-glass windows in European cathedrals, the massive Olmec sculptures and bas-reliefs were meant both to dazzle and instruct. A major lesson is the central place of maize, usually represented by a vertical ear with two leaves falling to the side, a talismanic symbol reminiscent of a fleur-de-lys. In sculpture after sculpture, ears of maize spring like thoughts from the skulls of supernatural beings. Olmec portraits of living rulers were often engraved on stelae (long, flat stones mounted vertically in the ground and carved on the face with images and writing). In these stela portraits, the king's clothes, chosen to represent his critical spiritual role in the society's prosperity, generally included a headdress with an ear of maize emblazoned on the front like a star. […] In the Maya creation story, the famous Popul Vuh, humans were literally created from maize. (Mann, 2006, p. 163)

In the same region of Oaxaca, Noemí Gómez (2016) accounted for the deep connection between maize production and the indigenous cosmovision. After conducting a series of local interviews, Gómez explains maize's importance for those people and their relationship to the land. When a baby is born, the mother drinks *atole*, a maize-based hot beverage, to get strength. In the life of a child born in the Mixe, maize is always part of

[22] Some varieties of maize, in the Mixes District of Oaxaca in southern Mexico, have developed aerial roots that produce a sweet mucus that feeds bacteria. The bacteria, in turn, pull nitrogen out of the air and fertilize the corn (Deynze *et al.*, 2018).

growth. The young man learns to labour the land for maize cultivation while young girls are taught to save, care for, and process maize into rich *tortillas*. In between, they are told how maize came into their communities by mythical encounters of people and gods (Gómez, 2016). These narratives are part of an oral history told from generation to generation, where maize symbolizes community, free labour, autonomy, future, luck, and health.

The central position that maize has in the construction of modern communities in Mexico was based on the importance of that crop in pre-Hispanic times. In the Codex Borgia, which is believed to have been written before the Spanish colonization, quetzals appear on top of a maize plant[23]. This picture composes the complex that Carmen Aguilera (2001) names quetzal-maize-water-land. This complex represents the total essence of pre-Hispanic modes of living, their culture, labour, and relationship with nature. Aguilera also points out, and according to the Codex Magliabechiano, that the serpent represents the land that is laboured and that the feathers of the quetzal are the leaves of the maize cobs. She proposes that Quetzalcóatl could signify "the land covered with the corn plants that grow on it" (2001, p. 233). As a way of living, maize is a means of making the immaterial cultural heritage of today's Mexican communities tangible (Gómez, 2016).

1.2.2 – Biological debates over the origins of maize

Among the several controversies regarding maize biology, we find the debate over its origin. The first proposal on the biological origin of maize traces teosinte as the ancestor of maize. Teosinte shares with maize the same number of chromosomes and hybridizes readily with it. Because maize has not been found in a wild state, the hypothesis that teosinte was its ancestor seemed plausible for more than half a century (Bonavia, 2013, p. 23). Archaeological maize, however, has raised the hypothesis of the existence of wild maize, which resulted in Mangelsdorf's (1974) proposal that maize could be separated

[23] As mentioned, Quetzalcóatl is the Nahuatl composition of the names of two animals. Coatl, who signifies serpent, and Quetzal, a bird known by the same name (*Pharomacrus mocinno*, La Llave, 1832). According to Carmen Aguilera (2001), the quetzal long tail feathers were much appreciated by the pre-Colombian civilizations of Mesoamerica, where there was even an interstate trade market for them. As a consequence of such trade routes, the quetzals became domesticated.

from teosinte. Furthermore, in the same archaeological sites, the absence of wild teosinte seemed to support the Mangelsdorf proposal. Nonetheless, the debate over the biological origin of maize is still unclosed as new molecular and genetic information is produced, feeding contemporaneous discussions within the conflict over genetically engineered organisms.[24]

The domestication of maize is estimated to have started around 5000−5400 BC until 2500 BC, in a period known as the Protoneolithic horizon or Protoagricultural (Benz, 2001; Escalante *et al.*, 2008). When I refer to the period of domestication, I am referring to the beginning of the domestication process that coincides with the social process of sedentary human life and the emergence of Mesoamerican agriculture. A process that is, of course, mediated by the cultural reproduction of the indigenous communities and peasants until today.

Although it is currently well accepted that the place of origin of maize is in Mesoamerica, scientists lacked the conceptual framework to locate its origin for centuries. Duccio Bonavia's (2013) work partially explains why it took centuries for scientists to determine the origin of maize. He accounts that by the year 1542, there were several controversies regarding the place of origin of maize. Because maize could be found in several world regions, European botanists struggled to defend their hypotheses regarding its origin. At the time, it appeared that maize could have originated in places such as Greece, Turkey, regions in Asia, or even Africa (2013, pp. 18−21). The resulting confusion was the product of several taxonomic mistakes, framed in the practice of the time and that there was no concept for the origin of cultivated plants. We needed to wait for the Russian revolution to occur so that Nikolai Vavilov could become director of the Lenin All-Union Academy of Agricultural Sciences at Leningrad and present his thesis over the centres of origin of cultivated plants.

According to this Russian biologist, in his presentation to the *Second International Congress of the History of Science and Technology*, in 1931, "contemporary European and American horticulture and agriculture know only fragmentary details, derived from ancient centres of agriculture, of the initial diversity of cultivated plants" (Vavilov, 2014, p. 98). Talking to the congress on the multiple expeditions conducted by Soviet revolutionary scientists in several places of the world, Vavilov accounts for the richness of plant varieties, which seem, still, to be unknown to

[24] The reporting of teosinte and maize × teosinte hybrid plants in EU fields have fuelled debate on the risks of GMOs.

European scientists and agricultural systems of our continent in the early 20th century. In his talk, he introduces proof that supports the theory of the existence of centres of origin of cultivated plants. Centres of origin of cultivated plants are geographical regions where we can find the more significant concentration of biodiversity of such plants in agriculture. According to Vavilov, cultivated varieties coexist (or used to coexist) with their wild relatives. Still, they resulted from different forms of agricultural production associated with each region's ways and modes of living (Vavilov, 2014). Since Vavilov, and as Kato *et al.* (2013) remind us, the studies for determining the centres of domestications of agricultural species became an interdisciplinary effort. With the introduction of this concept, botanists could no longer continue to explain the origin of a cultivated plant-based only on its taxonomy. They had to account for archaeological knowledge. Moreover, they had to integrate into their research the ways of maize cultivation and how deeply it connected with the ways of living of the communities.

This takes me to another example of how knowledge on maize, although present in Mesoamerican community practices, was for centuries absent in Europe and the object of scientists' research and controversy. As mentioned before, the majority of maize crops lack digestible niacin. Nicotinic acid, or vitamin B3, is essential for human nutrition. We obtain niacin from a variety of foods, but when absent, it is associated with diseases such as pellagra.[25]

> One limitation with maize is that while it contains the vitamin niacin, it is in a bound form that is not readily available to the body. It is also low in tryptophan, a niacin precursor. In order for niacin to be released from the bound form, it needs to have the pH increased before entering the low pH of the stomach. Early natives in Latin America stumbled upon a process, called nixtamalization, which involved soaking the whole maize in a lime solution (calcium hydroxide), followed by grinding to produce a paste, called masa, from which tortillas are made. This process had two benefits: it converted the hard-maize kernels into a more digestible form and released the bound niacin. Without this process there would have been much higher incidences of pellagra due to niacin deficiency. In Europe, North America, and Africa, where the nixtamalization process was not used, pellagra became a problem in some areas. One of the real success stories of cereal fortification was the addition of niacin to maizemeal beginning in 1941, which contributed to the elimination of pellagra as a major health problem in the Southeastern United States. Pellagra was not a public health problem in other parts of the world, perhaps because they had a more varied diet that provided sufficient amounts of niacin. (Ranum *et al.*, 2014, pp. 106−107)

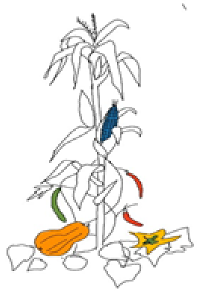
[25] In the 19th and early 20th centuries, pellagra was a problem in regions with maize-based food, such as in industrial zones of Italy, Spain and Portugal. In 1927, Dr. Manuel Joaquim Ferreira authored a doctoral thesis where he characterizes the disease and associates it with the ways of life of the proletarians in the municipality of Póvoa do Lanhoso in the District of Braga, Northern Portugal.

As Ranum *et al.* (2014) account, for maize’s niacin to become available to the human body, it is subjected to a food process that Mesoamerican communities call *nixtamalization*. This way of processing maize is a millennial practice within these communities, performed by women (figure 6). Still, it took 250 years since Mexico's colonization for Western scientists to understand the nutritional value of maize and how to access it. Furthermore, and as mentioned before, for Mesoamerican communities, maize was never planted alone. As a sociocultural form of production, the *milpa* was also able to provide the communities with abundant vitamins and nutrients.

> *Milpa* crops are nutritionally and environmentally complementary. Maize lacks digestible niacin, the amino acids lysine and tryptophan, necessary to make proteins; diets with too much maize can lead to protein deficiency and pellagra, a disease caused by lack of niacin. Beans have both lysine and tryptophan, but not the amino acids cysteine and methionine, which are provided by maize. As a result, beans and maize make a nutritionally complete meal. Squashes, for their part, provide an array of vitamins; avocados, fats. The *milpa,* in the estimation of H. Garrison Wilkes, a maize researcher at the University of Massachusetts in Boston, “is one of the most successful human inventions ever created.” (Mann, 2006, pp. 161−162)

Today, *milpa* can be understood as permaculture. A food production system based on a holistic and integrative approach of the relations between ecological landscapes, human practices and community resilience. *Milpa* has been for millennia the “traditional” ways of producing food in Mesoamerica. However, the *milpa* is one of the multiple forms of “traditional agriculture” that today combines prehispanic techniques and production modes with modern techniques, including some from the green revolution.

As an “indigenous technology”, the forms of agricultural production of Mesoamerican communities, although highly dependent on human labour, provided food for larger cities before the colonial period. For example, in the ancient Aztec city of Tenochtitlan, by 1519, the town had around 200 000 inhabitants, almost the same number, if not sometimes larger, as the most prominent capitals of that epoch in Europe. These facts highlight the importance of interdisciplinary research and require a major effort to decolonize interdisciplinary knowledge areas such as ethnobotanics.



1.2.3 - Maize in Mexico: struggles over diversity

Before the Spanish colonization of what is known today as the United States of Mexico, the region was constituted by "a vast domain of complex polities, ways of production, social relations, and cultural contexts" (Tutino, 2018, p. 34). The Aztec empire was an alliance of three city-states that expanded and dominated the region based on warfare. Subduing several other cities of the region with its military power, the Triple Alliance imposed the tribute form as the dominating political and economic relation of the Empire (Escalante, 2008; Morton, 2010).

With the arrival of the Spanish, the subjugated cities, allied with metal weaponry and firearms, stood against the Empire. Thus, the outnumbered Spanish conquerors could only disintegrate the Triple Alliance because of the indigenous armies that stood with them (Tutino, 2018). Furthermore, the indigenous, who were facing the Empire, were not the conquerors' only allies. An invisible ally came with the Spaniards in their ships. A pandemic of variola (smallpox) devastated the region. By the end of 1618, a hundred years after the first arrival of Hernán Cortés, the indigenous population had dropped to less than 1/3 (Diamond, 1999). With a devastated population unable to resist, Spain consolidated its power in the region. However, the success of Spain in establishing its colonial power can only be truly understood within the context of the global demand for silver (Tutino, 2018).

The new global silver economy, arising from the demand for silver by China and India, allowed Spain to consolidate its colonial state. Before silver, the colonial state coexisted in the region with the remaining indigenous communities, mostly due to the maintenance of the tribute form as the central economic relationship.[26] At the same time, the new settlers occupied most of the lands, now vacated due to the population's disappearance. With the rise of the silver economy and considering the fact that pre-colonial indigenous communities had already developed techniques for exploring precious metals, these became involved as well in the circuits of silver extractivism (Tutino, 2018).

[26] *Encomienda* was an imposed law of the Spanish crown that rewarded conquerors with indigenous labour by virtue of their successful conquest. Although the indigenous communities maintained their lands, they had to provide the settlers with labour force. In turn the *encomendero* was obliged "to press conversion to Christianity and provide protection from exploitation" (Tutino, 2018, p. 64). This form of tribute allowed support of an indigenous elite as well, that ruled the indigenous communities while maintaining commercial and political relations with the Spaniards.

Food production in this period went through profound changes. The agricultural techniques brought by the colonists were introduced in the region as new, labour-saving techniques of agricultural production. Considering that the pre-colonial method of cultivation was highly dependent on human labour and that such labour force was no longer available, the adaptation by the indigenous communities to the European forms of cultivation was both a matter of survival and resistance. The new techniques of production, in turn, allowed some labour-saving which could be redirected to the mining centres. Native production then became a way of sustaining indigenous communities and nearby cities, including mining centres. According to Tutino (2018):

> Silver rebuilt Mexico City as the northern pivot of Spain's American power. The regime congregated native survivors in landed republics, deepening autonomies in environments that enabled communities to produce most of the necessities of life: maize, frijol, chile, and the fermented pulque that provided key nutrients. […] All produced the Mesoamerican staples of life. […] The reconstruction that created republics and solidified community autonomies opened vacated lands to Spanish entrepreneurs who built commercial estates, aiming to profit from feeding the city and mining centers. Villagers still ruled the supply of native produce— maize, frijol, chile, and pulque— to Mexico City and the mines; Spaniards' estates focused on European wheat in the temperate basins, sugar in lowland Cuernavaca, sheep and other livestock in the dry Mezquital. Herding required little labor, often provided by enslaved Africans and their free mulatto descendants. To provide labor in new fields of wheat and sugar, the regime adapted the Mexica's *cuatequil* labor draft, requiring villagers to take weekly turns— now called *repartimientos*— laboring at nearby mines, cities, and estates. (Tutino, 2018, p. 44)

Tutino (2018) offers an account of how the complex colonial relations established in Mexico allowed for "communities to produce most of the necessities of life" and to develop their indigenous republics while, at the same time, serving the interests of the silver economy and the colonial rule.

In the 17th century, indigenous communities "could sustain themselves, sold maize and other native goods in the city mining towns, and sent workers to harvest wheat and sugar at commercial estates" (Tutino, 2018, p. 85). A century later, and with population rising, indigenous republics became labour-saturated, while the demand for labour boomed in mining centres. Population growing in this century also raised maize demands from the cities, which made maize scarce and costly. Responding to the emergent crisis, Spanish estates only produced European goods, adapted to native crops for commercial purposes (Tutino, 2018). Maize harvesting rose (Tutino, 2018, pp. 95–96), increasing the need for seasonal labour. Consequently, the price of maize became affordable and stable by the mid-1730s (Tutino, 2018, p. 96).

Generally speaking, during the 18th century, the silver economy expanded, and Mexico City prospered as the largest metropolis in the Americas. Supplies provided by the indigenous republic sustained the city markets and the labour force at the mines, consolidating the emergent capitalist system of the Spanish empire and the autonomies of the indigenous republics. Life was profitable under symbiotic exploitation until 1810 (Tutino, 2018).[27]

On September 16, 1810, the call to arms by Miguel Hidalgo triggered the Mexican War of Independence, dividing the country and testing the resilience of the symbiotic exploitation system. By 1811, silver production dropped to half (Tutino, 2018, p. 146), while in 1812 the new Spanish Constitution, the Cádiz Constitution, initiated the Mexican path to social and economic liberalism.

With the 1812 constitution, tributes were abolished but also the indigenous republics. Under the new law, all property was open to those who could buy it. The egalitarian dream tried to corrode indigenous autonomies, but few attempted to consolidate private property. The main influencing factor was that these same autonomies promoted the insurgencies that led to the new law.

In 1821, the silver Spanish Empire collapsed. Mexico proclaimed its independence, and a new economic era would start in the country. In a world where the industry was progressively concentrating capital and labour, Mexico became a marginal economy. However, the collapse of the silver economy became an opportunity for most of the communities. Between 1820 and 1850, estate maize production declined, but the supply of maize was not threatened. On the contrary, maize became available and affordable as family cultivation flourished (Tutino, 2018, p. 181). The new economy forged the reinforcement of local communities and the capacity of the workers to bargain for higher wages (Tutino, 2018, p. 237).

Meanwhile, after the loss of the war with North America, estate operators invested in a set of new techniques and products that would create a new market stimulus. According to John Tutino (2018, p. 238), seeds enhancement saw a rising effort. Contrary to the practices established by colonial New Spain, seeds were now being exchanged between estates in the search for high yields. Machines were acquired, and soil fertilization became massive. Although most of the new technologies introduced were

[27] According to Tutino, "symbiotic exploitations, are the structures of inequity so essential to the profit of the few and the survival of the majority that the latter rarely challenged them." (2018, p. 102).

labour-saving, the demand for labour increased. The expansion and the added innovation required more workers.

Nevertheless, the liberal dream was far from being achieved. For decades, community autonomies and insurgencies were based on the communal character of the property. Liberals attempted to break these autonomous powers by making land suitable for privatization. The goal of the liberals was to force the majority of agrarian labour into commercial activities while allowing land to become a property able to circulate, creating, therefore, land as capital (Tutino, 1992).[28] The immediate consequence was an escalation of the agrarian conflict from the autonomous communities, whose capacity for negotiation had always relied on their community lands.

To face the political turmoil, some estates turned to sharecrop. Again, this solution was new to Mexico (Tutino, 2018, p. 250). Sharecropping is an old form of the social organization of production, in which the owners of the land allow tenants to use the land in return for a share of the harvest. For the Mexican estates, it was a way to reduce production costs without losing their land in times of social and political disruption.

In 1876, Porfirio Díaz claimed power. According to Tutino, "by 1880 Díaz had consolidated a regime at once liberal in economic goals, authoritarian at the heights of power, yet ready to negotiate locally to keep order and seek capitalist prosperity" (2018, p. 262). Private investment and the estate market rose, subsidizing railroads and industry. Commercial cultivation also boomed under massive land privatization. For Ellen Wood (2002), the historical efforts of the liberals in pushing forward the privatization of lands were due to their need to pressure productivity increase through intensifying the exploitation of propertyless wage workers.

For example, in the state of Morelos, the main agricultural production was an extensive system of sugar cane production in the hands of only a few owners, cultivated by an army of peasant communities stripped of their land and traditional ways of labouring. Sugar-cane production is one of the most labour-intensive industrial crops.

Meanwhile, mechanized agriculture of maize became an investment of estates that acquired most of the machinery from the United States of America (USA). But this time, the new technologies did not come to provide any new labour. On the contrary, they left many adult men without any permanent employment. Deprived of full employment, men worked seasonally between the few remaining autonomous communities' fields, estate

---

[28] The Lerdo Law of June 25, 1856, decreed that all "rural and urban estates" held by civil and Church corporations would be "adjudicated in property to the renters" (Tutino, 2018, p. 245).

crops, or building the major infrastructures promoted by state investment. In this regard, Tutino accounts:

> The utopian promises of liberal capitalism became lived realities for small minorities at Chalco and Tenango del Valle, as across the states of Mexico and Morelos. The privatization of land and the commercialization of production benefited powerful minorities nationally, a few prospered in local towns. For the rest, privatization and mechanizing agro-industries intersected with population growth to generate social insecurities lived by men as challenges to patriarchy and women as new desperations. Family breakdowns came with rising violence among men, by men against women, and by one or both (actively or not) upon newborn daughters. (Tutino, 2018, p. 283)

Such events created the material and political conditions for the emergence of the 1910 insurgency. During these times, while men were fighting in the *guerrilla*, women took the fields to plant maize to feed their families and the insurgents (Tutino, 2018, p. 288). Maize, intended for local consumption, became a symbol within the fight for autonomy and land. Maize was the crop that symbolically faced the exploitation promoted by Mexican capitalism, embodied in sugar.

The renewed centrality of maize under the insurgencies of the 20th century served as the scaffold for resistance to capitalist penetration in the agricultural fields of Mexico that persists until today. While the world was experiencing the “green revolution” and foreign capital was invested in Mexico's transition, the state knew it had to lead the process[29]. One of the reasons was that the state expected resistance from the autonomous communities to the “green revolution” effort, so it took the effort into its own hands. However, this did not prevent Mexico from receiving the “green revolution” with major criticism (Janvry, 1990). By the end of the 1960s, State institutions, together with public universities and funds from North American foundations, such as the Rockefeller Foundation, initiated a programme to demonstrate the potential of the new technological products in alleviating rural poverty and increasing marketable surplus (Janvry,1990, p. 234). This effort's head was Norman Borlaug, an American scientist whose research created so-called miracle seeds (Clapp, 2012). Seeds that were, of course, intrinsically connected with the use of fertilizers, pesticides, and irrigation. In this sense, for the new industrial production to function in Mexico, the State made significant public investments in irrigation, turning the arid zones into new agricultural fields (Tutino, 2018, p. 342).

---

[29] According to Finn Bowring (2003), the green revolution was the west ideological attempt to oppose the red revolutions of Mao’s. For more on the green revolution see Kloppenburg (2004) and Shiva (1993a).

> While scientists tested seeds, herbicides, and pesticides, the government funded dam and irrigation projects— most in the north, far from land-reform communities. The goal was to favour "small proprietors." […] The chosen growers would work fifty to a hundred irrigated hectares (120 to 240 acres). They could gain credit, buy machines, and take advantage of scientific cultivation to profit and feed the cities. On its own terms, the program succeeded. (Tutino, 2018, p. 343).

The impact of this state effort was the emergence of two agricultural systems. One was based on the communities or "resistance" agriculture, while the other followed the commercial paradigm of the "green revolution". Moreover, the two systems created an asymmetry regarding national research. The efforts of the Green Revolution promoted the mainstream of modern science, which with the help of the Rockefeller and Ford Foundations, as well as FAO and the World Bank, allowed the establishment of agricultural research institutes, such as the International Maize and Wheat Improvement Center (CIMMYT) (Clapp, 2012).

The consequence of the high gains promoted by the capitalist agricultural mode of production was again a displacement of the workforce. In the 1980s, the industries that employed the displaced rural population could no longer absorb it. Cities expanded around the industrial centres with neighbourhoods of unemployed and precarious workers (Tutino, 2018). In the fields, producers struggled with a continuous debt system. As maize became more dependent on fertilizers and other agricultural chemicals, the families became tied to the continuing need to contract debt. At the same time, maize was a way of not starving, while other commercial crops and plantations claimed their place under the capitalist sun. The progressive construction of a new globalized economy based on the rationalization of labour destroyed the ecological autonomies that had persisted until pre-colonial times (Tutino, 2018, p. 408).

Another important feature of the Green Revolution in Mexico is its asymmetric implementation. According to Jennifer Clapp, in Mexico: "[green revolution] technologies were only promoted in areas with large tracts of land owned by fewer, wealthier farmers, where irrigation infrastructure was already in place. Areas with large numbers of poor peasants were almost completely by-passed by the Green Revolution" (2012, p. 41).

In the 1990s, Mexico lost its autonomy as a nation. Struggling with unprecedented external debt and following the 1980s structural adjustment programs, Mexico signed the NAFTA treaty liberalizing agricultural trade between the country, the United States of

America, and Canada (Clapp, 2012). The USA, with its subsidized corporate agriculture, flooded Mexico with cheap corn.

The new capitalist agriculture led by transnational corporate industries imposed on Mexico another technological shift. With the rise of transgenic organisms, capitalist corporations looked at Mexico as the perfect test tube. As one of the first countries in the world where the first requests were made to carry out experimental field tests, Mexico struggles until today with the loss of its maize diversity and for its food sovereignty. Industrial agriculture is dependent on a handful of varieties for its major crops (Altieri 1999 *apud* Clapp, 2012, p. 50), which resulted in Mexico losing 80 percent of its traditional maize varieties (Clapp, 2012, p. 50).

In 1994 Mexico, saw a new insurgent uprising. The Zapatista Army of National Liberation, often called Zapatistas, awoke a new call on rebellion against injustice and economic inequalities. Demanding land and justice, the Zapatistas occupied the Chiapas state capital. According to Tutino (2018), the first wave of Zapatistas was received, on the one hand, with a military response from the side of the State, and on the other hand, with apathy from the majority of the Mexican population. However, the second wave was marked by a shift of demands now focusing on the rights of indigenous peoples. For the Zapatistas, maize and native production have been essential in their insurgency and ability to persist until today. The Zapatistas' struggle reinforced the cultural importance of maize for indigenous autonomy and national sovereignty, while it has had a positive impact on local agrobiodiversity (Hernández *et al*., 2020).

In sum, the indigenous and peasant communities have produced and preserved maize diversity in their continuous struggle against exploitation and land grabbing as a form of producing social wealth. Paradoxically, however, and as demonstrated by Tutino (2018), the same communities, with their symbiotic system of exploitation, were the fundamental base for the emergence of the Spanish silver empire and later for the rise of global capitalism responsible for the destruction of diversity. If until the 20th-century, maize had been the anchor for autonomous and insurgent movements, today it is central to the struggles to safeguard Mexican sovereignty as a nation; to preserve its resources, biodiversity, cultures, and languages; to protect the people made of maize. Yet, it is also central to sustaining capitalism.

1.2.4 - Maize in the world: pathways for its commodification

1.2.4.1 - Maize expansions

According to Bonavia (2013), maize was first introduced in Europe by Columbus in 1493. The first documented plantation of maize in European soil was found in Bayonne, in the French Basque country, dating from 1523 (2013, p. 251). As observed by Bonavia (2013), at the time, maize was planted both as an ornamental plant and as grain for fodder. Other registers seem to account for the plantation of maize in Spain (Galicia, Castile, Andalusia) and Portugal (Bonavia, 2013).

As a consequence of the spreading of maize, it is said that millet (*Panicum italicum* L.), a crop that dominated European agriculture at the time, became residual. However, the centrality of maize in European cultivars can only be considered from the late 17th century onwards (Bonavia, 2013).

In countries such as Romania, the largest maize producer today in the European Union, the introduction of this crop happened mainly due to the capacity of maize to adapt to a variety of environments and a rotation farming system (Bonavia, 2013, p. 254). In most of the European countries, maize also found the technological conditions to its cultivation. Agricultural techniques of the time allowed maize to be grown as a monoculture (e.g., tilled), and its expansion followed the progressive mechanizing of agriculture. Maize in Europe was mainly introduced to save labour and increase productivity.

In Africa, and according to the sources of Bonavia (2013), maize may have been introduced by the Portuguese, within the context of their slave trade routes. Such a theory is also supported by Arturo Warman (1993, pp. 74–80), for whom the introduction of maize on the African coast was made by the Portuguese colonial empire as a way to provide cheap food to maintain its slave trade. Common to both authors is the thesis that the primary uses and plantations of maize, outside of what is today known as Latin America, were to sustain poor peasants or maintain the slaves in the colonies or during their slave routes.

The Portuguese are also suspected of having introduced maize in Asia. However, Arab merchants may have played an essential role in this regard (Bonavia, 2013, p. 256). Some registers account for the presence of maize in the Philippines, Indonesia, and Thailand by the year 1659 (Paliwal *apud* Bonavia, 2013, p. 256). In 1699, maize was a major crop in Timor, and despite its minor importance in East Asia during this century, it had become a major crop by 1800 in places like Java. In China, maize arrived during the 16th century. By the 19th century, maize became a major crop plantation in southwestern China (Bonavia, 2013, p. 257).

1.2.4.2 - Revolutions in Agriculture

The first revolutions in agriculture do not particularly refer to maize (Hohenberg, 1977). Still, it is essential to consider them since these revolutions had tremendous impacts on the ways and modes of maize production. Between the mid-17th century and late 19th century, Britain went through an unprecedented increase in agricultural production. The rising agricultural outputs allowed for the rapid growth of the population. Still, it also made the agricultural workforce less necessary, feeding the labour necessities for its Industrial Revolution. The major British improvements in agriculture impacted soil nutrition (starting to use turnips to fix nitrogen), country communication infrastructures (improvement of canals, roads and, later, railways), machinery development (new improved ploughs needed fewer animals, and Jethro Tull's seed drill allowed to save labour force [30]) and pushed forward major land reforms. (The British Enclosure legal process removed common rights over property and established a property regime favouring larger farms.)

The progressive mechanisation and industrial forms of agriculture not only changed agricultural labour, with impacts on the socioeconomy of peasants and their communities, it also had an effect on the social distribution of labour based on gender. Labour performed by women in agriculture varies according to the epoch, culture, and socioeconomic conditions (e.g., in war times, women's labour in agriculture intensifies). Depending on the time and place, women had complementary, distinctive, or egalitarian labour presence in agriculture. The progressive mechanization represented a progressive withdrawal of women from farm labour. Because labour-saving in agriculture had the effect of labour release — which was assimilated by other productive sectors, such as the rising industries —, women found jobs in the textile factories or other industrial factories (Middleton, 1981; Vaquinhas, 2004).

[30] Jethro Tull was an English man that invented and perfected the seed drill.

According to Marx (2017b, p. 611), the agrarian revolutions came to produce a new synthesis concerning the asymmetries of the rural and urban world. The mechanization of British agriculture, for example, released the labour force of women from agriculture into industrial plants. As a result, it broke the original family bond between agriculture and manufacturing, replacing it with a new "superior" form — agriculture and industry, both technological and rational, where the unit of production was no longer the household.

Land reforms were also central to the agricultural revolution and the progressive penetration of capital into it. While a class of agricultural capitalists rose under land concentration policies, so did a class of agrarian waged workers. The appropriate concept to account for agrarian waged workers is still debated among scholars. On the one hand, agricultural mechanization allowed for the emergence of a proletarian agrarian class that mainly worked with the newly introduced machines. On the other hand, these workers competed with a semi-proletarianized class, commonly referred to as the peasantry. The major difference between these types of workers resides in the possession and access to land. Peasants, however, even when holding land, which gave them access to the means of their fundamental subsistence, were dependent on agrarian capitalist production.[31]

But, having a non-fully proletarianized class does not mean that capital cannot extract surplus through its exploitation. On the contrary, it means that surplus labour appropriation had to occur historically by extra-economic means (Wood, 2002: Lewontin & Levins, 2007, see chapter 29, pp.329-341).[32] In a semi-proletarian system, although

---

[31] Wealth accumulation does not result directly from the capitalist mode of production, but it is its starting point. As Marx described, money, commodities, and even the means of production and subsistence are not capital per se (2017c, p. 892). For the emergence of capital, and the capitalist form of production, it is necessary to create a class of possessors of money, means of production and the subsistence forms of another class. The purpose of the possessing class is the valorisation of its products by acquiring the labour force belonging to the other class, which only holds its labour force as a commodity and is therefore compelled to sell it to survive. This class, considered by the capitalists as "free," is the result of a historical process of depriving them of their means of production and reproduction, as well as the conditions and ways necessary for this production, in which we must include knowledge. It is upon this fundamental polarization that the basis for the emergence of capitalist production is built (Marx, 2017c).

[32] Ben Fine (1991), writing about Marx's concept of primitive accumulation, states that "pre-capitalist relations of production are predominantly agricultural" (pp. 444-445). Because peasants are the original owners of the means of their production, the first stage for capitalism to be created is by dispossessing such land. Such may happen both by transforming the relations of production on the land, as well as by land grabbing. In terms of the transformation of the relations of production, it may occur through legislative means and market-oriented production, which in turn, force the peasants into a new mode of life. It is, of course, fundamental that such debate over the primitive accumulation is not disconnected from the construction of modern institutions such as the Modern state. For Fontana (2019), the construction of parliamentary democracies, whose bases are the constitutions that guarantee rights and freedoms to its citizens, is the same process that favours the capitalist class and its interests. Capitalism is not a natural product of the evolution of the economy, but a boost from governments through the establishment of new

property or access to the means of production may be in the hands of the direct producers, capitalist markets have become the dominant form of exchange relations, which subsumed social ties. In the semi-proletarianized agrarian system, we have historically observed the creation of dependence ties between the peasants and the capital markets and industries, the latter configuring the hegemonic force in the production process. So, even if rural property, and access to it, are still dominated by a peasant class, the latter are subject to the domination of capital, drawing on forms of extra-economic power.[33]

The need for revolutionizing the modes of production also happens because, in its attempt to penetrate agriculture, capitalism faces natural barriers existing in the environment (e.g., climate, soil, etc.) and within the cultivated species (e.g., reproductive barriers). In 1988, Jack R. Kloppenburg published one of the most important works to understand the political economy of agricultural plants and its relationship with the process of *primitive accumulation* (2004). Kloppenburg traces the attempt of the US state-scientific enterprise to develop agrarian biotechnology as a revolutionary mode of production that serves capital's strategy of pursuing labour and knowledge expropriation within the agricultural system. As the author states, one of the barriers needed to be broken by capitalism was the reproduction of seeds (Kloppenburg, 2004). Plants, particularly those that produce seeds, represent both production and the product. This means that they have a dual character both as grain and as seed. Seeds are used for the subsequent plantations, while the grain used to be sold or consumed. In this sense, the process of *real subsumption*[34] of agricultural products needed to break with this dual character of the seed, allowing for both seeds and grain to be commodified. This means

---

legalities, regulations that favour exploitation and expropriation, and advocate the application of repressive means.

[33] This explanation must be framed as simplistic and abstract. The purpose of presenting agrarian property in this way results from the need to give the reader an abstract idea of the symbiotic relations of exploitation resulting from capital creation. However, to better understand agrarian property a situated history is required. In the first part of this chapter, I looked at the issue in the context of Mexico, while in this section of the chapter the abstraction is mostly extracted from the English context. Moreover, it is important to clarify that European countries have a situated history when it comes to agrarian property. In this sense, when referring to property I am referring to collective property forms and "usufructuary" rights, as well as private property.

[34] "Real subsumption […], involves an intensification of the labour process in which workers surrender more of their autonomy. Marx had in mind the transition from dispersed to concentrated and increasingly centralized deployments of labour featuring cooperative labour processes, a deepening of the technical and social division of labour, and an increase in the role of fixed capital […] deployed in production. These transformations of the labour process result in a progressive loss of control and autonomy for workers, as well as deskilling as tasks become more finely differentiated and routinized while machines increasingly dictate the pace of production. Real subsumption also changes the logic of surplus value production since the intensification of the labour process results in workers producing more value per unit of labour time. Real subsumption thus refers to the production of relative surplus value via strategies aimed at making workers work harder, faster, and better. It is based on an intensive logic" (Boyd & Prudham, 2017, p. 878).

that producers sell their grain (commodity) in the market and need to return to it as buyers of seeds (commodity) every time they need to plant again, generating a new form of agricultural servitude. Likewise, sometimes, this purchase and sale relationship is carried out with the same company or corporation.

The commodification of the dual character of the seeds has been achieved, alongside several regulatory changes, with the development of hybrid plants (Kloppenburg, 2004). Hybrid plants, a major agricultural innovation from the beginning of the 20th century, produce higher yields but are economically sterile since producers do not have access to the inbred lines[35]. This constitutes a process of *primitive accumulation* because it separates the producers from the specific means of production, which now confront them as commodities.

Furthermore, another critical aspect of the technological development of hybrids was their compatibility with mechanized agriculture and saving production time in relation to labour time. Here, the goal was not to place labour ahead of the needs of production, but to intensify labour for surplus-value extraction. The revolutionized agricultural means of production have raised the necessary productive labour time, which resulted in an intensification of productive labour within agrarian systems. This happens because, in agriculture, production-time and labour-time do not always overlap (Kloppenburg, 2004). As Mann and Dickinson state:

> For example, cereal grain production is characterised not only by a relatively long total production time (as the produce only matures annually), but also by a great difference between production time and labour time; there is a lengthy period when labour time is almost completely suspended as when the seed is maturing in the earth. In this case the reduction of production time is severely restricted by natural factors and thus cannot easily be socially modified or manipulated as occurs in industry proper. Similarly, in stock production, the reproduction of the species is prescribed by definite natural processes. Neither the period of gestation nor the period of growth to economic maturity (i.e. to five-year-old cattle) can be easily shortened. (Mann & Dickinson, 1978, p. 472)

To some extent, hybrid maize was a way for capitalism to overlap production time with labour time, securing in this way the labour force necessary for value creation while coercively engage workers in a system of self-exploitation (Mann & Dickinson, 1978; Kloppenburg, 2004). Such time coincidence accelerates agricultural production, raising its productivity in capitalist terms, and intensifies the performed labour.

---

[35] An inbred line is a pure line, or nearly homozygous line, usually developed by inbreeding. Hybrid breeding was first proposed by George Harrison Shull as a result of his experiments with maize (Poehlman, 2013).

1.2.4.3 - Seeds colonialism

According to Sarah Easterby-Smith (2019), the ‘extraction’ of plants from the global south has not only been crucial for the European colonialism project, but it has also been fundamental for the development of the enlightenment period. Specimens of plants would travel to Europe, often without the knowledge necessary for its cultivation, fulling the necessity of research. In contrast, other plants would travel to the occupied territories to serve the interests of the settlers, transforming the natural landscape of those territories (Easterby-Smith, 2019).

Today, although old colonialism no longer stands, new forms of extraction of the global south nature still happen, sustaining a structure of uneven distribution of the world economy of plants. Global south, rich biodiversity, accounted in works of botanists such as Humboldt and Vavilov, has more recently been associated with a richness of genetic materials, creating a new exchange scheme that sustains the modern asymmetries of germplasm flow. Still today, gene-rich countries and regions, primarily located in developing countries, are subject to scientific extractivism, conducted by institutions from the industrialized or post-industrialized countries. Like in the past, the extractivism of nature is accompanied by the reinforcement of structures that define the practice of science while excluding other forms of knowledge (Kloppenburg, 2009; Tilley, 2011), a necessity for developing capitalist agriculture and for the biotech industry monopoly.

At present, biotech industries require this form of extractivism to produce the necessary agrarian inputs that sustain the capitalist form of agricultural production. Agricultural inputs such as GMOs, are kept as they justify other inputs, maintaining a structure of agriculture production dependent on chemicals and machinery. As Kloppenburg accounts:

> Germplasm, the genetic information encoded in the seed, is the raw material used by the plant breeder. The development of agriculture in advance capitalist nations has involved the systematic acquisition of this raw material from the “gene-rich” periphery. And agricultural productivity in the capitalist core remains fundamentally dependent on constant infusions of plant materials from the Third World. (Kloppenburg, 2004, p. 14)

For Vandana Shiva, the exploitation and expropriation of the germplasm of third world countries are due to the ideological idea of development, which is intrinsically related to colonialism and the patriarchal concept of productivity (Shiva, 1988, 1992), constituting the symbiotic exploitation system referred by Tutino (2018). Based on Rosa Luxemburg, Shiva states that colonialism is a constant necessity for capital to grow. Although the old form of colonialism partially disappeared, for Shiva, the ideological idea of continuous and desirable economic growth has developed new ways of neo-colonialism, exploiting even further the condition of women and nature. The idea of progress then plays a particular role within bourgeoisie ideology by simultaneously serving and obscuring the interests of capital.

Although it is a reality that the appropriation of germplasm of gene-rich countries by gene-poor countries constitutes a form of neo-colonialism, where gene diversity tends to be ruled and dominated by the foreign power of industrial economies, the phenomena of germplasm expropriation and accumulation cannot be seen, especially today, isolated from the theory of *internal colonialism* (Casanova, 1965). Such a theory is bound to the understanding of how power relations and racial construction are no longer the outcomes of external power but persist within post-colonized countries. Dominant groups within the society exercise power over so-called minorities, even when these are, in fact, a majority. Unfortunately, colonial structures of agrarian labour exploitation and nature extractivism have outlasted the colonial period.

Likewise, modern colonialism also accounts for the uneven distribution of the risks of biotechnological development. The history of GMOs has demonstrated that although they are produced in the global north, they first set the stage in southern countries in the form of experiments. These experiments intend to first push the rational reorganization of production in those countries into the agro-industrial model and then as end-products, kidnapping the possibility of escaping them. In Mexico, for example, for the period between 2005 and 2017, more than 60% of the requests for the release of transgenic organisms, primarily for experimental purposes, were made by foreign companies, such as Monsanto, Bayer, Syngenta, Dow, and Pioneer (Vázquez, 2017). The majority of the transgenic events regarded maize and cotton herbicide-resistant or Bt crops (Vázquez, 2017)[36]. This data is supported by Mayra Ruiz *et al.*, (2018).

Another important dimension of modern colonialism takes shape in the in-kind food aid programmes. According to Jennifer Clapp and Doris Fuchs (2009), in-kind food aid programmes distort markets and depress production incentives in developing countries, making them more vulnerable to food price fluctuation. But while the European Union countries, Canada and Austria, have been putting forward a new paradigm of the cash-based food aid system, the United Stated of American seems to be

[36] A transgenic event regards an unique recombinant DNA insertions which is used to generate a transgenic plant.

resisting this shift (Clapp & Fuchs, 2009). A resistance that is partially explained by USA internal corporate interests (Clapp & Fuchs, 2009). As Clapp & Fuchs highlight, corporations in the USA have established complex relationships with State and non-state actors, who safeguard their economic interests (2009, p. 130). Also, and considering the USA's interests in transgenic agricultural plants, in-kind food programmes introduce non-approved goods in recipient countries.

Furthermore, according to Gertel and Sippel (2016), European colonialism has set the stage for the age of financialization. The colonial economy has established the practices of measurement, standardisation, and centralisation of information, which are fundamental for the current financialization of food and agriculture. As the two authors refer, financialization is based on technological innovation, metrics standardization, and the expansion of private property rights.

1.2.4.4 – Seeds Financialization

The idea of seeds financialization refers to the financialization of the food system around the globe. On the one hand, the regulations protecting and allowing the commercial exchange of intellectual property rights became attractive to venture capital (Sell, 2009). Such attraction is assured by the power that biotech-corporations globally hold. As Susan K. Sell puts it:

> Agrifood corporations have deployed instrumental, structural, and discursive power to shift forums and join with states to influence rules […] Their *instrumental* power consists of their access to important decision-making bodies and influence over public-sector actors. Another element of their instrumental power is their ability to withhold the fruits of their invention. Even when they obtain patent rights over plant varieties, or genetic engineering tools or processes, they may choose not to license the technology. Corporations also deploy *structural* power, a more indirect form of influence. Structural power derives from their position in the seed industry. Global biotechnology fi rms enjoy broad property rights and economic concentration in the sector. This increases their profitability and their political power. The choices that these fi rms make have a significant impact on access to seeds. The third type of power is *discursive* power. Discursive power refers to the potency of the frames that actors use to couch their preferences (Sell, 2009, p. 188).

On the other hand, biotech-corporations increasingly engaged in the market for commodities as "virtual assets", speculating with commodity futures (Lawrence *at al.*, 2015).

According to Gertel and Sippel (2016) "financialization is a meta-narrative for global socioeconomic change, in which expanding and volatile financial capital penetrates and reshapes real economy, restructuring accumulation strategies and impacting more directly upon livelihood systems" (p. 215). For Lawrence *et al.*, the three main forms of financialization of agriculture are the takeover of food manufacturers and retailers; commodity speculation; and the direct investment in farmlands (2015, p. 314).

1.3 – Two notions of maize

Considering the above, the proposed 'two notions of maize' can be framed within two agricultural systems. On the one hand, represented by a maize that has lost its 'chulel', we can account for an industrial paradigm, implemented by the green revolution State effort and its financiers. The creation of such an agricultural system demanded, by command of capitalism, that State efforts would be made to achieve the necessary agrarian structure so that the products developed by *science* could meet both the fields and the market. On the other hand, represented by criollo maize, is the community paradigm or practice of 'resistance agriculture' that has been developed for centuries in a constant relation of symbiotic exploitation with capitalism. Despite this relationship being old, current practices of resistance agriculture seem to want to break free from this dynamic by keeping alive the practices of seed exchange and solidarity networks. However, do they also express two notions of science?

1.3.1 – The industrial paradigm

Plant science has been seen as non-ideological, benevolent, and working for the benefit of many, but, as Kloppenburg (2004) demonstrates, plant science subsumed under capitalism shapes the content and pathways of research as the characters of its products. In the following paragraphs, resorting to the example of the United States of America, I will try to explain the transformation that required state intervention for the emergence of the commercial paradigm, particularly at the level of plant science. The USA is an exemplary case, both descriptive and prescriptive, of the process under analysis.

Likewise, the following case reveals the public-private relationship patterns that have served as a model for many countries in the world.

For a long time, the State, through its public universities, education system, state institutions, and laboratories, led R&D investments and efforts in plant science. By the early 20th century, agricultural production was growing slowly. Its stagnation had directed the States to invest in agricultural research to deal with the problem, but the farmers' recalcitration to the new seeds blocked State efforts. In 1914, the USA established federal law, the *Smith-Lever Act*, which aimed to inform farmers on the latest agricultural developments. The goal was to convince farmers to adopt a more rationalized type of agriculture, which was machinery-dependent.[37] The promises of such adoption were anchored in the increasing productivity of the fields, and therefore its profitability.

At first, hybrids did not provide any advantage for the majority of the farmers, considering that these plants did not fit the prevailing modes of agricultural production. This led the State to intervene once again. This time, beyond the development of new knowledge provided by the hybrids, the State effort was directed at reforming the agricultural system and its transition to a petrol-dependent production that allowed for the success of these seeds.

To capture the entire value of the new organisms, the State also needed to reform its R&D system. The new reforms allowed for the consolidation of the division between public and private R&D systems, which included a progressive construction of legislative frameworks that brought the public methods and knowledge of agricultural plant systems to private companies, cornering local knowledge (Kloppenburg, 2009). This was one of the fundamental changes in the USA, which is regarded today as a model for the public-private forms of R&D relationship.

Later, in 1980, the *Bayh-Dole Act*[38] allowed the transformation of the entire system of scientific research, setting the stage for public-private alliances, private and public spin-offs produced within public institutions, "in which academics and venture capitalists come together to commercialize the results of public research" (Cooper, 2008, p. 27). Such, promoted the acceptance of the market as the main form of distribution of resources (Bowring, 2003).

[37] Smith-Lever Act can be seen as the first experiment of a technological transfer system, in which practical scientific knowledge produced within state institutions would be transferred to farmers.

[38] The Bayh-Dole Act or Patent and Trademark Law Amendments Act, allowed for the ownership of the inventions made both by contractors and researchers, with funding from the Federal government, to belong solely to the contractors or researchers.

Biotechnology, for example, is already a product of this organizational context that demands the presence of both public (upstream) and private (downstream) R&D efforts. Historically, R&D systems of agricultural research have, for a long time, been the subject of several performance shifts that combined both public and private schemes of investment. For example, the first hybrids were developed with efforts from farmers and State institutions, but this relationship had changed dramatically since the mid-20th century when the resulting public knowledge became privatized.

Keith Fuglie and Andrew Toole (2014), both employed by the US department of agriculture, provided a brief explanation of the evolution of these institutional relationships for the US context. Although public R&D has been a significant contributor to an increase in agricultural productivity in the USA since 1930, the continuous productivity over time cannot be explained in isolation from the advances made by private R&D investments in fields such as farm machinery and crop protection. Moreover, according to Fuglie and Toole (2014), since the 1970s, the private expenditure of R&D in some agricultural research sectors has surpassed the public investments. This is particularly true for research-oriented towards agricultural inputs (downstream research), such as those provided by agricultural business segments of chemical inputs and seeds, which are also the most profitable ones.

These patterns of public-private R&D relationships follow other series of governmental incentives, such as the research grant model, in which government funds private research-oriented to high government priorities (established in the US by the Small Business Innovation Development Act in 1982), or the joint-venture model, where companies and government research labs collaborate under the framework of a Cooperative Research and Development Agreement (established in the USA by the Federal Technology Transfer Act in 1986).

However, when it comes to developments of the productive forces that require large investments and longer production time, the State usually assumes the risks (Mann & Dickson, 1978). For example, R&D costs of developing a new genetically engineered organism are exceptionally high. From the research process until its commercial release, it can take up to 13 years and 130 million dollars (figure 7).

For this reason, the funding patterns for R&D on GMOs are quite heterogeneous from country to country, and despite everything, there seems to be a consensus on the need for the investment to be complementary, that is, to ensure that the costs are distributed among State and private efforts. However, when the science seems secure, that is, when the questions of uncertainty surrounding the new organism appear to be solved, the state retracts, and private companies assume the costs of R&D, which tends to concentrate research effort in the development of new varieties of seeds, by means of modern genetic engineering, into the hand of private interests. For example, in 2011−2012, 8 companies were responsible for the most significant slice of investments in transgenic seed R&D, but the available seeds in the market did not reflect the varieties developed by public or private R&D efforts. (Bonny, 2014).

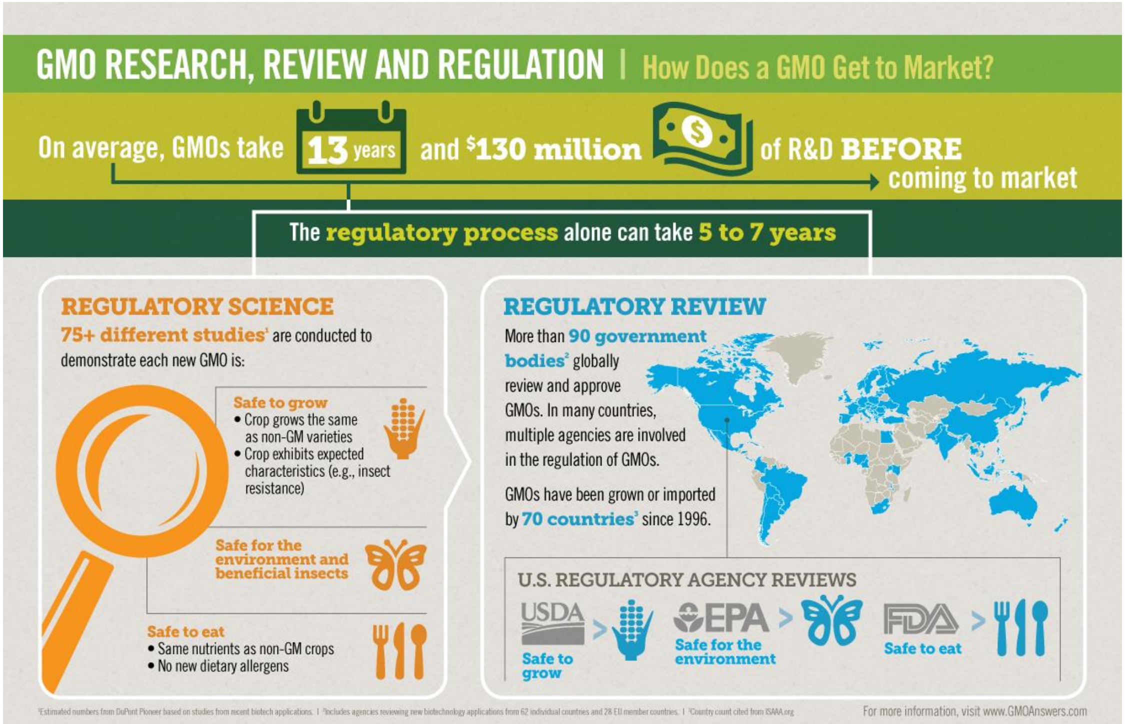


Figure 6 – Image retrieved from GMO answers website. https://gmoanswers.com/

On the other hand, private R&D efforts have stagnated over the last decade, focusing mainly on enhancing conventional pest control approaches, meaning developing pesticide-resistant or insecticide production plant-based GMO varieties (Ervin *et al.*, 2011). Yet, the industry blames the regulatory process for this stagnation and therefore has been pressuring states so that the product of ‘New Plant Engineering Techniques’ (NPET), such as those resulting from the use of CRISPR systems, are not regulated as GMO (Purnhagen & Wesseler, 2020). However, such stagnation can also be associated with the progressive concentration of private capital into the "Big Four" biotech companies (Bayer-Monsanto, DowDuPont/Corteva, ChemChina-Syngenta, BASF), which raises social concerns regarding its effect on R&D efforts. According to Valborg Kvakkestad (2009), private companies tend to only invest in the varieties that ensure their profits, a situation that raises a red flag on the impacts of research produced by companies on scientific literature.

In 2008, Sergio Sismondo alerted how pharmaceutical companies' interests dominate the scientific literature regarding clinical trials (Sismondo, 2008)[39]. Today the same question is being raised for the literature regarding genetically engineered organisms. A situation that only becomes more complex when publications are co-authored by individuals from companies and public bodies who are expected to be impartial.[40]. According to Krimsky *et al.*, (1991), in 1988, 37% of the biomedical and geneticists of the National Academy of Science had ties to the biotech industry.

The political economy of plant biotechnology is an exemplary case of the State playing the interests of private property and capital. Nonetheless, such only happens due to the existing convergence between the ruling classes and those holding the power of the State. This extends beyond the production of food and means of the subsistence of the working class.

---

[39] Other examples of companies' interests dominating scientific literature can be found regarding the tobacco industry and climate change (Proctor, 2012; Oreskes & Conway, 2010). In 1983, tobacco plant was the first plant subject to genetic engineering. More recently Peña-Azcona *et al.*, (2021) studied the relationships between private funding and conservation actions in Mexico.

[40] In this particular case I refer to the publication of "Teosinte and maize x teosinte hybrid plants in Europe - Environmental risk assessment and management implications for genetically modified maize" (Devos *et al.*, 2018) publish in 2018 at the journal Agriculture, Ecosystems and Environment. The papel is co-authored by Alan Raybould (Syngenta Crop Protection), Sol Ortiz-García (CIBIOGEM - Comisión Intersecretarial de Bioseguridad y Organismos Genéticamente Modificados), Karen E. Hokanson (Univ.Minnesota) and Yann Devos (EFSA - European Food Safety Authority). Quick research on scopus data base also reveal that Yann Devos (EFSA) and Alan Raybould (Syngenta Crop Protection) have already published together in the past (Devos *et al.*, 2018; Roberts *et al.*, 2014). Another research on scopus database also revels other publication that bring together EFSA and several multinational corporations such as BASF, Bayer CropScience, Dow AgroSciences, Dupont, ExxonMobil and BASF. Some of these publications include proposals to implementing systematic review techniques in chemical risk assessment: (Whaley *et al.*, 2016), overview of an ecological risk assessment process for honeybees (Alix *et al.*, 2014) and approaches for assessing risks to sensitive populations (Hines *et la.*, 2009)

1.3.2 – Resistance agriculture

Resistance agriculture refers to a type of agricultural production that attempts to resist the penetrations of capitalism. For maize, it refers to an alternative socio-technological model of production. Following the work of John Vandermeer (1995), resistance agriculture could be defined as a type of alternative productions that, although resorting to responsive technologies, focus its efforts on the application and development of preventive technologies. Meaning, it uses production techniques and social arrangements of production that ultimately prevent problems such as those associated with conventional or industrial agriculture (Vandermeer, 1995). Likewise, for Kloppenburg (2009), resistance agriculture is part of the "reconstructive" effort, where not only farmers are (re)entered as key actors in the production of knowledge, practices, and technologies for agricultural production, but also the scientific system if reformed. In other words, while critics of the industrial model, or the "deconstructive" task, aim to demonstrate that the current hegemonic model does not adequately account for the entire sphere of agricultural production, the "reconstructive" effort goes beyond the deconstructive critique by establishing the grounds for the "identification and legitimation of alternative sources of knowledge production for agriculture […]" (Kloppenburg, 2009, p. 248).

It is within the scope of these "reconstructive" efforts that we can place Elena Álvarez-Buylla. As mentioned in the opening story, Álvarez-Buylla 's speech reveals her scientific commitment to promoting alternative forms of agriculture production and valuing local knowledge within the scientific system of knowledge production. By detaching herself from the hegemonic scientific perspective of cartesian reductionism, Álvarez-Buylla attempts to establish new connections between science and local knowledge systems. Her strategy, clearly influenced by more than 30 years of feminism and sociological critique of science and technology (Knorr-Cetina, 1981, 2013; Rose, 1983; Harding, 1986) means that she not only embraces the perspective that science is socially constructed and that its epistemic demarcation has promoted a series of epistemic destruction (Gieryn, 1983; Sousa Santos, 2018), it also means she is part of the attempts to construct a scientific practice that is based on the principle of solidarity. A principle that Kloppenburg states to be fundamental to achieving sustainable agriculture (2009, p.259). For Álvarez-Buylla, the scientist's position within the world's effort of knowledge production should not be seen as a unique privileged capacity, rather more as one way of doing it. In this sense, she has been developing several actions that aim to implement “here-and-now prefigurative forms” (Rose, 1986). The episode of the opening story is one of those moments. However, this is an arduous effort, considering that the industrial paradigm was built by ensuring the silencing and devaluation of local forms of knowledge, despite these being the ones at the base of its emergence (Kloppenburg, 2009). Still, and as Kloppenburg accounts:

> Through all the lean decades of official neglect and an agricultural policy environment actively hostile to their interests, many alternative farmers and alternative institutions managed not only to survive but even to thrive. Their persistence, coupled with the increasingly conspicuous failings of conventional industrial agriculture and the pressures applied by agro-environmental public interest groups, have created an intellectual and political space in which the potentials of an improved goodness of fit, or substantive interaction, between scientists and farmers appears even to the NRC and the USDA as a means of developing kinder and gentler agricultural technologies and production practices. (Kloppenburg, 2009, p. 257)

These days, many advocates for this “resistance agriculture” or “reconstructive science”, even drink from the Cuban experience, which we can consider an attempt to build a “resistance agriculture” made at a national level. After the fall of the Soviet Union, Cuba had to reinvent their agriculture system. This was only possible by engaging local knowledge and promoting new ones, such as the experience of urban gardens. The organic farming system of Cuba has demonstrated that it is possible to approach the challenges of agriculture outside the industrial paradigm (Funes *et al.*, 2002), and this experience feeds utopias (Lewontin & Levins, 200, see chapter 30, pp. 343-364).

1.4 – Chapter 1 closing remarks

Why Elena Álvarez-Buylla stated that genetically engineered maize has no 'chulel' can only be explained by analysing her personal experiences in articulation with the political economy of plant biology and agriculture. The path that Álvarez-Buylla had to pursue to be one of the most prestigious Mexican scientists and at the same time able to use indigenous concepts such as 'chulel' is both personal and political. On the one hand, her contexts raised her with the instruments to critically analyse the world. Her career choices have definitely been influenced by a generation of critical biologists, whose roots have allowed for the development of research fields such as Development System Theory and the field of ecological evolutionary developmental biology (Eco-Evo-Devo) (Lewontin, 1961; Gould and Lewontin, 1979; Levins, 1998a; Gilbert, 2001; Nunes, 2001; Abouheif *et al*., 2014; Gilbert *et al*., 2015). On the other hand, her political engagement resulted from direct contact with the consequences of capitalism contradictions, both in agriculture and science.

It is within these relations that the scientific utopia of Elena Álvarez-Buylla is constructed. In it, another 'notion of maize' is actively constructed in symmetry with the practices of resistance agriculture. With its own project of knowledge production, these alternative notions challenge the dominant paradigm of industrial agriculture and plant sciences. We then face not only a sociotechnical imaginary (Jasanoff, 2004), but we are also in front of a concrete utopia in the sense that Bloch has imprinted into the concept, that they are "concrete action toward the anticipation of the not-yet" (Dinerstein, 2017). However, in its current form, this alternative 'notion of maize' is still connected with the industrial paradigm both because it is framed within the contradiction of the latter and because the industrial paradigm has not successfully subsumed agriculture, which makes the developments promoted by resistance possible spaces of future subsumption.

By answering the questions that frame 'two distinct notions of maize', new questions open up. Questions related to why a significant part of the scientists, not to say the majority, did not understand Elena Álvarez-Buylla critique. Why did they reject Elena Álvarez-Buylla's vision? Her utopia? What do they lack to understand "resistance agriculture"? These are the guiding questions that I will pursue in the next chapter.

This page intentionally left blank

Chapter 2 – Biology under the influence

This page intentionally left blank

2.1 - Introduction: The crossroad where we stand

Mainstream ideas, regarding science and technology, state that these have become a common symbol of modernity, economic progress, and national achievements.[41] Political leaders, scientists, and engineers have embraced scientific and technological developments as the confirmation that the rational model of science can conquer all frontiers on earth and space [42]. However, their enthusiasm for scientific and technological progress has made them hype its outcomes, or in other words, to promote the products of scientific activity with extravagant publicity (Lebrecht *et al.,* 2019). Such hyped promises, which began to intensify after World War II, with Vannevar Bush' Social contract for Science', not only reinforced a technological-fix bourgeois ideology [43] that has failed to fulfil its wonderful ambitions, but it has also promoted the progressive proletarianization of scientific work (Gorz, 1976). By the end of World War II, Vannevar Bush invoked the need for a social contract between science and democratic governments. As one of the leading administrative heads of the Manhattan project, Bush responded to President Franklin Roosevelt's request for counselling regarding the proper rule of public and private research and their interrelations. Bush asserted that a progressive investment needed to be made in public science, and he associated this investment with the creation of incentives able to attract people to pursue a scientific career. However, during the 1970s and 1980s, some anxieties regarding a technological-fix oriented science emerged:

---

[41] According to David Dickson (1985) during the 1980s the narrative of modernization was instrumental in regaining the confidence of the middle class. By endorsing modernization as apolitical, and therefore technology, the narrative aimed to build a common objective that cuts across all social classes. This created a spectrum that allowed modernization to be pursued by everyone. For Robins and Webster (1983) it was during this period that capital attempted the resolution of work conflicts. Using modernity, capitalists refined productivity as the workers duty and made private consumption the ultimate freedom. In this ways, Robins and Webster argue, capitalists desegregated the working-class communities.

[42] The defeats of socialism around the world had led States, worldwide, to embrace the capitalist form of scientific production. Today, a nation that rests its production on highly developed capitalist technologies and promotes those developments stands in a superior position within a world where the economy of knowledge exploits knowledge produced by a scientific working class, while it dispossesses indigenous people and artisan labour. The reasons for the current recognition of English, German and North American private and public institutions as references for scientific models worldwide, is not a product of chance. Modern robust scientific States embrace the 'Enlightenment' view that we can control both nature and labour for the betterment of all. In those States, science and technology have become symbols of civilization, ideals of progress and growth. (cf. Ágnes Heller in A Theory of Modernity (1999)).

[43] Technological fix is not about fixing the world in its inequalities, but to fix the falling rate of profit for capitalist investors. It serves not to save labour but to intensify it. Not to place the worker ahead of the needs of production, but to place the machine ahead of the need of the worker.

> The technological fix, the cosmetic alteration of the current system, can serve to reduce the visibility of the problems. A change in societal structures, on the other hand, can get to the root of the problems, and at the same time begin to challenge the institutional bases of other major problems in society. (Martin, 1977, p. 232)

Today, instead of having flying cars, journeys to Jupiter, clean water, and collective health care systems run by intelligent robot doctors, we live in a petro-dystopia of plastic islands, unbreathable cities, unsafe food systems, and emergent new biological hazards, such as epidemic and pandemic diseases. In the world we inhabit, the messages about science and technology by far exaggerate their benefits while keeping the tendency to ignore the risks and uncertainties that surround scientific and technological products.[44] Meanwhile, billionaires like Elon Musk and Jeff Bezos figure out how to get out of the earth and sell tickets for their evacuation.

In the public circuits of production and consumption of science and technology, everyone blames everyone for the bad outcomes, drawing on a recurrent argument, the ideological backgrounds of one´s work. Additionally, the recent emergence of old idealisms and conservative views, embedded in speeches of world leaders, together with a new pandemic, left science at a new crossroad. In order to escape this, several proposals for the reconstitution of science have emerged (Levins, 1990), among them, obviously, the proposal made by Elena Álvarez-Buylla. However, these proposals have not been able to gather the consensus of the academic community, regardless of their validity, generosity, and humility. So, what is missing from the majority of the scientific community to understand these proposals? Is it a collective stubbornness or the result of a labour structure that alienates them? This chapter seeks to understand what happened and still happens, in a structural way, to academics, that prevents them from reinventing a space for social emancipation and knowledge. The hypothesis here is that the subsumption of science under capitalism has further alienated scientific work, creating such a complex structure of submission and coercion that it keeps its members imprisoned through fetishization mechanisms (Feenberg, 2010a).

Considering that the processes of subsumption of labour to capital promote not only quantitative but also qualitative changes in the character of the general labour of a community (Marx, 2015), and that these processes are not protected from the internal contradictions of the capitalist system, it is also in this plot that alternatives emerge. Thus,

[44] Recognizing the state of ontological uncertainty of these products thus poses the challenge of how to develop critical thinking. How to resonate a sense of community united by affinity and ethical responsibility without falling into absolute relativism.

understanding why a majority remains subservient to a system of exploitation allows us to explain why others do not, reinforcing the argument that proposals such as those made by Elena Álvarez-Buylla are not just new sociotechnical arrangements, but utopias born of the conflict between labour and capital.

2.2 – Subsumption of science under capitalism

2.2.1.- Biology as an Ideology

To assign biology the status of ideology[45] is a provocative idea. Although the expression should not be taken literally, it has been used as an analogy by authors such as Richard Lewontin and Richard Levins to express the embedding of the social ideology of bourgeois society into biology (Levins & Lewontin, 2009). For Levins and Lewontin, such connection allows us to see biology, not as neutral praxis, but as cultural politics. Unveiling in these ways the "collective agendas that loom over epistemology" (Levins & Lewontin, 2009; Omodeo, 2019, p. 23). As discourses and practices that are produced by social groups, whose thoughts and actions are formed by their social interests. Biology as an ideology is then used to describe a set of epistemic qualities of the *praxis* of modern biology that are informed by implicit bourgeois agendas. Most commonly, modern biology is presented as a 'scientific' practice that advocates producing rational descriptions that adequately represent the biological world and gives biology the ability to predict how that world will look like if we experiment on it (Nunes, 2001). However, the ideological character is asserted when biology presents itself, in contrast to other practices, as the privileged source of knowledge and when it presents its project of 'gene-by-gene' reconstruction of nature, revolutionizing the way science is governed. Likewise,

[45] As a word, ideology comes from the late 18th century. Coined by the philosopher Antoine-Louis-Claude, Comte Destutt de Tracy, ideology was a school of thought influenced by Locke that aimed to establish a 'science of ideas'. In the beginning, ideology was a primitive scientific study of beliefs that tried to place ideas back in their place based on their material relations (Eagleton, 1991, pp. 63-92). Raised in a political turmoil, ideology aimed to explain and act upon human knowledge, constructing a truly rational society, at least until "the pejorative burden of the concept was superimposed on the analytical scope" (Carujo, 2019, p. 141). For scholars such as Jürgen Habermas, however, ideology cannot be thought outside the rise of the bourgeois society. For the German philosopher, there was no ideology before bourgeois society, and ideologies are contemporaneous with ideology critiques (Habermas, 2011, p. 66).

considering that the concept of ideology has several formulations, each of them entangled with a meaning (Eagleton, 1991), it is important to further clarify Levins and Lewontin's use of the concept when referring to modern biology. For these authors, biology as an ideology can also be described as biology under the influence of capitalism (Lewontin & Levins, 2007). In other words, it describes biology as a practice that aims to represent the biological realm in a way that renders it a form of privileged legitimations over other ways of knowing the world, having, therefore, also the function of coercion. A common expression of such coercive ability is the capacity of modern biology under capitalism to deny its ideological character and promote scornful description of other biology practices that escape, or try to escape, the influences of capitalist ideology.

> […] these groups of opponents to GMOs, among them the group of Unión de Científicos Comprometidos con la Sociedad, as if they were the only ones [committed to society], organized a supposed debate on transgenics from the 11 to 13 [April 2018] and to which we are invited, some of us not all of the committee members. It wasn't a debate […]. Unfortunately, as we say, it was manipulated by this group of activists, radicals and some of them dogmatic, used this debate to demonstrate, to demonize, transgenics without evidence of their harm.[….] this technology is demonized when in fact it is a marvellous tool for some of the several problems we face, many of the criticisms of this group and others, such as the NGO Green Peace, is mainly due to ignorance, others due to interests that they not speak. (Francisco G. Bolívar Zapata, biochemistry scientists and promoter of GMOs, during the Conference "Biotecnología: organismos transgénicos, sus grandes beneficios y la ausencia de daño, hold at the Faculty of Chemistry, UNAM, 23 of May 2018. Transcription and translation by the author).

While attending public debates over transgenic organisms, particularly the debates in Mexico, held by promoters and advocates of transgenics, it became almost predictable that someone, in the course of the debate, would accuse, directly or indirectly, their opposition of being ideological. For example, during the public debate "Transgénicos: Grandes beneficios, ausencia de daños y mitos", held on the 22 of February 2018 at Colegio Nacional, Elena Álvarez-Buylla was repeatedly accused of "being ideological" when it comes to her opposition on transgenic organisms.

As I dig into this relationship between ideology and biology and how it is often used to belittle contrarian-science, I realized two important aspects. The first is that accusing a scientist of ideology is intended to say that this scientist fails to meet the consensus of its community paradigm (Fourez, 2002, p. 197). However, this is a strategic accusation because it takes advantage of the audience's prejudices regarding ideology. The second aspect regards why promotional scientists believe to be outside ideology. According to Althusser, "those who are in ideology believe themselves by definition outside ideology: one of the effects of ideology is the practical denegation of the ideological character of ideology by ideology" (Althusser, 2014 *apud* Omodeo, 2019: 1). This happens because the dominant paradigm of biology subsumed under capitalism does not allow to prove or refute the influences of ideology based on the scientific method (Fourez, 2002). There is no way to prove or refute ideology based on the dominant scientific method of biology and considering that such practice of biology is the practice of testing, proving, and discarding what is alleged to be real or true, and because ideology cannot be tested proved or discarded according to the procedures of biology, modern biology has to deny its ideological assumptions. The problem is obvious. The incommensurability between biology and ideology, as postulated by Fourez, is that it questions ideology based on the same rules of science, rather than questioning 'science ideology' as an inquiry into the collective agenda that lies behind the scientific endeavour (Fourez, 2002; Omodeo, 2019).

> I would like to make a judgment of values regarding the socio-political positions that people take regarding a particular technology. Especially if supported by socio-political arguments. First, because I am not a scholar of sociology or politics. Second, because I would say that my position is perhaps a little off center due to the fact that I live in science. Science seen as a way of searching the world and obtaining knowledge. And so, when arguments depart from my traditional way of observing phenomena which is mainly based on the scientific method, I start to have difficulties […] I have difficulties in discussing these issues with people who do not have science as a basis for further discussion. I obviously understand and accept that there are other bases for the discussion, but I have difficulties. (Pedro Fevereiro, biologist, during a debate on bioethics, 2016. Transcription and translation by the author)

In this sense, an alternative approach to the study of the relations between biology practices and its ideological assumptions must be guided, not by the enterprise of 'truth', but by the desire to make 'biology as an ideology' an exercise of self-reflexivity (Omodeo, 2019). According to Terry Eagleton, this can be achieved by studying "ways in which people may come to invest in their own unhappiness." (Eagleton, 1991, p. 12).

As with any ideology, 'biology as an ideology' is based on qualities that project worldviews and possible futures. According to Pietro Daniel Omodeo (2019), for modern scientific practice, those would be epistemic qualities considered universal to the scientific mind, such as objectivism and neutrality. For the Italian scholar, "objective and impartial judgments are mostly self-proclaimed and rarely justified and deconstructed through critical inquiry into science itself" (2019, p. 1). Additionally, and following

Althusser, Omodeo highlights that ideology is not only present in science, but it also turns scientists "blind to the implicit agendas that are embedded in any discourse, especially for those that claim abstract university and disinterestedness" (2019, p. 1).

Moreover, as a Gramsci-influenced scholar, Omodeo sees the relationship between science and ideology in a similar way that Levins and Lewontin see that relationship for biology. All three authors would then agree that their definition of ideology can be framed as 'cultural politics' and consider that science (including biology), as a cultural activity, is framed by collective programs (ideologies) that define reality and propose visions of the future. Ideologies thus act both upon the social institutions of science and on the scientists. Ideology, in this sense, performs two determinant functions in the collective process of making science. The first happens at the level of determination and command of science; it is the direct control of labour and means of the scientific enterprise, and in this sense, it acts upon the scientist's consciousness (formal subsumption). The second, acts upon the consequences and meanings of science in the cultural-political realm, rendering its constant renewal of challenges and goals essential to its progression, acting upon the unconsciousness of the scientist (real subsumption).

2.2.2 – Formal and real subsumption

The concept of subsumption of labour under capitalism is how, as Marx explained, non-capitalist forms of labour organization are submitted to the capitalist social order and to the process of value and surplus-value production (Marx, 2015, p. 54-77). For Marx, this happens firstly by the process of formal subsumption, which means that labour is integrated into the production of surplus-value creation without radically changing the means of the organization of labour. The formal subsumption process corresponds to an absolute surplus value creation. For scientific labour, I argue, this is a more or less recent phenomenon. The absolute surplus value creation in science happens by ensuring that enough qualified workers can compete with each other (Boyd & Prudham, 2017). Because scientific labour is a timeless activity, meaning that the character of labour cannot be defined in terms of work hours, capital has the need to increase available work, not by raising the number of working hours but the number of workers. However, the investment in this *skilled worker* must happen under a coercive morality, which states that scientific work is qualitatively superior to other forms of work, and therefore the scientist cannot be compared to the working class as historically and currently defined. The separation of scientific labour from other forms of labour has for a long time justified a wage structure based on patronage and scholarships and the competition system that sustains it. Such has, for a period, avoided the class struggles of science to join the general struggles of the working class.

As formal subsumption of labour progresses, as Marx states, real subsumption may take place (Marx, 2015). Real subsumption is characterized by the revolutionization of production and a shift from absolute surplus-value creation to relative surplus-value. New technologies and forms of organization of labour are introduced, and capital assumes the direction of the labour process in its entirety. It is crucial to bear in mind that, although for Marx, both the formal and real subsumption processes happen consecutively, this does not happen to all forms of labour at the same time. For this reason, the subsumption process is never completed, and once capital has "really" subsumed one dimension, class struggle or the inner contradictions of the production system may initiate a new process of formal subsumption upon the same or a different dimension of labour or another.

According to Levins (1998b), there are two major contradictions within science subsumed under capitalism. The first concerns the "contradiction between scientific activity as the growth of generic human understanding passed along from society to society, and science as the particular product of a particular social context" (1998b, p. 558). The second refers to the "contradiction between the growing rationality and sophistication in the small and the increasing irrationality of the scientific enterprise as a whole, which mirrors the anarchy of capitalist production and the development of its technology" (1998b, p. 558).

For André Gorz (1976), one of the milestones in the proletarianization of scientific workers happens by the influence of the industrialist Carl Duisberg. By the beginning of the 20th century, as head of the Bayer company, Duisberg understood that scientific knowledge could be a force of production, but only if the structure of scientific labour would follow the same labour divisions as productive labour. This meant that scientific labour would need to be restructured into a hierarchic labour division under the capitalist's command, which means subordinating some forms of knowledge production, such as that of laboratory technician, to a higher placed intellectual boss (Gorz, 1976).

As the progressive industrialization of scientific work took place, so its fragmentation and sub-specialization proceeded, demanding more labour. However, and contrary to Friedrich Engels proposal (1974), where the disciplinary division arises due to the dialectical relationship between matter and practice, the disciplinary division under capitalism appears as an effect of the command of the capitalist needs for production, determining its usefulness on the basis of the capacity that the new divisions have to place themselves in 'strategic cooperation' (García-Barrios *et al.*, 2008)[46].

This new demand for scientific labour is also part of the explanation of the progressive proletarianization of academic work. Each disciplinary division, under capitalism, also entangles labour divisions that not only directly affect research performance, but also generated an army of 'non-scientific' workers that labour in "bullshit jobs" (Graeber, 2018). To be able to keep the structure of its command and ensure that each new labour form is placed in strategic cooperation, capitalism resorts to bureaucratic mechanisms who seek to maintain the organization of scientific work to a rational order determined by bourgeois ideology. Such gave rise to the dominant forms of science management and communication, management of ethics, and data management, among others [47], which flooded science with an enormous amount of 'unnecessary labour'. This definition of labour means that, although unnecessary from the worker's perspective, it is a requirement of contemporary capitalism. Following David Graeber (2018) concept, 'unnecessary labour' is thus, the labour that ultimately guarantees the maintenance and survival of the exploitation system, that perpetuates - in its coercive form - the violence over labour, and that is not justified either in its pretended rational or ethical assumptions. Ultimately, 'unnecessary labour' is the one that lets us 'manage stupid situations' without the concern of interpreting them (Graeber, 2018). Such 'rational stupidity' results from the increase rational uses of productive forces, which amplify social dimensions, previously subsumed to bourgeoise criteria of rational decision, and therefore move the subsumption process of science forwards under capitalism (Habermas, 2011; Marcuse, 1991). Yet, according to Herbert Marcuse, it is still 'stupidity' as it does not implement real rationality (Marcuse, 1991). According to the author, rationality - as a

[46] For García-Barrios *et al.*, 2008 strategic cooperation merges the idea that each rational agent, freely enters in cooperation, with the goal of receiving a shared benefit. Strategic cooperation is the classic liberal idea of a virtuous exchange of products and social relations. A type of market exchange relations that Karl Marx referred to as Robinson's idealism, which avoids understanding the true nature of exploitation. It is based on a vision that free and autonomous individuals engage with one another based on common grounds to maximize each part's benefit. Strategic cooperation is, in a first phase, ensured by a compensation system.

[47] The invisible dimension of the 'bullshit jobs' has not been studied. I refer to works such as ghost-writing and ghost-management. Although we all know these works exist, they are performed in the informal knowledge economy. This informal economy of knowledge is maintained by corporate interests in influencing scientific outcomes.

project of the bourgeoisie - only allows, within its authority over *nature* and society, to choose between strategies and uses of knowledge (and products) resulting from the scientific activity. For those, relations are subtracted from reason and from the social entanglements and interests that select the strategies.

Although it became apparent for Marcuse (1991) and Habermas (2011) that the history of rationality is fused with the history of the social modes of production; in the narratives of the classical history of science, science still appears as a productive force disconnected from the relations of economic production of its time. See, for example, the history of the *scientific revolution*. For most historians of science, the *scientific revolution* is a 'fact' that took place somewhere between the end of the 16th century and the beginning of the 18th century, and at the "exact" moments of the end of feudalism. Alexandre Koyré (1966) is one of those historians that not only highlights these dates as the time when a cataclysm of coherence and a fundamental way of knowledge production emerges but as the moment that inaugurates modernity[48]. However, authors such as Steven Shapin (1999) defend the thesis that the *scientific revolution* never existed and that it is a product minted by the liberal philosophy of the late 1950s. Shapin, for his part, argues that the changes in knowledge production generated during these periods were not revolutionary, as one usually seeks to acknowledge, but rather a routine alteration of a world also in transition itself. Following Shapin, we may say that this period saw the emergence of a set of knowledge production practices associated with new production regimes and social relations that held both the old and the modern. According to Richard Levins:

> Modern Euro-North American science is the creation of capitalism. It came upon the scene most self-consciously with Francis Bacon in the seventeenth century carrying a dual promise: practical solutions to technical problems which would enhance the power and prestige of the rising bourgeoisie, and a way out of the morass of conflicting opinion and sectarian dispute that fragmented the post-Reformation intelligentsia. Science promised to be a fundamental epistemological break from all past ways of knowing. So that these could be dismissed as superstition (Levins, 1990, p. 102)

[48] The long history of knowledge production and the emergence of the figure of the scientist is accounted for in the work of several historians. There is the agreement that it was during the seventeenth-century that a change in the patterns of knowledge production took place. The most important feature of this period is the transition of knowledge production as an amateur activity into a professional one and the progressive development of institutions that organized scientific practice. The other important feature to consider is how knowledge production has always been at the service of powerful entities. Galileo served the Medici in the establishment of their symbolic power. Both features are historically important when accounting for the class character of science and scientists (see Shapin, 2008 and Mario Biagioli, 1993).

This means that, although capitalism happens as a process of destruction of the feudal nobility by the alliance of royalty and the bourgeoisie, and by undermining the church's spiritual domination (Engels, 1974), the process is the result, as Kloppenburg (2004) says, of the progressive generalization of the commodity form[49]. We deduce from this statement that modern knowledge is not the mere result of individual 'brilliant minds' that revolutionized the world with their concepts, ideas, and theories. Instead, they are characters in a meta-narrative, or ideology, that has reorganized the structure of thought and knowledge to serve the progressive generalization of the commodity form.

According to John Desmond Bernal (1946), a pioneer communist scientist in molecular biology and a historian of science, science as we know it is a recent form of knowledge production. It took several centuries and a progressive transformation from a crafted and magical form of production into a rational exercise lead by an army of researchers to finally end up in what we know today as Modern Science. In this sense, for Bernal, our first approaches to *nature* cannot be understood as scientific. In the beginning, and according to my demonstration of the role of myths in chapter one, theory did not represent any essential function within humans' relationship with *nature*. *Nature* transformation, according to human needs, was approached in practice. Agricultural development, for instance, did not evolve from theoretical assumptions but from a practical transformation of *nature* by human labour, which would only later be theoretically developed into scientific concepts. As a result of the appearance of towns and agricultural surplus, the emergence of trade provided the basis for the possibility of using intellectual processes. As societies and their social relations become more complex, so did the intellectual necessities. The agricultural system, for example, required a set of knowledge forms that became progressively associated with the practice of astronomy. With astronomy, humans were led to develop systematic observation methods and elementary mathematics, but far more important, it led to the creation of a human activity dedicated to observations and calculus (Bernal, 1946, pp. 15-16). To medicine, says

[49] Historians of science hardly recognize the function of primitive accumulation within the construction of modern science. We rarely recognized that a large part of our modern ways of knowledge have already been produced by artisans, indigenous communities, and workers. So, one thing we need to realize is that the primitive accumulation was not only based on the expropriation of land and exploitation of labour, but in the theft of knowledge over nature and labour. Such theft has happened by creating institutions and laws that prevented traditional practices of production or that just created a system of production where that knowledge could not be used by those who have created them. In the way the story of science and technology is told, the processes of improvement are cleansed of any reference to the relations between victorious technologies and colonialism and class struggle.

Bernal, we owe the experimental character of science and the appearance of "scientific" education (1946, pp.16-17).

Under Bernal's perspective, and according to Omodeo (2019), it is impossible to escape the predicament of ideology in science. The "validity of any epistemological project cannot be disentangled from the vision of humankind and society fostered by diverging projects of cultural hegemony" (Omodeo, 2019, p. 4). In this sense, the goal of those concerned with the entanglements of ideology with science, rather than looking at someone's misconduct due to ideological assumptions, should be the search for the ways denial of ideology has merged with our traditional scientific-social structures.

2.2.3 – The fetishist character of science

The Marxist notion of 'fetish' refers to the process by which social relations subsumed under capitalism endow objects with capacities that are not materially given (Marx, 2017a, pp. 87-102), such as with the ability to "move and shape the world in particular or distinctive ways" (Harvey, 2003, p. 2). Within the realm of science, we tend to manage and communicate scientific knowledge as intrinsically having the capacity, *per se*, to revolutionize the world and with the capacities to solve the main socio-environmental problems of our time. Consider, for instance, the approach to biotechnology by Kaiser Jamil, president of the Third World Organization for Women in Science:

> Biotechnology holds tremendous possibilities for the developing world. The use of high-yielding, disease- and pest-resistant crops will have a direct bearing on improved food security, poverty alleviation and environmental conservation. GM crops will hopefully produce more yield on less land. This may increase the overall productivity and may offer developing countries a means to sustain themselves and reduce worldwide hunger. (Kaiser Jamil - president of the Third World Organization for Women in Science in https://www.un.org/en/chronicle/article/biotechnology-solution-hunger, retrieved in November 2020).

Such hyped expectations over the abilities of the final products of science impact the consciousness of scientists, who believe that the products of their work are qualitatively different from other products resulting from other forms of human labour (Feenberg, 2010b). According to André Gorz (1976), this predisposition, be it conscious or unconscious, regarding the qualitative character of the scientific labour of scientists, happens primarily due to the *status* that knowledge has in our modern societies. This means that *status* is not an invention of the minds of scientists. Instead, it is the product of science's economic and political relations and the implicit ideological content.

Science and technology in its version of science's offshoot provide the basis for the so-called knowledge economy. In this economic system, knowledge is massively produced by highly educated and skilled workers who labour for a society where products and services increasingly become rationalized. By believing that our labour improves, in the abstract, all forms of production, we also believe in improving social relations within current production modes. This hides, however, the progressive degradation of the scientist labour relations, what Gorz (1976) describes as "the proletarianization of scientific workers". Believing that scientific and technological knowledge is improving farm or factory production and the lives of those who provide the labour power is a fetish that blurs how the current labour structure of science has become progressively subsumed under capitalist social relations of production. Ultimately, the consequence is our inability to understand how labour is contributing, not to a more egalitarian world, but to the reinvention of the relations of exploitation of the capitalist order. This also means we are blind to the forms by which our labour is favouring Western modernity and its *epistemicide* project (Sousa Santos, 2018). The fetishizing character of scientific activity conceals how we become products, victims and/or privileged by strengthening global Northern institutions' positions as the core of the world-system of knowledge production (Feenberg, 2010a). How a system of symbiotic exploitations has been created.

According to Márton Demeter (2019), the core groups of scientific institutions are represented by USA elite institutions and elite universities in the UK, where we also find the leading publishing houses. A second level (semi-periphery) is formed by universities outside this core but subordinate to core institutions, such as the American University in Cairo, or having strong ties with the core elite institutions, such as some of those located in Israel, Hong Kong or Singapore. The last level (periphery) includes the remaining institutions. The same author signals that the core is mainly overrepresented in terms of publication outputs, editorial boards, and selection committees. All international publishing houses are located at the core, with the power to determine international publication standards. When it comes to knowledge development, core countries are the producers of new theories and methods, while the periphery mostly mimics the theories and methods produced in the North (Demeter, 2019). Furthermore, 'intellectual capital' from the peripheries flows to the core through processes that include the well-documented brain-drain phenomenon. However, three regions appear to resist this world system of knowledge production: Latin America, India, and China (Prakash,1999; Demeter, 2019).

In addition to understanding the forms of uneven and combined development of science, it is necessary to consider that the power of fetish has a material basis. According to David Harvey, the belief that a particular technology can do things it was not conceived to do has a material reason. In his article "The Fetish of Technology: Causes and Consequences" (2003), Harvey explains why capitalists believe that technology is a driving economic force and endorse it with the capacity to lead, not just economic forces, but social solutions as well. His Marxist materialist point of view states that the process of fetishization is not simply an exercise of imagination but has deep material roots.

One of these roots, Harvey proposes, is anchored in the abstraction of what productivity is and how technology acts on it. Following Harvey's perspective, there is also a material reason why sciences and scientific objects (thoughts or products such as technologies) are endowed with so much enthusiasm. One thing to account for is that today increasingly fewer science products escape from the process of commodification. For Marx, let us bear in mind that commodification cannot be oversimplified as the transformation of relationships into commercial objects of exchange, but that it addresses the issues of relations of exchange. This means that even when we are faced with a product of science that does not have an exchangeable commercial value, it does not mean it is free from the commodity form.

2.2.4 – The fetishism of genetically engineered organisms

During the course of my research, I realized that genetically engineered organisms are a paradigmatic example of a capitalist fetish. These artefacts of biotechnology, epistemologically produced in the north, are transferred to the global South, subverting both local forms of biological knowledge and local non-industrialized agricultural practices while promoting the image of saving the world from starvation. In all the GMO/GEO promotion initiatives that I attended during my fieldwork, the argument that genetically engineered organisms are key in the war against hunger was constantly wielded.

> One of the significant challenges we have to face with agriculture is food production. As it was mentioned during the morning, we are 7 billion people on earth. By 2050 it is estimated that we will be 9,700 million. What does that mean in terms of production? There are different estimates. I present one, in which it is estimated that by the year 2050, caloric production will have to increase by 100% (+/- 11%) for the case of crops. In the case of protein production, a 110% increase will also be necessary to cover the needs,

> according to the different population groups. (Sol Ortiz García, former Executive Secretariat of the Intersecretarial Commission for Biosafety of Genetically Modified Organisms, during the roundtable "Los alimentos transgénicos a debate" that took place between the 11th and 13th of April at UNAM. Transcription and translation by the author).

Likewise, this argument was always accompanied by the vital role that science plays in our contemporary societies, the role it plays in solving complex problems. Not completely disagreeing with the role that science currently has, it is nevertheless necessary to understand the bases of scientific optimism. One of the reasons that partially contribute to scientists' optimism, which reinforces their belief over their neutrality and objectivism, is that sometimes scientific and technological outcomes work for the benefit of the many (Levins, 1990). Nevertheless, even when we realize that such benefits are still unequally redistributed, the fetish over the commodity form of knowledge keeps the world of science apart from politics while feeding political decisions with an apparent rational direction. For example, the fetish of technological productivity and the illusion of solutionism of political problems such as hunger may have resulted in more food production for an ephemeral moment but have not ensured equal distribution of food. In fact, its results included new agricultural failures, whose inputs came to be subsumed under the permanent need for consumption of toxic products developed within agro-industrial capitalism; products such as pesticides and fertilizers, agricultural-industrial machinery, and transgenic seeds controlled by big corporations.

For advocates of agricultural transgenics, who are usually not economists but agrarian and biological scientists, these genetically engineered plants are associated with higher productivity [50]. However, in the face of data, it has become impossible to sustain a universal claim that all transgenic organisms promote that alleged higher productivity (Gurian-Sherman, 2009). Each transgenic productivity varies according to the technology and the type of crops and performs differently in different geographies and years. Furthermore, productivity does not automatically translate into profitability, as defenders of transgenics typically claim. Neither does it save labour time. Profitability also depends on the pressures faced by farmers and macroeconomic factors, such as per capita income. The agrarian question is much more complex than the solution presented via transgenics.

According to Julio Muñoz Rubio, our fetishization results from the deeply rooted deterministic and mechanistic conceptions of how science and technology work, which

[50] Productivity of transgenic crops is normally reported based on a single factor measure, the yield, i.e., production per unit of land.

tend to be publicly taken up as politically neutral and disconnected from social conflict and class struggle (Rubio, 2016). A perspective that follows the critique of Andrew Feenberg (1991, 210b) and Renato Dagnino (2002). Thus, as Harvey argues, the challenge is to unpack their actual role while demystifying science and its products by resisting the habit of endowing them with powers it does not and cannot have. This implies breaking with the idea that technological objects and scientific concepts determine social processes.

In other words, like money and commodities, machine-like objects, such as the transgenics, are fetishes that mystify unequal relations of exchange (Hornborg, 2013). When we look at the promises of such technological entities, we are led to believe that those organisms can save labour, time, and land. However, and as Alf Hornborg (2013) pointed out, the rationale of mechanization is inextricably interwound with global differences in prices of labour and resources. Within this context, western sciences, and technologies,

> […] must in themselves be recognized as contingent on specific global constellations of asymmetric resource flows and power relations. In other words, not only was the 'rise of the West' a geographical coincidence of world history – the location of Europe as middleman between the Old and New Worlds – but its economic, technological, and military means of expansion, generally viewed as European' inventions' and as contributions to the rest of humanity, were products of global conjunctures and processes of accumulation that coalesced after the economic articulation of the Old and New Worlds. (Hornborg, 2013, p. 4)

Scientific and technological progress is a cultural creation of the historical experience of privileged sectors of the world system. As Marx observed, in capitalist societies, relations between people assume the form of relations between things. Such fetish obscures the social foundation of exploitation and endemic inequality. For Bensaid (2020), fetish emerges as the absence of critical reflexivity, a feature also highlighted by Omodeo (2020) as a requirement for the ability to understand the attribution of natural proprieties to social phenomena. Yet, without altering social relations, the simple recognition of fetish does not bring it down. That is, it is not possible to transcend alienation merely pointing out that alienation is the inversion of the objective world.

2.2.5 – The hegemony of mechanism in biology

According to Lewontin and Levins, mechanism is the concept that anchors biology to a hegemonic programme (Levins & Lewontin, 2009). Mechanism was a concept raised during the 17th century, mostly due to Descartes's understanding of the physical world as constituted by *units*. *Units* were defined as well-established beings, and the role of philosophers under this perspective was to decode and describe the forces of motion among them. Under mechanism, it is possible to exclude God as the force that binds Nature without denying His existence. As Lewontin puts it:

> So, the ideology of modern science, including modern biology, makes the atom or individual the causal source of all the properties of larger collections. It prescribes a way of studying the world, which is to cut it up into the individual bits that cause it and to study the properties of these isolated bits. It breaks the world down into independent autonomous domains, the internal and the external. Causes are either internal or external, and there is no mutual dependency between them. (Lewontin, 1998, p. 16).

Lewontin's description accounts for the changes in the structures by which knowledge was divided and integrated under the epistemic quality of mechanism. For mechanist intellectuals, such as Descartes, Boyle, and Hobbes, knowledge starts from a general abstraction of complex problems[51]. In order to solve such problems, they divided the phenomena until they obtained the smallest part of which it was possible to describe its properties. From there, they mechanically joined the pieces and built bigger things. Although the process of decomposing seems a very passive action, the opposite, the construction, entangles a perspective of continuous violence. For Hobbes, all things are in constant growth and self-expansion, which inevitably originates conflicts that he considers permanent. According to his perspective, everything confronts everything that exists, and to avoid total annihilation, there is a need for a permanent form of sovereignty. With Charles Darwin, the tension for a permanent form of sovereignty was solved with the definition of the mechanisms of evolution. For example, within what came to be the dominant readings of the theory of evolution, conflicts are no longer a problem but the generating force of *nature*. Competition, for example, then turns out into not just the rule of the market but a natural law. And most important, an evolutionary natural law.

For authors such as Friedrich Engels, mechanism was a retraction of our thoughts, as it reduced the qualitative complexity to quantitative terms, excluding the

[51] Although the positions of Descartes, Boyle and Hobbes are not identical, and in fact found different positions and practices, the general description of the procedure as it is presented, seeks only to characterize the reductionist approach that characterizes the emergence of modern science from natural philosophy.

richness of encounters and experiences (Sheehan, 2017, p. 32). Engels's critiques stated that, although things existed in quantitative terms, it was necessary to understand the qualitative distinctness of each level, while maintaining the continuity of levels. According to Engels, we can explain processes in physical, chemical, and biological terms, but we cannot exhaust the essence of what they explain (Engels, 1974)[52]. For example, we may explain the colour of our eyes by reducing it to genes, but we cannot explain vision in those terms, which is fundamental to determine colour. Engels's perspective on the nature of matter is endlessly different from those that today dominate biology. Under the current hegemonic philosophy of biology, genes are the *unit* that dominates all levels of animal organization. The assumptions, and expectations, is that we can explain collective behaviour based on single genes. In this sense, mechanism has to be considered a style of thought (Fleck, 1986) rather than an epistemic quality. On its part, reductionism may be regarded as an epistemic quality that renders mechanism its legitimacy.

Prior to the new philosophy of *nature* of the 16th, 17th, and 18th centuries, *nature* was an indivisible entity. Any attempts at a division of this *nature* were the destruction of natural essence and social organization, which was considered indissoluble (Lewontin, 1998). The indivisibility of what was nature had the result that the *units* - and the individuals - were not causes of their social inclusions, but consequences. In capitalism, the divisibility of *nature* makes individuals and *units*, with their particular characteristics, the causes of the social. In other words, under capitalism society is a consequence, not the cause of individualistic properties. According to this perspective, all these *units* and individual properties face the external world and are the starting points of the complex collectivism of bodies.

> With the change in social organization that was wrought by developing industrial capitalism, a whole new view of society has arisen, one in which the individual is primary and independent, a kind of autonomous social atom that can move from place to place and role to role. Society is now thought to be the consequence, not the cause, of individual properties. It is individuals who make society. Modern economics is grounded in the theory of consumer preference. Individual autonomous firms compete with each other and replace each other. Individuals have power over their own bodies and labor power, in what

[52] Engels's critique of mechanism implied a critique of any notion that the spirit reigned over nature. Thanks to the materialism of Feuerbach, nature was brought back, and Engels believed in the possibility of exploring and explaining nature in materialist terms, discarding mythical, cosmological, or fetishistic additions (Sheehan, 2017: 32-34; Foster, 2011). Matter matters, and it is from it that concepts are abstracted. As a result, matter became the matter of abstraction. Engels also believed that materialism was implicit in science and that progressive discoveries would make that even more explicit, making idealism obsolete as a way of thinking that claimed to explain reality.

> MacPherson called "possessive individualism. "1 This atomized society is matched by a new view of nature, the reductionist view. Now it is believed that the whole is to be understood only by taking it into pieces, that the individual bits and pieces, the atoms, molecules, cells, and genes, are the causes of the properties of the whole objects and must be separately studied if we are to understand complex nature. (Lewontin, 1998, pp. 32)

Likewise, today we believe that 'machine-like' represents the world, a link to the consolidation of industrial capitalism, and the ideology of bourgeois society. Furthermore, and as Lewontin also pointed out, modern science tends to mistake analogies for facts. Hypothetical examples, analogous to social or immediate processes involving the senses, such as observation, tend to gain prominence and become truths that sustain the economic and social form of the relations of production (which include reproduction) even if such examples have never been effectively proved or even tested. Transgenic organisms are a "living" example of this situation.

Transgenic crops, particularly Bt crops, were designed not only to resist the use of pesticides; they have their cell mechanism changed to produce pesticide. Due to this design, it is said that Bt crops are more productive and that they reduce the use of pesticides, and in this sense, they are an answer to world hunger and climate change problems. Several studies demonstrate, however, that the assumptions are not only false, but they also move away from effective pathways to the problems that Bt plants vow to solve.

Under modern genetics, "genes contain the program, the essence of the organisms, while the cell machinery reads the blueprint and executes the directions" (Lewontin & Levins, 2007, p. 54). Biological determinism and ideals of reductionism have thus become the dominant modern rational philosophy (or epistemic qualities) that drives biology and genetics research. Determinism states that "for everything that happens there are conditions such that, given them, nothing else could have happened" (Bhaskar, 2006, p. 139), while the idealism around reductionism entails the belief that by reducing the study of matter into its single, more pure entity, we will be able to decode the universe.

In this line of thought, a gene is an epistemic object immersed in the aforementioned epistemic qualities. Long before the genes were observed, biologists were speculating over their existence within the framework of heredity. Darwin's theory of evolution had opened the search for explanations on how evolution works. Nevertheless, although Darwin's evolution theory was to be understood within the particular historical circumstances of its formulation, researchers keep studying its forces as *ahistoric*. However, the very history of the concept is rooted in historical factors. The gene and the understanding we have of it are based on the continuous development of methods of individuation of genetics. In other words, the concept is largely dependent on the technological apparatus of modern science. The critique here has nothing to do with the fragments (in abstract) obtained from the decomposition but rather how such a process of reduction generated a particular picture that dominates scientists' vision: that genes determine all living creatures, and therefore society is the result of individual organisms commanded by such units (Kay, 2000). Such a determinist assumption is false on the very basis of what is happening with matter. In fact, it leaves out developmental noise and the chance element, which is fundamental for understanding variation (Lewontin, 1998)[53].

For Lewontin (1998), the view that matter can be rationalized and that it can be explained by entomological behaviour is coercive. Such coercive violence finds its social parallel on Marcuse's (1991) vision of rationalization as the process by which the dominant political forces coerce society. This would mean that violence is rationally determined, which gives a conscious link to the manipulation and orientation of science, "tainting" the narrative that science is a pure, disinterested form of knowing.

By identifying rationality as an imperative and part of the epistemic qualities of scientific practices, this also means that the modern models of biology represent the putative method of the natural sciences for any given or possible scientific field. A model constructed by the ideological use of Weberian bureaucratic capitalism that ensures that any emancipatory uses of rationality are marginalized (Omodeo, 2019, p. 22).This allows us to state that modern biology is not just associated with the rationality of the bourgeoisie, but also that biology progressively turned into a form of bourgeois rationality, circumscribed to the possibilities of its application, to generate in itself the domination of the thought over *nature* and the social. As previously stated, this results in a rational construction of abstractions directed to ends. Under modern biology, the concrete is pre-determined by the ends. Moreover, as Habermas (2011) defended, the ends and interests of domination are not orthograde afterward and outside but are inserted in the construction of the technical apparatus. With the passing of the decades, it has become impossible to refute Marcuse's idea that exploitation and oppression become rational in societies of advanced capitalism. Exploitation and oppression are not just rational but calculated. In this sense, biology, under capitalism, is committed to the political project of manipulation and control of both *nature* and society (Marcuse, 1991).

[53] On the debates on genes, development, and evolution and on the key role of Lewontin's work, see Oyama, Griffiths and Gray (2001).

Considering all the above arguments, we cannot define 'biology ideology' as false consciousness; instead, 'biology ideology 'is an instrumental use of reason (Horkheimer, 2013). In other words, following Hilary Rose and Steve Rose's (1976) formulation of science as ideology, the coercive process by which bourgeois ideology subsumes science results in a reductionist construction of abstracted *ahistorical* natural laws that serve the interests of the ruling class (Feenberg, 2002). In it, scientists, alienated from their praxis, turn into ideologists that patrol not only the borders of disciplines but determine what counts as valid knowledge within the dominant ideology.

2.3 – Science resisting subsumption

2.3.1 – 'Revolution' and its influences on the resistance of science to capitalism

During the aftermath of World War I, the Russian revolution, the economic crisis, and the rise of fascism, science was at a crossroads. The revolutionary discoveries of the previous century and the political and economic crisis of the first decades of the 20th century left science in a profound crisis.

Previously, during the 19th century, materialist perspectives massively influenced by several breakthroughs and intensification of scientific labour seemed to be dethroning all idealistic philosophies. As Sheehan also pointed out (2017), the discoveries of the 19th century opened a crisis within science, whose association with the economic crisis of the time (the Long Depression 1873-1896), allowed the resurgence of a new type of idealism, in forms such as anti-materialism and anti-positivism. Nevertheless, this crisis of reality has also been accompanied by a new kind of materialism, which in part turned the proposal of historical materialism and the dialectics of nature into dialectical materialism and would fuel the debates over science for decades to come (Papadopoulos, 2010).

During this period, it is possible to say that the main philosophical debate was divided between materialists (dominated by empiricists) and idealists (speculative idealists). However, and particularly for Karl Marx, the debate was not well framed. In

Theses on Feuerbach (Marx, 1845), Marx points to 11 assumptions on philosophy and its relation to the world, where he is critical of both sides and emphasized that "any debate regarding the reality that did not consider human praxis was scholastic". It became clear that Marx and Engels' contribution to materialism depended on a dialectical materialist ontology of the word that considers two facts. The first, that matter (material world, nature) is the precondition of human existence, and that production of the means of subsistence is a precondition of human life (Foster, 2011). And the second, that materialism has to account for the active roles of human subjectivity in creating the abstractions and categories systems by which they perceive and act upon the world.

Marx and Engels' contribution is profoundly marked not only by practical observation of land and peasants' situations but also by a in depth study of natural sciences and physics [54]. In this sense, they could not avoid understanding the natural sciences, not only in their discoveries but also in their practice. The natural sciences are, in fact, a fundamental aspect of Marx's and Engels's materialist conception of history. For both authors, *nature* cannot be understood unless it is connected with humanity's practical activities, which we know that, for Marx, are submitted to the historical conditions of the productive forces and social relations. This also means that the social consciousness of any science is subject to the scientist's social relations. Science is a social activity, and scientists belong to a certain form of society. The point here, however, is to understand how dialectical materialism may be understood to drive science. According to Engels, there is no form of finished science. In opposition to metaphysical explanations, which state that things exist as separate and finished objects, Engels believed that the world was dynamic, fluid, and complex and that the separation of its components was artificially produced, a stubborn tendency to see natural objects and processes in isolation (Sheehan, 2017, pp. 37-38). His perspective impacted the way science was understood, for it also meant that the various sciences do not exist in isolation and that nature was subject to laws that were more general than those of any science in particular (Sheehan, 2017, p. 40). His notion of dialectics was meant to be an extended version of Marx's proposal. As

[54] In the nineteenth-century, Marx saw science as an active force of capital. It acted both as a direct force (knowledge) and as a means for social control. Science, however, is an abstracted concept of a multitude of modern knowledge, which has historically been subsumed to capitalism in regard to its social and productive function and according to the state of the means of production of each period. This helps in explaining how some branches of science appear more closely connected with capitalist production in each epoch, and why others do not. Science as a direct force of capital become more visible within the industrial form of capital production, as the growing demand for knowledge has transformed scientific knowledge production, from craft to industrialized production (Rose & Rose, 1976).

Sheehan noticed, Marx's dialectics were to be put to work in the sociohistorical sphere, related to human existence, while Engels tried to extend it to the phenomena identified with Nature (Sheehan, 2017, p. 54).

The dialectical interpretation of *nature* pushes forward materialism, but that materialism is in itself subject to ongoing renewal. In other words, a Marxist philosophy of science is a dialectical relationship embodied in the concrete historical process. As Gramsci puts it, it is not the atomic theory that explains the human history, but human history that explains atomic theory (Sheehan, 2017, p. 294). Furthermore, political struggles and class struggles are also fundamental aspects of what science is and will become. As Gramsci explained, science has inherent abstraction processes, allowing a class to appropriate the science of another class without accepting its ideology (Gramsci, 2011, p. 150).

Although natural sciences and Marxism seem two very different entities, there were moments in history when both went together. One of those moments took place in 1931 at the Second International Congress of the History of Science and Technology. A surprising Russian delegation appeared at the Congress. The papers presented by soviet philosophers and scientists, such as Nikolai Bukharin, Nikolai Vavilov, and Boris Hessen, among others, disrupted the conventional epistemological approaches found in capitalist societies by proposing not only that dialectical materialism could be applied to all science but that it was already in action through revolutionary soviet science. An exemplary presentation of their approach was made by Boris Hessen. Hessen addressed how dialectical materialism could be applied to the study of science.

In "The Social and Economic Roots of Newton's 'Principia'", Hessen offers an account of how Marxist philosophy was able to counteract subjectivism and arbitrariness in the interpretation of the history of science by seeking the roots of ideas in the state of the productive forces (Sheheen, 2017). In his critique of the dominant philosophy of science and current historical theories, Hessen highlights how the process of discovery, based only on the scrutiny of individual intellects and their personal characteristics as human beings. was part of ruling class ideology. (Hessen, 1971, p.153). As he stated,

> [I]n class society the ruling class subjects the productive forces to itself and, by virtue of its domination of material forces subjects all other classes to its interests. The ideas of the ruling class in every historical period are the ruling ideas, and the ruling class distinguishes its ideas from all previous ideas by putting them forward as eternal truths. It wishes to reign eternally and bases the inviolability of its rule on the eternal quality of its ideas. In capitalist society a separation of the dominating ideas from the production relationships occurs, and thus is created the view that the material structure is determined by ideas (Hessen, 1971, pp. 153-154).

Looking at the economic and social context of Newton's life and work, Hessen argued Newton's interests, including his interests in alchemy experiments, converged with the problems that arose from the needs of the economy of his time. Hessen connects Newton's achievements as well with the class struggle that dominated his epoch.

Alongside the scientific delegation of 1931, Y.M. Uranovsky, a historian and philosopher of science, also dedicated his work to the relationship between Marxism and natural science as a new scientific philosophy. In his essay "*Marxism and Natural Sciences*", Y.M. Uranovsky offers an account of how several breakthroughs in the natural sciences paved the way for the emergence of industrial capitalism and how it reflected the progress of the natural sciences as a practical activity of the bourgeoisie (Uranovsky, 1935). Turning to the field of agriculture, he highlights the developments promoted by chemists such as Sir Humphry Davy and Justus von Liebig in the development of fertilizers and other agrochemicals, laying the foundations for a rational organization of agricultural production.

However, the rich debate over the character of 'capitalist science' and of 'revolutionary science' would suffer a significant setback with the 1936-1938 purges promoted by the command of Joseph Stalin. Isolated from its own principles, 'revolutionary science' resulted in the dogmatic imposition of dialectical materialism and in an agricultural catastrophe.

Although Marxism had bad moments, it has not been refuted (Sheehan, 2017). Its proposal still provides a particular way of addressing the major challenges of capitalist societies and sets the stage for its dethroning. In particular, Marxism understands the historicity of natural sciences and is able to analyse its contradictions. In this sense, Marxists critics take the liberal critique of science further into the realm of transformation and as way to oppose capitalist science as an authority of realism (Levins, 1990).

During the 70s' and 80s' an immensity of response to the crises of capitalism began to take shape. Among them is the 'Science for the People' movement, funded in the United States of America by the late 60s', Richard Levins and Richard Lewontin were part of [55]. Agriculture was also one of the major focuses of this movement, which extended their critiques from the sphere of agricultural production into the production of scientific knowledge that supported the industrial-agricultural system.

The strategies of the movement, however, were not always the same. Three trends stood out within the critique to science: the feudal antiscience[56], the liberal critique, and the radical critique. According to Richard Levins (1990), feudal antiscience, which holistically approaches science, is too hierarchical and founded on a static holism, where things are either natural or divine. Liberal critique denounces the authoritarian way by which scientific knowledge dominates. It criticises science outcomes such its commoditization, as well as the implicit biases as prejudices of scientists and their theories (Levins, 1990). Notably, this movement had major contributions from feminists that since the 60s have been demanding their place within science. The radical critique, where Levins and Lewontin are included, was constituted by Marxists, feminists, and ecologists. According to Levins (1990), this trend included both some of the liberal critique and some precapitalist conservative critiques and a revolutionary perspective.

Marx and Engels were particular influences of this movement, as later would be accounted for by Levins and Lewontin. Marxism was fundamental to understanding the knowledge changes promoted by the revolution in genetics. Marxism, Levins and Lewontin stated, provided the instruments to understand science as "part of the growth of generic human understanding and as the historically bounded creation of a particular class society" (Levins, 1990, p. 112). Likewise, "Marxism has been most successful when it has provided self-consciously dialectical insights that have helped us think about science and scientific problems" (1990, p. 113).

---

[55] More recently, in 2015, the movement has re-emerged at the hands of a critical new generation. However, despite still being very focused on the United States, during my stay in Mexico I had contact with a group of young people who organized themselves around the name, symbol, and principles of the movement. Whether they are in articulation with the North American movement or not was an unexplored question. (see Science for the People new website: https://scienceforthepeople.org).

[56] Feudal antiscience coexists with high-tech rationality. Although both seem to belong to two distinct worlds in reality they are intimately linked. Into some extent, it has been the feudal worker that provided the path for high-tech.

2.3.2 – Counter-expertise and counter laboratories

Movements such as 'Science for the People' or the ones mentioned in the opening of this dissertation are constructed by a complex network of knowledge and political positions. Although some groups may only accept, as members, people with training in sciences, others have created forms of organisation that also integrate local knowledge. Even though the story of these movements is yet to be seriously analysed[57], less attention has been paid to the role of counter-expertise and counter laboratories within and outside these movements (Frickel & Gross, 2005).

I refer directly to laboratories because scientific laboratories are spaces where ideas are bound to their material existence. Within the laboratory, the researcher assembles an apparatus of machinery, protocols, and methods that are disciplinarily bounded and socially embodied in the context of the laboratory space. Like other infrastructures where labour is performed, such as crop fields and factories, a laboratory is a place that is socio-historically produced, and therefore laboratory life should be studied both as practice and as culture (Pickering, 1992). Likewise, as a particular science space, laboratories appear as places where another knowledge cannot be performed. But is this so?

According to the Oxford dictionary, Laboratory, as a word, has its origins in the early 17th century and comes from the Latin *laborare*, "to labour". *Laboratorium* was "a place to labour", where manual work was conducted. In these pre-modern laboratories, the type of work conducted was informed mainly by observing the natural world. Those who worked in these spaces were to imitate nature, trying to replicate naturally occurring phenomena[58]. Informed by artisan labour, pre-modern laboratories were tied to economic activities of central importance in the 17th-century, such as creating dyestuffs and metal extraction. Although Aristotelian philosophy informed practices, particularly the postulate that nature tended toward perfection, the work in those laboratories could only replicate nature in the shape of circumscribed activities in bounded spaces that were meant to replicate or recreate specific processes found in nature (Crosland, 2005). Over the following two centuries, the alchemists' laboratories gave way to the modern kinds of laboratory, bound to the modern changing conceptions of knowledge, and practices

[57] There are few works that analyse these movements. See: Downey, 1998; Moore, 2009

[58] These first laboratory practices are known as alchemy, and they were bound to the need to speed up the production of materials such as metals.

within the laboratory encompassed a range of procedures aimed at replicating nature and experimenting with it, downscaling natural processes to control and drive them. In other words, theory-oriented observation opened the possibility to replicate nature in an accelerated way and investigate it and transform it.

Although not all naturally occurring phenomena have been replicated in a laboratory, it is remarkable how the laboratory has gone beyond nature in creating new entities, such as new elements (e.g., transuranium elements), chemical compounds (e.g., organochlorine pesticides), and new organic beings such as transgenics (e.g., oncomouse, Bt plants). Today we have "beings" that only exist because there are laboratories. This laboratory dynamics have not only changed the realm of science, but it have also transformed our societies. As highlighted by Latour (1983), and considering that laboratories do not appear naturally, they provide an ideal for modern scientific culture, informing and informed by our society's dynamics and structural powers.

Both England and France played a crucial role in the emergence of laboratories as a legitimate place for modern scientific thought and practices (Shapin & Schaffer, 1985; Licoppe, 1996). In England, the Royal Society became a major player in promoting and supporting the new "experimental life" associated with the laboratory (Shapin & Schaffer, 1985). In France, the crown invested in creating laboratories in dedicated institutions and at universities, but Louis XIV also decreed that only certified people could have a laboratory (Crosland, 2005). This provided the opportunity for people like Lavoisier to engage in the circuits of knowledge production. In 1775, Lavoisier used his wealth to build the largest laboratory of the time (Crosland, 2005). Since then, laboratories began to be assembled in public spaces such as universities or private spaces such as the researcher's home. Researchers kept laboratory facilities in their houses, although most of them were bourgeois men for whom this was part of their leisure activity. But laboratories could be associated as well with their business interests. An example of this is Thomas Edison, who in 1886 created the first 'laboratory center' that is said to be the first private research center.

Another important feature of the laboratory is that it requires appropriate instruments and furniture. In the 16th century, the laboratory depended on artisanal labour to create and improve equipment, materials, and furniture. Today the laboratory is dependent on a set of industries dedicated to producing whatever is necessary to keep the laboratory going. Sustaining the modern laboratory's existence is an industry that encompasses a heterogeneous set of objects, systems, activities, and, of course, staff, from machinery to reagents, cleaning protocols and certification systems, energy, water and sewage infrastructures, model organisms, computers, researchers, research assistants, managers or maintenance and cleaning staff [59].

Dominique Vinck (2007) describes laboratories as active spaces. Despite being linked to society's dominant forms of organization, where "normal" science is conducted, laboratories can also be spaces of transgression (Gracia, 2019). An example of how this transgressive potential is enacted is the counter-laboratory.

Although the concept of counter-laboratory is open to multiple interpretations and constitutions, it is defined in this chapter as a space for the expression of dissident culture. To date, and with rare exceptions (Latour & Woolgar, 1986; Knorr-Cetina, 1995), the laboratory has been estranged from studies of controversies, despite its key role to understand how ideas emerge and circulate. In this context, the laboratory is more than the ground zero of knowledge production. It is a space where dissent is extended to the world of ontology and epistemology that supports the dissenting position. The counter-lab thus appears as a subversive space of science, whose purpose is to act on the daily violence generated in these spaces.

For example, since transgenics appeared, policy and regulatory actions have mainly depended on the reports and publications conducted by industry in private laboratories. Under the EU regulation 1829/2003, a company that has developed a transgenic and has the intention to place it in the market for cultivation and/or consumption must apply to a competent national authority of a member state that will forward the application to EFSA. The technical file of the application, produced by the company, is then assessed by an expert panel that reviews the company's report and considers relevant scientific literature, bio-safety research results, and knowledge gained from previous risk assessments carried out. Although it is not EFSA that authorizes transgenics, it advises the European Commission's Standing Committee on Plants,

---

[59] According to the Pharma Manufacturing (a Putman Media) website, there are 845 companies today specialized in laboratory equipment; 204 providing chemicals and raw materials; 1562 supplying the labs with manufacturing equipment and supplies; and 1238 companies registered as outsourced providers of services, such as aseptic processing, technology transfer, sterilization services, and software, among many others. In the 2019 March edition of the magazine "Chemical & Engineering News", the senior correspondent, Marc S. Reish, noticed that the top 5 firms providing life sciences and analytical instruments, in 2018, accounted for more than half of the sales of the 20 firms that C&EN tracks. "Thermo Fisher Scientific alone accounts for 23% of the top 20's instruments sales". According to the magazine Thermo Fisher Scientific 2018, instruments sales account for 6.33 thousand million dollars (which is equivalent to half of the total investment of the Portuguese government in science), and the top 20 firms account for almost 28 thousand million dollars in sales. This corresponds to 11.2 % of the Portuguese public debt. Laboratory suppliers are a vast industry, led by companies of the USA, Europe (England, Germany, and Switzerland), and Japan.

Animals, Food and Feed, which is the competent authority on approval of transgenics. However, the weight that science conducted in private spaces governed by industrial interests has in regulatory processes has been the target of social and scientific criticism.

In an article published in 2008, Sergio Sismondo, an STS scholar from Queen's University, provided a brief review of the impacts of pharmaceutical industry funding on clinical trial outcomes. According to his review, company funding is associated with published research that favors company interests, increasing the chances of pro-industry results. Research contracted by companies to assess the risks and safety of their products tendentiously pre-determines the research question and the research design, leaving little space for scientists to report differently from the expected results. In practice, the result for science is thousands of articles that, within a corporate publication scheme promoted by major publishers such as Elsevier and John Wiley & Sons, Inc., influence state of the art towards a bias of positive results. Consequently, this will influence the regulatory process (Mirowski & Van Horn, 2005; Sismondo, 2008).

In dealing with this situation, counter-experts tend to act in two ways. On the one hand, they engage in the practice of counter-assessment in the sense that they seek to verify and replicate the results obtained by the laboratory-industry, thus bringing more transparency to the research process. On the other hand, they get involved in the practice of counter-method, that is, looking for alternatives to the laboratories' protocols in order to develop forms of assessment that are more connected with the biological and social reality.

The counter-assessment practices, sometimes referred to as counter-expertise, provide society with research independent from the industrial reports embedded in an environment of increasing social mistrust of science. It must be understood not as an opposing practice but as a praxis of power formation that counterbalances industrial interests. Sezin Topçu's (2008) perspective of counter-expertise is that these groups exercise external control of the state and/or industrial research by mobilizing dissenting knowledge and audiences to establish a type of countervailing power. But, as Topçu explains, the construction of counter-expertise is a social process that redefines the dominant categories of science and is historically related to a public perception of risk and demands for environmental protection. Counter-laboratory researchers thus become social actors beyond their assigned role as scientists, watchdog groups devoted to counter-assess the private interests of industries.

Moreover, due to the character of their counter-expertise practices, these scientists engage in intense struggles over the definition and boundaries of sciences. This situation often results in the action of suppression against them (Delborne, 2005). It is within these actions of suppression that, and according to Jason Delborne, dissenter scientists are constituted (Delborne, 2005).

For Jason Delborne, an American sociologist at North Carolina State University, dissenter scientists and scientific controversies must be understood as a performative process in continuous development and not a self-given identity (Delborne, 2005). For Delborne, a scientist who abandons her field of studies due to controversial issues and applies her research efforts elsewhere is not a dissenter. Another example of a non-dissenter is a scientist that whistleblows a conflict of interests regarding science and industrial interests. From Delborne's point of view, a dissenter scientist must, first, produce new knowledge that is prevented from entering the circuits of knowledge production and circulation because it threatens the powerful interests involved, and secondly, he/she allegedly violates the structure of internal norms of scientific performance (Delborne, 2005, 2008, 2016). In this respect, according to the author, understanding dissent as performance also allows us to understand how dissident strategies represent a disruptive epistemic argument on the conventional way of considering the relationship between science and society. This thought has a Mertonian flavour, tempered by a Latourian methodological afterthought.

2.3.2.1 - The Molecular Genetics, Plant Development and Evolution Laboratory (Mexico)

The Molecular Genetics, Plant Development and Evolution Laboratory of the Department of Functional Ecology at the Institute for Ecology of the National Autonomous University of Mexico is one of the six laboratories in the Department of Functional Ecology, out of a total of 20 laboratories divided between 3 departments of that institute. Funding for the laboratory comes mostly from governmental sources such as Consejo Nacional de Ciencia y Tecnologia (CONACyT), Instituto Nacional de Ecologia y Cambio Climático (INECC) and from the university's own funds. Four women run the laboratory, all belonging to the Mexican National System of Researchers (SNI)[60]. One of these women is Elena Álvarez-Buylla.

I first heard about Elena Álvarez-Buylla due to her appearance in Marie Monique-Robin's 2008 documentary "The World According to Monsanto". I remember seeing her laboratory in the documentary, where she presented her findings on the phenotypic expression of genetically engineered plants when the transgene is distinctly located in the genome. Her biggest fear, at the time, was the impossibility of predicting the expression of transgenic genes after they crossbreed with local non-transgenic varieties. Since then, Elena has dedicated her work to a number of topics related to transgenics research, including GEO/GMOs maize monitoring in Mexico (Dyer *et al.*, 2009; Piñeyro-Nelson, 2009; van Heerwaarden, 2012), being this last an engagement that became a permanent feature of Álvarez-Buylla's research after the controversy that involved Ignacio Chapela and David Quist (2001).

In 2001, Chapela co-authored with Quist a controversial paper about the flow of transgenes into wild maize in the region of Oaxaca. Since the opening of the Chapela-Quist controversy (Delborne, 2005), Elena's team has been involved in further exploring Chapela's claims, which resulted in developing new approaches and methodologies for monitoring transgenic maize:

> A possible consequence of planting genetically modified organisms (GMOs) in centres of crop origin is unintended gene flow into traditional landraces. In 2001, a study reported the presence of the transgenic 35S promoter in maize landraces sampled in 2000 from the Sierra Juarez of Oaxaca, Mexico. Analysis of a large sample taken from the same region in 2003 and 2004 could not confirm the existence of transgenes, thereby casting doubt on the earlier results. These two studies were based on different sampling and analytical procedures and are thus hard to compare. Here, we present new molecular data for this region that confirm the presence of transgenes in three of 23 localities sampled in 2001. Transgene sequences were not detected in samples taken in 2002 from nine localities, while directed samples taken in 2004 from two of the positive

[60] The National System of Researchers (SNI) of Mexico was created in 1984 by the Mexican President Miguel de la Madrid. Madrid's presidency 1982-1988 is known to have initiated the widespread introduction of neoliberal reforms in the country, and the primary goal of the SNI at the time was to face the "brain drain" of Mexican researchers that have, for a long time, been leaving Mexico looking for better research career opportunities. According to Hugo Gudiño, professor of political science at UNAM, "*[e]l SNI quedó instituido como la principal respuesta gubernamental de los años ochenta para atender la problemática de sobrevivencia de la comunidad científica en el país, pero también se convirtió en piedra angular de la política científica de las décadas subsecuentes*" (p.223). Among its promoters, during the 80s, is José Sarukhán Kermez, a prominent plant biologist and ecologist, who was Buylla's mentor during her master's studies in the same decade. The SNI today has 30549 members, divided into 3 categories: a) Candidate, b) National Researcher (with 3 levels, I, II, III) and c) Emeritus. This system tends to confront the university's academic statutes, which, for example, at UNAM recognize 3 categories: A, B and C, being C the highest level. In this sense, the SNI works more as compensation system for researchers, than as a real career statute, creating a hybrid form of scientific employment that duplicates processes of career promotion.

> 2001 localities were again found to contain transgenic sequences. These findings suggest the persistence or re-introduction of transgenes up until 2004 in this area. We address variability in recombinant sequence detection by analyzing the consistency of current molecular assays. We also present theoretical results on the limitations of estimating the probability of transgene detection in samples taken from landraces. The inclusion of a limited number of female gametes and, more importantly, aggregated transgene distributions may significantly lower detection probabilities. Our analytical and sampling considerations help explain discrepancies among different detection efforts, including the one presented here, and provide considerations for the establishment of monitoring protocols to detect the presence of transgenes among structured populations of landraces (Piñeyro-Nelson *et al.*, 2009, p.1. abstract of the article).

As a scientist specialized in evolutionary ecology, Elena Álvarez-Buylla is embedded in a network of complexity that requires the assemblage of a multi-institutional interdisciplinary style of thought.

Contrary to what I was expecting, not all the laboratory team members can be defined as counter-scientists or even dissent scientists. In fact, heterogeneity is part of its strength. The engagement of multiple people with different backgrounds and assumptions about science makes the science conducted within the laboratory even more rigorous. In this sense, the balance found in Álvarez-Buylla's laboratory is coherent with her ethical appeal for a robust science and profound respect for each individual path.

Another defining feature of Álvarez-Buylla's laboratory research is that it is based on fundamental science (or basic science) in articulation with practical uses. Research along these lines is conducted to understand the mechanisms and processes that occur at the plants' genetic and molecular levels. With more than 60 publications related to dynamic genetic networks, Álvarez-Buylla is robustly placed in a leading position in research on genetic expression from epigenetics and complex network models.

> Evolutionary biology is largely concerned with the patterns of heritable phenotypic variation within populations and its dynamics during long transgenerational time periods. Historically, population-level models in evolution have been developed under certain simplifying assumptions. Two salient assumptions are: 1) the idea of genetic change as a direct indicator of phenotypic variation, and 2) the additivity of genetic effects on the phenotype. A more faithful model of biological evolution should explicitly consider a genotype-phenotype map and back mediated by a developmental mechanism, which specifies how phenotypic variation is generated in different environments, in an analogous way to that in which positional information emerges as a result of the feedback between internal and external restrictions. A dynamic non-linear perspective is thus mandatory to understand how phenotypic variation is generated given a genetic background; or in other words, to study the mechanistic basis of the genotype-phenotype map within an ecological and evolutionary context. The field that focuses on this is Ecological Evolutionary Developmental Biology (Eco-Evo-Devo) with a systemic approach and, in Mexico, it is an emergent field (Álvarez-Buylla *et al.*, 2017, p.14, abstract of the article)

However, her approach does not only follow the mainstream of evolutionary science, it also accounts for a proposal such as the Ecological Evolutionary Developmental Biology (Eco-Evo-Devo), which resulted from decades of critiques of the gene-centric approach (Lewontin, 2001). Eco-Evo-Devo is today a way of studying the relationship between genes, developing organisms, and the environment. (Gilbert & Epel, 2015). But the novelty of Eco-Evo-Devo is that it integrates the socio-ecological context of local knowledge and practice into its research efforts (Levins, 2015; Benítez, 2018).

2.3.2.1.1 – Inside and out Álvarez-Buylla's laboratory

I did not really know what I was expecting by going to her laboratory. For a long time, I had followed Elena Álvarez-Buylla 's work, scientific publications, and scientific activism [61], but I was curious to know if there was anything different happening inside her laboratory. I also believed that I would have some kind of advantage as an ethnographer because I have been socialized in laboratory practices [62]. Maybe it was like riding a bike, I thought! I never considered that my recent socialization in the social sciences would interfere with my ability to see what was going on inside the lab. In my mind, I was more concerned about doing everything correctly from the point of view of ethnography (e.g., minimize the disruption of my presence), than worried about my inability to understand what was happening.

I put on a blouse that I bought to meet Elena Álvarez-Buylla 's team, and I went to the laboratory[63]. When I arrived, it was just like any other laboratory. Individual workbenches, shared equipment space, drying oven, washbasins, centrifuges, pipettes,

[61] In 2006, Álvarez-Buylla co-founded the *Unión de Científicos Comprometidos con la Sociedad*, a Mexican non-profit organization formed by initiative of a group of scientists from diverse disciplinary fields. Álvarez-Buylla was sure that the Mexican scenario regarding struggles for social-environmental justice needed an organization of scientists willing to assume their socio-ethical responsibilities.

[62] Between 2010 and 2011 I conducted laboratory research for my master's thesis in Environmental Engineering, at the Universidade de Trás-os-Montes e Alto Douro. My thesis, "Quantificação da actividade colinesterásica no cérebro e valores morfométricos em *Alectoris rufa*. [Quantification of cholinesterase activity in the brain and morphometric values in *Alectoris rufa*]" was the result of my laboratory work both at UTAD an CIIMAR. This work was surpervised by José Manuel de Melo Henriques de Almeida and Lúcia Maria das Candeias Guilhermino.

[63] I put on a blouse and not a white coat because the work that I was going to conduct inside the laboratory was separate from the work that the people present there were performing. On the day I got involved in the laboratory practice, I was given a white coat, and at that moment, I found myself camouflaged, not only among them but in their discipline.

pipette tips, flasks, plates, laboratory diary, equipment usage records, usage protocols, recycling, and of course, the teddy bear that holds the keys to the PCR equipment[64].

Social relations within the laboratory are smooth. People come and go quietly, smiling politely at me every time they passed by. It did not take long for the first postdoctoral researcher to ask what I was doing. I briefly explained that I was conducting laboratory ethnography and what it was about. They would smile at me and ask if I needed any help understanding what was going on around the lab. Every time, I accepted. It was just like Latour and Woolgar stated:

> If [S/]he is a fellow professional scientist working in a different field, or if [S/]he is a student working towards final admission into the scientific profession, the outsider will usually find that his interest is easily accommodated. Barring any circumstances involving extreme secrecy or competition between the parties, scientists can react to expressions of interests by adopting a teaching role. Outsiders can thus be told the basic principles of scientific work in a field which is relatively strange to them. (Latour & Woolgar,1986, p. 19).

One day Morado and Azul[65], whom I had previously met at the laboratory, passed by me, and told me they were going to the field to collect maize samples. I jumped into the car and went with them. They were collecting maize samples from some maize plantations nearby. The collection of samples takes place within the scope of the team's monitoring work on maize in Mexico. In addition to collecting the samples, classifying them, and appropriately packaging them to be transported to the laboratory, the team carries out a questionnaire whose objective is to obtain geographic, agronomic, and socioeconomic information on the families and places where the sampling takes place. All this information is later integrated into the analysis they carry out under Eco-Evo-Devo. In addition to this data, the team also chats with the producers, seeking to obtain the socio-cultural perception of maize and the impact of hybrid varieties and transgenics. Although the team members are not all trained in the social sciences, their research approach follows ethnobotanics, on the one hand, and action research, on the other.

Not long after this visit to the field, I discovered that the researchers and the maize producers were engaged in a network of "alternative food production and consumption" (Box 1). Alternative food networks (AFNs) are alternative circuits of goods that aim to break with the existing intermediaries between producers and

[64] Most natural science research laboratories have sacred objects. In other words, objects that, due to their nature, either because they are expensive or rare, or because they are used by almost all researchers, are managed in a special and careful way.

[65] Their names have been altered to maintain anonymity.

consumers (Renting *et al.*, 2003). Sometimes, these networks emerged from the dynamics of contestation over the industrial forms of food production, seeking to create new dynamics where production and consumption are associated in an organic, situated, temporal and fair way (Velicu & Ogrezeanu, 2021). By reconnecting the diversity of local-production with local-consumers, AFNs aims to overcome the impersonality of the market by promoting a position that is open to reflexivity; both on the part of the producer and the consumer (Pratt, 2007). However, and despite AFNs being a social phenomenon with more than two decades of existence, the different experiences of AFNs around the globe give them more of a heterogeneous character than a fixed one. For this reason, when talking about AFNs, we need to account for both the economic and social outcomes and the reasons why agents engage in the promotion and performance of an alternative.

Box 1: AliSa (Alimentación Sana) is a solidarity network of producers and consumers of criollo maize operating in the center of Mexico. Their goal is to support the peasants and farmers. Consumers buy their products at a fair price. Although the final price may be higher than that found in the conventional market, the price reflects the importance of traditional farmers' livelihoods and their efforts to conserve native maize in Mexico. The network is organized to minimize waste, ensuring that from harvesting to delivery of the final product there are enough buyers. The final native maize products are also free of pesticides and transgenes. This is ensured by Álvarez-Buylla's laboratory, which carries out, free of charge, periodic analyses of the maize fields involved in the network. The engagement of scientists in this network helps maintain the traditional ways of life, helping the agricultural and indigenous communities to protect their seeds and maize diversity. This makes Álvarez-Buylla's laboratory more than just a traditional molecular biology lab. It is a *response-able* laboratory, where science accounts for the continuous forms of primitive accumulation of the agricultural system, where they use their privileged position to ensure that producers have more allies to resist capital penetration.

Six months of fieldwork in Mexico left me with an amount of complex information that only finds a framework within the biological theory developed by Richard Levins and Richard Lewontin. I argue that Álvarez-Buylla laboratory follows their tradition of thought because: first, their starting point is that nature is historical, and such history is dialectical to human history. In this sense, nature's complexity is analysed with the complex relations that humans established among themselves and with nature. This frames a vision that nature is already socialized, and therefore, the synthesis of this dialectical relation is ecohistorical formation (Levins, 1990). Second, such ecohistorical formation which can be understood as a systems theory result in a study of "historically evolved wholes defined not by a systemwide goal but by the structuring of complex mutually determining, reinforcing, and contradictory processes" (1990, p.120). The explanation resides not on hierarchical structures of individual parts but in the whole (1990). Third, and finally, Álvarez-Buylla laboratory practices account for the reproductive dimensions of nature and societies. Such reproductive dimensions refer to the roles that gender plays within the agrarian systems, therefore their contribution to evolution and to the aspect of matter conservation.

2.3.2.2 – Comité de Recherche et d'Information Indépendantes sur le Génie Génétique - the laboratory without walls

Founded on June 1, 1999 CRIIGEN (Comité de Recherche et d'Information Indépendantes sur le Génie Génétique) intended to create a structure that would provide French society with independent research and counter-expertise on GMOs. A few days later, on June 25, 1999, France and Denmark, Italy, Greece, and Luxemburg stopped the authorization for the culture and marketing of new GMO plants.

Due to the co-dependency relationship between GMO crops and pesticides, CRIIGEN encompasses in its counter-expertise activities the risk assessment of these agrochemicals, focusing mainly on their impact on animals and environmental health (Séralini *et al.*, 2007; Le Curieux-Belfond *et al.*, 2009; Vendômois *et al.*, 2009; Clair *et al.*, 2012; Séralini *et al.*, 2012; Defarge *et al.*, 2018; Mesnage *et al.*, 2020). This has turned CRIIGEN into one of the leading European voices advocating for better and more robust assessment protocols that consider the relationship between these two products (Mesnage *et al.*, 2016).

Constituted under the French law of associations, known as the 1901 law, CRIIGEN is composed today by many different people covering a variety of forms of knowledge and expertise. According to CRIIGEN's website and informative publications, they are an international (from France, Switzerland, Italy, and non-EU countries) and interdisciplinary group of experts with different scientific backgrounds (e.g., biology, biochemistry, medicine, agricultural sciences, law, sociology).

CRIIGEN currently has 27 members. Seven are women (five on the administrative board and two on the scientific board). It is a small structure that intends to remain so, as they never envisioned to become a big organization with hundreds of members. Over the years, CRIIGEN has had a balanced membership. People who joined CRIIGEN were known to the members, and they were invited or applied to join. The general assembly decides to accept a new member. But because being a member of

CRIIGEN requires some time to spend on its activities, some members have left for professional or personal reasons.

All these people have their employment or are owners of their businesses or pensioners. 67% of the members work in public research institutions or as professors or researchers at public universities. The majority have a stable job, but younger members are mostly under precarious labour conditions at their institutions, making them more vulnerable to suppression under scientific controversies. As a senior member told me, “There are brave young researchers who have everything to lose by being a counter-expert when it comes to their scientific careers” (CRIIGEN member, 2018). Furthermore, not all members of CRIIGEN are scientists. In fact, to be a member of CRIIGEN, a person does not need to be a scientist or have a degree but just possess practical, valuable expertise and express commitment to the organization's goals.

CRIIGEN's governing structure is divided into two boards. A president and a vice-president constitute each board. The administrative board also has two treasurers and one secretary, while the scientific board has one project manager. The only structure of CRIIGEN that requires a scientific degree, and some level of scientific expertise, is the scientific council. This is also a structure that works horizontally. Although a president and a vice-president exist formally, the scientific council has a horizontal mode of functioning in practice. Within this structure, research lines are discussed, the projects are planned, and the scientific work is organized. This structure also functions as a network of experts who share their data and results, ask for peer opinion and advice.

CRIIGEN holds yearly general assemblies to approve and determine their subsequent activities and share ongoing work. According to its members, CRIIGEN assemblies are an important moment in the democratic life of the organization. As a member shared with me, there are internal clashes regarding scientific knowledge and approaches, which are debated in the scientific council and in general assemblies. These clashes result from having a variety of people from different sectors of activity and disciplinary backgrounds. Although most members have a Ph.D. in biology, there are also medical doctors, biostatisticians, lawyers, sociologists, economists, and farmers, constituting a heterogenous group that, despite their different disciplinary perspectives, respectfully share their ideas, resulting in an enriching experience for everyone.

According to one of its members, "CRIIGEN is [politically] neutral because it's the sum of a group of people who do not have the same opinion on everything. People are not neutral" (CRIIGEN member, 2018). All these people work to the best of their abilities to provide society with research and information independent of corporate economic interests. They conduct research, and communication actions, such as conferences, workshops, opinion articles in newspapers and magazines, participation in tv shows and radio interviews. They seek to inform the public on the state-of-the-art regarding transgenics, pesticides, and endocrine disruptors while putting pressure on the scientific community and the regulatory processes to adopt complementary analyses and foster the long-term study of the effects of the products of genetic engineering.

2.3.2.2.1. - The laboratory-network

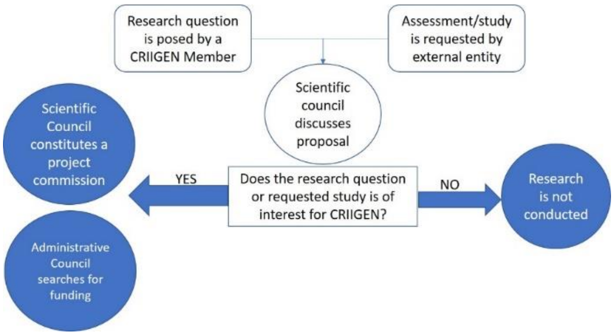
In a book published in 2016, Sun-Ha Hong and François Allard-Huver wrongly describe CRIIGEN as "Séralini's independent lab at the University of Caen". Although the attempt is genuine, it could not be further from the truth. CRIIGEN does not have its laboratory facilities. Laboratory work, under CRIIGEN, is mainly conducted in two ways. The first regards the research conducted within its members' laboratories, at their research institutions. The second way refers to the research carried out through subcontracting specific analyses[66]. Within CRIIGEN laboratories, scientific life is not different from "normal science". So, what differentiates CRIIGEN research?

What differentiates CRIIGEN's research and its laboratory life is not so much the ritualistic work of the experiments but how the specific investigation is decided. As one of its members told me, CRIIGEN's research is not commanded by a technoscientific perspective. What commands CRIIGEN research in the deep commitment to the future generation and the goal of promoting environmental protection.

According to its members, the way research questions are decided allows them to conduct robust scientific research and risk assessment with social significance. Because CRIIGEN research does not follow pre-determined industrial methodologies, protocols, or techniques of risk assessment, the result of their work is more than just another laboratory analysis. For its members, CRIIGEN research has social value and is intended to answer society's critical questions regarding healthy food and sustainable food systems. The process of research decisions has been described to me in the following way:

---

[66] This type of subcontracting scheme is not exclusive from CRIIGEN. Also PTF (Plataforma Transgenicos Fora) conducted a research during 2018, regarding presence of glyphosate in urine. More information at: https://www.stopogm.net/category/pesticidas/



"[…] while in "normal science," we look for funding (State funding/European Commission), and then we write a project according to the scope of the call, in CRIIGEN we write the project and then look for the funding. It is research that orients the money and not the money that orients research […]" (CRIIGEN member, 2018). It has also been reported to me that civil society or companies may address CRIIGEN, requesting the detection of glyphosate (or transgenics) or analysis of their products. Before CRIIGEN researchers take care of the research design, they debate the social importance and relevance of the request. If the request has social value, CRIIGEN accepts the proposal to conduct the analysis. If the request only has value for the entity that presents it or favours commercial interests, CRIIGEN rejects it.

These assessments are made under a contract between the entity and CRIIGEN. Because CRIIGEN does not have its laboratory, the scientific commission first establishes whether the laboratories of its members have the technical capacity to conduct the research. If not, CRIIGEN subcontracts external laboratories to perform the analysis. However, research design and sampling and data analysis and conclusions are performed by the research members of CRIIGEN and supervised by the Scientific Council.

Among the expertise requests that CRIIGEN has responded to, we find that in 2009 they conducted a counter-expertise review on transgenic salmon's health and food risks from the AquaBounty Technology Society, a Canadian Government Research Project (Le Curieux-Belfond *et al.*, 2009). Also, in 2009 and 2016, CRIIGEN ran a project on behalf of Greenpeace and the Supreme Court in India regarding BT eggplant (Séralini, 2009) and transgenic mustard.

Like all scientific research, CRIIGEN's work may contain some limitations or bold conclusions, but these are due more to the constraints and requirements of the publication process than to any bias towards political or corporate private interest. As one of its members told me, "[…] the most exaggerated conclusions are a result of a need, imposed by publishers, of having an investigation that has some kind of novelty" (CRIIGEN member, 2018).

The analysis of CRIIGEN publications, as well as the public interventions of their members, reveal that CRIIGEN work *praxis* engages the complexity of GEO's/GMOs' issues. Likewise, CRIIGEN provides an assessment of the safety of transgenics and pesticides by conducting research independent from industrial interests, re-analysing data obtained from the industry through court actions, and suggesting methodological, protocols, and regulatory improvements based on transparency.

> In summary, **decisions about aquatic GMOs should follow some important general principles, starting with transparency with respect to projects, procedures, results of experiments, and decisions**. Guarantee of independent expert controls is necessary to assure and maintain citizen confidence in the evolving capacities of public evaluation and control. Other important aspects include implementation of the precautionary principle, adoption of a transdisciplinary, integrated and ecosystemic approach, and evaluation and monitoring of long-term effects of aquatic GMOs. Further, evaluation should concern not only scientific aspects of aquatic GMOs but also alternatives to this new technology, benefits and costs, and broader social aspects, including availability of information for consumers, and issues of concern in North–South and West–East relations. If aquatic GMOs are authorized, environmental monitoring, traceability and labelling for consumers appear to be unavoidable steps towards social acceptability if the citizens are included in the decision process. (Curieux-Belfond *et al.*, 2009, p.184. Author's emphasis).

> **We call for more serious standardized tests** such as those used for pesticides or drugs, on at least three mammalian species tested for at least three months employing larger sample sizes, and up to one and two years before commercialization, for GM food or feed specifically modified to contain pesticide residues. **We also call for a serious scientific debate about the criteria for testing significant adverse health effects** for pesticides or chemicals, but overall for GM food or feed products, such as MON 863. (Séralini *et al.*, 2009, p.442. Author's emphasis).

> In conclusion, our data presented here **strongly recommend that additional long-term (up to 2 years) animal feeding studies be performed in at least three species**, preferably also multi-generational, to provide true scientifically valid data on the acute and chronic toxic effects of GM crops, feed and foods. Our analysis highlights that the kidneys and liver as particularly important on which to focus such research as there was a clear negative impact on the function of these organs in rats consuming GM maize varieties for just 90 days. (Vendômois *et al.*, 2009, p.718. Author's emphasis).

> As a conclusion, we call for the promotion of transparent, independent and reproducible health studies for new commercial products, the dissemination of which implies consequences on a large scale. Lifetime studies for laboratory animals consuming GMOs must be performed, by contrast to what is done today, like the two-year long tests on rats for some pesticides or some drugs. Such tests could be associated to transgenerational, reproductive or endocrine research studies. And moreover, shortcomings in experimental designs may raise major questions on other chemical authorizations. (Vendômois *et al.*, 2010, p.597).

> We can conclude, from the regulatory tests performed today, that it is unacceptable to submit 500 million Europeans and several billions of consumers worldwide to the new pesticide GM-derived foods or feed, this being done without more controls (if any) than the only3-month-long toxicological tests and using only one mammalian species, especially since there is growing evidence of concern (Tables 1 and 2). This is **why we propose to improve the protocol of the 90-day studies to 2-year studies with mature rats, using the Toxotest approach,** which should be rendered obligatory, and

> including sexual hormones assessment too. The reproductive, developmental, and transgenerational studies should also be performed. The new SSC statistical method of analysis is proposed in addition. This should not be optional if the plant is designed to contain a pesticide (as it is the case for more than 99% of cultivated commercialized GMOs), whilst for others, depending on the inserted trait, a case-by-case approach in the method to study toxicity will be necessary. (Séralini *et al.*, 2011, p.9. Author's emphasis).

> To address these challenges, we propose a European Network for systematic GMO impact assessment (ENSyGMO) with the aim directly to enhance ERA and post-market environmental monitoring (PMEM) of GM crops, to harmonize and ultimately secure the long-term socio-political impact of the ERA process and the PMEM in the EU. (Graef *et al.*, 2012, p.74 abstract of article)

CRIIGEN's re-analysis and re-assessment of industrial publications seem to disturb industrial interests, as demonstrated by the recently declassified documents made public during litigation, known as the Monsanto Papers.

Among the many e-mails that regarded Séralini *et al.*, 2012 study, Monsanto employees accused the retail companies Carrefour and Auchan of orchestrating the conclusions based on their support to CRIIGEN and Séralini's study. This connection has fed various blog posts and GEO/GMO-friendly websites, such as 'Genetic Literacy Project | Science not Ideology', resulting in accusations about how these companies promote greenwashing of GEO/GMO-free demands. They implicitly say that the private interests of these companies instrumentalized CRIIGEN. Although CRIIGEN members reject such accusation, particularly that funding by these companies influenced the research process and its results, given the corporate dynamics in the food sector, it is impossible to ignore the presence of big corporations also engaged in the anti-GMO movement.

According to Jennifer Clapp (2012), since the 70s and 80s, agricultural input corporations have fostered the agro-industrial model. During the 90s, grocery retail corporations also began to go global, increasing their economic activity both at processing foods and direct acquisition of goods. Together, says Clapp, these corporations have shaped the food markets to their interests. The progressive growth and concentration of retail food firms gave them the "power to drive down prices of their suppliers and edge out competitors to build their own customer base further" (Clapp, 2012, p. 111). Moreover, the three major corporate agents that today determine the agro-food industry are seeds and agricultural inputs – food processing – food retail, engaged in commercial alliances and competitions. As Clapp stated:

> Competition between the segments of the agrifood sector became especially apparent in the late 1990s over the issue of GMOs. As this new technology was promoted by the agricultural input industry, the rapidly expanding grocery retail sector, at least in Europe, did not follow suit. Picking up on rising consumer concern about the health and environmental safety of GMOs, European supermarkets in fact led a campaign for labeling of GMO food products. Because these retailers were already concentrated, it was important to them to maintain the trust and reputation they had with their consumers. This helps to explain why they fought for labeling of GMOs, which had direct implications for their share in the retail market in Europe. Similarly, traders and processors were pushed to provide information to retailers on ingredients, which put them in conflict as well with the agricultural input industry that was pushing GMOs. Competition between sectors has also become evident over the pricing practices of retailers, who have pressured suppliers in the commodity and food-processing sectors to lower their prices (as will be discussed more fully below). This practice has in fact led to increased pressure for yet more concentration in the food-processing sector. (Clapp, 2012, p. 112-113)

Both competition and alliances constitute the commercial relationships that allow these industries to control agri-food. Their power rests both on their capacity to set prices, set standards for production, processing, and distribution, and influence public policy and regulations, all for the sake of their dominance (Clapp, 2012). CRIIGEN, particularly Eric Séralini, are well aware of the market dynamics in which their work is inscribed.

In a book published in 2013, Séralini states that “Large-scale distribution can thus pose as a promoter of sustainable development.” (Séralini, 2013, p. 97) And he adds: “Large retailers are therefore an economic actor aware of the issue of food safety, partly out of fear of the repercussions (legal and financial) that other health scandals would have on them, partly out of opportunism or interest, of course.” (Séralini, 2013, p. 101. Author’s translation)[67]. For Séralini, the role that retail companies have, not only in orienting production but also as actors in promoting food security and consumers' health has always been clear. When facing economic giants, such as pharmaceutical, chemical and seed corporations, some strategies begin to include alliances with actors whose size can provide counter-influence to some of the hegemonic powers of agribusiness, even if they are part of such business.

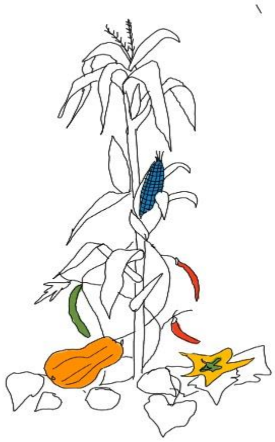
In sum, CRIIGEN’s independence is understood as an opposition to the industrial interests of biotech corporations driven by the market's competitive rules and laws of surplus-value production and capital accumulation, which have influenced scientific research and scientific literature for decades. In other words, they do not

[67] Translated quotation that appeared in the chapter:

“La grande distribution peut ainsi se poser en promoteur du development durable” (Séralini, 2013, p. 97) adding “La grande distribution est donc un acteur économique sensibilisé à la question de la sécurité alimentaire, en partie par crainte des retombées (juridiques et financières) qu’auraient sur elle d’autres scandales sanitaires, en partie par opportunisme ou intérêt bien entendu” (Séralini, 2013, p. 101).

conduct profit-oriented research, even when research is funded by companies such as Carrefour. None of their publications or public interventions endorse any Carrefour product or promote any advocacy favoring Carrefour or other private companies. Moreover, a close look at CRIIGEN's publications reveals that their conclusions are cautious when judging the level of danger of GEO/GMOs. Their research often highlights not the danger of the products but the bias existing within the current assessment protocols and how current state-of-the-art and research conducted by industry does not allow the inference of the safety of GEOs/GMOs. In this sense, CRIIGEN has always been more than just a group of scientists doing counter-expertise. Its founding members reveal the political, economic, and social complexity of the debate on transgenics, that can be framed within the liberal tradition, even when we consider that some of its members mobilize both precapitalist criticism and revolutionary perspectives.

The liberal traditions in which CRIIGEN inscribes its actions alerts for the failed promises of GEOs/GMOs and attempts to solve the scientific failures associated. In a larger picture, CRIIGEN criticism of GEOs/GMOs refers most directly to science as a private interest. Their voices are then counter voices that try to democratize science and push forward liberal critics. However, their approach to the subsumption of science under capitalism is not one of revolution but of reform. Meaning, CRIIGEN members do not attempt to build a new science. Instead, they work to reform the current system in a more liberal democratic, transparent, sustainable, and just way.



2.4 – Conclusions of Chapter II

As I tried to demonstrate throughout this chapter, and in order to understand why the majority of scientists did not understand Álvarez-Buylla's 'chulel', *science* is the historical product of the progressive subsumptions of scientific labour under capitalism. A subsumption heightened by neoliberal politics that has furthered the artificial division of 'scientific knowledge' into practice (technology and markets; private initiatives) and theory (reproduction and labour; public initiatives), thus further promoting the alienation of scientists from their work and the reinforcement of the already unprecedented gap between scientific expertise and popular culture[68]. This increasing disassociation from society and the divisions within science, associated with its massification, resulted in an even more divided type of scientific labour, which can only be considered useful when combined, under strategic cooperation, with other subdivisions in the larger industrialized institutions of science (García-Barrios *et al*., 2008; Gorz, 1976). As noticed by Gorz in the 70s, this new scientific expertise became so atomized that it was impossible to integrate its components into a larger culture, besides the corporate culture (Gorz, 1976). The illusion was sold to us and today we are all imitators of Icarus.

Likewise, the gap between science and society is a requirement of today's neoliberalism. Only by ensuring that laws of science and political economy are two incommensurable things, is it possible to deny scientists their capacity to directly act upon political decisions while making instrumental uses of reason to justify political decisions. As pointed out by Habermas (2011), as rational uses of the productive forces increase in efficiency, science and technology no longer act as informers of political decisions but become the basis for the legitimation of politics.

In the face of these transformations, it becomes almost impossible to act on the current system only from positions of critical rhetoric, or exclusively mobilized in alternatives produced outside the scientific system. The current structure of global modern science demands that strategies are found that mobilize both more reformist perspectives and more utopian and revolutionary visions, where the need for involvement with local knowledge is a *sine qua non* condition for both.

---

[68] According to Petrović (1991b), alienation is always self-alienation, meaning an "alienation from historical created human possibilities, especially from the human capacity for freedom and creativity "(p.14), and this is the very essence of alienation (p.11). Yet, it can only be overcome by adequately knowing it.

This page intentionally left blank

Chapter 3 – The violence of subsumption

How about if we rave for a little while // How about we fix our eyes beyond the infamy // To imagine another possible world? // The air will be cleaner of all the poison that // Do not come from human fears and human passions. // On the streets, cars will be crushed by dogs. // People will not be driven by cars // Nor will they be programmed by the computer.// Nor will they be bought by supermarkets // Nor will they be watched on TV // TV will no longer be the most important member of the family, // It will be treated like an iron // Or a washing machine. // Will be incorporated into penal codes // The crime of stupidity for those who commit it // For living just to have something to earn // instead of simply living// How the bird sings knowing it sings // And how a child plays without knowing he is playing. // In no country will young people be arrested // for refusing military service// If not those who want to serve you. // Nobody will live to work. // But we will all work for a living. // Economists will no longer call // from standard of living the level of consumption // And they won't even call the quality of life // The amount of things. // The cooks will no longer believe // that lobsters like to be boiled alive. // Historians will not believe that countries love to be invaded. // Politicians will not believe that the poor // Delight in eating promises. // The solemnity will no longer believe that it is a virtue, //And no one, no one will take anyone seriously who are not able to laugh at themselves. //Death and money will lose their magical powers // And neither by death nor by fortune // He will turn the scoundrel into a virtuous gentleman. // Food will not be a commodity // Not even communication a business // Because food and communication are human rights. // no one will starve // Because no one will die of indigestion. // Street children will not be treated as if they were garbage // Because there will be no street children. // Rich kids won't be like money // Because there will not be any rich kids. // Education will not be the privilege of those who can afford it // And the police will not be the curse of those who can buy it // Justice and freedom, Siamese sisters // doomed to live apart // They will come together again, very close, // Back to back. // In Argentina, the mad women of Plaza de Mayo // Will be an example of mental health // Because they refused to forget // The times of obligatory amnesia. // Holy Mother Church will correct // Some errata from the Taboas of Moses, // And the sixth commandment will command to celebrate the body. // The Church will dictate another commandment that God had forgotten: "You will love nature, of which you are a part" //The deserts of the world will be reforested // And the deserts of the soul // The desperate will be expected // And the lost will be found // Because they're the ones who despaired of waiting too long //And they got lost because of so much searching. // We will be compatriots and contemporaries //of all who have // The desire for beauty and the desire for justice // were born when they were born // have lived where they have lived // without caring a bit // The boundaries of the map and time. // we will be imperfect //Because perfection will remain the boring privileges of the gods // But in this world, bumbling and fucked up, // we will be able // To live each day as if it were the first // And each night as if it were the last.

Eduardo Galeano

3.1 – Introduction to Chapter III

My inquiry into violence comes as an attempt to understand how we can explain, on the one hand, why proposals made by scientists like Elena Álvarez-Buylla are received with a Schwarz-type of hostility, thus making them the target of suppression, and on the other hand, connect such hostility to the multiple and structural forms of the violence promoted by GEOs/GMOs. For that, I must explain both the forms of violence that ensue within the modern scientific system and the forms of violence that the system imposes on the world, framed here within the GEO/GMO controversy.

Within the modern scientific system, I propose to highlight two forms of violence. The first is considered as implicit violence of scientific practice subsumed under capitalism. Such violence is often abstract, unconscious, and invisible and acts on the matter and thought. It relates to the coercive forces of capitalism but lives above all from the moral absolutes of the Enlightenment (Strevens, 2020). To further explore this form of violence, I will mobilize Adolfo Sánchez Vázquez's work (2013). The second will then explain the forms of violence used against scientists who, like Elena Álvarez Buylla, seek to build other paths to *science*. For this subject, I will engage with Brian Martin's, and Jason Delborne's work on suppression and dissent studies, as well as with the stories of suppression that emerged during my fieldwork between 2018-2019 (Martin, 1992, 1996, 1997, 1999; Delborne, 2005, 2008, 2016)

Regarding the forms of violence that GMOs impose on the world, and considering them as historical, heterogeneous, and situated, I will draw my arguments based on work such as that of Ravi Rajan (2001) and Vanda Shiva (1993a, 1993b, 1994). More specifically, Rajan's work "Toward a metaphysic of environmental violence: The case of the Bhopal gas disaster" (2001) provided the pathways to analyse several testimonies that took place at the International Monsanto Tribunal, thus enabling the identification of three forms of violence directly related to GEO/GMO: violence on the right to dream, the violence of structural ambiguity, and the violence of stupidity.

The International Monsanto Tribunal (IMT) was an *Opinion Tribunal* held at The Hague in October 2016.[69] When national or international laws fail to address major

[69] The Monsanto Tribunal took place in 2016, having its result presented in 2017 by the collective of judges. Five judges delivered a legal opinion and concluded that Monsanto's (now, Bayer's) activities have a negative impact on basic human rights. Better regulations are needed to protect the victims of

human rights violations, Opinion Tribunals emerge as a "determination of civil society" (IMT, Advisory Opinion, 18 April 2017, p. 9). As described by the promoters of the Tribunal:

> […] An Opinion Tribunal is neither an ordinary court that falls within the judicial order of a State, nor a court set up by an international organization. […]. It follows the long tradition of opinion tribunals created in 1966 under the impetus of the philosophers Bertrand Russell and Jean-Paul Sartre and whose principles are well-known. In 1979, at the initiative of the senator and theorist Lelio Basso, the Russell-Sartre Tribunal extended into the Permanent Peoples' Tribunal. […] Opinion tribunals are tasked with examining, using a judicial method, the rule of law applicable to highly problematic events or situations which directly affect and are of serious concern to people or groups of people as well as to society as a whole. Their objective is twofold: alerting public opinion, stakeholders and policymakers to acts considered as unacceptable and unjustifiable under legal standards; contributing to the advancement of national and international law. (IMT, Advisory Opinion, 18 April 2017, p. 9)

During the hearings, the five judges that composed the court listened to more than 25 witnesses that accounted for the nefarious impacts of Monsanto's activity on human and environmental rights, including the freedom of scientific research. I was present during the hearings as a volunteer and an activist.

The IMT was an intense experience, and we all worked tirelessly to make IMT possible. Not only did it take more than a year to establish the Tribunal and a fierce global coordination effort, but the process also mobilized the most prominent figures in the resistance to the big biotech corporations. People such as Marie-Monique Robin, Vandana Shiva, Corinne Lepage, Shiv Chopra, Nnimmo Bassey.

Parallel to the Tribunal, movements from all parts of the world set the stage for a global People's Assembly. This Assembly was established in parallel to the IMT in order to set a stage for another form of Justice to be performed. One that relies more on the ethics of the collective and not so much on the instruments of the law of the State. Together, these two spaces reclaimed and reinterpreted the concepts of Justice, which deserve to be mentioned, even though it is not specifically discussed in this dissertation. Overall, the following reflections thus result from my engagement in preparing and organizing these two moments. Yet, considering the richness and complexity of both spaces, even my accounts will fall short of what we all experienced and achieved in those

---

multinational corporations. International law should be improved for better protection of the environment and include the crime of ecocide.

A further analysis of the International Monsanto tribunal has been co-developed with my good friend and colleague Sérgio Martín Arguello. The analysis was published in 2016, in the May edition of Le Monde Diplomatique – Edição Portuguesa (pages 14-15). A copy of the article is included in the annex to this dissertation.

days. Other reflections on the matter can be found in Afonso & Belaidi (2018), Gerber & Rössler (2018), Busscher *et al.,* (2019), Prete & Cournil, (2019).

To avoid any unnecessary exposure of the suffering depicted by every testimony, I will try to keep the reproduction of the testimonies to its pragmatical objectives.[70] Hence, I will directly address three forms of violence that I have identified during the hearings.

However, before we start, I must frame the concept of violence that I will mobilize within some of the significant contributions to its understanding. This exercise will allow me to explore the hypotheses raised at the beginning of this dissertation, that the violence reported in the fields is deeply connected with the coercive forces that subsume science under capitalism and that such violence is met with resistance opening the possibility of new conceptions of science.

[70] Interested readers may access all testimonies on the online page of IMT (https://www.monsanto-tribunal.org/)

3.2. Framing violence

Dating back to mid-13th century England, violence is a concept present in everyday life.[71] According to Sousa Ribeiro (2013),

> [r]emembering that the problem of violence thoroughly permeates the world in which we live and remains an omnipresent dimension in the contemporary universe is nothing more than repeating a commonplace (Sousa Ribeiro, 2013, p. 7. Author's translation) [72]

Through both the direct and diffuse experience of this commonplace, violence is as much fascinating as an experience as controversial as a concept (Sousa Ribeiro, 2013). Violence inhabits a diversity of times and spaces. It is both destroyer and creator as it questions fixing the meaning of its reiteration as a commonplace.[73] Thus, repeating the commonplace of violence means that we can refer to it in situations that enhance its visibility, such as wars and revolutions, their inner history, and their diverse everyday expressions and representations. The situated and contested accounts of violence in history and social experience stand in the way of attempts to formulate a universal theory of violence.

The forms and consequences of violence were historically subjected to a range of theoretical and philosophical reflections. Authors such as Hannah Arendt (1970), Frantz Fanon (1983), Jean-Paul Sartre, Slajov Žižek (2008), Walter Benjamin (2010), Friedrich Engels (2020), Georges Sorel (2011) or Adolfo Sánchez Vázquez (2013) are among the many intellectuals that engaged this subject, proposing interpretations and explanations that attempt to bring some light to the prevalence of the phenomena of violence in our history and our exposure and vulnerability to it. However, and

[71] According to the online Etymology Dictionary, violence is a late 18th century Anglo-French concept that signifies physical force used to inflict injury or damage. Peter Imbusch, however, in his chapter "The concept of violence" reflects on the German roots of *Gewalt*, that in contrast with the Anglo-French, means both a physical assault and the authority of the state and its institutions (Imbusch, 2003, p. 15).

[72] Translated quotation that appeared in the chapter:

"Lembrar que o problema da violência permeia por completo o mundo em que vivemos e permanece uma dimensão omnipresente no universo contemporâneo não é mais do que repetir um lugar comum" (Sousa Ribeiro, 2013, p.7).

[73] Violence inhabits time in the sense that it is present in history. Violence is the past, in the present, and in the future. Violence inhabits space in the sense that it seizes physical worlds, such as land and body, but also cognition and imagination. For example, in his book *Slow Violence* (2011), Rob Nixon deals with the distribution and refraction of violence in time. He explains how violence is endowed with properties that do not act on the immediate, and whose magnitude cannot be predicted by analogies with immediate uses and expressions of violence. This means that the violent use of an instrument may reflect over time other expressions of violence that may interfere with the understanding of its origins.

considering all the efforts to study violence, most natural science approaches still reduce violence to simple linear cause and effect relations (Krasikov, 2007). For example, some approaches relate hormones to violent behaviours, while others with a more metaphysical bent see violence as a fundamental force of evolution.

Inevitably, natural sciences are prone to draw on biological determinism of human behaviour to generalize ideas over human nature, moral, political, and social behaviour. Sometimes, violence is abstracted by the natural sciences to a point where it can easily be identified with a natural force or a law of nature. This process amounts to a *biologization* of violence and offers an anchoring point for frameworks that point to the exercise of reason as a response to violence. This positioning of violence as a natural force was rejected by critical biologists such as Richard Lewontin, Richard Levins, or Peter Taylor, but also by philosophers, like Hannah Arendt:

> Nothing, in my opinion, could be theoretically more dangerous than the tradition of organic thought in political matters by which power and violence are interpreted in biological terms. As these terms are understood today, life and life's alleged creativity are their common denominator, so that violence is justified on the ground of creativity. The organic metaphors with which our entire present discussion of these matters, especially of the riots, is permeated—the notion of a "sick society," of which riots are symptoms, as fever is a symptom of disease—can only promote violence in the end." (Arendt, 1970, p. 111)

Given the prevailing epistemic hegemony of the natural sciences, particularly biology, I argue that it is crucial to address their process of constructing violence through a situated knowledge approach (Haraway, 1988). Accordingly, my inquiry on violence articulates both the exercise of abstraction made by the natural sciences with the reported forms of violence experienced by many people present at the IMT hearings.

The bias within the natural sciences to theorize violence as inescapable destiny is part of the types of problems that authors such as Friedrich Engels (2020) have addressed. In his debate with Karl Eugen Dühring, Engels tried to break the argument on which Dühring's positivism stood, that violence was a natural force. Conversely, Engels placed violence in a historical context. As an emergent phenomenon of the coercive forces of the economic system, Engels tells us that violence is a manifestation of the power created by an economic system that builds new legalities to legitimize the way productive forces are (re)organized in time and space (Engels, 2020). Hence, the idea that violence is an inherent natural force is a fallacy perpetuated by liberal ideologies and mainstream natural sciences.

For example, when looking at the theory of evolution, Darwin's concept of *competition* is often confused with *violence*. More specifically, this occurs because mainstreaming uses of the concept of *evolution* often mistake this phenomenon for one of its forces, *competition,* which is narrated in biology by extremely violent metaphors. To be fair to evolutionary theory, Darwin's concept of *competition* would need to be referred to in its articulation with concepts such as Kropotkin's *mutual-aid* and Lynn Margulis's *symbiogenesis*.

Another point to consider is that it is not just the association of *violence* with *force* that generates confusion around the phenomena of violence. The appealing association of the concept of violence with *aggression, coercion,* and *power* has also resulted in conflicting understandings of violence (Imbusch, 2003). To this matter, Hannah Arendt has made a valuable contribution (1970).

In her book *On Violence*, Arendt approaches violence from a historical perspective that tries to denaturalize it (1970, p. 91). She recognizes the instrumental character of violence and its historical context, emphasizing that modern technological progress, oriented by a "*Hobbesian natural warfare*" narrative, has produced instruments of violence that no longer represent any reasonable advantage, "*unless we are willing to commit collective suicide*" (Arendt, 1970. p. 18).

To cast some insight into violence, Arendt differentiates two essential aspects of it. The first is the difference between *strength* and *force* and the distinction between these and *violence*. *Strength*, according to her, is a human characteristic, while *force* belongs to the realm of nature. Such division between specific characteristics that belong exclusively to both realms is also proposed by Adolfo Sánchez Vázquez, who differentiates force into *forces in action* and *forces in use* (2013, pp. 446-473). The second aspect relates to her separation of *violence* from *rage*. *Rage* is a reaction to an offense to the persons' sense of Justice. But a *violent* response is not necessarily guided by emotional triggers, for the same reason that "absence of emotion neither causes nor promotes rationality" (Arendt, 1970, p. 98). For both authors *force* is not *violence*. Furthermore, Arendt asserts that although violence is used to confront or protect *power,* it is unable to create power. Power in Arendt's proposal is the property of a group that uses *strength* within personal social relations (1970, p. 65). Violence, in her view, is the degradation of power.

In *Reflections on Violence* (2011), George Sorel constructs a functionalist theory of violence linked to a proletarian morality, which ultimately seems to result in its defense. However, it is crucial to consider that for Sorel the only legitimate violence is the violence used against an oppressor, in this case, the bourgeois state. A Sorelian approach to violence must then consider that although violence seems to be the way of rupture with a bourgeois state, it involves a new conception of its means and ends, or, in other words, an *ethics of revolution* where the ends need to be alive and operative within the means. For Sorel, not all violence is justified.

Alongside Sorel, Frantz Fanon (1983) discusses how colonial violence guides the colonised subjects into a collective catharsis, exposing in this way the paradox of violence; subjects of violence find their freedom from violence by appealing to it. However, for both authors, the defence of violence appears not because it is natural but because violence is, in principle, the instrument of the oppressors. They appeal to violence not because it is in the nature of the oppressed to be violent but because it is necessary to disrupt the structural violence (Galtung, 1969) of a colonial and bourgeois state.

Within the paradox of violence, Slavoj Žižek (2008) highlights how the dialectical character of violence produces blindness among the different forms that violence can take. Juliana González (1998) concurs:

> It cannot fail to recognize that the creations of human culture also serve at times to mask, evade and hide violence; that this too can happen precisely as institutionalized violence; that there are ways to sanctify the world of mere violent impulses, to consolidate it through "noble and sublime" forms. Even the most malign modalities of violence can survive in disproportionate cultural manifestations. Morality, particularly, has been defined with frequency in history as a form of representation, cruelty and suffering, and as a constriction of life the paralysis of this in the petrification of costumers and in the escape from liberation. In this sense, morality can be a form of violence, masked or sublimated violence, but violence in the end — as it can also occur with religion, medical practices, education, etc. (González, 1998, p. 143. Author's translation)[74]

This means that the meaning of violence can be blurred when the notion of efficiency elapses the consequences of violence with the moral adequacy of means to ends (Nunes, 2001). In other words, the paradox and the blindness are the reason for the instrumental rationality of violence once God is declared dead (Muguerza, 1998). This instrumental

[74] Translated quotation that appeared in the chapter:

"No puede dejar de reconocerse que también las creaciones de la cultura humana sirven en ocasiones para enmascarar y embozar la violencia; que también ésta puede darse justamente como violencia institucionalizada; que hay maneras de santificar el mundo de los meros impulsos violentos, de consolidarlo a través de formas "nobles y sublimes". Incluso las modalidades más malignas de violencia pueden pervivir disfrazadas en manifestaciones excelsas de cultura. La moral en especial se ha definido con frecuencia en la historia, ya como forma de represión, crueldad y sufrimiento, ya como constricción de la vida o parálisis de ésta en la petrificación de las costumbres y en la fuga de la libertad. En este sentido la moral puede ser forma de violencia, violencia enmascarada o sublimada, pero violencia al fin —como puede ocurrir también con el derecho, las religiones, las prácticas médicas, educativas, etcétera" (González, 1998, p. 143) rational violence is present in the reality we construct and is reproduced by biotechnology's epistemologies and artifacts.

3.2.1 – Suppression of matter

Adolfo Sánchez Vázquez's (2013) concepts of *forces in act* and *forces in use* are central to my framing of violence. According to the author, *forces in act* belong to the natural realm, and *forces in use* belong to humankind and are present within any *praxis*. Because he asserts that nature knows no violence, violence only appears as a result of human activity. In his theory, human *praxis* entangles the formation or transformation of matter. Such (trans)formations represent the *use of force in act* to deal with the legalities (laws) of the natural and social worlds. However, according to Vázquez, *violence* does not pour directly from the uses of *forces in act*. For it to be *violence*, it must both try to dismantle the legality of the object or subject that it wants to submit to the new order and face social resistance to such an attempt.

To make his point clearer, he asserts that, although all *praxis* intends to transform the social or material order by using the *forces in act*, violence manifests itself when the social world resists such transformation attempts. Again, he makes an essential distinction between nature (opposition) and humans (resistance). In his chapter on violence, Vázquez refers to opposition as "*internal forces at act within the matter that opposes the praxis attempt to transform its legality*." (2013, p. 448) For him, this does not constitute a resistance to *violence* because the opposition of matter "*is opaque, blind and is restricted to the natural order…*" (2013, p. 448-449). Resistance, on the other hand, is a collective social action. Hence, resistance is a matter of social struggle, of social organization, of collective human construction. Thus, the cartography of GEOs/GMOs violence is also the cartography of the movements that resist such violence.

Correspondingly, the adequacy of his theory to GEOs may be formulated as follows; the species that are the object of biotechnology (such as maize) have *forces in act*. Biotechnology studies such forces in order to use them to create a new kind of organism, a transgenic, for example, which allows those who hold the means of biotechnology to impose new legality in the world. However, for this to happen, the internal legality of the organism had to be submitted to a new order as well. An order where the internal limits of matter (or the *forces in act*), in this case of reproduction and expression (genotype), are overcome and replaced by one that is imposed not by nature but by a human goal.

Forces in use under biotechnology are assembled in the body of transgenics and impose new forms of production in agriculture that ensure both the survival of the new organism and a new form of production from which the owners of the biotechnology can extract surplus value (Cooper, 2008). Resistance to new forms of production on the part of farmers, peasants, consumers, and autonomous and indigenous communities, whose ways of life are profoundly altered by the new legality imposed by transgenics, allow exposing the violence of the new organisms (the mean) and the purposes for which it is intended (the ends).

3.3– The violence of GEOs

3.3.1 - From Hybrids to Transgenics: escalating violence

The emergence of transgenics applied to agricultural practice happens due to the appearance and application of a previous ‘organism-tool’ - the hybrids (not transgenics by definition)[75]. Hybrids were central instruments of the green revolution of the fifties and the industrial hegemony of the United States (Veraza, 2008). As seen before, hybrids are a technology that introduces a new way of saving labour force in the crop and new forms of consumption within the productive system through the use of large machinery and new forms of agricultural management. Hybrids pioneered the first form of property over seeds, which resulted in the promotion of the new legality under which organisms became homologous by international law. In *First the Seed: The Political Economy of Plant Biotechnology* (2004), Jack Ralph Kloppenburg explains the rise of the biotechnology complex through an analysis of the development of hybrid corn. His main focus is on the relationship between the success of this technological output and primitive accumulation and commodification of seeds and how these were fundamental for the subordination of agricultural systems to capitalist production.

[75] Organism-tool is here defined as an organism that has been shaped into a tool that is used by capitalism to produce and reorganize the spaces and logic of its production system in order to move forwards surplus value extraction.

Likewise, in 1993, Vandana Shiva accounted for the paradoxes of violence of the so-called Green Revolution in her book *The violence of the Green Revolution. Third World Agriculture, Ecology and Politics*. Although the world experienced a set of agricultural improvements that have resulted in abundance, mainly in countries of the Global North, other regions of the world, such as Punjab in India, experienced a wave of economic, environmental, and social destruction. Also, one of her multiple accounts of violence focuses on seeds.

Until the Green Revolution, farmers worldwide were responsible for maintaining the richness and the flux of biodiversity through seed (re)production, selection, and conservation (Shiva, 1993a). But according to Shiva, the miracle seed has "shifted the traditional farming systems controlled by peasants to one controlled by agrichemical and seed corporation and international agricultural research centers". (1993a, p. 64). While the new seeds freed Indian farmers from nature as destiny, they also imposed a form of production that dried up the fields of the local varieties, replacing the entire ecology of the region with one that was capitalism designed by capitalism:

> The irony of the capital intensive, high input agricultural strategy that was initiated with the Green Revolution, and is being carried to the next stage with the biotechnology and food processing revolution, is that it generates violence and distress not only to those for whom it fails but even where it succeeds. It creates social, political and economic crisis by generating scarcity on the one hand and generating surplus on the other. The crisis of scarcity and the crisis of surpluses are two aspects of the same crisis generated by non-sustainable resources and capital-intensive agriculture. Small farmers are victims of both aspects of the crisis, in the North and in the South, in industrialised countries as well as in largely agrarian societies. (Shiva, 1993a, p. 224).

Moreover, the miracle seeds resulted in forms of violence such as dependence, dispossession and scarcity and have allegedly increased armed violence and suicide rates among men [76].

Together, Kloppenburg's (2004) and Vandana Shiva's (1993a) accounts frame the picture for the emergence of the phenomena of violence in biotechnology.

Whether through patents or through the biological mechanism that impedes their reproduction, hybrids generated a new 'organism-tool' capable of maintaining class

[76] I write allegedly because until now no study has been conducted on this matter. The fact that there is not, however, a study focused on the relationship between suicide and the use of transgenics should not make us ignore the multiple reports that try to account for this reality (Shiva, 1993b, 2014). Moreover, we need to address the fact that the denying of this problem is based on a view of suicide as a linear consequence of the use of transgenics.

Research conducted under the frame of masculinity studies are showing that "[…] men are almost twice as likely to die by suicide as women are… Failure to fulfill the socially prescribed role of financial provider can drive some men in the direction of self-harm and suicide." (Heilman & Barker, 2018).

division and allowing capitalists to overcome problems related to land ownership. Rather than resourcing to direct violence, such as war and militarized actions, they set the global stage for a new form of capital-oriented agriculture capable of submitting production to the command of capital.

At the same time, hybrid organisms were able to break with the dual quality of seeds - being both seed and grain -, subsuming the biology of the plants under a single conception of utility. These organisms deprive seeds of their dual quality, maintaining the grain as a way of keeping the workforce, while literally appropriating the reproduction of the production of the crop. This amounts to depriving those who work in agriculture of their means of production.

Transgenics, in turn, follow the development of those productive forces, but bring in more precision, able to connect with emergent specializations of agricultural work, creating new forms of labour division, and saving labour force applied to both cultivations and improvement of seeds. Transgenics further allowed to foster the normative and legal conditions that accelerate the interpenetration of industry and the scientific world (Garcia, 2006), while stripping from the hands of peasants the work of improving agricultural varieties. In this sense, transgenics surpass hybrids in their capacity to overcome the restriction of reproduction completely. In productive terms, both hybrids and transgenics play the role of shortening the rotation cycles of capitalism. But transgenics promote a final proletarianization of the peasantry, which no longer holds neither the means of production nor the products (Veraza, 2008).

Marx has explained how capitalists always need to revolutionize the means of production. Although this process is guided to some extent by the capitalist fetish with technology (Harvey, 2003), which induces them to continuously invest or lobby the State to invest, in the development of technological details, they all obey the fundamental tenet that the development of technologies under capitalism must never move in the opposite direction of surplus-value accumulation. As we have seen, hybrid seeds were a means of accumulating surplus-value, but biological and social factors hampered them until the appearance of transgenics (Kloppenburg, 2004). As Kloppenburg explained, the success of hybrids owes less to their self-capacity to increase productivity and more to their ability to incorporate a system of agricultural production that aimed to promote an industrial escalation of agriculture so that it could assimilate products from other industries, which after the Second World War were in a crisis of overproduction (e.g., chemical industry). This means that. the GMOs/GEOs *per se* do not lower the prices of food, but they are part of an agricultural, industrial complex, mostly known as agri-business, that transformed the tools for production and reorganized the spaces and logic of agricultural production.

As an 'organism-tool', GEOs/GMOs work to reduce the commodity prices of the raw materials needed for industry while absorbing others. As we know, the narrative of the development and production of GEOs is embedded in a worldwide scenario of hunger and climate change. Promoters of GEOs tend to explain their importance and hype the goals of GEO production as the solution for world problems, strategically leaving aside how they have introduced new forms of strategic cooperation between industries.

However, unlike hybrids, transgenics are no longer organisms specifically of one industry but belong to several. While hybrids contributed to an impasse in coordination between industries, transgenics allow the interrelationship of industries that, even when isolated by the social division of labour, are now intertwined in the overall production process. The need for transgenics thus comes from the very needs of the industries and for no other substantial reason. Most obviously not for the reasons that are usually presented. For the industries in which transgenics are not linked to food production, these organisms arise to solve the problem of shortage of raw material or save labour from the extraction of that raw material. However, in the end, the most fantastic character of the transgenics is that they incorporate in themselves the technological fetishism of which the capitalist system is dependent: the need to generate new use values for the process of capitalist accumulation (Harvey, 2003, Kovel, 2000).

4.4.2 – The forms of the violence of genetically engineered organisms

Genetically engineered organisms are 'organism-tools' inscribed in bioeconomic societies. As Melinda Cooper (2008) and José Luis Garcia (2006) described, biotechnology emerges within intense speculation about the future promoted by neoliberal ideology. In this sense, the visions of the future promoted by neoliberalism must be incorporated into the analysis of possible futures built by biotechnology (Jasanoff & Kim, 2013), mainly because these futures disregard the harmful effects of post-Fordist production and its violence.

For instance, facing the prospect of the apocalypse of climate change, transgenics are presented as a technical solution to the disappearance of arable land and biodiversity loss. So why should we oppose them? Under neoliberal biotech perspectives, opposition to GMOs is considered a crime against all humanity, and although the promoters of GEO/GMOs recognize the associated risks, the assessment of these risks is always favourable to the adoption of the technology in a deregulated form. In the face of the apocalypse, any form of violence, be it expropriation, extractivism, commodification, or other, is always more beneficial than doing nothing. The catastrophic narrative of climate changes allows for the acceptance of violence in the process. Violence is thus accepted and justified by its ends.

Accepting such violence carries a cost to human rights, which needs to be critically examined. Although the Universal Declaration of Human Rights is generally accepted, it still does not respond to situations where people find no answers in institutions that represent state law. To some extent, the universal human rights granted in response to the violence of capitalism do not respond to causes but tend to sustain the current balance of power. Entitlement to rights is based on reducing what is regarded as *fair* to an adjustment that mistakes *Justice* for *necessity*. Such rights appear as socially unjust because they seek to satisfy, not the need for justice, but the need to maintain the rule of the market and the accumulation of relative surplus-value (Benjamin, 2010, Marx, 2017b). A striking example is presented at the final hearing of the Permanent People's Tribunal: Free Trade, Violence, Impunity and People's rights in Mexico (2011-2014). Although the Right to Food is enshrined in Article 4 of the Mexican Constitution, since the 1980s governmental policies have made it almost impossible to lead an autonomous and independent way of life, forcing peoples and communities to integrate globalised agro-industrial markets (PPT, 2011, PPT-Mexico, 2012).

We then face the first form of violence of GMOs, which I have named the *violence on the right to dream*. GMOs as ‘organism-tools’ of biotech neoliberalism empty out all possible and available alternatives. This constructed emptiness of alternatives imprints violence on the right to dream, in the sense that neoliberalism, despite creating futures, is an ideology that is unable to imagine any other possibility, and much less one based on self-determination, unable to be or become (Sousa Santos, 2002).

Although the *right to dream* does not formally exist, during the hearings of the International Monsanto Tribunal (IMT), I was faced with the constant denial of those peoples’ right to dream. According to several testimonies, corporations such as Monsanto have continuously engaged in practices that have destroyed our environments and health and our collective ability to dream. For example, aspiring to a world free of pesticides is a dream that has to account for the adverse effects of the decades of use of chemicals such as glyphosate-containing herbicides. Meaning, our ability to dream of a world free of pesticides has to account for soil and water contamination, crop dependence on chemicals and the deterioration of human health exposed to these chemicals. Therefore, our dreams are conditioned by these corporations actions, even if we can get rid of them. The ongoing destruction promoted by these companies conditions our ability to dream, framing our utopias as restorative utopias (cf. Louçã, 2021).

Moreover, the denial of the *right to dream* results from the philosophical domination of TINA (There Is No Alternative) promoted by neoliberalism (Queiroz, 2018). The *right to dream* of better health, a better environment, the freedom to collectively decide the future of communities has been denied over and over again to all those who gave their testimony at the IMT. For some of them, this denial started well before the development of biotechnology, as in the case of the victims of the Vietnam war and Agent Orange (Gerber and Rössler, 2018). Likewise, TINA is enforced by means of coercion and control over the institutions of justice, namely courts. The coercive strategies use tactics that invite farmers to incriminate their neighbours when using unlicenced seeds (Bowring, 2003), while corporations such as Monsanto use law to avoid their responsibility and set agreements whose costs are always less than the costs of changing its operations.

In this sense, the nobility of GMOs/GEOs ends is a narrative that is based on fear and uncertainty. A "necessarily urgentista application syndrome" as posed by the Mexican economist Jorge Veraza (2008). Also, this use of fear to justify an end deeply affects how knowledge is produced, generating a paranoid epistemology that reproduces an extension of the politics of fear and distrust. Its consequence is the proliferation of agnotology (Proctor & Schiebinger, 2008). Then, GMOs/GEOs are not only the result of the exercise of violence over our ability to dream, but they also impose violence on the way we imagine dreaming.

The second form of violence follows the concept of *structural ambiguity*. *Structural ambiguity* is the continuous exploitation of ambiguity to advance the promoter's political position. It follows Robert Proctor's notion of culturally-induced ignorance or doubt (Proctor, 2008), but in this case it takes advantage of the uncertain ontological character of science to distinguish between what is valid knowledge and what is not. As described by David Magnus (2008), this form of violence explores uncertainty in science glorifying it to avoid the definition of a comprehensive scientific framework to, for example, assess the risks of GEOs/GMOs. Although most of the doubts cast on GEOs/GMOs indeed come from its opponents (see the testimonies of Miguel Lovera, Nicolas Defarge, Shiv Chopra, Peter Clausing, and Claire Robinson), the industry further explores doubts to cast ambiguity on the intentions of the scientists that raised the concerns. As indicated by the testimony of Claire Robinson, editor at GMWatch, during the IMT hearings, companies such as Monsanto often orchestrate defamatory public campaigns against studies that contradict its results (Cf. Castro & Serra, 2020). The companies' deceptive tactics aim to cast doubt on the credibility of counter-scientists, but this tactic only works because companies operate behind renowned scientists who "apparently" have no cross interests with the interests of the companies[77]. However, and as witnessed at the IMT, scientists who attack their counter-peers are often associated with the interests of companies, as is the case of the Illinois Professor, Dr. Bruce M. Chassy, who repeatedly failed to disclose his financial relationship with Monsanto company.

The deceptive tactics promoted by the industry aim to discredit counter-scientific research and other forms of knowledge by saying that their conclusions are value-based or non-scientific, making it seem that the knowledge positions that question GMOs are movements of technological denial. The result is that ethical principles, such as precaution, are cast as nonrational, allowing industry to push forward its "objective" agenda within the realm of scientific practices and politics. In sum, suppression of counter-science is a requirement for the use of *structural ambiguity*.

This strategy fits perfectly in a bioeconomy society that values the property form of both biological knowledge and bio-objects (Garcia, 2006). Deceptive tactics that suppress knowledge can then be mobilized to enforce arguments that GEOs/GMOs are qualitatively the same as their referent organism, but better. In this sense, I argue that such association is a *structural ambiguity* type of violence because it navigates the ambiguity of concepts, such as species, to determine an equivalence that it knows to be false but only stands as truth because counter-knowledge have been targeted by

[77] For more than a decade, investigations have been published around the world that reveal the coercive tactics of companies like Monsanto. Among them are the hiring of mercenary agencies like the Pinkenton Agency (USA) and Robinsons (Canada) to ensure producers do not re-sow seeds. They also hired the military company Academi, formerly Blackwater, to spy on anti-GMO activists. Other tactics are also described in Rick Weiss (1999).

suppression. With this strategy, the boundaries of the concepts are set to their interests while denying the possibility of others. If they are equal, then there is no controversy, or if it exists, it is motivated by interests outside the practice of biotechnology. But the fact is that transgenics and their reference organisms are profoundly different, as are the methods for their creation and the methods used for their production.

Unlike millenary practices of improvement of crop species, the production of transgenics means the creation and imposition of a new legality that is both biological and social. As Melinda Cooper stated for the case of recombinant DNA:

> Recombinant DNA (rDNA) differs from previous modes of biological production in a number of ways. First, while microbial biotechnologies such as fermentation are among the oldest recorded instances of biological production, recombinant DNA constitutes the first attempt to mobilize the specific reproductive processes of bacteria as a way of generating new life forms. Moreover, recombinant DNA differs from the industrial mode of plant and animal production in the sense that is mobilizes the transversal processes of bacterial recombination rather than the vertical transmission of genetic information. This is a technique that lends itself to the specific demands of post-Fordist production – flexibility and speed of change – to a degree that was impossible in traditional plant breeding (Cooper, 2008, p. 33)

However, we need to consider that the new legality imposed on the organisms to generate transgenics is not entirely external to them. This means that the *use of force* has a material connection with the *forces in act*, and in this sense, it is the reductionist exercise of describing the units of life as the genes and their utilitarian use that allows the subsumed science to transform a *force in act* within an organism into the *use of force* of the capitalist technoscientific apparatus.

The third form of violence I have named is *stupidity*. *Stupidity* follows David Graeber's (2016) line of thought on how bureaucracy represents a form of State control and results in routinized stupidity[78]. Stupidity, under Graeber's perspective, is the establishment of certain mechanisms that "naturalizes violence". Graeber also explains that stupidity is less a form of power and more an instrument of violence of the powerful. For him, stupidity is a weapon used against workers, routinized within the bureaucratic system, making physical violence less needed but keeping the "range and density of social relations that are ultimately regulated by the threat of violence" for capital accumulation. Stupidity is a violent instrument for constructing a self-sense of dissatisfaction - a lack of purpose and inability - that makes us believe the problem is in

[78] David Graeber's proposal seems to be influenced by the perspective of Marx Weber (2001), who characterizes bureaucracy as the use of rational ends or the use of rational means for goals that do not have rationality in themselves. On the other hand, Ernest Mandel (1992) identifies that in the capitalist economy bureaucratic institutions are the result of a combination of rationality and irrationality.

us and not in the system. In this sense, stupidity as a form of violence present in IMT is associated with bureaucracy and is close to Ravi Rajan's definition of bureaucratic violence (Rajan, 2001, p. 391-395). In the case of the Bhopal disaster, this type of violence is mainly determined by absence, in the sense that authorities fail to cope with basic human needs adequately, displaying an incapacity actively constructed by powerful interests. Therefore, the bureaucracy that appears in moments of disaster tends to mimic the ritual of everyday life governance, which includes certification forms for the authenticity of victims. This form of violence prevails in time and sometimes for long periods after the disaster or after denouncing a problematic situation (Rajan, 2001).

As was the case with Bhopal, also during the IMT we are confronted with testimonies that account for this violence. Either because there are no mechanisms to act on the chronic impacts of exposure to pesticides or the impacts of cross-contamination of agricultural fields, or due to the lack of information and consent of indigenous communities, or even the lack of mechanisms that allow for the rejection of these organisms and chemicals, the testimonies at IMT further develop how the violence of bureaucracy breeds stupidity when the bureaucratic mechanics, created in the meantime, persecute and blame the victims.

> **Patrick Moore**: I do not believe that glyphosate in Argentina is causing cancer increases. You can drink a whole quart, and it will not hurt you.
> **Journalist**: You want to drink some? We have some here.
> **Patrick Moore**: I'll be happy to actually, but not really but…
> **Journalist**: Not really?
> **Patrick Moore**: …I know it would not hurt me.
> **Journalist**: If you say so, I have some glasses…
> **Patrick Moore**: No, no, I'm not stupid.
> **Journalist**: So it's dangerous?
> **Patrick Moore**: I know that people tried to commit suicide with it and failed regularly.
> **Journalist**: Tell the truth.
> **Patrick Moore**: It is not a danger to humans. No it's not.
> **Journalist**: So you're ready to drink one glass of glyphosate?
> **Patrick Moore**: No, I am not an idiot.[79]

[79] Transcription of part of Patrick Moore's interview with journalist Paul Moreira for the documentary "Bientôt dans vos assiettes" (Soon on your plate), originally broadcast by the French TV channel Canal +. Available at: https://www.youtube.com/watch?v=QWM_PgnoAtA.

Patrick Moore is considered by Greenpeace as a spokesman for the genetic engineering industry.

3.4 – Suppression of Science

3.4.1 – From the study of controversies to dissenter studies

Scientific controversies are a noteworthy feature of the *praxis* of science. For the classical “internalist” scholars, the phenomenon of scientific controversy is seen as natural to the scientific spirit and a crucial feature of the progress of modern scientific knowledge (Brante & Eizing, 1990). Considering that each epistemic break has been entangled in scientific controversy, philosophers and historians of science have dedicated great effort and time to think about its formulations, reasons, justifications, and results. Authors such as Gaston Bachelard even suggested that science had a dual character erected on an indissoluble reciprocal interaction between experience and thought, from which epistemological breaks emerge, as a phenomenon produced by the rupture with everyday experience (Bachelard, 2006; Rheinberger, 2010). This tradition of taking for granted scientific controversies as part of the “business as usual” of science has drawn particular attention during the breakthroughs of physics in the 1920s when philosophers of science had to open for the possibility of coexistence between a “normal” science and theoretical alternatives that could even reject the most solid knowledge of the time.

However, during the 1990s, several studies began to emerge regarding scientific controversies by focusing on dissident agents revealing the violent character of suppression (Martin, 1996, 1997, 2010, 2020). For example, the work of Brian Martin, a social scientist at the School of Humanities and Social Inquiry, Faculty of Law, Humanities, and the Arts, of the University of Wollongong in New South Wales, Australia, showed that suppression, contrary to what is echoed among contemporary established views, is not unusual. On the contrary, suppression permeates the life of scientific practice when faced with dominant political, economic, and social interests. Suppression studies thus identify the internal structural power relations of the scientific system reported in the countless stories of dissent that confront private political-economic activities or interests. For example, when confronted with industrial or even some State interests:

> Most environmental scientists are afraid to take a public stand if it means appearing to challenge powerful corporations, governments or professions. They are afraid of what top officials in their organisation may think and do. They are aware of legislation which prohibits them from speaking to the media about their work without permission. They are afraid that they might be blocked from promotion, shunted to less interesting work, or even dismissed. (Martin, 1992 [https://documents.uow.edu.au/~bmartin/pubs/92habitat.html]).

However, Martin has also stressed that, although some attacks on scholars may come directly from corporations or the state apparatus, internal suppression, peer promoted, is the most substantial and most lasting form of suppression (Martin, 1997). But this suppression violates all the ‘internalist’ assumptions about the norms of science [80].

> A study of Cornell University agricultural and nutrition-science faculty and extension educators found that although almost half had environmental or public health reservations about genetically-engineered foods and crops, educators with such concerns were less comfortable in expressing their views with colleagues and other constituents than those with pro-genetically engineered food opinions. The authors suggest that those with a precautionary viewpoint toward genetically engineered foods may not feel free to express their views openly, particularly where they are seeking tenure or reappointment, out of concern over antagonizing agribusiness interests within the university." (Wilkins *et al*., 2001 apud Kuehn, 2004)

Indeed, in practical terms, suppression acts as a warning not just to the dissenter scientists but to the whole community. This coercive effect is only possible due to the asymmetries established by the hierarchical status of academic *praxis*.

In sum, Martin’s studies on the social reality of dissenter scientists allow us to identify, on the one hand, agents of power and private interests who, despite not always being visible, are involved in the production of scientific knowledge and its legitimation (e.g., through the patterns of the forms and magnitudes of suppression (Martin, 2020)). They also open up a space to give visibility to the alternative epistemic forms that have emerged and/or are already at work within these controversies. This theoretical framework, however, is only possible because of Martin's continuous collection of records of dissenting accounts and situations, which, as Bruno Latour (1987) stated, allows the sociologist to place all evidence and allegations in a situation akin to that of a trial in a "court".

3.4.2 – Some suppression stories

The two stories of suppression that I mobilize for this thesis result, on the one hand, from fieldwork conducted during 2018-2019, and on the other hand, from a situation that took place during 2016-2017 and which became known as the Monsanto Papers. In addition to these stories, which join the story of Elena Álvarez-Buylla, other reflections were published in 2020 and 2021 (Castro & Serra, 2020; Castro, 2021).

---

[80] Self-censorship became a particular feature of academic work after the end of the cold war when the concealing of the scientist's political commitment became a tendency among scientists (Kuehn, 2004; c, 2019).

3.4.2.3. – The attempts to suppress Angelika Hilbeck

Angelika Hilbeck is a renowned German entomologist and agroecologist, currently working at ETH Zürich, Department of Environmental Systems Science, who played an important role in the implementation of the United Nations Cartagena Protocol on Biosafety. Currently, she is a non-executive member of the European Network of Scientists for Social and Environmental Responsibility (ENSSER), a member of the Board of the Critical Scientists Switzerland, and a member of the scientific council of CRIIGEN.

Over the last 30 years, Hilbeck's research has focused on biosafety issues and agroecology, including environmental risk assessment of GMOs. She is also a known voice that advocates for farmer-participatory agroecology research.

Angelika Hilbeck was awakened to science through research into food production processes and the biology behind it. Born in Germany during the late 1950s, Hilbeck’s path towards the world of science comes after completing her vocational gardening course in the early 1980s. During this period, she developed an interest in the workings of food production, particularly agricultural practices, which she saw in constant evolution and adaptation and dependent on scientific research. At the same time, the German Green Party (founded in 1980) emerged in West Germany and grew to become a mainstream force in addressing a set of problems related to intensive food production, whose production practices were highly dependent on large machinery and agrochemicals. Faced with contradictory answers to the same problems, Hilbeck decided to start her university studies in agricultural biology. In 1982 she joined the University of Hohenheim in West Germany, where she was confronted with conventional and intensive methods of food production and alternatives that were being developed. For Hilbeck, this was a pivotal moment in her career, as she knew that the only way to position herself in this debate would be to rigorously study both proposals from a biological and scientific point of view. Unknowingly - because the concept was not yet well developed and much less present in German vocabulary -, what Hilbeck was interested in was agroecology. Aware that this field of study was still under development in her country, Hilbeck traveled to the United States in 1986 for an internship at the University of California at Davis, where critical agricultural science was being developed.

In the 1980s, the United States was the world's pioneer of ecology and multidisciplinary environmentalism. It was there that Hilbeck came across Miguel A.

Altieri's book *Agroecology: the scientific basis of alternative agriculture* and thus encountered the concept that would guide her subsequent academic and scientific activity in agroecology. After completing her Ph.D. in Entomology in 1994 at North Carolina State University, Raleigh, she specialized in biocontrol and entomology. Today, Hilbeck's expertise includes biological control and insect ecology and the GEO/GMO production system assessment.

When Hilbeck started her work on the impacts of Bt persistent transgenic plants in insects, this technology was still on the regulatory pipeline, so the companies were applying all their effort to move from pre-commercial to commercial status. The year was 1994, two years before the approval of the first commercial transgenics. But even at that time, Hilbeck was demonstrating the uncertainties and insecurities of that product. In the 1990s, Ciba-Geigy, known today as Novartis, signed a partnership agreement with Agroscope, Hilbeck's research organization in Switzerland. This agreement contained a dimension of secrecy that was about to impact Hilbeck's research significantly. After the company refused to accept her research results that demonstrated that pesticidal crystal protein Cry1Ab was toxic to lacewings, Hilbeck refused not to publish. After unsuccessfully attempting to pressure the research organization not to let her publish, the company accepted the publication of the results but was prepared to counterattack. Although it was impossible to access the public campaign launched to discredit Hilbeck's reputation after the publication of her research, the practical effect of the relationship between the research organization and the company was the non-renewal of her labour contract in 1999. After that, Hilbeck and the industry would enter a conflicting dynamic that was at odds with the Bachelard-Mertonian values of science. After she restarted her career at the Department of Environmental Systems Science at ETH Zurich, in 2000, it has been reported (Hakim, 2016) that she was a personal target of Jörg Romeis, a former postdoctoral fellow at Bayer AG, and the person that substituted Angelika at Agroscope. Although all scientific research must be open to contestation and be challenged, including the research conducted by dissenter scientists, we still need to draw the line between assessment and critique of scientific knowledge and personal and professional harassment. As reported by the New York Times journalist Danny Hakim in his article from "Scientists Loved and Loathed by an Agrochemical Giant":

> In 2014, as Dr. Romeis was developing a paper assailing Dr. Hilbeck's work, one U.S.D.A. scientist, Steven E. Naranjo, joked in a message to Dr. Romeis: "Joerg, its generous of you to see that Hilbeck gets published once in a while :).

(Hakim, 2016 [https://www.nytimes.com/2016/12/31/business/scientists-loved-and-loathed-by-syngenta-an-agrochemical-giant.html)

The story of Hilbeck and Romeis deserves deeper research by dissent studies. I hypothesize that when promotional scientists engage in a dynamic that constantly targets the same dissenting actor, we are likely to witness a suppression strategy based on harassment, which should not be mistaken for counter-assessment studies. Counter-assessment studies aim to open discussion, promote inquiry, and improve research on theoretical and methodological approaches to new technologies, while promotional scientists aim to close the debate and discredit and silence the dissenter. As any dissenting woman would advise, once you turn a dissenter, you must not dissent alone. The act of dissent, which Jason Delborne (2005) so well described, is always a collective effort. However, I argue that the reason for considering it as a collective effort is different from Delborne's. While Delborne (2005) sees it as an act in the performance of dissidence, I see it as an act of support for dissidence and the pathway for the construction of a new community of thought or style of thought (Fleck, 1986).

3.4.3.2 - Monsanto Papers – attempts of suppression

The "Monsanto Papers" are a set of declassified documents that, according to the law firm Baum, Hedlund, Aristei & Goldman, "[…] tell an alarming story of ghostwriting, scientific manipulation, collusion with the Environmental Protection Agency (EPA), and previously undisclosed information about how the human body absorbs glyphosate. These documents, which Monsanto does not want you to see, provide a deeper understanding of the serious public health consequences surrounding Monsanto's conduct in marketing Roundup." (BH, 2019). In 2012, Gilles-Éric Séralini (former president of the scientific council of CRIIGEN), together with other researchers from public universities in France and Italy (not all the authors of the article were CRIIGEN members), published an article in Food and Chemical Toxicology (FCT), reporting an increase in tumors among *Virgin albino* Sprague-Dawley rats fed with GM corn and herbicide RoundUp, in a two-year study trial. As the first long-term study of GMOs and pesticides, the study has been highly criticized based on several accusations, later assessed and answered by the team (Séralini *et al.*, 2013). The attacks have taken different forms in different formats of science dissemination. [81]From articles in mainstream newspapers attacking the study to letters to the editor, the Séralini affair achieved worldwide visibility and has divided the scientific community (Fagan *et al.*, 2015). The pressure put on the journal regarding accusations of misconduct during the research, bad experimental research design, misinterpretation of data, and unsubstantiated claims, among other criticism, resulted in the paper's retraction. According to Wallace Hayes, Editor-in-Chief of FCT at the time, "[…] the results presented (while not incorrect) are inconclusive, and therefore do not reach the threshold of publication for Food and Chemical Toxicology" and justified the retraction, he stated, based "only on the inconclusiveness of this one paper" (FCT, 2013). Since then, several articles have focused on the issue of retraction, both analysing the claims that sustain the decision for a retraction but also investigating the conflict of interest behind it and its impacts on science (Piron & Varin, 2014; Portier *et al.*, 2014; Fagan, 2015; Novotny, 2018). From the perspective of the regulatory process, it is important to mention that these retractions have a negative impact. The regulatory process is globally dependent on the scientific literature and state of the art, but as previously mentioned, industry-sponsored studies significantly impact literature, thereby influencing the assessments made by regulatory agencies. If counter-expertise is excluded from the scientific acquis, the regulatory process is led to believe there is an apparent scientific consensus regarding the safety of GMOs and pesticides. This situation has led a group of scientists with various backgrounds in natural and social sciences to make a joint statement opposing the claimed consensus on the safety of GMOs (Hilbeck *et al.*, 2015). CRIIGEN members are among the authors of this statement.

Likewise, it is important to mention the company's role in retracting the Séralini *et al.*, 2012 article. Among the 141 de-classified documents, several emails and documents demonstrate how Monsanto conspired with Wallace Hayes, "Wally" to David Saltmiras, toxicology manager of Monsanto, to retract the Séralini *et al.*, 2012 paper. Besides personal phone calls between the editor and Monsanto staff, members of the company mobilized their networks to put forward letters to the Editor requesting the retraction of the article. All this was orchestrated under a request to "keep internal correspondence down on this subject." (MONGLY00936725, released on 01/08/2017).

[81] Several other members of CRIIGEN haven been target of suppression attempt. Amongst them is Christian Vélot. His suppression history is briefly addressed in André Rubião (2013).

3.5 - Conclusions

The violence of GMOs is expressed in many different ways. Either because they serve the coercive interests of capital, imprint new legalities to the production and reproduction of crops (e.g., the production of territories as is the case of the soy runners in Latin America (Correia, 2017)), or because of the subjective and diffuse forms of violence resulting from their use, transgenics are violent 'organism-tools' produced by violent neoliberal delights. This produces types of violence that, according to Rob Nixon (2011), distribute and refract violence in time. In the sense that GMO/GEO violence is endowed with properties that do not act on the immediate and whose magnitude cannot be predicted by analysing the immediate uses and expressions of violence. The violent use of an instrument may reflect other expressions of violence whose origin may sometimes be difficult to understand. For this reason, the assessment of GMOs must always be made from a long-term perspective, and not only based on the immediate risk that they may or not impose. Moreover, GMO/GEO technical advances sustain the political project of the continuous process of subsumption of epistemology. Consequently, the ethics of biotechnology is transfigured to one of inevitability, ensured by the suppression of alternatives. As violence, GMOs carry the ontological properties of neoliberalism, imposing a techno-scientifically fixed ideology to world problems and to the ways we practice and manage biological science applied to agriculture. As a result of subsumption, scientific knowledge imprints new forms of collective suffering justified by the instrumental rationality of its ends.

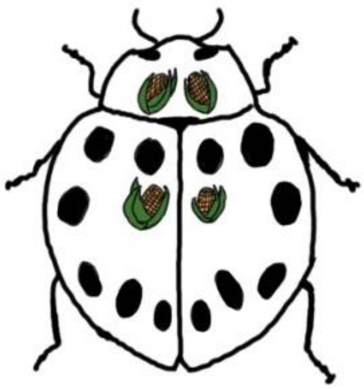
As I have tried to demonstrate, the violence of GMOs is simultaneous expressed within science and upon nature and society. Within science, capitalist subsumes labour that in its turn produces bio-objects that threaten autonomous forms of life. As the violence exerted on these forms of life becomes visible, new scientific orientations emerge with the aim of "reforming" or "revolutionizing" the scientific system. These new scientific orientations are met with the most advanced tactics of deception that can result in public discredit, harassment at work, destruction of character, intimidation, espionage, etc. Such tactics promote the emergence of dissent scientists that together create a new space for resistance and questioning of scientific ethos, norms, objectives. Such collective organization has been characterized by Jason Delborne (2005) as a dissent performance. To this matter, and although I agree with Delborne that dissent performance challenges prevailing notions of scientific autonomy and objectivity and generate new forms of scientific accountability, my proposal of placing dissent performance within the setting of the laboratory displays some of the limits of Delborne's dramaturgical approach, with its focus on the significance of dissent as an act of audience construction. Rather than treat the performance of scientific dissent as an act that aims at persuading the audience to stand by the dissenter's narrative, I use the dramaturgical lens of the oppressed, inspired by Augusto Boal. This means that the performance of dissent is a license to make theoretical and practical sense of what is both happening within the laboratory and connections beyond the latter's boundaries, to imagine what did not happen, and to rehearse the possibility of other things happening (Boal, 1996). It follows Augusto Boal's philosophy of perplexity (Castro, 2019a), a philosophical positioning that seeks infinite answers to the questions that seek to dominate us by means of bourgeois rationality and capitalist technique. Dissent performativity is not just an event, but a way of life. It is a process where one learns and teaches, where science and politics are democratized. It is an insurgence from the inside out, where we stop being passive spectators of what happens to start to be able to act on reality.

Dissident scientists are aware of politics in and around science, bringing to the public concerns over the political aspects of scientific knowledge that are often narrated as mere technical controversies. It is thus not surprising that many stories of dissent occur after the real understanding of the impacts of science, marked in history by moments such as the use of nuclear bombs. In fact, the devastating effects of the bombs were unable to sustain, for the scientists themselves, the ideology that science and technology were equated with social progress (Rose & Rose, 1976).

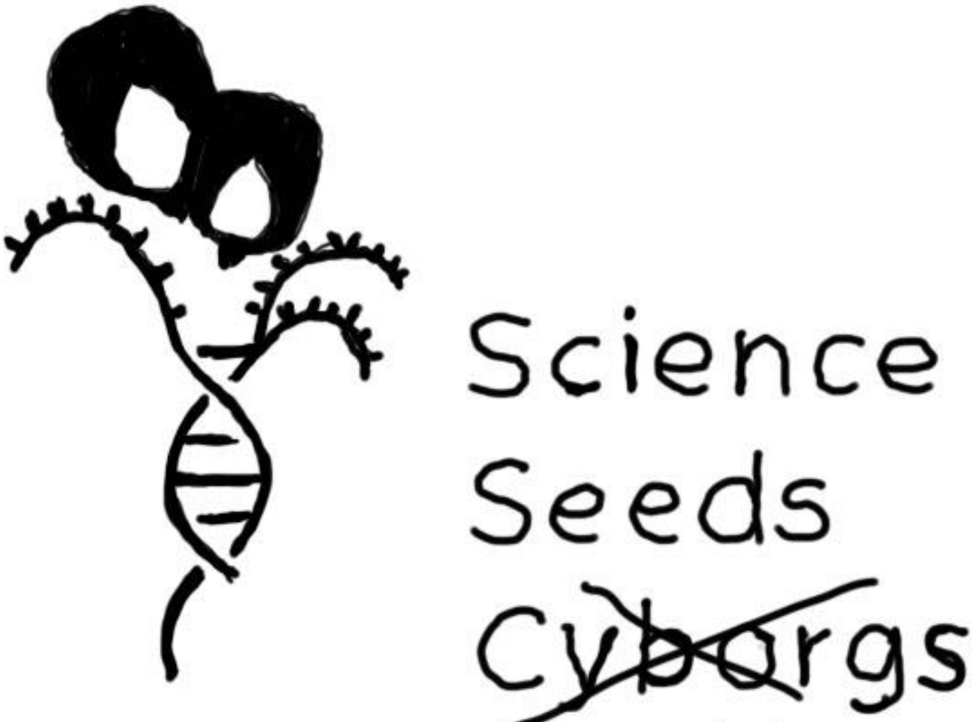
My approach to dissent studies demonstrate that scientific dissent can be committed to another onto-ethical-epistemological form of knowledge production, and even, sometimes, free from the commodity form (e.g., their engagement with AFN), thus promoting another kind of legitimacy for scientific knowledge production. This is contrary to what is commonly asserted in mainstream scientific debates, that dissidents contribute to a nihilistic relativism that is at the root of the spread of pseudoscientific facts. In that sense, the dissensus that furthers the possibility of emancipation from the current domination of capitalism over social relations of (re)production, is subject to violent scrutiny by the hegemonic forces acting both within and beyond the science worlds.

To resist the continuous and progressive attacks on dissenters, beyond constructing an audience (as proposed by Jason Delborne), scientists require the formation of a global network of dissenting movements that continuously reinvent methodologies of research and new research infrastructures, and promotes and supports a sense of collective that allows them to resist and counteract violent hegemonic powers. *Science for the people*, union(s) of concerned and committed scientists (UCS-USA, UCCS-Mexico, CSS-Switzerland), and networks of scientists for social and environmental responsibility (ENSSER) are some of the many movements that constitute the heterogenous of dissenting collective organizations. In these collective acts of dissent, we find alliances between the natural and social sciences, and between scientific movements and other social movements, in a performance that resembles Augusto Boal's epistemic triad (Castro, 2019a). Within the laboratory they construct a new aesthetic space, that enables them to contract and expand time and space, observe, and produce knowledge on the sources and means of oppression.

It is my strongest belief that these dissent practices restore the legitimacy of science as a producer of knowledge and technologies, in the interests of a society of virtuous and non-violent moral values. Yet, the process of creating a living science, one that is not objectified, will face the violence and the petty fury of private interests (Marx, 2017a).



Chapter 4 – Conclusions: Zombie *mea p.*



4.1 - What is a genetically modified seed?

4.1.1. Implications for Science

During the eight years that I dedicated to the question "What is a genetically modified seed?", episodes such as those of the opening of this dissertation have been troubling my thoughts. The main reason for considering them troubling was the fact that this type of episode required me not only an objective analysis but also a continuous exercise of self-reflexivity (Omodeo, 2019). Likewise, this research was developed in parallel with the professional activity of project manager at the Centre for Social Studies, University of Coimbra. Despite having had the opportunity to carry out field work, due to a scholarship of two and a half years provided by FCT, the research was mostly carried out simultaneously with my technical professional activity as project manager. What at first appears to be a barrier to the good performance of both activities, becomes an opportunity within the framework of the exercise of self-reflexivity proposed by Omodeo (2019). Understanding why scientific practice constitutes dissent, and why these dissenters are suppressed, cannot be carried out without understanding the institutional mechanisms that condition R&D. In this sense, despite not being explicit in the dissertation, working as a project manager, who follows the entire research process from the analysis of funding programmes to the submission of final payment requests, has become fundamental for the adoption of the critical framework of the subsumption of science under capitalism. In turn, the exercise of self-reflexivity allowed me to keep breathing in this competitive world that science has become and that suffocates the creativity and imagination potential of scientists.

In this sense, with the progression of my research, I realized that I could not understand the "golden egg" without understanding the hen that lays the egg. For this matter, I needed to approach genetically engineered organisms both from the perspective of what happens to scientists under capitalism and how these technoscientific organisms become constitutive of capitalist agriculture and science. My work then converged with Garcia & Martins's (2009) proposal that argues that to analyse the incorporation of 'post-academic' science in a market economy, we required a 'post-constructivist sociology of science and technology', one that is in strict collaboration with the philosophy of science and technology.[82] For this subject, I mobilized the scientific critique of social and biology scientists of the 70s, 80s, and 90s, who saw in Karl Marx and Friedrich Engels's philosophy of science (Sheeehan, 2017) a route to explain the paths and consequences of its subsumptions under capitalism, and who approach the sociology of *things* as a matter of class struggle. Moreover, this meant that answering my question implied questioning who the scientists of this debate are, why do they say what they say? Why do they disagree with each other, to the point that sometimes they get into violent conflicts?

To be a scientist is to accept a set of complex codes that determine, in a Luhmannian sense, who is inside and who is outside (Luhmann, 2012, García-Barrios *et al.*, 2021)[83]. Such codes exist to frame the scientific institutions and practices that sustain *science* as a privileged place for knowledge production. However, areas of research such as STS, suppression studies, among others, have continually demonstrated that the codes of science sometimes are like Groucho Marx's principles: if you don't like the ones they present to you they have others. As García-Barrios, Serrano and Hinojosa *al*. (2021) defend, *science* codes can move in the direction that best grants privileged positions in modern society. Such mobility of principles and codes happens on the one hand, because the so-called 'academy' establishes, in the name of the well functioning of its institutions, a rigid division that determines the spaces of what should be and the spaces of being, in constant confinement of theoretical and practical imagination (García-Barrios *et al.*, 2021). In other words, it gives its members freedom to navigate and expand science frontiers, as long as such freedom is governed by the universal foundations of consensus, objectivism and universalistic neutrality, communicability, and transferability to the market. With it, the code blurs the borders of responsibility, alienating the scientists further (Bowring, 2003).

On the other hand, capitalist entanglements with science reframe such codes. Under the triad of science-technology-industry, what was a common becomes individual, what was public becomes private, what was open becomes secret. And scientists perform

---

[82] A post-constructivist approach to STS can be understood as the dialectical study of science and scientific practice. Such a proposal addressed our contemporaneous turn to materialism and our necessity to explain the nature and politics of scientific practices. Post-constructivism emerges as a critique of constructivism. Although constructivism has abandoned the path of explaining reality by means of objective reality, liberating science from determinism and allowing for the introduction of observer's standpoint, scholars argued that it reduced everything to the social (Knol, 2011).

[83] The acceptance of this code is often not conscious and undergoes a normalization of it through the practices of the community. In other words, scientists as members of the community live the scientific and professional reality, interacting, sharing, reproducing, and sometimes reflecting on the code that unites them. Ultimately the code is a product of the mass work that governs the life of this community.

such dedication and effort to this triad because the scientific system is today ruled by the capitalist market's principles, which also means scientists are subject to its forms of coercion and submission. As a result, we have a science where alienation and lack of solidarity are perfectly congruent with high standards of living and education (Rendueles, 2013, p.148).

But if the ‘knowledge machine’ is so powerful (Stevens, 2021), how can we explain the emergence of counter-science and dissent scientists? Three paths help explain this. The first is a path where critiques existed before the confrontation with *science*. This is partially the case of Elena Álvarez-Buylla. Her critical position regarding science was previous to her integration into science. Álvarez-Buylla then approaches *science* with a set of pre-science critical assumptions that make her evaluate scientific practices and claims. The second path is the path of matter. As described in the story of Angelika Hilbeck, the contradictions of science, when visible, make scientists question the assumptions of the system they belong to. This happens because the *praxis* of genetic biology cannot produce meaningful knowledge without simultaneously engaging in uncertain experiments (Bowring, 2003), thus raising ethical questions for the scientist, making them question the assumptions of the *praxis*. They then move onto the exploration of alternatives.[84]

The third follows the second but generates its own path when these scientists face suppression (Delborne, 2005). Suppression of science can then make clear the private interests that corrupt our scientific codes (Bowring, 2003; Martin, 2020).

These three paths will then constitute heterogenous forms of resistance to the subsumption process of science under capitalism, paving the way for the emergence of utopias within science. Still, such utopias, when developed in practice, also require a set of conditions. The first is resources. Without full employment and resources for research, counter-expertise is not possible. These require the continuous alliance between scientists with secure jobs and scientists who only know precarious labour conditions. Likewise, it requires the capacity for, on the one side, mobilizing resources from ongoing research into the alternative and, on the other, the search for outside sponsors.

The second condition is a collective. That is, counter-science and dissent scientists require national and international networks. Such networks act as a community of practices (Gherardi, 2009) and allow for the creation of a style of thought (Fleck,

[84] Another example would be Rachel Carson and Lynn Margulis (Castro & Serra, 2020).

1986). Critical and dissent scientists mobilize alternatives within movements such as UCCS, ENSSER, and CRIIGEN, provide a network of support for dissidents, and perform dissent not just as a scientific action, but as political action that demands the constitution of another science. However, we will require a restorative starting point before we can even think of a science capable of standing up to the destructive experiences and collective suffering. For a 'restorative science' to emerge, the new *praxis* needs to be guided by restorative justice principles. I have tried to demonstrate that this process can find a robust methodological and epistemological guide in dialectical materialism.

The adoption of a dialectical materialist perspective means to endorse a 'reason' committed to the principles of interpretation and transformation, "outside the limits of the paradigm of explanation or determinations" (Zemelman, 1996, p. 41-42). Thus, the hegemonic paradigm model is replaced by a utopian paradigm where the category of necessity is not excluded from the scientific debate, as does the mechanistic conception. Furthermore, such transformations will be anchored in the utopia of the monism of theory and practice. For example, Bukharin's ‘theoretical practice’ will turn theory into the accumulation and condensation of practice and practice the inner character of theory.[85] This utopianism will guide us in the process of distinguishing the essential from the accessory. It will serve as the matrix that will distinguish our utopia from those of 'mistakes' and 'faith'. Under this line of thought, techno-utopianism will construct technologies that guarantee conditions for transformations and emancipation.

With time, dialectical materialism will allow us to progress further into the fabric of science and technology production. History of science will be transformed and give way to a historicization that will no longer be built on subjectivities and arbitrary interpretations of the history of science but on studying the state of the productive forces in which each idea emerged. The progressive dialectical understanding of nature and scientific discoveries within this framework will make nature's materialism more explicit and make idealistic perspectives obsolete, advancing the determination of materialism.

[85] According to Helen Sheehan (2017), Bukharin’s “theoretical practice” was first used by Karl Marx and refers to theory as accumulated and condensed practice, which in its turn is theoretical (p. 207). For Bukharin, one of the most imposing figures of the 1931 soviet delegation, “theoretical practice” represented a rupture with the modern schools of capitalist philosophies. By placing dialectical materialism as philosophy, both Marx and Bukharin attempt to overcome the narrowness resulted from the crises of capitalism, both at a social and epistemological way. However, this attempt does not go without a critique, made by Bukharin itself, as highlighted by Rui Borges (2021). Althusser also used the concept “theoretical practice” but with a very different goal and explanation.

The heresies of the past and of the present will be discussed in their context of political struggle. Discoveries will be grounded upon the material conditions that allow them to emerge and triumph. The 'sociology of scientific praxis' will become the study of the coincidences of the transformation of circumstances with human activity in producing universal- situated laws.

In this sense, the dialectic materialism of science is not a finished concept (Papadopoulos, 2010). This is a fundamental character of the new *praxis*. Only by means of *praxis* of becoming (-with), which will continue to draw on empirical data, will we further the explanation of materialism. Thus, praxis is understood here as a critical human practice that is generated by the dialectical relationship between humanity and nature. Moreover, *praxis* appears as a mediator concept in the historicization process of scientific activity, a collective commitment to reason and reflexivity, and not a move towards neutrality and self-autographed objectivism. The praxis of science allows the scientist to understand the activity of knowledge in a much more historical way than any theory produced until now. Also, the forms of dialectical materialist thought are more integral and less prone to hegemonic unilateralism. The recognition of the importance of hypotheses and deductive thinking will not deny the existence of inductive ways of knowing or even abductive, for that matter. The ability to understand complexity will not refuse the need for patterns (Taylor, 2005). Nor will our renunciation of the search for the ultimate truth announce the end of epistemology (Nunes, 2009).

Likewise, the materialist method allows us to understand how capitalism transhistorically organizes nature and denies the fundamental condition of sustainable human development (O'Conner, 2001)

4.1.2. Implications for Seeds

As I have tried to demonstrate, maize seeds have been vital in developing and sustaining capitalism. Today, its capacity to answer to new developed machinery and forms of production, as well as its multiple uses in several industries (e.g., flour, syrup, popcorn, penicillin, sugar, whiskey, animal feed, glue, oils, ethanol, starch, etc.), made maize central to modern agroindustry. Even so, maize has also been central to the organization of capitalist resistances in several global geographies. As we saw, maize is crucial to Mexican resistance and to some scientific utopias. In this regard, to state that maize lost its 'chulel', its 'essence', is a way to account for the progressive subsumption of science and agriculture under capitalism. It addresses a type of ‘organism-tool’ that does not promote autonomous communities' nourishment and emancipatory needs. An ‘organism-tool’ that neither respects nature nor humans.

Genetically engineered seeds are a product of neoliberal philosophy. It is a philosophy guided by the needs of a financial regime of accumulation that determines seeds' premises and future achievements. As Melinda Cooper (2008) analysed, the biotech revolution resulted from a series of legislative and regulatory measures designed to relocate economic production at the genetic, microbial, and cellular level so that life becomes, literally, annexed to capitalist processes of accumulation.

Undoubtedly, because R&D efforts in improving seeds and crop protection generate an apparent, although ephemeral, productivity, we are led to believe that these technologies are vital when facing present and future challenges, such as world hunger and climate change. For example, one of the significant arguments for promoting transgenic maize is its promise to raise yields while reducing the use of agrochemicals (Zapata, 2017). Conversely, Charles Benbrook (2016) stated that introducing herbicide-tolerant transgenic seeds in 1996 boosted the use of herbicides. Before 1996, glyphosate was the 7th most used pesticide in the USA, but its application arose after the introduction of herbicide-tolerant transgenic seeds. In the USA, Benbrook (2016, 2019) noticed that, regarding the total volume of glyphosate used between 1974 and 2014, nearly 67% corresponded to the period 2005−2014. Worldwide, the use of glyphosate, for the same period, corresponded to 71.6%. The increase of glyphosate use is due to both the penetration of this product in Third World markets and the emergence of pest resistance (Benbrook, 2016, 2019, Bowring, 2003)

Likewise, as Álvarez-Buylla *et al.* (2013) have shown, most of the available market varieties of transgenics were not designed for yield increase but rather to resist the constant use of pesticides. Within the business of transgenics, it has become more and more apparent that those profiting from biotechnological developments are private companies, such as Bayer, Syngenta, and Dow Chemicals. Such private companies are not only sellers of farm inputs, but they also are part of the complex industrialized agricultural system that was implemented since the “green revolution”. Currently, retail corporations and trade-related intellectual property rights have also joined this global complex industrialized agricultural system (Clapp & Fuchs, 2009). The achievements of these multi-national co-operating clusters have been predicted by Finn Bowring (2003). The multi-national co-operating cluster now holds patents and germplasm, determines which seeds and agrochemicals will see the light of day, control the production and the distribution of the harvest, command their process into food and its commercialization (2003).

Indeed, transgenic maize seems to point out that its current form is not separated from the compulsive dynamics of capitalism of extracting surplus from its devastated inner crisis. While capitalism promises more abundance, it also generates more damage. And more damage generates new technologies whose intentions are not to stop the process but to keep the accumulation engine mechanisms oiled (Castro, 2019b). The promise of more and improved maize transgenic varieties is part of the politics of continuous growth in the face of food crisis and agricultural losses due to contamination, the emergence of pest resistance, and climate change. In this sense, genetically engineered organisms, as products of a capitalist industrial-agricultural production system, are no different from other pollutant forms of production whose negative externalities become heavy burdens for governments, citizens, and nature (Wallace, 2016). Also, and despite all the promises made, most maize in the world is humdrum. The majority of the commercial maize we know globally is yellow maize, followed by white maize (FAO, 1997). This contrasts with the maize's found at its place of origin. Mexico currently hosts 64 of the 220 known varieties of maize in the world, and as Kato-Yamakake (2004) accounts, once contaminated with genes from GEO varieties, it would not be possible to return criollo maize to its original state. It's a path of no return.

Likewise, genetically engineered seeds block alternatives. They impose new proprietary forms into life and pressure to deregulate their uses while setting legal blocks to praxis associated with a possible alternative production model. Such is the case of several national and international schemes of plant certifications (Bocci & Chable, 2009). Moreover, the predominance of genetically engineered seed traits in crops, like soybeans, cotton, and maize, may also represent a loss of conventional varieties, where the supply is in a shortage situation when compared to GEOs, and therefore discouraging farmers from returning to non-transgenic plantations (Bonny, 2014).

Outside this neoliberal philosophy, genetically engineered seeds would not exist.

4.1.3. Implications for Cyborgs

Before addressing my proposal of genetically modified seeds as zombies, I need to clarify why the concept of cyborg appears at the image illustrating the chapter. At the time my thesis project was built, the concept of the cyborg, as formulated by Donna Haraway, promised to find an emancipatory path for genetically engineered organisms. When Donna Haraway first described the cyborg, she addressed it as “a cybernetic organism, a hybrid of machine and organism, a creature of social reality as well as a creature of fiction” (1991, p. 149). To be a cyborg is, for Haraway, an ontology consisting of properties belonging to both the realms of reality and of fiction. When flesh meets the machine for the constitution of a new entity, it is unfaithful to the natural order, and for her, it is in such blasphemy that the potential of emancipation resides. For me, at the time, the cyborg was a path to escape essentialism and politics of identity that surrounded the anti-GEO movement, or in Richard Levins’s words, the pre-scientific conservative approach to the controversy (Levins, 1990).

Following Haraway, I hypothesized that GEOs could reconnect science to culture, nature to humankind, machine to matter as a cyborg ontology. However, as demonstrated, GEO ontology is not of connection but estrangement. Although we both established our perspective on the fact that revolution of the scientific means, in late capitalism, that it has been boosted by a scientific praxis of instrumental reductionism, a hegemonic project to restrict the integrative culture of complexity (Wynne, 2013), I diverge from Haraway when it comes to ultimate ends of our proposals. For Haraway, the cyborg fostered disorder at the old borders of knowledge and reality, for me the zombie reinforces such borders. The possible use of the cyborg metaphor for genetically modified organisms was then discarded.

Likewise, her uses of the cyborg concept are also not always very clear, not always sustainable, and sometimes they pose greater questions than the ones she aims to answer. As Kate Soper puts it, “the irony of Haraway’s invitation to blur these divisions [organic-inorganic, human-animal conceptual divisions] is that if we’re truly to do so we would no longer recognize the force of the moral problem she poses for us. A world bereft of these distinctions is a world bereft of the grounding conditions of the moral, political and scientific critique. Is that indeed a livable world?” (Soper, 1999, p.80).

Similarly, when it comes to the case of genetically engineered organisms, although she states that these produce ruptures on the borders between what counts as organic and machine, she also acknowledges that those carrying unrelated genes do not seem to question the taxonomic and hegemonic evolutionary discourses. "What was distant and unrelated become intimate" (Haraway, 1997, p. 56), she states. A statement that does not disturb Linnaeus's hierarchies subsumed under the technoscientific ideology.

Unlike Haraway, Finn Bowring (2003) discusses how capital techno enthusiasts mirror the cyborg as a way to keep humanity in competition with the machine. The promises of the 4th industrial revolution, of artificial intelligence and the ambition of individuality, have been promising an intelligence that will overcome our own. The fear of machines replacing our species has always been associated with the revolutionization of the means of production from which machines emerge. But is this about keeping humans in place of creation leaders, or is it about adapting workers to the new means?

> "What is desired by the cyborg enthusiasts is, in effect, the elimination or revision of those features of human existence which, being censored, repressed, harmed and alienated by modern social conditions, lead to disempowerment, frustration and suffering. The elimination of our capacity to suffer is not, however, a satisfactory answer to suffering – or at least not a human one. The human answer to suffering is relief from suffering, which must also suffer the precariousness of this relief and the knowledge of the burden that has been lightened. Because the elimination of human's capacity to suffer would mean the creation of a post-human being, the goal and beneficiary of this solution cannot be humanity itself. The need for the cyborg, in other words, is not a human need, a need whose satisfaction would reaffirm the essence of humanity. It is, rather, a technological imperative, for the true purpose of the re-engineering of the human being is the abolition of the obstacles presented by people to the reproduction of machines" (Bowring, 2003, p. 274)

Those who imagine the cyborg do it to answer the deskilling of humanity as it faces machine evolution. And if we accept that cyborgs can be troubling entities in Haraway's sense, we must acknowledge that transgenics cannot be considered cyborgs. They haven´t disrupted anything. Although what was once unrelated indeed becomes intimate, this new organism exists only and within the sole purpose of capital extension. GEOs have not disrupted our understanding of matter and its complexity but rather maintained a political system, creator of normative and legal conditions for accelerating the interpenetration of capital and knowledge production (Garcia, 2006). And what makes GEOs disruptive is the inner contradiction of science under capitalism. In other words, the forms and modes of production that gave rise to these monstrous creatures.

4.2 - The Zombies

In 2012 the American journalist Amy Wilentz wrote in The New York Times:

> Most people think of them as the walking dead, a being without a soul or someone with no free will. This is true. But the zombie is not an alien enemy who's been CGI-ed by Hollywood. He is a New World phenomenon that arose from the mixture of old African religious beliefs and the pain of slavery, especially the notoriously merciless and coldblooded slavery of French-run, pre-independence Haiti. In Africa, a dying person's soul might be stolen and stoppered up in a ritual bottle for later use. But the full-blown zombie was a very logical offspring of New World slavery. (Wilentz, 2012, 30-10-2012, https://www.nytimes.com/2012/10/31/opinion/a-zombie-is-a-slave-forever.html)

According to her research on the brutality of the slavery system in Haiti under the rule of the French, the idea of the zombie was a coercive discourse against the slaves who used suicide as a form of liberation from its miserable condition. For the slaves, suicide was a way to return to their homeland, from where their being had been stolen. But for the colonial French, their suicide was seen "as the worst kind of thievery, since it deprived the master not only of a slave's service, but also of his or her person, which was, after all, the master's property" (Wilentz, 2012).

In an attempt to avoid slaves freeing themselves by suicide, from the brutality of their life and of the labour conditions imposed by the French in the sugar cane plantations in Haiti, the French colonialists resorted to the Voodoo figure of Baron Samedi. Baron Samedi is the entity responsible for welcoming a person to the world of the dead. The French colonials concocted the story that suicide was considered an offensive act against Baron Samedi, who in turn would not allow the slave who committed suicide to free themself, but she/he would instead condemn him/herself to the eternal condition of slavery. To become a zombie, to be dead, and still a slave. Moving flesh, dispossessed from the self through its reduction to a labouring object (McNally, 2012).

For Terrence W. Deacon, the zombies inhabit a world where care and kindness are absent, and they are unable to share any collective experience that goes beyond one's pleasures and pains (2011, p. 94). The idea behind Deacon's (2011) concept of zombies is that they resemble the living in all its aspects, but they lack any subjective experience associated with the act of being alive. A zombie is no more than an automatic action without consciousness and an inability to become. Or, more clearly, of becoming. This is Álvarez-Buylla critique to transgenics when she states that maize has lost its 'chulel'.

Similarly, for David McNally (2012), industrialized capitalism submits the flesh of the workers to an “animated monster” made of steel, cement, and plastic. Such a monster, he says, is the capitalist form of production, which is endowed with a soul and intelligence of its own (McNally, 2012 *apud* Marx, 1976, p. 95). Following Marx, McNally points out that such a monster reduces the worker's body into mere flesh, and its presence is a continuous amputation, where the process of production is constantly reduced to the smallest notions of time and motion.

Not so different from David MacNally, for Rita Serra and Raúl García-Barrios (2019), under capitalism, the constant motion for competition among cooperation units breaks the ontological properties of beings. However, it is important to explain that for the emergence of a new being or phenomena, those that compose it always have to lose parts of their ontological properties. The new organisms, beings, or phenomena may develop new properties unknown to the previously existing beings and entities. According to Serra and García-Barrios (2019), it is not in the creation of new entities, with new ontological properties, that the problem is to be found, but in the contracts made to achieve such entities. For them, in capitalism, the prevalence of the Faustian contract is the new ethics for constructing modern zombies. Under a Faustian contract, which is absurdly surrounded by illusions, the aim is the pursuit of a fetish form of freedom and autonomy that has, in fact, been renounced from the beginning of their search (García-Barrios & Serra, 2019).

Following these authors' proposals and the several accounts that I have made on *science* throughout this dissertation, I am led to conclude that the contract needed for the emergence of a genetically engineered organism is no different from a Faustian one. As argued, it is not only the social relations of exploitation within science that need to be perceived as inherent to the organization of the newest form of collaborations, (e.g. between different disciplines, national research centers, public and private R&D, convergence programs), it also requires a new social agrarian contract which makes inevitable the consumption of "monsters" produced by late capitalism (McNally, 2012). A genetically engineered organism is both a creature of fetish consumption and a creature of alienated labour, producing the wealth of others (2012).

The reification[86] of genetics through reductionism and strategic cooperation originates a new 'organism-tool' that apparently benefits from unrelated genes, deriving unique traits with new characteristics still unknown to the species of interest but determined by the laws of capitalist accumulation. Hidden from this relationship is an entity that has been ontologically dismembered, subsumed to an eternal existence of creation within the laboratory of corporate culture, and unable to evolve within its own legality. In other words, a genetically engineered organism does not evolve outside the laboratory. They do not exist outside the constant need for capital to penetrate agricultural systems. They belong to modes of industrial-agricultural production, where they are no more than factors of production, together with the machine, spatial organization, and agrochemicals. If, for example, a transgenic organism escapes, it will not escape following its destiny. It will continue to be an 'organism-tool' contaminating other fields of non-transgenic crops, multiplying zombies, and submitting more labour to the horror of capitalism. Even if we free the genetically modified being from their condition as property, as some suggest, I argue that they will keep the shackles of capitalism, as its not only its property form that determines their ontology, rather the rules and needs of agrochemical companies to whom these beings obey without a soul.

Likewise, such rules and needs are in constant transformations. If in the past companies producing and selling these 'organism-tools' have defended the idea that cross-contamination was impossible or possible to control, years of counter-expertise and dissent science have proved otherwise[87]. Today, the idea is that genetic alterations, to be transmitted within the population, become the new operational goal for R&D. Gene drives provide the most lucid example of how we have moved from the denial of contamination to regarding it as a desirable action.

Gene drives are an emergent genetically engineering technology that disseminates genetic modification in wild populations through an organism's offspring. Currently, this technology is being used to modify, among other species, mosquitos such as *Anopheles*

[86] Reification is here used as "the act (or result of the act) of transforming human properties, relations and actions into properties, relations and actions of person-produced things which have become independent of the person and govern his life.[…] reification is a special case of alienation, its most radical and widespread form characteristic of modern capitalist society" (Petrović, 1991c).

[87] In 2001, Ignacio Chapela and David Quist published a report on the leading natural science journal Nature, providing evidence that cross-contamination was not only possible, but it was also already happening in Mexico. But the pathways of transgenic contamination are not strictly by biology. Álvarez-Buylla *et al.*, (2009) have discovered that transgenic contamination was also associated with socio-economic practices. Transgenic seeds were being smuggled into Mexico by farmers and State companies such as Diconsa S.A.

gambiae and *Aedes aegypt*i, responsible for the transmission of malaria and other epidemic diseases. In a recently published report by a group of concerned scientists (Dressel, 2019), and to which I contributed as the co-author of a chapter (Lebrecht *et al.*, 2019), we have concluded that gene drives may have unpredictable and irreversible effects once released in the environment. Likewise, we have determined that although gene drives may be free from patents, and in this sense, from their property form, they require the constant production of first line altered organisms. In other words, they need the permanent presence of private corporate actors that are the holders of the know-how when it comes to these technologies. Also, these organisms hide the structural problems of human and environmental health. As McNally defended "[…] capital's great powers of illusion lie in the way it invisibilises its own monstrous formation" (2012, p. 114).

These zombies may become uncontrollable, releasing new forms of suffering upon the world that are not yet known to us. As I tried to demonstrated, the violence of genetically engineered organisms can be expressed in many different ways. Either because they serve the coercive interests of capital, imprint new legalities to the production and reproduction of crops, or because of the subjective and diffuse forms of violence resulting from their use, genetically engineered organisms are violent 'organism-tools' produced by neoliberalism violent delights.

As they serve the political project of the continuous process of subsumption of epistemology, consequently, the ethics of biotechnology is transfigured to one of inevitability (Garcia & Martins. 2009), ensured by the suppression of alternatives. Because the new ethics that emerge is anchored in the dysmorphia caused by violence, the new ethos becomes a producer of Moreau creatures.

Doctor Moreau is a fictional character of H.G. Wells' novel "*The Island of Doctor Moreau*", whose ambition was to overcome the limits imposed by nature on organic life. To suppress God's will, Doctor Moreau resourced to blasphemy science and created human-like hybrids. Still, these creatures expressed the blasphemy that has given them existence, which threatens their survival. To overcome this contradiction, Doctor Moreau creates his law, which all creatures, humans and beastlike, must follow. But the problem remains. The problem remains because the law that keeps the creatures from self-destruction interprets violence as natural and not a consequence of their new legality. Therefore, the need for Moreau's violent procedure is continuously repeated in a cycle of violence. This is happening with genetically engineered organisms in all their novel forms. Biology subsumption under capitalism has allowed for ideas and means where violence is naturalized to become hegemonic rather than seeing it as a result of capitalist production. Rather than accepting that transgenics continually fail in their goals, capitalism spins the mill faster and faster, trying to catch up with its second contradiction (O'Connor, 2001, Castro, 2019b). The second contradiction is O'Connor's proposal on the contradictions between capitalist operations and the environment. It does not matter how many risks assessment protocols we establish or how rationally we try to manage risks and uncertainties. The second contradiction will always stand in the way of capitalism, pushing it to adopt new technologies that allow it to surpass biological limits and negative externalities that impact it accumulation process, thus producing more monsters.

Capitalism will never accept that its uses of force for domination over nature have failed, or that in reality, the uses of such forces do not represent any form of power over nature. Although the violence of GEOs demonstrates how they are, in fact, the result of the deterioration of capitalist power, and not an instrument of power over nature, their promoters still refuse to accept that power does not need to come from domination.

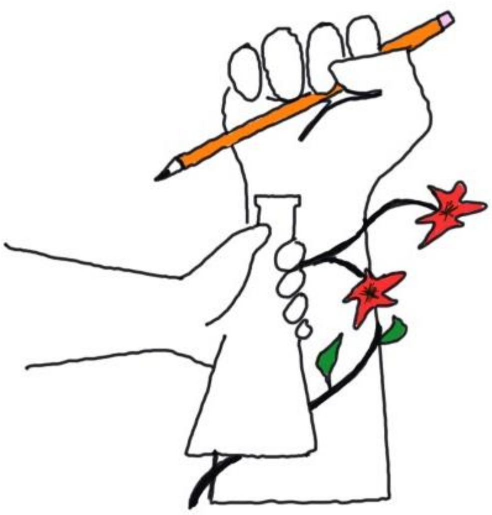
In sum, the study of genetically engineered organisms requires an ontological dialectical material approach that focuses the practices in both the hands of humans and nature (Garcia & Martins. 2009, Papadopoulos, 2010a). This means that practice and matter are not independent. As suggested by Dimitris Papadopoulos (2010a, 2014), the current break between matter and practice, and to some extent, theory and practice, is not epistemological but political. My work then attempts to demonstrate that dissent science, particularly the radical critique supported by dialectical materialism, can help restore the breaks promoted by capitalism. According to Papadopoulos, my dissenter practices would constitute an alter-ontological politics (2010b).

> Alter-ontologies go beyond the subject–object dichotomy, not because everything is hybrid or because everything is related to everything else, but because they establish forms of life that are simultaneously the effect and the precondition for the continuation of existence of marginalized actors (Papadopoulos, 2010b, p.193)

Under my argument. the political ontology of dissent science is the weapon against the zombie ontology of GEOs.

Likewise, to counteract the rise of Moreau's ethics, we require the development of active non-violence. Although the development of a theory on non-violence that can neutralize the violence of transgenics is not the scope of this dissertation, it is essential to note that the practices that constitute a non-violent ethics are already in place, framed within utopias such as those proposed by Elena Álvarez-Buylla. More importantly, these practices determine that non-violence does not necessarily have to be a moral action of a religious character. On the contrary, the ethics of non-violence must be political. Considering that the concept of violence used here is based on the theory of Adolfo Sanchez Vázquez (2013), resorting to non-violent practices means resorting to forces in action without the objective of imposing new legality determined by just a few. Only then will we be able to stop these zombies and *become with* our utopias.

> Philosophers have sought to understand the world. The point, however, is to change it. (Karl Marx in Theses on Feuerbach, Theses XI, 1845)



References

Abouheif, Ehab, Fave, M., Ibarraran-Viniegra, A. S., Lesoway, M. P., Rafiqi, A. M., & Rajakumar, R. (2014). Eco-evo-devo: the time has come *in* Landry, Christian & Aubin-Horth, Nadia (Eds.), *Ecological Genomics: Ecology and the Evolution of Genes and Genomes Advances in Experimental Medicine and Biology* (pp. 107-125) (Volume 781). New York: Springer. DOI: 10.1007/978-94-007-7347-9_6

Afonso, Vitória & Belaidi, Rabah (2018). Tribunal Monsanto: um estudo de caso. *Revista do Conselho Nacional do Ministério Público*, (7), 211-226. DOI: 10.36662/revistadocnmp.i7.110

Aguilera, Carmen (2001). El simbolismo del quetzal en Mesoamérica *in* Torres, Yólotl (Ed.), *Animales y plantas en la cosmovisión mesoamericana* (pp. 221-240). Mexico, DF: Plaza y Valdes.

Alix, Anne, Steeger, T., Brittain, C., Fischer, D., Johnson, R., Moriarty, T., ..., Fry, M. (2014). 10 Overview of Ecological Risk Assessment Process for Honeybees (*Apis mellifera*) and Non-Apis Bees *in* Fischer, David & Moriarty, Thomas (Eds.), *Pesticide risk assessment for pollinators* (pp. 121-148). Hoboken, New Jersey: John Wiley & Sons, Inc.

Álvarez-Buylla, Elena & Piñeyro-Nelson, Alma (Eds.) (2013). *El Maíz en peligro ante los transgénicos: un análisis integral sobre el caso de México*. Ciudad de Mexico: Centro de Investigaciones Interdisciplinarias en Ciencias y Humanidades, UNAM.

Álvarez-Buylla, Elena, Garay-Arroyo, A.; León, B., …, Piñeyro-Nelson, Alma (2017). La Ecología Evolutiva del Desarrollo en México. *Revista Mexicana de Biodiversidad*, 88, 14-26. DOI: 10.1016/j.rmb.2017.10.009

Arendt, Hannah (1970). *On Violence*. Harcourt Brace Javanovich.

Bachelard, Gaston (2006). *A formação do espírito científico. Contribuições para uma psicanálise do conhecimento* (Estela dos Santos Abreu Trans.). Lisboa: Dina Livros.

Barad, Karen (2007). *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Duke University Press.

Benbrook, Charles M. (2016). Trends in glyphosate herbicide use in the United States and globally. *Environmental Sciences Europe*, *28*(3), 1−15. DOI: 10.1186/s12302-016-0070-0

Benbrook, Charles M. (2019). *Evidence of the Magnitude and Consequences of the Roundup Ready Soybean Yield Drag from University-Based Varietal Trials in 1998*. Available at: https://www.researchgate.net/publication/237296807

Benítez, Mariana (2018). Ecological evolutionary developmental biology in dialogue with agroecology. *Interdisciplina*, *6*(14), 69-87. DOI: 10.22201/ceiich.24485705e.2018.14.63381

Benjamin, Walter (2010). *Critica de la violencia*. Biblioteca Nueva.

Bensaid, Daniel (2020). *Espetáculo, Fetischimo e Ideologia*. Fortaleza: Plebeu Gabinete de Leitura.

Benz, Bruce F. (2001). Archaeological evidence of teosinte domestication from Guilá Naquitz, Oaxaca. *Proceedings of the National Academy of Sciences, 98*(4), 2104-2106. DOI: 10.1073/pnas.98.4.2104

Bernal, John D. (1946). *The Social Function of Science*. London: George Routledge & Sons Ltd.

BH (Baum Hedlund) (2019). Monsanto Lawsuit Documents. Retrieved on November 14, 2019, from: https://www.baumhedlundlaw.com/toxic-tort-law/monsanto-roundup-lawsuit/monsanto-secret-documents/

Bhaskar, Roy (2006). Determinism *in* Bottomore, Tom (Ed.), *A Dictionary of Marxist Thought* (2nd Edition) (pp. 139-141). New Jersey: Blackwell Publishing.

Biagioli, Mario (1993). *Galileo, Courtier. The Practice of Science in the Culture of Absolutism*. London: University of Chicago Press.

Boal, Augusto (1996). *O arco-íris do desejo: método Boal de Teatro e Terapia*. Rio de Janeiro: Civilização Brasileira.

Bocci, Riccardo & Chable, Veronique (2009). Peasant seeds in Europe: stakes and prospects. *Journal of Agriculture and Environment for International Development*, *103*(1/2), 81-93. DOI: 10.12895/jaeid.20091/2.26

Bonavia, Duccio (2013). *Maize: Origin, Domestication, and its Role in the Development of Culture*. Cambridge: Cambridge University Press.

Bonny, Sylvie (2014). Taking stock of the genetically modified seed sector worldwide: market, stakeholders, and prices. *Food Security*, *6*(4), 525−540. DOI: 10.1007/s12571-014-0357-1

Borges, Rui (2021). *Einstein e Lenine em Moscovo. Polémicas filosóficas da ciência soviética*. Lisboa: Parsifal.

Bowring, Finn (2003). *Science, Seeds, and Cyborgs: Biotechnology and the Appropriation of Life*. London: Verso

Boyd, William & Prudham, Scott (2017). On the Themed Collection, The Formal and Real Subsumption of Nature. *Society & natural resources*, *30*(7). DOI: 10.1080/08941920.2017.1304600

Brante, Thomas & Elzinga, Aant (1990). Towards a theory of scientific controversies. *Science & Technology Studies, 3*(2), 33-46. DOI: 10.23987/sts.55012

Bukharin, Nikolai I. *et al.* (1971). *Science at the Cross Road. Papers from the Second International Congress of the History of Science and Technology 1931 by the delegates of the URSS*. London: Frank Cass & Co. Ltd.

Busscher, Nienke, Colombo, E. L., Ploeg, L., Gabella, J.I.; & Leguizamón, A. (2019). Civil society challenges the global food system: the International Monsanto Tribunal. *Globalizations*, *17*(1), 16-30. DOI: 10.1080/14747731.2019.1592067

Carrasco, David (2000). *Quetzalcóatl and the Irony of Empire. Myths and Prophecies in the Aztec Tradition*. Boulder, CO: University Press of Colorado.

Carujo, Carlos (2019). No século XXI, a Ideologia ainda serve para alguma coisa? *in* Príncipe, Catarina & Mineiro, João (Eds.), *ABC do Socialismo. Um outro mundo não é só possível, ele está a caminho* (pp. 141-150). Lisboa: Parsifal.

Casanova, Pablo G. (1965). Internal colonialism and national development. *Studies in Comparative International Development*, *1*, 27–37. DOI: 10.1007/BF02800542

Castro, Irina & Serra, Rita (2020). A dissidência científica no feminino: contributos para a proposta tecnocientífica do ecossocialismo. *e-cadernos* CES @cetera, 34, https://journals.openedition.org/eces/6010.

Castro, Irina (2019a). Augusto Boal. *Mestras e Mestres do Mundo: Coragem e Sabedoria.* Retrieved on June 16, 2021, from: https://alice.ces.uc.pt/mestrxs/?id=27696&pag=23918&id_lingua=1&entry=34600. ISBN: 978-989-8847-08-9

Castro, Irina (2019b). Podemos salvar o clima no capitalismo?" *in* Principe, Catarina & Mineiro, João (Eds), *ABC do Socialismo. Um outro mundo não é só possível, ele está a caminho* (pp. 32-39). Lisboa: Parsifal.

Castro, Irina (2021). El conflicto científico sobre los transgénicos. De la disidencia científica a la construccíon de otra forma de producir conocimiento *in* Muñoz Rubio, Julio (Ed.), *Proceso a los Alimentos Transgénicos* (pp. 167-220) (E-book). Mexico City: Itaca,

Charles, Daniel (2002). *Lords of the harvest: Biotech, Big Money, and the Future of Food*. New York: Basic Books.

Clair, Emilie, Linn, L., Travert, C., Amiel, C., Séralini, G. E., & Panoff, J. M. (2012). Effects of Roundup® and glyphosate on three food microorganisms: Geotrichum candidum, Lactococcus lactis subsp. cremoris and Lactobacillus delbrueckii subsp. bulgaricus. *Current microbiology*, *64*(5), 486-491. DOI: 10.1007/s00284-012-0098-3

Clapp, Jennifer & Fuchs, Doris (2009). Corporate Interests in US Food Aid Policy *in* Clapp, Jennifer & Fuchs, Doris (Eds.), *Corporate power in global agrifood governance* (pp. 125-152). Cambridge & London: Massachusetts Institute of Technology. DOI: 10.7551/mitpress/9780262012751.001.0001

Clapp, Jennifer (2012). *Food*. Cambridge: Polity Press.

Cooper, Melinda (2008). *Life as Surplus: Biotechnology and Capitalism in the Neoliberal Era*. Seattle & London: University of Washington Press.

Correia, Joel (2017). Soy states: resource politics, violent environments and soybean territorialization in Paraguay. *The Journal of Peasant Studies*, *46*(2), 316-336. DOI: 10.1080/03066150.2017.1384726

Crosland, Maurice (2007). Early Laboratories c.1600–c.1800 and the Location of Experimental Science. *Annals of Science*. *62*(2), 233-253. DOI: 10.1080/00033790410001724801

Dagnino, Renato (2002). Enfoques sobre a relação ciência, tecnologia e sociedade: neutralidade e determinismo. *DataGramaZero*, (3),6.

De Vendômois, Joël S., Cellier, D., Vélot, C., Clair, E., Mesnage, R., & Séralini, G. E. (2010). Debate on GMOs health risks after statistical findings in regulatory tests. *International Journal of Biological Sciences*, *6*(6), 590. DOI: 10.7150/ijbs.6.590

De Vendômois, Joël S., Roullier, F., Cellier, D., & Séralini, G. E. (2009). A comparison of the effects of three GM corn varieties on mammalian health. *International journal of biological sciences*, *5*(7), 706. DOI: 10.7150/ijbs.5.706

Deacon, Terrence W. (2011). *Incomplete Nature. How mind emerged from matter*. New York & London: W.W. Norton & Company.

Defarge, Nicolas, De Vendômois, J. S., & Séralini, G. E. (2018). Toxicity of formulants and heavy metals in glyphosate-based herbicides and other pesticides. *Toxicology reports*, *5*, 156-163. DOI: 10.1016/j.toxrep.2017.12.025

Delborne, Jason A. (2005). *Pathways of Scientific Dissent in Agricultural Biotechnology*. PhD dissertation in Environmental Science, Policy and Management. University of California, Berkeley [fall 2005].

Delborne, Jason A. (2008). Transgenes and transgressions: scientific dissent as heterogeneous practice. *Social Studies of Science, 38*(4), 509-541. DOI: 10.1177/0306312708089716

Delborne, Jason A. (2016). Suppression and Dissent in Science *in* Bretag, Tracey (Ed.) *Handbook of Academic Integrity*. *Springer* (pp. 943-958), Singapore: Springer. DOI: 10.1007/978-981-287-098-8_30

Deleuze, Gilles & Guattari, Felix (1987). *A Thousand Plateaus: Capitalism and Schizophrena*. Minneapolis & London: University of Minnesota Press.

Demeter, Márton (2019). The World-Systemic Dynamics of Knowledge Production: The Distribution of Transnational Academic Capital in the Social Sciences. *Journal of World-Systems Research*, *25*(1). DOI: 10.5195/jwsr.2019.887

Devos, Yann, Ortiz-García, S., Hokanson, K. E., & Raybould, A. (2018). Teosinte and maize× teosinte hybrid plants in Europe. Environmental risk assessment and management implications for genetically modified maize. *Agriculture, ecosystems & environment*, *259*, 19-27. DOI: 10.1016/j.agee.2018.02.032

Deynze, Allen; Zamora, P.; Delaux, P.-M.c; Heitmann, C.; Jayaraman, D.; Rajasekar, S.; Graham, D.; Maeda, J.; Gibson, D., ..., Bennett, A. B. (2018). Nitrogen fixation in a landrace of maize is supported by a mucilage-associated diazotrophic microbiota. *Plos Biology*, *16*(8). DOI: 10.1371/journal.pbio.2006352

Diamond, Jared M. (1999). *Guns, germs, and steel: The Fates of Human Societies*. New York & London: W.W.Norton & Company.

Dickson, David (1984). Radical Science and the Modernist Dilemma *in* Radical Science Collective (Eds.), *Issues in Radical Science* (p. 127). London: Radical Science Collective.

Dinerstein, Ana C. (2017). *Concrete Utopia (Re)producing life in, against and beyond the open veins of capital*. Retrieved on June 22, 2021, from: https://publicseminar.org/2017/12/concrete-utopia/]

Downey, Gary L. (1988). Reproducing Cultural Identity in Negotiating Nuclear Power: The Union of Concerned Scientists and Emergency Core Cooling. *Social Studies of Science*, *18*(2), 231-264. DOI: 10.1177/030631288018002003

Dressel, Holly (Ed.) (2019). *Gene Drives. A report on their science, applications, social aspects, ethics ana regulations*. Bern: Critical Scientists Switzerland, European

Network of Scientists for Social and Environmental Responsibility, Vereinigung Deutscher Wissenschaftler.

Dyer, George A., Serratos-Hernández, J. A., Perales, H. R., Gepts, P., Piñeyro-Nelson, A., Chávez, A. & Alvarez-Buylla, E. R. (2009). Dispersal of transgenes through maize seed systems in Mexico. *PloS one*, *4*(5), e5734.

Eagleton, Terry (1991). *Ideology: an introduction*. London: Verso.

Easterby-Smith, S. (2019). Recalcitrant seeds: material culture and the global history of science. *Past & Present*, *242*(14), 215-242. DOI: 10.1093/pastj/gtz045

Engels, Friedrich (1974). *Dialéctica da Natureza* (Joaquim Moura Ramos & Eduardo Lúci Nogueira translation). Lisboa: Editorial Presença e Livraria Martins Fontes.

Engels, Friedrich (2020), *Anti-Dühring* (José Barata-Moura translation). Lisboa: Edições Avante [88]

Ervin, David E., Glenna, L. L., & Jussaume, R. A. (2011). The Theory and Practice of Genetically Engineered Crops and Agricultural Sustainability. *Sustainability*, *3*(6), 847-874. doi:10.3390/su3060847

Escalante, Pablo G. (2008). El México Antiguo *in* Escalante, Pablo G., Martínez, B. G., Jáuregui, L., Vázquez, J. Z., Guerra, E. S., García Diego, J., & Aguilar, L. A. (Eds.), *Nueva historia mínima de México ilustrada* (pp.21-109). México DF: El Colegio de Mexico.

Escalante, Pablo G., Martínez, B. G., Jáuregui, L., Vázquez, J. Z., Guerra, E. S., García Diego, J., Aguilar, L. A. (Eds.) (2008). *Nueva historia mínima de México ilustrada*. Mexico, DF: El Colegio de Mexico.

EZLN (2017). *El pensamiento crítico frente a la hidra capitalista*. Participación en la comisión sexta del EZLN. Editado junto a El Colectivo y Red de Solidaridad con Chiapas.

Fagan, John, Traavik, T., & Bøhn, T. (2015). The Séralini affair: Degeneration of science to re-science? *Environmental Sciences Europe*, *27*(1), 19. DOI: 10.1186/s12302-015-0049-2.

Fanon, Frantz (1983). *Los condenados de la tierra*. Ciudad de Mexico: Fondo de Cultura Económica México.

FAO — Food and Agriculture Organization of the United Nations (1997) *White Maize: A Traditional Food Grain in Developing Countries*. Rome: FAO and International Maize and Wheat Improvement Centre (CIMMYT).

FCT (Food and Chemical Toxicology) (2013). Retraction notice to ‘‘Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize’’. *Food and Chemical Toxicology*, 50, 4221–4231.

Feenberg, Andrew (1991). *Critical theory of technology*. New York: Oxford University Press.

Feenberg, Andrew (2002). *Transforming Technology. A critical theory revisited*. New York: Oxford University Press.

[88] Versions also consulted.: Engels, Friedrich (2015 [1878]). *Anti-Dühring* (Nélio Schneider translation). Boitempo Editorial; Engels, Friedrich (2014). *Anti-Dühring* (Émile Bottigelli translation). Montreuil-sous-Bois: Editions Science Marxiste.

Feenberg, Andrew (2010a). From Essentialism to Constructivism: Philosophy of Technology at the Crossroads *in* Higgs, Eric, Light, A. & Strong, D. (Eds), *Technology and the good life?* (pp. 294-315). Chicago: University of Chicago Press.

Feenberg, Andrew (2010b). Democratic rationalization: Technology, power, and freedom *in* Kaplna, Davida (Ed.), *Readings in the philosophy of technology* (pp. 139-155). Lanham: Rowman & Littlefield Publishers.

Fine, Ben (1991). Primitive Accumulation *in* Bottomore, Tom (Ed.), *A Dictionary of Marxist Thought* (pp. 444-445) (2nd Edition). Oxford: Blackwell Publishing.

Fleck, L. (1986). *La génesis y el desarrollo de un hecho científico: introducción a la teoría del estilo de pensamiento y del colectivo de pensamiento*. Madrid: Alianza.

Fontana, Josep (2019). *Capitalismo y democracia 1756-1848. Cómo empezó este engaño*. Barcelona: Editorial Crítica.

Foster, John B. (2011). *A Ecologia de Marx: materialismo e natureza*. Rio de Janeiro: Civilização Brasileira

Fourez, Gérard (2002). *A Construção das Ciências. As Lógicas das Invenções Científicas*. Lisboa: Instituto Piaget.

Franklin, Sarah (2007). *Dolly Mixtures: The Remaking of Genealogy*. Durham: Duke University Press.

Frickel, Scott, & Gross, Niel (2005). A general theory of scientific/intellectual movements. *American sociological review*, *70*(2), 204-232.

Fuglie, Keith O. & Toole, Andrew A. (2014). The evolving institutional structure of public and private agricultural research. *American journal of agricultural economic*s, 96(3), 862−883. DOI: 10.1093/ajae/aat107

Funes, Fernando, Garcia, L., Bourque, M., Pérez, N., & Rosset, P. (2002). *Sustainable agriculture and resistance: Transforming food production in Cuba*. Oakland: Food First Books.

Galtung, Johan (1969). Violence, Peace, and Peace Research. *Journal of Peace Research*, *6*(3), 167–191.

Garcia, José L., Jerónimo, H. M., & Carvalho, T. M. (2018). Methodological Luddism: A concept for tying degrowth to the assessment and regulation of technologies. *Journal of Cleaner Production*, *197*, 1647-1653. DOI: org/10.1016/j.jclepro.2017.03.184

Garcia, José Luís & Martins, Hermínio (2009). O ethos da ciência e suas transformações contemporâneas, com especial atenção à biotecnologia. *Scientiae Studia, 7*(1), 83-104. DOI: 10.1590/S1678-31662009000100005

Garcia, José Luís (2006). Biotecnologia e biocapitalismo global. *Análise Social*,vol. XLI, 181, 981-1009.

Garcia, José Luís (2011). Tecnologia, mercado e bem-estar humano: para um questionamento do discurso da inovação *in* Costa, Manuel S. & Neves, José P. (Eds.), *Tecnologia e Configurações do Humano na Era Digital – Contribuições para uma nova sociologia técnica* (pp. 65-90). Porto: Edições Ecopy.

Gracia, Laura P. (2019). Curating Sonic Laboratories. *in* RE: SOUND 2019–8th International Conference on Media Art, Science, and Technology, 8 (pp. 22-30).

García-Barrios, Raúl & Serra, Rita (2016). ¿Cuál es la ética capitalista hoy? El contrato social fáustico y sus consecuencias *in* Barreda Andrés, Enríquez L.., & Espinoza, R. H. (Eds.), *La devastación ambiental de México. Contextos, problemas y conflictos* (pp.59-93). Ciudad Universitaria, Mexico: UNAM.

García-Barrios, Raúl (2014). El origen de la reserva ecológica de la UNAM en CU: historia de un conflicto patrimonial y ambiental. *Cultura y representaciones sociales, 9*(17), 177-226.

García-Barrios, Raúl, Barrios, L. G., Álvarez-Buylla, E. R. (1991). *Lagunas: deterioro ambiental y tecnológico en el campo semiproletarizado*. Mexico City: El Colegio de Mexico. DOI: doi.org/10.2307/j.ctv512rjr

García-Barrios, Raúl., Hernández, B., & Appendini, K. (2008). La cooperación estratégica: una introducción al debate *in* García-Barrios, Raúl., Hernández, Beatriz., & Appendini, Kirsten (Eds.), *Instituciones y desarrollo. Ensayos sobre la complejidad del campo mexicano* (pp.17-32). Cuernavaca: UNAM.

García-Barrios, Rául., Serrano, O., Hinojosa, J. (2021). El Cuidado de la Gallina de los Huevos de Oro *in* García-Barrios, Raúl & Estrada, Sayani (Eds), *Problemas del agua en México. ¿Cómo abordarlos?* Ciudad de Mexico: Consejo Nacional de Ciencia y Tecnología.

Gerber, Esther & Rössler, Michael (2018). *Ecocide. Corporations on trial. International Monsanto Tribunal, the Hague 2016*. Basel: European Civic Forum (EBF) Association.

Gertel, Jorg & Sippel, Sarah R. (2016). The financialisation of agriculture and food *in* Shucksmith, Mark & Brown, David (Eds.), *Routledge International Handbook in Rural Studies* (pp. 215-226). London & New York: Routlege.

Gherardi, S. (2009). Community of practice or practices of a community in Armstrong, Steven & Fukami, Cynthia (Eds.), *The Sage handbook of management learning, education, and development* (pp. 514-530). SAGE Publications.

Gieryn, Thomas F. (1983). Boundary-work and the demarcation of science from non-science: Strains and interests in professional ideologies of scientists. *American sociological review*, 781-795. DOI: doi.org/10.2307/2095325

Gilbert, Scott F. & Epel, David (2015). *Ecological Developmental Biology. The Environmental Regulation of Development, Health, and Evolution*. Oxford: Oxford University Press.

Gilbert, Scott F. (2001). Ecological developmental biology: developmental biology meets the real world. *Developmental Biology, 233*, 1-12. DOI: doi.org/10.1006/dbio.2001.0210

Gilbert, Scott F., Bosch, T. C. G. & Ledon-Rettig, C. (2015). Eco-Evo-Devo: developmental symbiosis and developmental plasticity as evolutionary agents. *Nature Reviews Genetics, 16,* 611– 622. DOI: doi.org/10.1038/nrg3982

Gómez, Noemí Bravo (2016). Cosmovisión y ciencia del maíz mixe. *Ciencias*, *118-119*, 50-57.

González, Juliana (1998). Ética y violencia (la vis de la virtude frente a la vis de la violencia) *in* Sánchez Vázquez, Adolfo (Ed.), *El Mundo de la Violencia* (pp. 139-145). Ciudad de Mexico: UNAM & Fondo de Cultura Económica.

Gooday, Graeme (2008). Placing or Replacing the Laboratory in the History of Science?. *Isis, 99*(4), 783-795. DOI: doi.org/10.1086/595772

Gorz, André (1976). On the class character of science and scientists *in* Rose, Hilary & Rose, Steve (Eds.), *The political economy of science. Ideology of/in the Natural Sciences*. (pp.59-71). London and Basingstoke: The Macmillan Press LTD. DOI: doi.org/10.1007/978-1-349-15725-9_4

Gould, Stephen J. & Lewontin, Richard (1979). The spandrels of San-Marco and the Panglossian paradigm - a critique of the adaptationist program. *Proceedings of the Royal Society Series B-Biological Sciences, 205*(1161), 581-598. DOI: doi.org/10.1098/rspb.1979.0086

Graeber, David (2016). *The Utopia of Rule. On technology, stupidity and the secret joys of bureaucracy*. London: Melville House Publisher

Graeber, David (2018). *Bullshit Jobs: a theory*. New York: Simon & Schuster.

Graef Frieder, Roembke, J., Binimelis, R., Myhr, A., …, & Werner, A. (2012). A framework for a European network for a systematic environmental impact assessment of genetically modified organisms (GMO). *BioRisk*, 7, 73-97. https://doi.org/10.3897/biorisk.7.1969

Gramsci, Antonio (2011). *Prison Notebooks. Volume II*. New York: Columbia University Press.

Gurian-Sherman, Doug (2009). *Failure to yield: Evaluating the performance of genetically engineered crops*. Cambridge: Union of Concerned Scientists.

Habermas, Jürgen (2011). *Técnica e Ciência como "Ideologia"*. Lisboa: Edições 70.

Hakim, Danny (2016). Scientists Loved and Loathed by an Agrochemical Giant. The *New York Times*. Retrieved December 02, 2018, from: https://www.nytimes.com/2016/12/31/business/scientists-loved-and-loathed-by-syngenta-an-agrochemical-giant.html

Hall, Peter & Soskice, David (2001). *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford: Oxford University Press.

Haraway, Donna (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies, 14*(3), 575-599. DOI:10.2307/3178066

Haraway, Donna (1991). *Simians, Cyborgs, and Women: The Reinvention of Nature*. New York: Routledge.

Haraway, Donna (1997). *Modest_Witness@Second_Millennium. FemanleMan©_Meets:OncoMouseTM: Feminism and Technoscience*. New York and London: Routledge.

Haraway, Donna (2008). *When Species Meet.* Minneapolis & London: University of Minnesota Press.

Harding, Sandra (1986). *The Science question in feminism*. Ithaca: Cornell University Press.

Harvey, David (2003). The fetish of technology: Causes and consequences. *Macalester International*, *13*(1), 7.

Heilman, Brian & Barker, Gary (2018). *Masculine Norms and Violence: Making the Connections*. Washington DC: Promundo-US

Heller, Ágnes (1999). *A Theory of Modernity*. Malden & Oxford: Blackwell Publisher.

Hernández, Carol, Perales, H., & Jaffee, D. (2020). "Without Food there is No Resistance": The impact of the Zapatista conflict on agrobiodiversity and seed sovereignty in Chiapas, Mexico. *Geoforum*, [in Press]. DOI: 10.1016/j.geoforum.2020.08.016

Herring, Ronald J. (Ed.) (2007). *Transgenics of the Poor; Biotechnology in Development Studies*. Routledge.

Hessen, Boris (1971). The Social and Economic Roots of Newton's 'Principia'. *Paper presented to the second international congress of the history of science and technology. Held in London from June 29th to July 3rd, 1931, by the delegates of the U.R.S.S* (pp. 151-203). London: Frank Cass and Company Limited.

Hilbeck, Angelika., Binimelis, R., Defarge, N., Steinbrecher, R., Székács, A., Wickson, F., ... & Wynne, B. (2015). No scientific consensus on GMO safety. *Environmental Sciences Europe*, *27*(1), 1-6. DOI: 10.1186/s12302-014-0034-1

Hines, Ronald N., Sargent, D., Autrup, H., Birnbaum, L. S., Brent, R. L., Doerrer, N. G., ..., Slikker, W. (2010). Approaches for assessing risks to sensitive populations: lessons learned from evaluating risks in the pediatric population. *Toxicological Sciences*, *113*(1), 4-26. DOI: 10.1093/toxsci/kfp217

Hohenberg, Paul (1977). Maize in French agriculture. *Journal of European Economic History, 6*(1), 63-101.

Horkheimer, Max (2013). *Critique of Instrumental Reason*. London: Verso.

Hornborg, Alf (2013). Technology as Fetish: Marx, Latour, and the Cultural Foundations of Capitalism. *Theory, Culture & Society*, *31*(4). DOI: 10.1177/0263276413488960

Imbusch Peter (2003). The Concept of Violence *in* Heitmeyer W. & Hagan J. (Eds), *International Handbook of Violence Research* (pp. 13-39). Dordrecht: Springer. DOI: 10.1007/978-0-306-48039-3_2

IMT (2017). *Advisory Opinion*, 18 April 2017. Author personal records.

Janvry, Alain (1990). *The Agrarian Question and Reformism in Latin America* (4th Edition). Baltimore & London: The John Hopkins University Press.

Jasanoff, Sheila & Kim, Sang-Hyun (2013). Sociotechnical Imaginaries and National Energy Policies. *Science as Culture*, *22*(2), 189-196. DOI: 0.1080/09505431.2013.786990

Jasanoff, Sheila & Kim, Sang-Hyun (2015). *Dreamscapes of modernity. Sociotechnical imaginaries and the fabrication of power.* Chicago: University of Chicago Press.

Jasanoff, Sheila (Ed.) (2004). *States of knowledge: the co-production of science and the social order*. Routledge.

Kato, Ángel., Paczka, R., Boege, E., Wegier, A., Hernández, J., Alavez, V., …, Vecchyo, D. (2013). Origen y diversidade del Maíz, *in* Álvarez-Buylla, Elena & Piñero-

Nelson, Alma (Eds.), *El Maíz en Peligro ante los Transgénicos* (pp.25-59). Ciudad de Mexico: Centro de Investigaciones Interdisciplinarias en Ciencias y Humanidades, UNAM.

Kato-Yamakake, Ángel. (2004). Variedades transgénicas y el maíz nativo en México. *Agricultura, sociedad y desarrollo*, *1*(2), 101-109.

Kay, Lily (2000). *Who wrote the book of life? A history of the genetic code*. Stanford: Stanford University Press.

Kinchy, Abby (2012). *Seeds, Science, and Struggle: The Global Politics of Transgenic Crops (Food, Health, and the Environment)*. Cambridge & London: The MIT Press.

Klein, Naomi (2000). *No Logo: Taking Aim at the Brand Bullies*. London: Picador.

Kloppenburg, Jack R. (2004). *First the Seed. The political economy of plant biotechnology* (2nd Edition). Wisconsin: The University of Wisconsin Press.

Kloppenburg, Jack R. (2009). Social theory and the de/reconstruction of agricultural science: Local knowledge for an alternative agriculture *in* Henderson, George & Waterstone, Marvin (Eds.), *Geographic Thought. A praxis perspective* (pp.248-265). London & New York: Routledge

Knol, Maaike (2011). Constructivism and post-constructivism: The methodological implications of employing a post-constructivist research approach. Trial lecture. Retrieved on November 21, 2021, from:https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjrj96EqO_0AhWEzoUKHX4TD8QQFnoECAMQAQ&url=https%3A%2F%2Fmunin.uit.no%2Fbitstream%2Fhandle%2F10037%2F4106%2Farticle.pdf%3Fsequence%3D4%26isAllowed%3Dy&usg=AOvVaw3r6um-dS-CbQjM0MciNALX

Knorr-Cetina, Karin (1981). The micro-sociological challenge of macro-sociology*:* Towards a reconstruction of social theory and methodology *in* Knorr-Cetina, Karin & Cicourel, A.V. (Eds), *Advances in social theory and methodology: toward an integration of micro- and macro-sociologies* (pp. 1-47). Boston: Routledge.

Knorr-Cetina, Karin (1995). Laboratory studies: The cultural approach to the study of science *in* Jasanoff, Sheila *et al.*, (Eds), *Handbook of science and technology studies* (pp. 140-156). Sage. DOI: DOI:10.4135/9781412990127.d12

Knorr-Cetina, Karin (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge, MA: Harvard University Press.

Knorr-Cetina, Karin (2013). *The manufacture of knowledge: An essay on the constructivist and contextual nature of science*. Oxford: Pergamon Press

Kovel, Joel (2000). The struggle for use-value: Thoughts about the transition. *Capitalism Nature Socialism*, *11*(2), 3-23. DOI: doi.org/10.1080/10455750009358910

Koyré, Alexandre (1966). *Études Galiléennes*. Paris: Hermann.

Krasikov, V. I. (2007). Main Models of Violence in Natural and Social Sciences. *European Journal of Natural History*, (3), 131-136.

Krimsky, Sheldon., Ennis, J., Weissman, R. (1991). Academic-Corporate Ties in Biotechnology: A Quantitative study. *Science, Technology and Human Values*, *16* (3), 257-2587. DOI: 10.1177/016224399101600301

Kuehn, Robert (2004). Suppression of Environmental Science. *American Journal of Law & Medicine,* 30, 333-369. DOI: 10.1177/009885880403000210

Kvakkestad, Valborg (2009). Institutions and the R&D of GM-crops. *Ecological economics*, *68*(10), 2688-2695. DOI:10.1016/j.ecolecon.2009.05.004

Latour, Bruno & Woolgar, Steve (1986). *Laboratory Life: The Construction of Scientific Facts*. Princeton and New Jersey: Princeton University Press.

Latour, Bruno (1983). Give Me a Laboratory and I will Raise the World *in* Knorr-Cetina, K. & Mulkay, M. (Eds.), *Science Observed: Perspectives on the Social Study of Science*. London and Beverly Hills: Sage.

Latour, Bruno (1987). *Science in action: How to follow scientists and engineers through society*. Cambridge: Harvard University Press.

Lave, Rebecca., Mirowski, P., & Randalls, S. (2010). Introduction: STS and Neoliberal Science. *Social Studies of Science*, *40*(5), 659-675. DOI: 10.1177/0306312710378549

Lawrence, Geoffrey., Sippel, S., & Burch, D. (2015). The financialisation of food and farming *in* Robinson, Guy M. & Carson, Doris A. (Eds.), *Handbook on the Globalisation of Agriculture* (pp. 309-327). Cheltenham & Northampton: Edward Elgar Publishing.

Le Curieux-Belfond, O., Vandelac, L., Caron, J., & Séralini, G. É. (2009). Factors to consider before production and commercialization of aquatic genetically modified organisms: the case of transgenic salmon. E*nvironmental Science & Policy*, *12*(2), 170-189. DOI: 10.1016/j.envsci.2008.10.001

Lebrecht, Tamara, Wallace, H., & Castro, I. (2019). Social Issues *in* Critical Scientists Switzerlan, European Network of Scientists for Social and Environmental Responsability, Vereinigung Deutscher Wissenschaftler (Eds.) *Gene Drive - A report on their science, applications, social aspects, ethics and regulations* (pp.159-241). Bern & Berlin: Holly Dressel.

Levins, Richard & Lewontin, Richard (2009). *The Dialectical Biologist*. Delhi: Aakar Books.

Levins, Richard (1990). Towards the Renewal of Science, *Rethinking Marxism: A Journal of Economics, Culture & Society*, 3(3-4), pp: 100-125. DOI: 10.1080/08935699008657929

Levins, Richard (1998a). Dialectics and systems theory. *Science & Society, 62*(3), 375-399.

Levins, Richard (1998b). The internal and external in explanatory theories. *Science as Culture*, 7(4), 557-582. DOI: 10.1080/09505439809526525

Levins, Richard (2015). *Una pierna adentro, una pierna afuera.* México DF: Editora C3

Lewontin, Richard & Levins, Richard (2007). *Biology under the influence. Dialectical essays on ecology, agricultural, and health*. New York: Monthly Review Press.

Lewontin, Richard (1961). Evolution and the theory of games. *Journal of theoretical biology, 1*(3), 382-403. DOI: 10.1016/0022-5193(61)90038-8

Lewontin, Richard (1998). *Biologia como Ideologia*. Lisboa: Relógio D´Água.

Lewontin, Richard (2001). *The triple helix: Gene, organism, and environment*. Harvard University Press.

Licoppe, Christian (1996). *La formation de la pratique scientifique. Le discours de l'expérience en France et en Angleterre (1630 - 1820)*. Paris: La Découverte.

López Austin, Alfredo (2006). *Los Mitos Del Tlacuache. Caminos De La Mitología Mesoamericana*. Ciudad de Mexico: UNAM-Instituto de Investigaciones Antropológicas.

Louçã, João C. (2021). *Pensar a Utopia, Transformar a Realidade. Práticas concretas*. Lisboa: Parsifal.

Luhmann, Niklas (2012). *Theory of society*. Stanford: Stanford University Press.

Magnus, David (2008). The Green Revolution in Bioethics. *The American Journal of Bioethics, 8*(8), 1-2. DOI: 10.1080/15265160802424135

Mandel, Ernest (1992). *Power and Money: A Marxist Theory of Bureaucracy*. London: Verso.

Mangelsdorf, Paul C. (1974). *Corn. Its origin, evolution and improvement* (2nd edition). Cambridge, Massachusetts & London: The Belknap Press of Harvard University Press.

Mann, Charles C. (2006). *1491: New Revelations of the Americas Before Columbus* (2nd edition). New York: Vintage Books.

Mann, Susan A. & Dickinson, James M. (1978). Obstacles to the development of a capitalist agriculture. *The Journal of Peasant Studies*, *5*(4), 466–481. DOI: .1080/03066157808438058

Marcuse, Herbert (1991). *One-dimensional man: studies in the ideology of advanced industrial society*. Boston: Beacon Press.

Martin, Brian (1977). A critique of the Australian National University's Centre for Resource and Environmental Studies. *The Ecologist*, 7(6), pp. 224-232

Martin, Brian (1992). Intellectual suppression: why environmental scientists are afraid to speak out. *Habitat Australia*, *20*(3), 11-14.

Martin, Brian (1996). Critics of pesticides: whistleblowing or suppression of dissent?. *Philosophy and Social Action*, *22*(3), 33-55.

Martin, Brian (1997). *Suppression Stories*. Wollongong: Fund for Intellectual Dissent.

Martin, Brian (1999). Suppression of dissent in science. *Research in social problems and public policy*, 7, 105-135

Martin, Brian (2010). How to Attack a Scientific Theory and Get Away with It (Usually): The Attempt to Destroy an Origin-of-AIDS Hypothesis. *Science as Culture*, *19* (2), 215-239. DOI: 10.1080/09505430903186088.

Martin, Brian (2020). What I've learned about suppression of dissent. Medium.com.

Marx, Karl (1845) "Theses on Feuerbach" Marxists Internet Archive https://www.marxists.org/archive/marx/works/1845/theses/theses.htm [25 August 2019]

Marx, Karl (2015). *El Capital. Livro I. Capítulo VI (inédito). Resultados del proceso inmediato de producción*. Ciudad de México: Siglo XXI Editores.

Marx, Karl (2017a). *El Capital, Tomo I, vol 1*. (Pedro Scaron Trans.) (11th Edition). Ciudad de México: Siglo XXI Editores.

Marx, Karl (2017b), *El Capital, Tomo I, vol 2*. (Pedro Scaron Trans.) (11th Edition). Ciudad de México: Siglo XXI Editores.

Marx, Karl (2017c), *El Capital, Tomo I, vol 3*. (Pedro Scaron Trans.) (11th Edition). Ciudad de México: Siglo XXI Editores.

Matos Moctezuma, Eduardo (2018a). Festividades practicadas del lado de Tláloc, *Arqueología Mexicana*, *81*, 32−33.

Matos Moctezuma, Eduardo (2018b). Mito del robo del maíz del Tonacatépetl o Montaña de los Mantenimientos. *Arqueología Mexicana, 81*, 34-42.

McNally, David (2012). *Monsters of the Market. Zombies, Vampires and Global Capitalism*. Chicago: Haymarket Books

Medina, Eden (2011). *Cybernetic revolutionaries. Technology and Politics in Allende's Chile*. Cambridge and London: The MIT Press.

Mesnage, Robin, Agapito-Tenfen, S. Z., Vilperte, V., ... & Antoniou, M. N. (2016). An integrated multi-omics analysis of the NK603 Roundup-tolerant GM maize reveals metabolism disturbances caused by the transformation process. *Scientific reports*, *6*(1), 1-14. DOI: 10.1038/srep37855

Mesnage, Robin, Oestreicher, N., Poirier, F., Nicolas, V., Boursier, C., & Vélot, C. (2020). Transcriptome profiling of the fungus Aspergillus nidulans exposed to a commercial glyphosate-based herbicide under conditions of apparent herbicide tolerance. *Environmental research*, *182*, 109116. DOI: 10.1016/j.envres.2020.109116

Middleton, Chris (1981). Peasants, Patriarchy, and the Feudal Mode of Production in England: A Marxist Appraisal: 1 Property and Patriarchal Relations within the Peasantry. *The Sociological Review*, *29*(1), 105–135. DOI: 10.1111/j.1467-954X.1981.tb03025.x

Mirowski, Philip, & Van Horn, Robert (2005). The contract research organization and the commercialization of scientific research. *Social studies of science*, *35*(4), 503-548. DOI: 10.1177/0306312705052103

Moore, Mark P. (2009). The Union of Concerned Scientists on the Uncertainty of Climate Change: A Study of Synecdochic Form. *Environmental Communication*, 3(2), 191-205. DOI: 10.1080/17524030902916657

Morton, Adam D. (2010). Reflections on uneven development: Mexican revolution, primitive accumulation, passive revolution. *Latin American Perspectives*, 37(1), 7-34. DOI: 10.1177/0094582X09350767

Muguerza, Javier (1998). La no-violencia como Utopía *in* Sánchez Vázquez, Adolfo (Ed.), *El Mundo de la Violencia* (pp. 31-46). Ciudad de Mexico: UNAM & Fondo de Cultura Económica.

Myers, Judith H. (2001). Predicting the Outcome of Biological Control *in* Charles W. F., Derek A. R. & Daphne J. F. (Eds.), *Evolutionary Ecology: concepts and case studies* (pp. 361-370). Oxford: Oxford University Press.

Nixon, Rob (2011). *Slow Violence and the Environmentalism of the Poor*. Harvard University Press.

Novotny, Eva (2018). Retraction by corruption: the 2012 Séralini paper. *Journal of Biological Physics and Chemistry*, 18, 32–56. DOI: 10.4024/19NO17F.jbpc.18.01

Nunes, João Arriscado (2001). A síndrome do Parque Jurássico: história(s) edificante(s) da genética num mundo “sem garantias”. *Revista Critica das ciências Sociais*, 61, 29-62.

Nunes, João Arriscado (2004). Do «nome das acções» ao «nome das coisas»: Crenças e produção de objectos epistémicos nas ciências da vida e na biomedicina *in* Fernando Gil *et al.* (Eds.), *O processo da crença* (pp. 402-412). Lisboa: Gradiva.

Nunes, João Arriscado (2009). Rescuing Epistemology (Karen Bennett translation), *RCCS Annual Review*, 1, 1-27. DOI: 10.4000/rccsar.165

Nunes, João Arriscado & Roque Ricardo (Eds.) (2008). *Objectos Impuros. Experiências em Estudos sobre Ciência*. Porto: Edições Afrontamento.

Nunes, João Arriscado, Diego, C., Matias, M., & Costa, S. (2003). *GMO and Public Policy in Portugal or How Not to Put GMOs into Politics, Research report*, PubAcc Project. Coimbra: CES.

O’Connor, James (2001). *Causas Naturales. Ensayos de Marxismo Ecológico*. Ciudad de Mexico: Siglo XXI editores

Omodeo, Pietro D. (2019). *Political epistemology*. Springer International Publishing.

Oreskes, Naomi & Conway, Eric M. (2010). *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Climate Change*. New York: Bloomsbury Press

Oyama, Susan, Griffiths, P. E., & Gray, R. D. (Eds.) (2001). *Cycles of contingency: Developmental systems and evolution*. Cambridge: MIT Press,

Papadopoulos, Dimitris (2010a). Activist Materialism. *Deleuze Studies, 4,* 64-83. DOI: 10.3366/dls.2010.0206

Papadopoulos, Dimitris (2010b). Alter-ontologies: Towards a constituent politics in technoscience. *Social Studies of Science, 41*(2) 177–201. DOI: 10.1177/0306312710385853

Papadopoulos, Dimitris (2014). Politics of Matter: Justice and Organisation in Technoscience. *Social Epistemology, 28*(1), 70–85. DOI: 10.1080/02691728.2013.86287

Peña-Azcona, Ivett, García-Barrios, R., García-Barrios, L., Ortega-Argueta, A., & Elizondo, C. (2021). The unruly complexity of conservation arrangements with Mexican rural communities: Who really funds the game?. Journal of Rural Studies, 87, 112-123. DOI: 10.1016/j.jrurstud.2021.08.027

Petrović, Gajo (1991a). Praxis *in* Bottomore, Tom (Ed.) *A Dictionary of Marxist Thought* (2nd Edition) (pp. 435-440). New Jersey: Blackwell Publishing.

Petrović, Gajo (1991b). Alienation *in* Bottomore, Tom (Ed.) *A Dictionary of Marxist Thought* (2nd Edition) (pp. 11-16). New Jersey: Blackwell Publishing.

Petrović, Gajo (1991c). Reification *in* Bottomore, Tom (Ed.) *A Dictionary of Marxist Thought* (2nd Edition) (pp. 463-465). New Jersey: Blackwell Publishing.

Pickering, Andrew (1992*). Science as Practice and Culture*. Chicago, University of Chicago Press.

Piñeyro-Nelson, Alma, Van Heerwaarden, J., Perales, H. R., Serratos-Hernández, J. A., Rangel, A., Hufford, M. B., & Álvarez-Buylla, E. R. (2009). Transgenes In Mexican Maize: Molecular Evidence and Methodological Considerations for GMO Detection In Landrace Populations. *Molecular Ecology*, *18*(4), 750-761. DOI: 10.1111/j.1365-294X.2008.03993.x

Piron, Florence, & Varin, Thibaut (2015). El caso Séralini y la confianza en el orden normativo dominante de la ciencia. *Sociológica* (México), *30*(84), 231-274.

Poehlman, John M. (2013). *Breeding field crops* (3rd Edition). New York: Springer Science & Business Media.

Portier, Christopher J., Goldman, L. R., & Goldstein, B. D. (2014). Inconclusive findings: now you see them, now you don't!. *Environmental Health Perspectives, 122*(2), A36. DOI:10.1289/ehp.1408106

PPT (2011). Session on Agrochemical Transnational Corporations. *Permanente People's Tribunal, 3-6 December*.

Prakash, Gyan (1999). *Another Reason: Science and the Imagination of Modern India*. New Jersey: Princeton University Press.

Pratt, Jeff (2007). Food values: The local and the authentic. *Critique of anthropology*, *27*(3), 285-300. DOI: 10.1177/0308275X07080357

Prete, Giovanni, & Cournil, Christel (2019). Staging International Environmental Justice: The International Monsanto Tribunal. *PoLAR: Political and Legal Anthropology Review*, 42(2), 191-209.

Proctor, Robert & Schiebinger, Linda L (Eds) (2008). *Agnotology: The making and unmaking of ignorance. California*: Stanford University Press.

Proctor, Robert (2008). Agnotology: A Missing Term to Describe the Cultural Production of Ignorance (and Its Study) *in* Proctor, Robert, & Schiebinger, Linda L (Eds), *Agnotology: The making and unmaking of ignorance. California*: Stanford University Press.

Proctor, Robert (2012). *Golden Holocaust: Origins of the Cigarette Catastrophe and the Case for Abolition*. Berkeley: University of California Press

PTT-Mexico (2012). Libre Comercio, Violencia, Impunidad Y Derechos De Los Pueblos En México (2011-2014). Audiencia General Introductoria. *Tribunal Permanente de los Pueblos*. Ciudad Juárez, Chihuahua, 27-29 May.

Purnhagen, Kai & Wesseler, Justus (2020). EU regulation of new plant breeding technologies and their possible economic implications for the EU and beyond. *Applied Economic Perspectives and Policy*, *43*(4), 1621-1637. DOI: 0.1002/aepp.13084

Queiroz, Regina (2018). Neoliberal TINA: an ideological and political subversion of liberalism, *Critical Policy Studies*, 12(2), 227-246. DOI: 10.1080/19460171.2016.126321

Quist, David & Chapela, Ignacio H. (2001). Transgenic DNA introgressed into traditional maize landraces in Oaxaca, Mexico. *Nature, 414*, 541-543. DOI: 10.1038/35107068

Rajan, Ravi (2001). Toward a Metaphysic of Environmental Violence: The Case of the Bhopal Gas *in* Peluso, Nancy Lee & Watts, Michael (Eds), *Violent Environments* (pp. 380-397). Ithaca & London: Cornell University Press.

Ranum, Peter; Peña-Rosas, J. P.; Garcia-Casal, M. N. (2014). Global maize production, utilization, and consumption. *Annals of the New York Academy of Sciences*, *1312*(1). DOI: 10.1111/nyas.12396

Rendueles, César (2013). *Sociofobia. El cambio político en la era de la utópia digital*. Madrid: Capitán Swing.

Renting, Henk., Marsden, T. K., & Banks, J. (2003). Understanding alternative food networks: Exploring the role of short food supply chains in rural development. *Environment and Planning A: Economy and Space*, *35*(3), 393–411. DOI: 10.1068/a3510

Rheinberger, Hans-Jörg (2010). *An Epistemology of the Concrete: Twentieth-Century History of Life*. Durham: Duke University Press.

Roberts, Andrew, Devos, Y., Raybould, A., Bigelow, P., & Gray, A. (2014). Environmental risk assessment of GE plants under low-exposure conditions. *Transgenic Research*, *23*(6), 971-983. DOI: 10.1007/s11248-013-9762-z

Robins, Kevin, & Webster, Frank (1983). Luddism: New technology and the critique of political economy. *Science, Technology and the Labour Process: Marxist*, *2*, 9-48.

Robins, Kevin, & Webster, Frank (1985). Intellectual self-mutilation. *Higher Education Quarterly*, *39*(2), 97-104.

Robles, Braulio., Flores, J., Martínez, J. L., Herrera, P. (2018). The Chinampa: An Ancient Mexican Sub-Irrigation System. *Irrigation and Drainage*, 68(1), 115-122. DOI: 10.1002/ird.2310

Rose, Hilary & Rose, Steve (1976). The Problematic Inheritance: Marx and Engels on the Natural Sciences *in* Rose, Hilary & Rose, Steve (Eds.), *The political economy of science. Ideology of/in the natural sciences* (pp. 1-13). London and Basingstoke: The Macmillan Press Ltd.

Rose, Hilary (1983). Hand, brain, and heart: A feminist epistemology for the natural sciences. *Signs: journal of Women in Culture and Society*, 9(1), 73-90.

Rose, Hilary (1986). Beyond masculinist realities: A feminist epistemology for the sciences *in* Bleier, Ruth (Ed.), *Feminist approaches to science* (pp. 57-76). New York: Pergamon Press.

Rubião, André (2013). *História da Universidade. Geneologia de um "Modelo Participativo"*. Coimbra: Edições Almedina

Rubio, Julio Muñoz (2016). El Fetichismo en la Biología Reduccionista Contemporánea: Una Crítica desde el Marxismo y la Dialéctica *in* Manus, F,. Valadez, O., & Xilotl, E. (Eds.), *Naturaleza, Ciencia Y Sociedad: 40 años de pensamiento crítico* *interdisciplinario en la Facultad de Ciencias, UNAM* (pp. 155-170). Ciudad de México: UNAM.

Ruiz, Mayra, Knapp, A., & Garcia-Ruiz, H. (2018). Profile of genetically modified plants authorized in Mexico. *Biotechnology in Agriculture and the Food Chain*, 9(3). DOI: 10.1080/21645698.2018.1507601

Saraiva, Tiago (2016). *Fascist Pigs. Technoscientific organisms and the history of fascism*. Cambridge & London: The MIT Press.

Sell, Susan (2009). Corporations, Seeds, and Intellectual Property Rights Governance *in* Clapp, Jennifer & Fuchs, Doris (Eds.), *Corporate power in global agrifood governance*. Cambridge & London: Massachusetts Institute of Technology.

Séralini, Gilles. E, De Vendômois, J. S., Cellier, D., Sultan, C., Buiatti, M., Gallagher, L., ... & Dronamraju, K. R. (2009). How subchronic and chronic health effects can be neglected for GMOs, pesticides or chemicals. *International Journal of Biological Sciences*, 5(5), 438. DOI: 10.7150/ijbs.5.438

Séralini, Gilles. E, Mesnage, R., …, & Clair, E. (2011). Genetically modified crops safety assessments: present limits and possible improvements. *Environmental Sciences Europe*, 23, 10. DOI: 10.1186/2190-4715-23-10

Séralini, Gilles. E. (2013). *Tous cobayes!: OGM, pesticides, produits chimiques*. Flammarion.

Séralini, Gilles. E., Cellier, D., & de Vendômois, J. S. (2007). New analysis of a rat feeding study with a genetically modified maize reveals signs of hepatorenal toxicity. *Archives of environmental contamination and toxicology*, *52*(4), 596-602. DOI: 10.1007/s00244-006-0149-5

Séralini, Gilles. E., Clair, E., …, &Mesnage, R. (2014). Republished study: long-term toxicity of a Roundup herbicide and a Roundup-tolerantgenetically modified maize. *Environmental Sciences Europe*, 26, 14. DOI: 10.1186/s12302-014-0014-5

Séralini, Gilles. E., Clair, E., Mesnage, R., Gress, S., Defarge, N., Malatesta, M., ... & De Vendômois, J. S. (2012). RETRACTED: Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize. *Food and Chemical Toxicology*, *50*(11), 4221-4231. DOI: 10.1016/j.fct.2012.08.005

Séralini, Gilles. E., Mesnage, R., Defarge, N., Gress, S., Hennequin, D., Clair, E., ... & De Vendômois, J. S. (2013). Answers to critics: Why there is a long-term toxicity due to a Roundup-tolerant genetically modified maize and to a Roundup herbicide. *Food and Chemical Toxicology*, 53, 476-483.

Shapin, Steven & Schaffer, Simon (1985). *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. New Jersey: Princeton University Press.

Shapin, Steven (1999). *A Revolução Científica*. Lisboa: Difel.

Shapin, Steven (2008). *The Scientific Life: a moral history of a late modern vocation*. Chicago & London: The University of Chicago Press.

Sheehan, Helena (2017). *Marxism and the philosophy of science: A critical history*. London: Verso Books.

Shiva, Vandana (1988). *Staying Alive: Women, Ecology and Survival in India*. London: Zed Books.

Shiva, Vandana (1992). The seed and the earth. Biotechnology and the colonisation of regeneration. *Development dialogue*, (1-2), 151–168.

Shiva, Vandana (1993a). *The violence of the Green Revolution. Third World Agriculture, Ecology and Politics*. London & New Jersey: Zed Books, Lda.

Shiva, Vandana (2013b). *Seeds of Suicide and Slavery Versus Seeds of Life and Freedom*. Retrieved on February 22, 2019, from: https://www.aljazeera.com/opinions/2013/3/30/seeds-of-suicide-and-slavery-versus-seeds-of-life-and-freedom

Shiva, Vandana (2014). *The Seeds of Suicide: How Monsanto Destroys Farming*. Retrieved on February 22, 2019, from: http://www.globalresearch.ca/the-seeds-of-suicide-how-monsanto-destroysfarming/5329947.

Sismondo, Sergio (2008). How pharmaceutical industry funding affects trial outcomes: causal structures and responses. *Social science & medicine, 66*(9), 1909-1914. DOI: 10.1016/j.socscimed.2008.01.010

Smith, Jonathan Z., Buxton, R. G.A., Bolle, K. W. (2020). Myth *in* Encyclopedia Britannica: https://www.britannica.com/topic/myth. [Accessed on February, 8 February 2020].

Soper, Kate (1999). Of OncoMice and Female/Men: Donna Haraway on Cyborg Ontology. *Capitalism Nature Socialism*, *10*(3), 73-80.

Sorel, Georges (2011). *Reflexiones sobre la violencia*. Comares

Sousa Ribeiro, António (2013). Introdução: A representação da violência e a violência da representação *in* Sousa Ribeiro, António (Ed.), *Representações da violência*. Coimbra: Almedina.

Sousa Santos, Boaventura (2002). Para uma sociologia das ausências e uma sociologia das emergências. *Revista Crítica de Ciências Sociais*, *63*, 237-280.

Sousa Santos, Boaventura (2018). *The end of the cognitive empire. The coming of age of epistemologies of the south*. Durham & London: Duke University Press.

Star, Susan L. (2007). Living grounded theory: Cognitive and emotional forms of pragmatism *in* Bryant, Antony & Charmaz, Kathy (Eds.), *The Sage handbook of grounded theory* (pp. 75-94). London: SAGE Publications Ltd.

Star, Susan L., & Strauss, Anselm (1999). Layers of silence, arenas of voice: The ecology of visible and invisible work. *Computer supported cooperative work (CSCW)*, *8*(1), 9-30. DOI: 10.1023/A:1008651105359

Strevens, Michael (2020). *The Knowledge Machine: How Irrationality Created Modern Science*. New York: Liveright.

Taylor, Peter (2005). *Unruly complexity. Ecology, Interpretation, Engagement*. Chicago & London: The university of Chicago Press.

Taylor, Peter J. & Patzke, Karin (2021). From Radical Science to STS. *Science as Culture, 30*(1), 1-10. DOI: 10.1080/09505431.2020.1857351

Tilley, Helen (2011). *Africa as a Living Laboratory. Empire, Development, and the Problem of Scientific Knowledge, 1870-1950*. Chicago: Chicago University Press.

Timmermans, Stefan & Tavory, Iddo (2012). Theory construction in qualitative research: From grounded theory to abductive analysis. *Sociological theory*, *30*(3), 167-186. DOI: 10.1177/0735275112457914

Topçu, Sezin (2008). Confronting nuclear risks: counter-expertise as politics within the French nuclear energy debate. *Nature and Culture*, *3*(2), 225-245.

Tutino, John (1992). Historias del México Agrario (Translated by Mario A. Zamudio Vega). *Historia Mexicana*, *42*(2), 177−220.

Tutino, John (2018). *The Mexican Heartland. How communities shaped capitalism, a nation, and world history, 1500−2000*. Oxford: Princeton University Press.

Uranovsky, Y.M. (1935). Marxism and Natural Sciences. *Marxists Internet Archive* https://www.marxists.org/subject/science/essays/science.htm [14 of October 2019].

van Heerwaarden, Joost., Ortega Del Vecchyo, D., ´Slvarez-Buylla, E. R., & Bellon, M. R. (2012). New genes in traditional seed systems: diffusion, detectability and persistence of transgenes in a maize metapopulation. *Plos One*, *7*(10): e46123. DOI: 10.1371/journal.pone.0046123

Vandermeer, John (1995). The ecological basis of alternative agriculture. *Annual Review of Ecology and Systematics*, *26*(1), 201-224. DOI: 10.1146/annurev.es.26.110195.001221

Vaquinhas, Irene Maria (2004). As mulheres na sociedade portuguesa oitocentista. Algumas questões económicas e sociais (1850-1900) *in* Vieira, Benedicta (Ed.) *Grupos sociais e estratificação social em Portugal no século XIX* (pp 149-164). Lisboa: Centro de Estudos de História Contemporânea Portuguesa, CEHCP – ISCTE.

Vavilov, Nikolai (2014). The Problem of the Origin of the World's Agriculture in the Light of the Latest Investigations *in* Bukharin, Nikolai I. *et al.* (Eds.) *Science at the Cross Road. Papers from the Second International Congress of the History of Science and Technology 1931* (pp. 97-106). London: Routledge.

Vázquez, Adolfo Sánchez (2013). *Filosofía de la praxis*. Ciudad de Mexico: Siglo Veintiuno Editores.

Vázquez, Daniel S. (2017). *Treinta años de transgénicos en México (compendio cartográfico).* Ciudad de México: Centro de Estudios para el Cambio en el Campo Mexicano.

Velicu, Irina & Ogrezeanu, Andreea (2021). Quiet no More: The Emergence of Food Sovereignty Movement in Romania. *Journal of Rural Studies*, 89, 122-129. DOI: 10.1016/j.jrurstud.2021.11.024

Veraza, Jorge (2008). *Subsunción real del consumo bajo el capital*. México: Editorial Itaca.

Vinck, Dominique (2007). Back to the laboratory as a knowledge production space. *Revue d'anthropologie des connaissances*, *1*(2), 160-166. DOI: 10.3917/rac.002.0160

Wallace, Rob (2016). *Big farms make big flu: dispatches on infectious disease, agribusiness, and the nature of science*. New York: Monthly Review Press.

Warman, Arturo (1993). *La historia de un bastardo: maíz y capitalismo*. Ciudad de Mexico: Fondo de Cultura Económica.

Weber, Marx (2001). *A Ética Protestante e o Espiríto do Capitalismo* (Ana Bastos & Luís Leitão Trans.) (10^{th} Edition). Barcarena: Editorial Presença.

Weiss, Rick (1999). Seeds of Discord: Monsanto's Gene Police Raise Alarm on Farmers' Rights, Rural Tradition. *Washington Post*, February 3, p.A1-A6 https://www.washingtonpost.com/archive/politics/1999/02/03/seeds-of-discord/c0f613a0-02a1-476f-b54d-af25413844f5/

Whaley, P., Halsall, C., Ågerstrand, M., Aiassa, E., Benford, D., Bilotta, G., ... & Taylor, D. (2016). Implementing systematic review techniques in chemical risk assessment: Challenges, opportunities and recommendations. *Environment international*, *92*, 556-564. DOI: 0.1016/j.envint.2015.11.002

Wilentz, Amy (2012). A Zombie is a Slave Forever. New York Times. Retrieved on April 6, 2020, from: https://www.nytimes.com/2012/10/31/opinion/a-zombie-is-a-slave-forever.html

Wood, Ellen M. (2002). *The origin of capitalism: A longer view*. London: Verso.

Wynne, Brian (2013). Ciencia global, el maíz mexicano y el neoliberalismo molecular: cambiando los fundamentos de la ciencia, innovación y políticas para una alimentación y una agricultura sostenibles *in* Álvarez-Buylla, Elena & Piñeyro-Nelson, Alma (Eds.), *El Maíz en peligro ante los transgénicos: un análisis integral sobre el caso de México* (pp. 279-312). Mexico City: Centro de Investigaciones Interdisciplinarias en Ciencias y Humanidades, UNAM.

Zapata, Francisco (Ed.) (2017). *Transgénicos. Grandes benefícios, ausências de daños y mitos*. Ciudad de Mexico: Academia Mexicana de ciencias A. C.

Zemelman, Hugo (1996). *Problemas antropológicos y utópicos del conocimiento*. Mexico DF: Colegio de Mexico.

Žižek, Slavoj (2008). *Violência*. Boitempo Editorial.

Context of drawings

Pages 2, 107. Represents the conflict over maize. The draw is based on a photograph by Sasa Miljevic (2011) taken during a rehearsal of the theatre of the oppressed play of the "Students on loan". Draw by the author.

Page 13. Draw by the author, reproducing mural that was installed on August 26, 2011 at the El Colegio de la Frontera Sur, Mexico. Author of the mural Liqen.

Page 21. Draw by the author, representing Quetzalcoatl transforming into an ant to steel the maize kernel.

Pages 32, 100. Draw by the author representing milpa.

Page 54, 146. Draw by the author of the Science for the People movement logo.

Page 57. Draw by the author of our modern dystopia.

Page 103. Draw by the author, representing maize as bombs. Inspired by the work of Vandana Shiva.

Page 130. Draw by the author of a ladybug. Inspired by the work and life of Angelika Hilbeck.

Page 131. Draw by the author on the logo of this Ph.D. project. Original image by André Queda.

Annexes

Annex 1: Text co-authored with Sergio Martín Tapia Argüello on the International Monsanto Tribunal, published in the Portuguese Edition of Le Monde Diplomatique in May 2016 (pp.14-15). The text is in Portuguese and has 2 pages.

Annex 2: Text co-authored with Rita Serra with the title "Feminine Scientific Dissidence: Contributions to the Technoscientific Proposal of Ecosocialism" [translation of the article], published in CES *e-cadernos*.

The text has attempted to contribute to the ecosocialist project. The text addresses the stories of three dissident women scientists (Rachel Carson, Lynn Margulis, and Elena Álvarez-Buylla) in light of the new materialist feminism.

It contributes to the dissertation narrative by providing two other dissent stories.

The text is in Portuguese and has 12 pages.

Annex 3: Chapter published in the book "Proceso a los Alimentos Transgénicos" [E-book], edited in 2021 by Júlio Muñoz Rubio.

The chapter contributes to the dissertation narrative by expanding the discussion on the formation of dissent studies.

The text presented is a pre-publication version, given that the book cannot be reproduced by any means other than its e-book format.

The text is in Spanish and has 18 pages.

Annex 4: Chapter published in the book "ABC do Socialismo. Um outro mundo não é só possível, ele está a caminho", edited in 2019 by Catarina Príncipe and João Mineiro.

The chapter discusses why it is not possible to save the climate within the framework of capitalism.

The text presented is a pre-print version, given that the book cannot be reproduced by any means other than its physical format.

The text is in Portuguese and has 8 pages.

Annex 5: Text about "Augusto Boal" published in 2021 at Mestras e Mestres do Mundo: coragem e Sabedoria.

The text contributes to the dissertation by providing more information regarding Augusto Boal's influences on the author when analysing Jason Delborne's proposal on the performative aspects of dissent scientists.

The text is in Portugueses and has 6 pages.

Annex 6: Text co-authored with Tamara Lebrecht and Helen Wallace, on the social issues regarding gene drive. The chapter was published by the Critical Scientists Switzerland, European Network of Scientists for Social and Environmental Responsibility, and Vereinigung Deutscher Wissenschaftler on the *Gene Drive - A report on their science, applications, social aspects, ethics, and regulations*.

The chapter contributes to the dissertation by providing more information regarding new GEO developments, such as gene drive.

The text is in English and has 56 pages.

ANNEX 1

Ambiente

Glifosatos, OGM e segurança alimentar em Portugal

Tribunal Monsanto: novo capítulo dos tribunais ético-populares internacionais

O debate sobre as consequências para a saúde e o ambiente da utilização de organismos geneticamente modificados (OGM) pela indústria agroquímica está a ganhar relevo em Portugal. Afinal, o país é um dos poucos da União Europeia que continua a permitir o cultivo de OGM. A realização de um Tribunal Monsanto, prevista para Outubro de 2016, insere-se numa história de realização de tribunais ético-populares que pretendem mobilizar a cidadania e reforçar a capacidade de intervenção dos poderes públicos.

IRINA CASTRO e **SERGIO MARTÍN ARGUELLO** *

O Tribunal Monsanto[1] é uma iniciativa popular internacional, lançada em Dezembro de 2015, que visa avaliar as acusações feitas contra a empresa *transnacional norte-americana Monsanto. A empresa é conhecida mundialmente por ser o símbolo da indústria agroquímica e pioneira na criação de patentes e comercialização de organismos geneticamente modificados (OGM),* o que a torna o centro de muitos debates técnico-científicos, morais e até mesmo legais sobre a viabilidade, relevância e legalidade do uso de tais organismos.

Como em outros casos semelhantes, a empresa é actualmente acusada de múltiplas violações dos direitos fundamentais e dos povos, que, de acordo com quem as sustem, incluem práticas comerciais pouco éticas e até mesmo alguns casos ilegais de ocultação sistemática e estratégica de informação relevante para a tomada de decisão política, financiamento de estudos científicos fraudulentos, manipulação da imprensa e ameaças a cientistas e jornalistas independentes.

A maioria destas questões poderão ser resolvidas (e às vezes são) a partir de uma abordagem predominantemente legal. No entanto, processos de desterritorialização dos grandes capitais, a disparidade crescente das possibilidades de resposta de actores internacionais e locais, bem como a diferença entre os tempos legais, políticos e tecnológicos, impedem uma resposta adequada a partir da lei nacional. Lei nacional esta que ainda se encontra ancorada em velhas ideias de soberania, em processos de largo alcance e em dinâmicas de problemas locais, gerando assim muitas vezes respostas incompletas ou obsoletas para os problemas que foram superados na prática, nem sempre da melhor maneira possível.

Confrontada com este problema, a visão neoliberal propõe uma espécie de auto-regulação social que permita a resolução de conflitos de uma forma harmoniosa, assegurando ainda que é preferível a não intervenção dos Estados. Esta visão, no entanto, esconde o seguinte facto: numa sociedade em que o poder social e as diferentes formas de capital existentes se encontram distribuídas de forma desigual, todas as formas da chamada «auto-regulação» tornam-se imposições da vontade daqueles que têm melhores recursos para isso.

Devido a isso, existem actualmente várias iniciativas para preencher a lacuna, cada vez mais clara, deixada pela impossibilidade do sistema jurídico do Estado de regular situações específicas que, pela sua natureza e perigos que potencialmente representam, devem ser tratadas imediatamente e da forma mais completa possível. Neste sentido, os promotores do Tribunal Monsanto, provenientes de várias associações e movimentos pela justiça ambiental de todo o globo, e onde se encontram nomes como Vandana Shiva, Corinne Lepage, Marie-Monique Robin, Olivier De Schutter e Gilles-Eric Séralini, procuram, através do fortalecimento dos chamado «tribunais ético-populares» encerrar o ciclo de impunidade que possibilita a empresas transnacionais a contínua perpetuação de crimes contra a humanidade e o ambiente.

Tribunais ético-populares internacionais

Em 1966, Bertrand Russell e outros filósofos, juristas, escritores e activistas políticos iniciaram o processo constitutivo do Tribunal Russell, que viria a expor no ano seguinte os crimes contra a humanidade cometidos em nome da política externa norte-americana, tais como os cometidos durante a Guerra do Vietname. *No seio do grupo que iniciou o processo constitutivo dos primeiros tribunais ético-populares internacionais* encontrava-se Lelio Basso, advogado socialista italiano, que viria a inspirar a fundação do Tribunal Permanente dos Povos (TPP). Legitimado pela intervenção colectiva e participação democrática, o TPP constituiu-se em 1979 como um tribunal moral, independente dos Estados, capaz de examinar e exercer juízos sobre violações dos direitos humanos e dos direitos fundamentais dos povos. Partindo da base ética e jurídica patente na Declaração Universal dos Direitos dos Povos, assinada na Argélia em 1976, o Tribunal foi fundado como parte da missão da secção internacional da Fundação Lelio e Lisli Basso - Issoco[2].

As lições aprendidas nos cinquenta anos da existência de tribunais ético-populares prendem-se com a forma como o constitucionalismo neoliberal tem invadido as instituições formais de justiça, quer ao nível nacional, quer ao nível internacional. Se por um lado se assiste, através dos tribunais éticos, ao surgimento de uma nova constitucionalidade não neoliberal e promotora dos direitos fundamentais, observa-se paradoxalmente a degeneração da justiça nacional e internacional em matéria de incumprimento dos direitos fundamentais dos povos, e a crescente incapacidade governativa que impossibilita a construção de novos projectos ético-nacionais.

Apoiando-se no conceito de *Estados Sequestrados* estes tribunais, que incluem para além dos já referidos o Tribunal Latino-americano da Água e o recém-anunciado Tribunal Monsanto, procuram sentenciar a noção moderna de Estado por desviar de si mesmo o poder em matérias de direitos fundamentais, e por constantemente privilegiar os interesses corporativos privados. Em causa está *a degeneração da justiça no que toca aos direitos económicos, sociais, culturais e* ambientais, e a imposição de uma racionalidade jurídica neoliberal promotora de vazios legais cujo único propósito é proteger os interesses das burguesias nacionais e internacionais.

Por outro lado, estes tribunais têm vindo também a denunciar a forma como se têm organizado os conceitos, fundamentos e as próprias actuações do Direito Internacional (TPP 1992 e 2002[3]), no sentido de ocultar outras formas de relação económicas, sociais e culturais não capitalistas. Em suma, a crítica debruça-se sobre o esvaziamento do conceito de soberania, e da interpretação neoliberal do Direito como ferramenta administrativa e não como exercício da moral.

Uma crítica mais radical[4] descreve os quadros normativos do capitalismo como instáveis, e com o propósito de induzir a interpretação da lei como mercadoria de valor negociável. Em causa estão relações globais de poder fáctico que nos iludem em construções de identidades globalizadas do que é ser humano, de paz e segurança e de desenvolvimento sustentável, mas cujo propósito é a construção de quadros jurídicos que apenas favorecem grandes investigadores transnacionais.

Conscientes de que a justiça depende do poder relativo das partes e da estrutura normativa do espaço de negociação e litígio, os tribunais ético-populares recorrem a uma estratégia de acção em duas frentes. Por um lado concentram-se na denúncia das sistemáticas e incontestáveis violações dos direitos dos povos, perpetuadas por Estados e organizações privadas, e por outro na construção de normas jurídicas colectivas capazes de estabelecer o respeito universal e efectivo dos direitos fundamentais dos povos e minorias.

Portugal e os Tribunais Internacionais

A presença portuguesa é ainda limitada nos TPP e noutros tribunais ético-populares internacionais. Em boa verdade, são poucas as pessoas portuguesas envolvidas nos comités, não tendo sido até à data encontrados pelos autores deste texto casos específicos de denúncia ou acusação por parte de organizações ou pessoas portuguesas a tribunais ético-populares. Portugal parece então surgir neste cenário internacional como um país sem conflitos, principalmente no que diz respeito à Monsanto. Não devemos no entanto esquecer que na União Europeia é apenas possível o cultivo de OGM em países como a República Checa, Eslováquia, Roménia, Espanha e Portugal. Por outro lado, a visão de que Portugal é um país sem conflitos é contrariada na prática por lutas como as que se desenrolaram em torno das barragens, e por recém-formados movimentos e plataformas como a *Não ao TTIP e a Plataforma Algarve Livre de Petróleo, que revelam uma realidade* bastante distinta. Neste sentido, e porque as ausências são processos activos de construção das mesmas, iniciou-se um trabalho de pesquisa que visa avaliar os poderes que actuam na ocultação dos conflitos entre pessoas/organizações e empresas transnacionais. Este trabalho encontra-se ainda em desenvolvimento.

No que diz respeito à presença portuguesa em comités do TPP, a primeira representação do país no TPP fez-se através de Ernesto Melo Antunes, militar do Movimento das Forças Armadas (MFA) e duas vezes ministro dos Negócios Estrangeiros dos governos provisórios. Melo Antunes foi membro do TPP sobre a Argentina (1980) e El Salvador (1981), que condenou ambas as juntas militares por crimes contra a humanidade, e do TPP sobre o Afeganistão (1981), que condenou a intervenção soviética no país, considerando-a um atentado à soberania dos povos e ao direito internacional. À presença de Melo Antunes segue-se um vazio de representação portuguesa, unicamente preenchida pela sessão TPP sobre Timor-Leste realizada em Lisboa em 1981, e que no seio das suas resoluções imputava ao governo português a responsabilidade de, enquanto ex-potência colonizadora, garantir o direito à autodeterminação do povo timorense.

Em 1990, Portugal voltaria a estar representado no TPP através de Maria Amélia Santos, eleita para o Parlamento Europeu entre 1989 e 1994, na condição de presidente do Grupo dos Verdes no Parlamento Europeu. Em 1998, Luís Moita, então professor universitário da Universidade Autónoma de Lisboa, surge como membro do TPP sobre direitos dos trabalhadores e consumidores das indústrias de confecção (1998). Um ano depois junta-se com Maria Catalina Batalha Pestana ao TPP sobre a violação dos direitos fundamentais das crianças e adolescentes do Brasil (1999). Luís Moita foi ainda membro do TPP sobre violações dos direitos humanos na Argélia (1992-2004).

Portugal voltaria a um TPP em 2010, mas em circunstâncias bastantes distintas das anteriores. Durante o TPP sobre a União Europeia e Corporações Transnacionais na América Latina, o Banif foi referenciado como uma das multinacionais envolvidas na destruição ambiental e degradação das condições de vida das populações afectadas pela barragem do rio Madeira, no Brasil. Outra acusação feita a este grupo económico foi o seu favorecimento no âmbito das renegociações das dívidas que ocorreram entre os anos 80 e 90 em vários países da América Latina. Perante as acusações, o Banif foi condenado pelo impacto ambiental e social nefasto dos seus investimentos, e o Estado português foi condenado por não providenciar mecanismos de protecção às vítimas destas estruturas.

ANDRÉ LUZ · Sem título, 2016 (fotografia original de Popeye Logic, 2013) · www.andreluzdesign.com

Tribunal Monsanto

Os tribunais ético-populares são hoje uma realidade global na luta pela construção de um outro Direito. É pois com base nestas experiências e com o objectivo de configurar novas formas ao movimento que se planeia o Tribunal Monsanto (TM). Previsto para Outubro de 2016, o TM visa avaliar as acusações feitas contra a empresa Monsanto no que respeita à sua actuação global, e às sucessivas violações dos direitos fundamentais e dos povos. Entre as múltiplas acusações encontram-se os crimes de violação do direito a um ambiente seguro (Direito Internacional dos Direitos Humanos), violação do direito à alimentação (Pacto Internacional sobre Direitos Económicos, Sociais e Culturais) e de cumplicidade na perpetração de um crime de guerra no contexto da operação «Ranch Hand» (Tribunal Penal Internacional).

Baseando-se nos «Princípios Orientadores sobre Empresas e os Direitos Humanos», aprovados na ONU em 2011, e no Estatuto de Roma de 2002, o Tribunal Monsanto visa também a realização de um processo de reforma do Tribunal Penal Internacional no sentido de este passar a incluir o crime de ecocídio. Este processo sucede assim às recomendações efectuadas no âmbito do TPP sobre Indústrias Transnacionais de Agroquímicos realizado em 2011. Nesse ano, o TPP debruçou-se sobre um colectivo de seis empresas (que no seu conjunto dominam 72% do mercado global de pesticidas, entre elas a Monsanto) que foram indiciadas pelos crimes de violação dos direitos à saúde e à vida e de violarem os direitos dos povos indígenas, entre outros.

A tipificação do crime de ecocídio permitirá a possibilidade de instaurar processos crimes contra pessoas singulares ou colectivas pela destruição ou degradação ambiental enquanto crimes contra a natureza, a paz, a humidade e as futuras gerações. Apesar de a questão não ser nova no debate internacional, o conceito foi recentemente reelaborado pela advogada Polly Higgins.

Actualmente, o campo jurídico ambiental está pautado por uma panóplia de leis e regulamentações, tratados internacionais e convenções não vinculativas, que na cacofonia das múltiplas ferramentas disponíveis, o tornam ineficaz. Este é, aliás, o campo do Direito onde melhor se revelam as formas de sequestro de Estados por parte da constitucionalidade neoliberal. Por ser um campo recente do Direito, o direito ambiental tem-se vindo a constituir em simultâneo com um conjunto de transformações económicas e sociais que buscam, por um lado, transformar esse Direito numa ferramenta de acumulação de riqueza das burguesias nacionais ou internacionais e, por outro, resistir-lhes procurando legitimar outras formas de relacionamento moral entre povos.

A par desta crítica estabelece-se ainda uma outra ao direito internacional enquanto ferramenta pouco vinculativa, débil, e limitada a uma visão legalista. Em grande medida, esta crítica passa pela forma como o direito internacional busca apenas constituir-se no quadro da legalidade ao invés de promover justiça. Os tribunais ético-populares internacionais escapam assim à armadilha tecnocrata do neoliberalismo ao estabelecerem novos quadros morais, o que lhes confere legitimidade para condenar situações legais consideradas imorais, como é o caso da destruição ambiental promovida pela maioria dos investimentos em grandes infra-estruturas hidroeléctricas, ou dos danos causados ao ambiente e à saúde pela aplicação de pesticidas, como o glifosato, no âmbito do projecto político de agricultura industrial.

O Tribunal Monsanto, tal como os outros tribunais ético-populares internacionais, configura-se como uma forma de justiça alternativa, cuja legitimidade advém do carácter colectivo da moral das suas resoluções e dos fundamentos jurídicos que as sustentam. Neste sentido, é necessário que todas as pessoas se unam em torno desta iniciativa. ■

* Respectivamente, voluntária no Tribunal Monsanto, ecóloga e investigadora júnior do Centro de Estudos Sociais (CES), doutoranda em Governação, Conhecimento e Inovação, Faculdade de Economia da Universidade de Coimbra – CES; e advogado pela Benemérita Universidade Autónoma de Puebla, membro do grupo «Crítica Jurídica Latino-americana» e doutorando em Human Rights in Contemporary Societies no Centro de Estudos Sociais, Universidade de Coimbra.

[1] www.monsanto-tribunalp.org.
[2] www.fondazionebasso.it.
[3] As datas indicam os anos em que sessões do TPP se dedicaram ao tema.
[4] Ver o dossiê «Las victimas del desarrollo: discusiones para la acción colectiva», *El Otro derecho*, n.º 51, 2016.

e-cadernos CES

34 | 2020
Alerta vermelho, alerta verde: dar forma à transformação ecossocialista

ANNEX 2

A dissidência científica no feminino: contributos para a proposta tecnocientífica do ecossocialismo

Feminine Scientific Dissidence: Contributions to the Technoscientific Proposal of Ecosocialism

Irina Castro e Rita Serra

Edição electrónica
URL: https://journals.openedition.org/eces/6010
DOI: 10.4000/eces.6010
ISSN: 1647-0737

Editora
Centro de Estudos Sociais da Universidade de Coimbra

Referência eletrónica
Irina Castro e Rita Serra, «A dissidência científica no feminino: contributos para a proposta tecnocientífica do ecossocialismo», *e-cadernos CES* [Online], 34 | 2020, posto online no dia 09 julho 2021, consultado o 23 outubro 2021. URL: http://journals.openedition.org/eces/6010 ; DOI: https://doi.org/10.4000/eces.6010

IRINA CASTRO, RITA SERRA

A DISSIDÊNCIA CIENTÍFICA NO FEMININO: CONTRIBUTOS PARA A PROPOSTA TECNOCIENTÍFICA DO ECOSSOCIALISMO*

Resumo: Através de três histórias de mulheres cientistas dissidentes (Rachel Carson, Lynn Margulis e Elena Álvarez-Buylla) e à luz do novo feminismo materialista, procuramos contribuir para o projeto ecossocialista de uma nova estrutura tecnológica das forças produtivas.

Palavras chave: ciência e tecnologia, dissidência científica, ecossocialismo, feminismo.

FEMININE SCIENTIFIC DISSIDENCE: CONTRIBUTIONS TO THE TECHNOSCIENTIFIC PROPOSAL OF ECOSOCIALISM

Abstract: Through three stories of dissident women scientists (Rachel Carson, Lynn Margulis and Elena Álvarez-Buylla) and in light of the new materialist feminism, we seek to contribute to the ecosocialist project of a new technological structure for the productive forces.

Keywords: ecosocialism, feminism, science and technology, scientific dissent.

INTRODUÇÃO

Este texto[1] procura realçar a importância da integração de uma visão feminista na proposta ecossocialista para uma nova estrutura tecnológica das forças produtivas (Löwy, 2010).

* Este trabalho recebeu apoio de fundos nacionais do Estado português através da bolsa de doutoramento SFRH/BD/117707/2016 da primeira autora do texto, atribuída pela FCT – Fundação para a Ciência e a Tecnologia. As autoras agradecem ainda às organizações que promoveram o IV Encontros Internacionais Ecossocialistas – Alerta vermelho, alerta verde: dar forma à transformação ecossocialista, e em particular à Paula Sequeiros e à Carmo Bica.

[1] Este ensaio resulta da reflexão promovida no âmbito dos IV Encontros Internacionais Ecossocialistas – Alerta vermelho, alerta verde: dar forma à transformação ecossocialista. Irina Castro foi oradora do evento no painel "Ecofeminismos: conhecimento e ação" e Rita Serra no painel "Debater os sistemas alimentares".

Por exemplo, a crítica feminista sobre como a história da ciência oculta ativamente o trabalho feminino, contribuindo ainda para a manutenção de uma forma de produção de conhecimento capitalista, tem permitido uma melhor interpretação relativamente ao processo de desvalorização do trabalho feminino que tende a alargar-se a todo o tecido "proletário" científico. Neste texto, no entanto, iremos referir-nos de forma particular às críticas feministas cujos contributos têm permitido desconstruir a forma dominante de pensamento dualista e reducionista que guia a noção de racionalidade do pensamento científico moderno ocidental. Invocamos o novo feminismo materialista, pois este, ao focar-se na matéria, isto é, na materialidade e processos da materialização, gera uma nova posição ético-onto-epistémica (Barad, 2007). Ou, por outras palavras, uma morfologia da mudança que nos permite não apenas interpretar as relações de poder internas na ciência, mas também como estas relações de poder originam artefactos de conhecimento que se representam como factos universais inabaláveis.

De entre as múltiplas frentes de pensamento que promove, o novo feminismo materialista resgata a visão crítica sobre a produção de conhecimento das suas formas subsumidas aos interesses do capital. Destacamos de entre estas formas as que, como diria Robert N. Proctor (2008), atuam com o objetivo não de produzir um conhecimento alternativo ou emancipador, mas espaços de ignorância.

No sentido de melhor enquadrar as críticas do novo feminismo materialista sobre a produção científica, optamos por recorrer às histórias biográficas de três mulheres cientistas. Para nós, estas três histórias não são apenas histórias de mulheres na ciência, mas exemplos de dissidência com a forma hegemónica patriarcal e capitalista de produzir conhecimento. Iremos por isso iniciar este contributo explicando o nosso entendimento sobre a importância da dissidência científica, em particular a feminina, para o processo de construção de uma crítica capaz de contribuir para a nova estrutura tecnológica das forças produtivas. Esta crítica é fundamental, pois consideramos que até à data os debates sobre a ciência e a tecnologia no seio do ecossocialismo têm reproduzido a estrutura patriarcal dominante, deixando assim escapar uma reflexão sobre as consequências desta forma de produção relativa à formação da consciência acerca do conhecimento (da verdade e dos factos).

Ainda assim, queremos reforçar a importância do ecossocialismo, em particular, no apurar das formas alternativas de organização da produção, fazendo frente à barbárie capitalista.

1. O QUE É A DISSIDÊNCIA CIENTÍFICA?

Os processos coercivos do capital sobre as formas de trabalho, bem como o controlo que hoje detêm sobre os meios e processos de produção, resultaram numa classe trabalhadora alienada e impedida de se apropriar diretamente do produto do seu trabalho. O trabalho académico, apesar do discurso de excecionalidade de que se reveste, não está imune a estes processos coercivos, nem aos seus encantos e feitiços. No entanto, e na maioria das vezes, as formas de coercividade sobre o trabalho académico apenas são visíveis em situações de controvérsia. Como têm vindo a demonstrar os estudos do sociólogo Brian Martin (1997, 2010), a coercividade é sempre mais visível quando em situação de controvérsia, pois desta brotam as estratégias de supressão organizada (Martin, 2010). Isto não significa, no entanto, que a coercividade seja esporádica. Pelo contrário, de acordo com Martin (1996, 1997, 2010) a controvérsia é uma característica endémica da atividade académica e a coercividade um aviso disciplinar.

Ser um dissidente implica, por isso, viver em conflito contínuo com as relações de poder estabelecidas na atividade científica (Delborne, 1993, 2016) e, portanto, uma construção contínua de redes de apoio onde essa dissidência adquire corpo político. Isto não significa que todas as dissidências resultem em formas alternativas de produção de sistemas de conhecimento e tecnologia. Aliás, o nosso argumento aqui é que as redes de apoio que sustentam a dissidência são muitas das vezes reprodutoras de estruturas de poder que estão na origem do conflito. Ainda assim, devemos aproveitar a oportunidade que muitas histórias de dissidência nos abrem, nomeadamente por revelarem as estruturas de poder que impedem o acesso e o controlo democrático sobre as formas de produção de conhecimento.

Mas tal como a dissidência pode resultar em alternativas, também pode ser deturpada e apropriada com o objetivo de revitalizar as formas de coerção. Esta coercividade é assim aceitadora da crítica, mas apenas e só se esta se submeter a uma forma tímida. Não é de estranhar, por isso, que a própria história da ciência dê tanta ênfase à dissidência "desejável".

A dissidência desejável é enquadrada pela hegemonia narrativa da história da ciência como forma de justificar a excecionalidade das formas de trabalho científicas. Não é por isso contraditório que histórias de teorias como a do modelo heliocêntrico ou da evolução sejam descritas por dissidências que visam cristalizar o ato como parte do espírito científico moderno. Em boa verdade estas dissidências desejáveis contribuem para a manutenção da narrativa de que a ciência desinteressada é antidogmática, pois ela própria se desafia continuamente, animando assim a ideia revolucionária do conhecimento e a narrativa da inovação. Uma narrativa que, quando olhada através da lente do feminismo, revela como essas dissidências desejáveis se compõem de histórias masculinas, brancas e oriundas do ocidental Norte. É por isso que queremos aqui visibilizar as dissidências de mulheres. Mulheres que nesta história de ciência construída no masculino se apresentam como anti-heroínas. Mulheres como Hipátia, Aspásia, Hipárquia, Émilie du Châtelet, Sophie Germain, Maria Gaetana Agnesi, Augusta Ada Byron King, Sofia Kovalevskaya, Hildegard de Bingen, Mamie Phipps Clark, entre tantas outras, cujos trabalhos académicos, e suas dissidências, contribuíram para uma constante revisão crítica do conhecimento.

Neste ponto, algumas/alguns das/dos nossas/os leitoras/es poderão questionar a figura de Marie Curie: não será ela uma dissidente desejável, símbolo do feminismo? Em primeiro lugar, queremos dizer que, se a considerarmos uma dissidente desejável, ela é a exceção que confirma a regra, pois nos demonstra como o sistema de produção de conhecimento é estruturalmente patriarcal e capitalista. Não o fosse, Marie Curie não seria uma excecionalidade na história da ciência, mas uma norma. Em segundo lugar, queremos reforçar que a sua história biográfica tem sido apropriada pela narrativa masculinizada. Da sua biografia tem sido ocultada a Marie "transgressora", limitando a sua existência ao campo da ciência.

É neste sentido, e como diria Hilary Rose (1994), que a história da ciência masculinizada está aberta às múltiplas leituras que o(s) feminismo(s) nos podem fornecer. Uma delas, por exemplo, é a de que as mulheres não são apenas uma parte invisibilizada da produção do conhecimento, mas sim a estrutura de base do trabalho necessário para produção e reprodução do conhecimento científico (Fox, 2006). Secretárias, gestoras, assistentes técnicas, funcionárias de limpeza de laboratórios. Mulheres que ocupam lugares de trabalho já por si genderizados e sem os quais a atividade científica não seria possível.

Olhar a história da ciência através de uma lente feminista é, por isso, mais do que contar histórias de mulheres. Contar que foi negado duas vezes o prémio Nobel a Marie Curie, bem como o seu acesso à Royal Society (Rose, 1994: 145), permite não apenas expor a discriminação baseada no género à qual foi submetida, mas também expor como o trabalho das mulheres serviu para desvalorizar de forma generalizada certas formas de trabalho científico. Por exemplo, considerar certos trabalhos científicos como de baixa intensidade intelectual, trabalhos estes normalmente atribuídos a mulheres, permite que se disponibilize tais trabalhos de forma barata.

2. Grandes desafiadoras do cânone científico

Entender a história da ciência através das histórias de mulheres em nada se compara à construção patriarcal da narrativa individualista que constrói a história hegemónica atual da ciência. A dissidência no feminino contribui para dotar a história da ciência de novas representações, e revela as tensões que essas novas representações geram no seio da produção do conhecimento. Neste sentido, a nossa abordagem está comprometida com o projeto político do feminismo. Neste campo, consideramos que uma ciência feminista (Rouse, 1996) é distinta de uma ciência liberal das mulheres. Esta última, apesar de centrar o foco sobre a opressão de género, não ambiciona, *per se*, derrubar todas as estruturas de opressão.

2.1. Rachel Carson (1907-1964)

Rachel Carson é uma das figuras mais importantes da história da dissidência científica. Autora de vários trabalhos académicos que popularizaram a ciência, Rachel é hoje mais conhecida pelo seu trabalho *Silent Spring* (1962) do que pelos seus diversos artigos e livros sobre biologia marinha. De acordo com Arlene Quarantiello (2004), Rachel nasceu longe do oceano, numa família humilde da Pensilvânia, nos Estudos Unidos da América. Apesar das distâncias, seria a paixão pelo oceano que a iria influenciar a percorrer uma carreira científica. No entanto, a distância ao mar obriga-a ao exercício da imaginação, e é nessa imaginação que Rachel desenvolve a sua paixão pela observação naturalista que, juntamente com a sua majestosa capacidade literária, a transformará numa das grandes ambientalistas da nossa história (Waddell, 2000).

Apesar de não ser uma pessoa muito social, Rachel sempre esteve cercada por pessoas que desempenharam papéis fundamentais para o seu trabalho, e contribuíram de várias maneiras com reflexões e informações sobre as quais Rachel posteriormente trabalharia (Quarantiello, 2004). Entre essas figuras, destacamos o relacionamento de amizade com Dorothy Freeman. Dizem que o relacionamento das duas transgredia o entendimento à época sobre amor e amizade. Uma transgressão que não passaria despercebida pelos seus detratores.

Em *Silent Spring*, Rachel alerta sobre os possíveis efeitos nocivos do uso de pesticidas para o meio ambiente e a saúde humana. No entanto, as suas críticas não se limitaram apenas às evidências científicas ou, neste caso, à ausência de evidências que apoiavam o uso massivo de pesticidas. As críticas de Rachel abriram espaço a um debate social sobre os limites do conhecimento científico e técnico e a invocação das suas certezas, principalmente quando esse conhecimento, produzido de forma reducionista e confinada, interage em sistemas complexos.

Rachel desafia, nos seus múltiplos trabalhos, as ideias dominantes de que através do conhecimento científico é possível obter controlo e domínio sobre a natureza. Em vários dos seus trabalhos a bióloga aponta que a relação entre humanidade e natureza não pode ser vista como um conflito que foi incorporado na prática da produção do conhecimento. Em vez disso, Rachel desafia-nos a perseguir uma ciência responsável com a vida, ancorada em conceitos de amor e cuidado.

Silent Spring foi alvo de várias tentativas de supressão pela indústria química. Tanto a National Chemical Association quanto a Manufacturing Chemists' Association investiram milhões de dólares em campanhas públicas contra Rachel (Waddell, 2000). As pressões sobre os editores e as distribuidoras foram feitas por empresas como a Velsicol Chemical Corporation, ameaçando com procedimentos legais caso a obra fosse publicada (Lear, 2009; Waddell, 2000).

Juntamente com as pressões para suprimir a publicação e a relevância do seu trabalho, foram ainda esgrimidas campanhas difamatórias sobre a vida de Rachel pela indústria. Velsicol acusou a autora de ser comunista e de se organizar com o bloco soviético na destruição da agricultura e da economia americanas. A empresa Monsanto promoveu uma paródia do trabalho de Rachel que foi publicada em vários jornais (Quarantiello, 2004: 107). À credibilidade científica de Rachel foram ainda tecidos argumentos pejorativos por esta ser mulher, solteira, sem filhos, sem doutoramento e por não ser uma cientista empírica (Quarantiello, 2004; Lear, 2009; Waddell, 2000).

Apesar dos contínuos ataques, *Silent Spring* teve um grande impacto social ao ecoar em várias vozes – cientistas e ativistas – que na época tentavam alertar para os perigos do uso não regulamentado de pesticidas. A publicação teve tanto impacto que o presidente norte-americano John F. Kennedy ordenou que o seu Comité Consultivo Científico procedesse a uma investigação especial. Esse comité garantiu a veracidade e a importância do trabalho de Rachel, iniciando um caminho que culminaria na formação da Agência de Proteção Ambiental (EPA) e na proibição do uso do pesticida DDT (Waddell, 2000).

2.2. Lynn Margulis (1938-2011)

Lynn Margulis foi uma bióloga que desenvolveu o entendimento moderno da evolução através do "mecanismo de simbiose". É considerada uma das mais brilhantes e importantes teóricas da evolução do nosso tempo, mas as suas ideias e obras nem sempre foram recebidas com o mesmo otimismo que hoje usamos para falar sobre Lynn. A sua teoria simbiótica da evolução, descrita no seu artigo "On the Origin of Mitosing Cells", publicado em 1967, representou uma nova maneira de entender a evolução: como uma rede complexa de relacionamentos, demonstrando como, à data, a visão darwiniana da árvore evolutiva baseada na competição não era a representação mais correta (Bybee, 2014). Como se pode ler no livro que publicou em coautoria com o seu filho, Dorion Sagan, "a vida não conquistou o planeta por via do combate, mas formando-se em redes. As formas de vida multiplicaram-se e complexificaram-se através da cooptação, não através da morte" (Margulis e Sagan, 1997: 26; tradução nossa). A sua proposta foi tão ousada para o seu tempo que somente à décima quinta tentativa Lynn conseguiu publicar o seu artigo (Sagan, 2014).

Lynn entendeu que a teoria da evolução darwinista era uma proposta brilhante que, no entanto, tinha sido transformada e usada como dogma para servir os interesses do capitalismo. Discordante da ideia de que a evolução era orientada pela competição, Lynn também não se identificava com o socialismo e a "ajuda mútua" de Kropotkin, apesar de se aproximar mais dessa metáfora do que a usada pelos neodarwinistas (Khalil, 2014: 45-46). Para Lynn, tanto a seleção natural quanto a ajuda mútua permitem a eliminação e/ou a sobrevivência, mas não a criação. É por isso que ela apresentou, ao contrário de Darwin e Kropotkin, uma teoria que não se concentra na manutenção da vida, mas na criação dessa própria vida (Sagan, 2014).

Lynn nunca guardou palavras para descrever a maneira pela qual o neodarwinismo não estava apenas cientificamente errado, como fazia parte das interpretações capitalistas da vida. Com Richard Dawkins, um dos seus principais oponentes, animou históricos debates sobre a teoria da evolução (*ibidem*). Ainda assim, Dawkins ocupa um espaço público na história da ciência que oculta o trabalho de Lynn.

Tal como Rachel, também Lynn recebeu duras críticas, maioritariamente baseadas não em argumentos científicos, mas em reproduções estereotipadas de género. Se, por um lado, era ativamente ignorada pela comunidade científica, por outro, Lynn era acusada de ser ideológica, radical e às vezes histérica demais. Foi ainda ridicularizada pelo seu trabalho enquanto comunicadora de ciência. Essa forma de descrédito de Lynn contrasta, no entanto, com o entusiasmo que a história da ciência demonstra perante comunicadores de ciência como Carl Sagan, ex-companheiro de Lynn.

2.3. Elena Álvarez-Buylla (1959-)

Nascida na Cidade do México, Elena começou cedo a desenvolver o seu interesse particular pelas plantas, observando as flores e outras espécies vegetais do seu jardim e questionando-se sobre o funcionamento da vida e sobre o impacto que a prática humana tem sobre o mundo vegetal. Esse caminho conduzi-la-ia à agricultura e a um envolvimento próximo com comunidades indígenas e camponesas no México.

Enquanto estudante na Universidade Nacional Autónoma do México (UNAM), Elena envolveu-se em vários ativismos, incluindo a luta pela designação de parte do campus universitário como reserva natural (Barrios, 2014). Essa experiência política, na qual os seus estudos em biologia apoiaram as suas ações, foi um fator decisivo na construção do seu espírito científico – que não nega a importância de uma investigação científica robusta, mas que é sensível às necessidades sociais e políticas de transformação do momento histórico em que se vive. Anos mais tarde, Elena muda-se para os Estados Unidos da América, onde desenvolve as suas habilidades em biologia do desenvolvimento, combinando-as com ecologia evolutiva, e centra o seu interesse científico sobre o milho.

Para Elena, o milho, para além de permitir investigar processos evolutivos, recorrendo à biologia molecular, é um exemplo de cultivo humano cujos avanços tecnológicos lhe conferiram a capacidade de mudar o mundo. No entanto, no México, o milho tem uma centralidade histórica e cultural incomparável a qualquer outro país. Elena encontra assim no milho a possibilidade de unir a ciência básica à compreensão dos processos agroecológicos ligados às comunidades camponesas e indígenas e, em particular, aos seus processos de resistência e luta por autonomia territorial. O resultado foi a criação de uma conceção sobre a ciência baseada no mais profundo rigor, mas incorporada numa postura crítica comprometida com processos e lutas sociais. A síntese produzida por Elena é a de uma ciência cujo rigor não procura responder unicamente aos critérios internos da prática do conhecimento, mas que, sobretudo, se faz responsável.

Atualmente é alvo de duras críticas por parte dos seus detratores, principalmente devido à sua posição crítica sobre os transgénicos, e sobre a forma como descreve as consequências da hegemonia científica ocidental capitalista sobre as formas ancestrais de produção de conhecimentos situados; o que Santos (1999) denomina de epistemicídio.

Adicionalmente, vivemos numa época em que uma grande parte das formas de desacreditar cientistas dissidentes passa pelas redes sociais, tornando-se este um novo canal de supressão que ainda não está a ser consistentemente trabalhado pela literatura sobre dissidência científica. A título exemplificativo, no grupo do Facebook "Não à pseudociência na UNAM", Elena é constantemente alvo de ataques. Entre os diversos membros do grupo incluem-se pessoas como Mauricio-José Schwarz. Schwarz é um jornalista e escritor, nascido no México, atualmente a viver em Espanha, cujas múltiplas intervenções públicas passam por promover a desacreditação de Elena enquanto cientista. É, por exemplo, a ele que podemos atribuir a autoria da comparação, no seio deste grupo de rede social, da figura de

Elena com Trofín Lysenko. Nos seus diversos comentários e publicações nesta rede, bem como no seu canal de Youtube, Schwarz apelida-a várias vezes como “doutora Lysenko”, a “nova Lysenko”, “Elena Lysénkova Álvarez-Buylla”. A associação de Elena a Lysenko, além de claramente abusiva, revela uma tentativa de desacreditar Elena enquanto cientista, ao pregar sobre ela uma figura controversa como a do cientista comunista russo. Desta forma, os seus detratores encontram uma estratégia que nega à Elena, e à comunidade académica, o direito de serem também sujeitos políticos.

CONCLUSÕES

O que estas três histórias refletem é que, por oposição à história masculinizada e individualista dominante, existe uma história, cujo olhar feminista permite promover alternativas e novas objetividades comprometidas com a evolução do sentido de justiça e responsabilidade. Nelas, a responsabilidade é entendida como uma postura de produção que vai além da ideia de responder imediata e tecnicamente a problemas sociais e ambientais urgentes. Estas histórias dialogam com as múltiplas ontologias do conhecimento global, na construção das questões e possibilidades de resposta, com base numa ética de cuidado e preservação.

Infelizmente a atual forma de produção de conhecimento, cada vez mais orientada para a sua “projetificação” e ancorada nas necessidades socioeconómicas de uma forma de produção capitalista, apesar de possibilitar novos e alternativos desenvolvimentos teóricos e produtos, também impõe duras barreiras materiais a uma prática transformadora generalizada. Neste sentido, as histórias das mulheres dissidentes podem ser úteis para o processo da interpretação, mas este ainda se encontra limitado na sua capacidade de transformação. Daí surge a relevância de uma ação dissidente coletiva.

Consideramos, assim, que é neste ponto que reside a importância do diálogo entre o novo feminismo materialista e o ecossocialismo. O novo feminismo materialista dota a proposta ecossocialista não apenas com um novo olhar sobre os problemas da produção, mas com alternativas concretas enquadradas no objetivo de uma nova estrutura tecnológica dos meios de produção.

As práticas transformadoras existem na atualidade, e acontecem a cada momento em que o sistema de produção de conhecimento capitalista se contradiz. As dissidências de cientistas, como as mencionadas, resultam das contradições fundacionais da forma de produção capitalista da ciência, denunciando ao mesmo tempo o epistemicídio (Santos, 1999) e os danos da ética capitalista. Consideramos, pois, que a “outra” ciência já é praticada e merece a atenção dos e das ecossocialistas – que apesar de assertivos/as sobre os efeitos danosos de algumas verdades e objetos do conhecimento moderno, permanecem benevolentes com o modo de produção capitalista do conhecimento.

Aprender com a dissidência científica das mulheres é um caminho necessário para a construção de um conhecimento socialista anticapitalista. Aprender com a sua dissidência é também relembrar uma das lições mais importantes de Karl Marx: que o nosso objetivo é interpretar o mundo para o transformar.

Revisto por Ana Sofia Veloso

IRINA CASTRO

Investigadora júnior no Centro de Estudos Sociais da Universidade de Coimbra
Colégio de S. Jerónimo, Apartado 3087, 3000-995 Coimbra, Portugal
Contacto: belacastro@ces.uc.pt

RITA SERRA

Centro de Estudos Sociais da Universidade de Coimbra
Colégio de S. Jerónimo, Apartado 3087, 3000-995 Coimbra, Portugal
Contacto: ritaserra@ces.uc.pt

REFERÊNCIAS BIBLIOGRÁFICAS

Barad, Karen (2007), *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham: Duke University Press.

Barrios, Raúl García (2014), "El origen de la reserva ecológica de la UNAM en CU: Historia de un conflicto patrimonial y ambiental", *Cultura y representaciones sociales*, 9(17), 177-223.

Bybee, Joanna (2014), "Ningún tema es demasiado sagrado", *in* Dorian Sagan (org.), *Lynn Margulis. Vida y legado de una científica rebelde*. México DF: Tusquets Editores, 213-220. Tradução de Ambrosio García Leal.

Carson, Rachel (1962), *Silent Spring*. Boston: Houghton Mifflin Company.

Delborne, Jason (1993), *Pathways of Scientific Dissent in Agricultural Biotechnology*. Berkeley: University of California.

Delborne, Jason (2016), "Suppression and Dissent in Science", *in* Tracey Bretag (org.), *Handbook of Academic Integrity*. Singapore: Springer, 943-956.

Fox, Mary Frank (2006), "Gender, Hierarchy, and Science", *in* Barbara Risman; Carissa Froyum; William Scarborough (orgs.), *Handbook of the Sociology of Gender*. Boston: Springer.

Khalil, Andre (2014), "Arriba y abajo", *in* Dorion Sagan (org.), *Lynn Margulis. Vida y legado de una científica rebelde*. México DF: Tusquets Editores, 33-46. Tradução de Ambrosio García Leal.

Lear, Linda (2009), *Rachel Carson: Witness for Nature.* New York: Mariner Books.

Löwy, Michael (2010), "Cenários do pior e alternativa ecosocialista", *Serviço Social & Sociedade*, 104, 681-694.

Margulis, Lynn; Sagan, Dorion (1997), *Microcosmos: Four Billion Years of Evolution From our Microbial Ancestors*. Berkley/London: University of California Press.

Martin, Brian (1996), "Critics of Pesticides: Whistleblowing or Suppression of Dissent?", *Philosophy and Social Action*, 22(3), 33-55.

Martin, Brian (1997), *Suppression Stories*. Wollongong: Fund for Intellectual Dissent.

Martin, Brian (2010), "How to Attack a Scientific Theory and Get Away with It (Usually): The Attempt to Destroy an Origin-of-AIDS Hypothesis", *Science as Culture,* 19(2), 215-239.

Proctor, Robert (2008), "Agnotology. A Missing Term to Describe the Cultural Production of Ignorance (and Its Study)", *in* Robert Procter; Londa Schiebinger (orgs.), *Agnotology: The Making and Unmaking of Ignorance.* Redwood: Stanford University Press, 1-36.

Quarantiello, Arlene (2004), *Rachel Carson. A Biography*. London: Greenwood Press.

Rose, Hilary (1994), *Love, Power and Knowledge: Towards a Feminist Transformation of the Sciences*. Cambridge: Polity Press.

Rouse, Joseph (1996), "Feminism and the Social Construction of Scientific Knowledge", *in* Sandra Harding (org.), *The Feminist Standpoint Theory Reader. Intellectual & Political Controversies*. New York: Routledge, 353-374.

Sagan, Dorian (org.) (2014), *Lynn Margulis. Vida y legado de una científica rebelde*. México DF: Tusquets Editores, 213-220. Tradução de Ambrosio García Leal.

Santos, Boaventura de Sousa (1999), *Pela mão de Alice. O social e o político na pós-modernidade*. Porto: Edições Afrontamento.

Waddell, Craig (2000), "The Reception of Silent Spring: An Introduction", *in* Craig Waddell (org.), *And no Birds Sing: Rhetorical Analyses of Rachel Carson's Silent Spring*. Illinois: Southern Illinois University Press, 1-16.

ANNEX 3

In *Proceso a los Alimentos Transgénicos* [E-book], editado por Muñoz Rubio, Júlio, 167-220. Mexico City, México: Itaca, 2021.

El conflicto científico sobre los transgénicos - de la disidencia científica a la construcción de otra forma de producir conocimiento

Irina Castro – Centro de Estudios Sociales y Facultad de Economía, Universidad de Coimbra, Portugal

belacastro@ces.uc.pt

1 – Introducción: La disidencia científica

Las controversias sobre el conocimiento, o de forma más correcta, sobre lo que se considera verdaderamente científico o no, siempre formaron parte de la actividad de la ciencia. Galileo Galilei enfrentó a los tribunales de la Santa Fe por su defensa del sistema Copérnico, y las propuestas darwinianas fueron satirizadas en periódicos a través de interpretaciones pictóricas de sus obras (Camerota, 2007; Bower, 2007; Daintith, 2008). Sin embargo, el estudio sociológico de estas controversias, como forma de intentar entender los procesos sociales de la construcción de conocimientos científicos, son un campo de estudios reciente.

Sin la intención de demeritar trabajos anteriores, es a partir de la década de los 1970 cuando estos estudios cobraron una nueva dimensión, al ser relacionados - de una forma sistemática - con los contextos económicos, sociales y políticos en que las controversias se producían históricamente (Latour, 1987). El estudio de las controversias científicas es hoy un campo de la sociología del conocimiento, o de forma más programática, de los estudios sociales de la ciencia y de la tecnología.

Como precursores de este enfoque analítico están importantes pensadores de la ciencia como Ludwig Fleck (1986 [1935]), Thomas Kuhn (2016 [1962]) y Robert Merton (1973), cuyos trabajos abrieron espacio para pensar la ciencia no sólo en su relación con las otras esferas de la actividad humana, sino además, demostraron que las controversias ofrecían importantes espacios para reflexionar sobre la organización de la producción de conocimientos y hechos científicos.

Para los historiadores y sociólogos clásicos de la ciencia, las controversias eran inherentes a la forma en que progresaba el pensamiento científico. A diferencia de otras formas de saberes consideradas dogmáticas, como las de la religión o el nacionalismo (Delborne, 2016), a la ciencia se le atribuía un espíritu creativo y progresivo de indagación libre y constante, cuya regulación provenía de los miembros de la comunidad que la constituyen. El origen y existencia de la controversia no era un factor problemático para estos autores clásicos, pues la comunidad científica era vista como dotada de instrumentos y normas que permitían juzgar la credibilidad de los nuevos conocimientos y de sus promotores (Merton, 1973). Se abría así espacio a la construcción de la idea de una ciencia que, a pesar de estar intrínsecamente ligada al mundo social, se mantenía protegida de intentos de manipulación por parte de intereses externos a los de la actividad científica.

Esta perspicacia celebrada en las ceremonias revolucionarias de la ciencia determinaba la actividad científica como un sistema de producción distante, si no es que superior, a los intereses sociales, y por lo tanto, abstraída en sí misma de la producción material humana, de los intereses y conflictos de clase. A pesar de reconocer a los científicos como habitantes del mundo social, los autores clásicos afirmaban que la coherencia y la lógica interna del funcionamiento de la producción de conocimientos se basaba en valores y formas de control que sólo actuaban en el sentido de la progresión del conocimiento; se colocaba así a los científicos en la posición de agentes autónomos frente al mundo social, objetivamente comprometidos con su comunidad, con su actividad y con la revelación neutra y objetiva de los misterios universales de la naturaleza. Es decir, sin existencia social y política en su acción, y que intentan descubrir de forma neutra y objetiva de los misterios universales de la naturaleza.

Los disidentes, aquellos y aquellas que por razones de sus investigaciones y conclusiones rompen con los paradigmas dominantes de sus disciplinas, son vistos, siguiendo con esta lógica, adjetivos de la forma natural del funcionamiento del espíritu científico. Por lo menos hasta cierto punto.

Al principio, la disidencia es una característica intrínseca del espíritu científico. Una curiosidad innata y arraigada, construida en la base del constante escepticismo ante la construcción de hechos que son puestos a prueba para confirmarlos o refutarlos. La "buena" disidencia es así gestionada internamente, de forma organizada, y orientada por los valores mertonianos del desinterés, la comunalidad y la universalidad del conocimiento (Merton, 1973 pp. 228-278). Sin embargo, la idea que la ciencia es una actividad puramente racional pasó a ser cuestionada por un conjunto de nuevos historiadores y sociólogos de la ciencia que entendían las controversias como forma de explicar la ciencia en cuanto práctica que se encuentra inmersa en las relaciones políticas, económicas y sociales de las sociedades de su tiempo histórico (Latour, 1987). Esto permitió hacer una nueva historia contextual y situada sobre la construcción de hechos científicos y sus controversias, basada no sólo sobre las normas de organización social internas de la ciencia, pero demostrando qué hechos y conocimientos se constituyen también en redes complejas de poder (Shapin, 1999), que incluyen también de forma estructural momentos de incertidumbre y suerte (Fleck, 1986).

Históricamente, la historización de la epistemología se transforma en una necesidad racional después de la segunda guerra mundial. Por ejemplo, frente à Hiroshima y Nagasaki, hasta los avances, pero también impactos de la revolución verde, frente a los movimientos por la descolonización y derechos civiles, del sufragio universal a las luchas de las mujeres por el reconocimiento de su cuerpo no subsumido a la biología masculina, pasando por desastres como Minamata y Chernóbil, las controversias científicas encontraran en la sociedad su razón ontológica.

Como ejemplo de la creciente necesidad de gestionar las relaciones entre la política de la sociedad y la política de la ciencia, las décadas entre los 60s y 80s fueron décadas que vieron emerger importantes movimientos sociales en torno a la ciencia y sus formas de producción. En Europa, las Science Shops surgían directamente de la revolución cultural de 1967 mientras en Estados Unidos. Science for the People y Union of Concerned Scientists se formaron como grupos críticos a las orientaciones militaristas de la ciencia promovidas por el complejo militar del Estado, y denunciaban abiertamente el racismo intrínseco que envolvía la construcción del campo de la genética moderna.

El surgimiento de estos movimientos, constituidos tanto por científicos como por ciudadanos, buscaba denunciar la forma promiscua en que la narrativa de la contribución de la ciencia a la economía y a la sociedad se encontraba subsumida a las lógicas capitalistas de la producción industrial y a los intereses privados en torno de éstas; al mismo tiempo que alertaban sobre las consecuencias dañinas de los científicos que emergían bajo tales lógicas productivas capitalistas, como ejemplo, los plaguicidas y los transgénicos.

Este nuevo encuadramiento de las controversias permitía reconceptualizar el concepto de disidencia como agencia política, más allá del simples verbo. Así, durante los años 1990 empezaron a surgir estudios en torno a las controversias enfocadas en los agentes disidentes. Como precursor de tales estudios, el científico social Brian Martin se dedicó al estudio de las formas de supresión de las controversias científicas. Martin (1996, 1997, 2010) encontró en las controversias científicas y en sus protagonistas, la fuente principal de lo que sería una sociología de la praxis científica . Esta forma de estudiar la realidad social de los científicos y de sus actividades, permite identificar, por un lado, los agentes de poder y los intereses qué no siempre visibles. Pero que están involucrados en la producción de conocimientos científicos y en las formas de su legitimación (ej. a través de los patrones de las formas y magnitudes de la supresión). Por otro lado, el estudio de la praxis científica permitía encontrar qué formas epistémicas distintas emergían, o ya actuaban, en el seno de estas controversias. Este cuadro teórico, sin embargo, sólo es posible debido a la colección continua de registro y relatos, que como dijo Bruno Latour (1987) permite al sociólogo colocar todas las pruebas y alegaciones en situación de "tribunal".

El trabajo de Brian Martin tuvo otra importante consecuencia a la forma de pensar la ciencia y la disidencia al demonstrar que la supresión, al contrario de lo que se predica, no es un fenómeno inusual. Por el contrario, la supresión infiltra la práctica científica cuando ésta se enfrenta con intereses políticos, económicos y sociales. Los estudios de la supresión evidenciaron que las innumerables historias de disidencia tenían como contexto las relaciones estructurales de poder internas al sistema científico (público o privado) con la actividad e intereses económicos privados (e.g. de las industrias), o de los Estados (ej. necesidades de seguridad y militares).

Para Jason A. Delborne, sociólogo norteamericano de la Universidad Estatal de Carolina del Norte, la disidencia debe incluso ser entendida como un proceso performativo en continuo desarrollo (Delborne, 2005). Entender la disidencia como performance permite, según el autor, entender también las estrategias de disidencia como argumentos epistémicos irruptores de la forma convencional de entender la relación de la ciencia y de la sociedad. Este planteamiento, bastante mertoniano en su base, pero metodológicamente latouriano, nos dice que a través del análisis de la operación de la disidencia es posible distinguir entre una controversia que, aunque irresuelta, no origina disidencia, y una controversia que al convertirse en disidente origina una ruptura onto-ético-epistemológica (Barad, 2007).

Un rasgo interesante del trabajo de Brian Martin y Jason A. Delborne es la similitud entre los casos de estudio, mayormente relacionados con la ciencia dedicada a la biología molecular, la ingeniería genética, la química, la biología, la ecología y medicina. Se demuestra así como las ciencias naturales, en particular en el tema del desarrollo biotecnológico, configuran un campo privilegiado para entender los mecanismos de poder em torno de la práctica científica. Sin embargo, esta relación no es casual.

La historia de la ciencia, en particular de las ciencias naturales, es reveladora de la propia historia de la naturaleza, que es a su vez reveladora de la historia de la humanidad y por consecuencia de las ciencias. La historia de las ciencias, como el descubrimiento de los secretos de la naturaleza, es también la historia de cómo nuestra existencia es productora de la materialidad de nuestras vidas. Es en este contexto que las ciencias naturales, en particular las modernas y occidentales, asumen la forma privilegiada de conocer. Tal como describió Engels (1974 [1883] p.11) "La moderna investigación de la naturaleza es la única que ha logrado un desarrollo científico, sistemático, en todos y cada uno de sus aspectos, por oposición a las geniales intuiciones de los antiguos en torno a la filosofía de la naturaleza y a los descubrimientos extraordinariamente importantes, pero esporádicos y en su mayor parte estériles, de los árabes […]". Se refiere a las modernas, pues éstas: la moderna biología, la moderna química, la moderna física, apenas adquieren su calidad de moderna en el seno ideológico del contexto específicamente histórico de la producción capitalista.

En este sentido, el estudio de la disidencia es también el estudio de las contradicciones generales de la producción de conocimiento frente a su forma específica en el capitalismo. Sin embargo, el estudio de la disidencia no parte del proceso social que la subyace, sino del capital producido como indicador del grado en que el conocimiento social se ha convertido en una fuerza directa de la producción. Por este motivo, incluso los estudios sociales de la ciencia y tecnología se centran en los objetos de la producción de la ciencia: como los medicamentos y las terapias biomédicas, las formas de energía como la nuclear, los productos químicos como los plaguicidas y los productos de la engeñaría genética como los transgénicos.

En este capítulo, a través de una breve reseña de las controversias sobre los transgénicos —y teniendo como fuente de análisis los estudios sobre supresión y disidencia – se busca promover una persuasiva crítica sobre la controversia de los transgénicos, en el sentido de demostrar cómo genera nuevas posiciones onto-ético-epistemológicas que conllevan una crítica profunda al capitalismo. Esto implicará tener presente que la historia y los casos serán analizados bajo la lente de la economía política marxista - interesada en identificar los momentos de coerción, inclusión y sus mecanismos –, con el propósito de proveer un análisis comprensivo de la forma en que la producción específicamente capitalista subsume la producción de conocimiento científico.

2 - Evolución histórica de los debates científicos sobre los transgénicos y su crítica al modelo neoliberal de producir ciencia

El debate sobre los transgénicos es una disputa de décadas. La cuantiosa literatura producida en diversos campos disciplinarios demuestra cómo el tema de la biotecnología, particularmente aquella centrada en las semillas, atrae mucha atención, haciéndole motivo de abundante controversia (Kinchy, 2012; Kloppenburg, 2004; Myers, 2001; Nunes et al., 2003).

Los cultivos de plantas son, por un lado, determinantes de la forma productiva actual. Se utilizan tanto como suministro de la base alimentaria, ya sea en forma directa o indirecta (a través de raciones de animales), ya sea como fuentes de materias primas de varias industrias como la de los biocombustibles, industrias de fibras, o farmacéutica. Además de su centralidad en las diversas industrias, las sucesivas crisis relacionadas con los costes de producción obligan a una continua búsqueda por nuevas y mejoradas variedad de plantas adaptadas tanto a la maquinaria industrial, como a los cambios ambientales resultantes de los cambios climáticos (Castro, 2019). Sin embargo, el desarrollo continuo de variedades de transgénicos, bien como, la expansión de la engeñaría genética a una gran variedad de plantas, se debe por mucho a la competencia real entre industrias en el sector agroindustrial, en particular las empresas de agroquímicos. La competencia real entre industrias demanda la continua innovación de las semillas transgénicas de forma a que pueda absorber el mercado de gran maquinaria e insumos químicos.

Por otro lado, la biología de las plantas, les confieren una ventaja cuando se inserta en las lógicas de trabajo de laboratorio; lugares de origen de los transgénicos. En el confinamiento del laboratorio las plantas, en particular las transgénicas, son fáciles de reproducir y cultivar, planteando muchas cuestiones morales en torno a su manejo laboratorial . Además, debido a su plasticidad genética y diversidad funcional, estructural y fenotípica representan un acervo de información como ningún otro organismo vivo .

La primera planta transgénica surgió en 1983. Se trataba de una planta de tabaco genéticamente alterada para resistir a un antibiótico (Mackenzie, 1994). Es también el tabaco, la planta que ha constituido los primeros ensayos de campo de plantas transgénicas en 1986 en los Estados Unidos y Francia (James & Krattiger, 1996). Si embargo, al largo de los años lo tabaco ha perdido su centralidad en el plantío de variedades vegetales genéticamente modificadas. La industria tabacalera ha sufrido grandes pérdidas comerciales, no debido a problemas de producción, sino a cambios en las políticas públicas frente a los problemas de salud asociados con el consumo de tabaco.

En 1994 Flavr Savr, un tomate modificado genéticamente, fue el primer alimento en recibir una licencia para consumo humano. Los tomates se han utilizado como un organismo modelo para estudiar la maduración de la fruta, sin embargo, el tomate había sido modificado para ralentizar el proceso de maduración del tomate y evitar que se ablandara durante su transporte. El Flavr Savr ha fracasado comercialmente, y los motivos de su fracaso son variados. En primera instancia el fracaso se debió al hecho de que los tomates eran más caros que las variedades convencionales, pero algunas personas atribuyen al fracaso a los resultados de la investigación de Stanley Ewen y Árpad Pusztai (1999).

En 1999, Stanley Ewen y Árpad Pusztai cuestionaron la afirmación de seguridad alimentaria del consumo de alimentos transgénicos. En un estudio con ratas alimentadas con papas transgénicas, los científicos encontraran diferencias estadísticamente significativas en el grosor de la mucosa del estómago de las ratas alimentadas con papas transgénicas. Durante un programa televisivo anterior a la publicación del estudio, Árpad Pusztai demostró su preocupación ante los efectos impredecibles del consumo de transgénicos y la ausencia de estudios toxicológicos sobre efectos adversos para la salud. Desde entonces, la controversia ha escalado, ganando importantes dimensiones desde el punto de vista de la ética de la ciencia, de los intereses que conducen a la investigación, y de la relación entre los productos tecnológicos, la regulación y la seguridad ambiental y humana, así como sobre las formas de comunicar la ciencia y los riesgos asociados a esta actividad.

Al largo de los anos, científicos de diversas disciplinas han producido un amplio abanico de posiciones y reflexiones sobre estés organismos tan polémicos. El inicio del milenio está especialmente marcado por un conjunto de trabajos dedicados a esta controversia. En 2001, George Gaskell y Martin W. Bauer, editaron una obra intitulada “Biotechnology 1996-2000: The Years of Controversy”, en el mismo año Gerald C. Nelson publicó “Genetically Modified Organisms in Agriculture: Economics and Politics”. En 2002, de nuevo George Gaskell y

Martin W. Bauer publicaron "Biotechnology - the Making of a Global Controversy". En 2004 aparece la segunda edición de la obra de "First the Seed" de Jack Ralph Kloppenburg, Jr., y se publica en México el libro "Alimentos transgénicos. Ciencia, ambiente y mercado: un debate abierto" editado por Julio Muñoz Rubio. Un año después Daniel Lee Kleinman, Abby J. Kinchy, y Jo Handelsman presentaron "Controversies in Science and Technology: From Maize to Menopause". Estas son sólo algunas de las obras publicadas al inicio del milenio y que marcan una discusión mundial que integra casi la totalidad de las disciplinas científicas.

El punto interesante de estos trabajos, aunque no siendo ese su objetivo final, es que construyeron una colección de historias, narrativas y registros, que permiten a la socióloga colocar, de acuerdo con Bruno Latour (1987), todas las evidencias y alegaciones en una situación de "tribunal", identificando los agentes del poder y exponiendo los patrones de la supresión y los caminos de la disidencia en torno de la controversia de los transgénicos.

Además, estas contribuciones revelan bien cómo la controversia se encontraba escalando en intensidad y propuesta. Este proceso estuvo acompañado de un crecimiento de 2.8 millones de hectáreas cultivadas con transgénicos en el mundo en 1996 a 27.8 millones en 1998 (James & Krattiger, 1996; James, 1997), 52.6 millones en 2001 (Ribeiro, 2004), 81 millones en 2004 (Delborne, 2005) y 189.9 millones en 2017 (ISAAA, 2017). Sin embargo, a diferencia de lo que cabría esperar, el número de países que cultivan organismos transgénicos no creció en las mismas proporciones. En el año 2004, Estados Unidos, Argentina, Canadá y China, figuraban como los principales países productores (Ribeiro, 2004); hoy, Estados Unidos siguen siendo líderes en las hectáreas plantadas, seguido de Brasil, Argentina, Canadá y la India (ISAAA, 2017). Los datos recientes demuestran también una desigualdad profunda entre los países desarrollados (5 son productores) y los países en desarrollo (17 son productores) donde estos últimos son la amplia mayoría.

En México, la obra "Alimentos transgénicos. Ciencia, ambiente y mercado: un debate abierto" (Muñoz Rubio (Coord.), 2004), fue producida en el seno de un ciclo de mesas redondas que tuvo lugar en 2002 y que buscó una reflexión integral y global sobre las controversias de los transgénicos en general y en México en particular. Organizada en capítulos que se van contraponiendo, la obra va mostrando las diferencias claras entre los enfoques, así como los objetos de controversia centrales al debate en aquel momento. A tal heterogeneidad de objetos se atribuyen también de forma particular y general, las diferentes perspectivas presentes en el libro. Lo que hoy nos permite analizar de forma comparativa su evolución. Esta comparación se puede hacer a través del análisis de los discursos que tuvieron lugar en un nuevo debate en abril de 2018 en la UNAM, que involucró a muchos de los autores del trabajo publicado en 2004.

También hoy se puede afirmar que muchas de las preocupaciones expresadas por científicos de todo el mundo sobre la seguridad de los transgénicos para la salud y el medio ambiente se han demostrado correctos y científicos, a pesar de las constantes acusaciones de su falta de cientificidad. A continuación se presentan algunos ejemplos: la seguridad de las inserciones genéticas y la estabilidad del genoma es hoy reconocidamente incierta (Sawasaki et al., 1998; Svitashev et al., 2000; Latham et al., 2006; Ben Ali et al., 2014); la productividad de los cultivos se restringe a una ventana de oportunidad inicial (Elmore et al., 2001; Men et al., 2004); la contaminación cruzada es posible y los efectos imprevisibles (Watrud et al., 2004; Galeano et al., 2010); las manipulaciones genéticas pueden resultar en la producción de nuevas proteínas que están en la base de nuevas resistencias a plaguicidas, antibióticos y cuyos efectos en la salud son desconocidos (Vazquez-Padron et al., 2000; Gunning et al., 2005; Finamore et al., 2008; Tabashnik et al., 2009); y por último, el carácter epigénetico de las modificaciones es hoy reconocido (Jagtap et al., 2011; Cortessis et al., 2012).

Sin embargo, el entusiasmo por la tecnología de edición genética continúa dominando el campo político y científico. Las promesas de hace 30 años siguen siendo recicladas pese a su carencia de validez científica: en otras palabras, esto puede denominarse hegemonía. Esta hegemonía es mantenida por una ideología tecnocientífica, que cree que para cada problema político hay una solución tecnológica, neutra de la política en sí, y objetiva. Esta ideología es sustentada por el fetiche de la tecnología, y ese fetiche tiene, como en tantos procesos de la sociedad, raíces materiales (Harvey, 2003).

Paradójicamente, la disidencia científica no resulta automáticamente en una contrahegemonía. Muchas de las historias de disidencia mantienen el lugar privilegiado de la ciencia y siguen presas al fetiche de la tecnología. No obstante, el concepto de disidencia trata de un desafío a las nociones convencionales de defender la legitimidad de la ciencia, incorporando la disputa intelectual con la acción social. El disidente, alerta a la política dentro y en torno a la ciencia, trayendo al público preocupaciones del foro político que parecen ser meras controversias técnicas. El, o ella, es claramente un agente político en conflicto entre su consciencia científica y la realidad objetiva de los usos de la ciencia. No es de extrañar que muchas historias de disidencias ocurran después de la comprensión real de los impactos de la ciencia, marcadas en la historia por momentos como las bombas nucleares. De hecho, los efectos devastadores de las bombas fueron incapaces de sostener, para los propios científicos, la ideología de que la ciencia y la tecnología eran progreso social (Rose & Rose, 1976).

La disidencia científica por estar comprometida con otra forma onto-ético-epistemología de producción de conocimiento, e incluso a veces libre de la forma de mercancía, promueve otra forma de legitimidad de la producción del conocimiento. Esto está en contra de lo que se ha afirmado últimamente con respecto a que los disidentes contribuyen a un relativismo nihilista que está en la base de la propagación de hechos pseudocientíficos. En ese sentido, la disidencia por contener la posibilidad de emancipación de la actual dominación del capitalismo sobre las relaciones sociales de producción es objeto de un escrutinio violento. De forma sistemática, se aplican diversas tácticas de desacreditación sobre el trabajo científico y del disidente como su carácter individual, actuando así también de forma cohesiva sobre toda la comunidad científica.

Esto obliga a una continua reinvención de estrategias de resistencia, organización pública y de estructuras que permitan contrarrestar los poderes hegemónicos, en un acto colectivo que Jason Delborne llamó de performatividad (2005). En estos actos colectivos de construcción pueden todavía verse como alianzas en las ciencias naturales y sociales fueron construidas, y como éstas se alían a movimientos y demandas sociales.

La forma más predomínate de estas construcciones colectivas son las redes de científicos comprometidos con la sociedad y el ambiente. En 1959 se forma en Alemania la “Vereinigung Deutscher Wissenschaftler e. V.”, en los Estados Unidos existe desde 1969 la “Union of Concerned Scientists”, en 1992 se formó en Inglaterra la rede “Scientists for Global Responsibility”, en 2006 surge en Mexico la “Unión de Científicos Comprometidos con la Sociedad”, y desde 2009 en Europa la “European Network of Scientists for Social and Environmental Responsibility”. Más recientemente en 2015 se formó la “Critical Scientists

Switzerland" y en ese mismo año se constituye en Argentina la "Unión de Científicos Comprometidos con la Sociedad y la Naturaleza de América Latina".

Estas redes y organizaciones trabajan local y globalmente en el sentido de consolidar un argumentario coherente y sistematizado sobre los problemas que los transgénicos (no exclusivamente) plantean en el mundo, y qué desde varias perspectivas disciplinarias permiten revisar tanto el debate sobre la contaminación, seguridad y peligrosidad, como explorar las dimensiones de la controversia que se relacionan con la ética, bioseguridad, neoliberalismo, procesos regulatorios, agricultura campesina, entre otros. Al mismo tiempo, se busca de forma progresiva manejar con la complejidad del problema, que actualmente incluye dimensiones que discuten no sólo la producción de saberes científicos, sino su relación con la construcción de otros saberes sobre el mundo.

Otras organizaciones como la GMWatch, fundada em 1998, tienen un carácter más diseminación de la información, al paso que iniciativas como el "Comité de Recherche et d'Information Indépendantes sur le Génie Génétique (CRIIGEN)" en Francia, buscan de forma independiente de los intereses de la industria conducir estudios científicos y contra-ciencia con el fin de proporcionar una evaluación más robusta y cuidadosa de los desarrollos biotecnológicos. Por ejemplo, en 2012, Gilles-Éric Séralini y su equipo publicaron un artículo "Long-term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize" que plantea cuestiones sobre la seguridad de los transgénicos para la salud. El artículo cobra atención mediática gigantesca y es objeto de supresión organizada de forma deliberada por la industria, como se demostró más tarde con el caso de los Monsanto Papers. Varios estudios que analizan esta controversia se publicaran en los años siguientes (Fagan et al., 2015, Piron & Varin, 2015, Krimsky, 2015), incluyendo análisis de cómo el caso causó daños a la credibilidad de la ciencia y a los científicos (Arjó et al., 2013). Sin embargo, los análisis sistemáticos de las formas de supresión de la ciencia demuestran que no son los disidentes quienes causan daños a la credibilidad de la ciencia, sino la forma en la que los intereses corporativos privados se vuelven visibles a un público más amplio (Delborne, 2005, p. 396). Son ejemplo situaciones como las que relacionan Exxon y Shell con situaciones de ocultación de información científica importantes para el público, pero perjudiciales para productos y / o actividades industriales.

La progresiva visibilidad de los conflictos de interés entre ciencia e industria cuestiona la legitimidad del conocimiento que se comunica en espacios públicos como periódicos y en espacios políticos como parlamentos y agencias reguladoras.

Mas recientemente, las denuncias de supresión y de la relación permisiva entre la industria y la ciencia se aglutinaron en el caso Monsanto Papers (McHenry, 2018). Los documentos recientemente desclasificados y hechos públicos durante el curso de un proceso legal demuestran que la empresa Monsanto influye desde los bastidores en la ciencia, y revela el nivel de coordinación cotidiano entre las empresas, instituciones de Estado, instituciones de ciencia pública y científicos. Los documentos confirman también las categorías de supresión que Brian Martin ha elaborado. Desafortunadamente la influencia que las empresas ejercen sobre científicos y sobre el proceso de la ciencia no es novedad. Basta con analizar la biografía de Rachel Carson (Quarantiello, 2004; Lear, 2009; Waddell, 2000) para encontrarnos con un ejemplo paradigmático de la capacidad de coordinación y supresión por parte de los intereses privados sobre el proceso de construcción de conocimientos.

Si bien es cierto que los intereses comerciales condicionan la ciencia, este control de los intereses privados sobre la producción de conocimiento no sería posible sin el sistema político, en particular el Estado (Garcia, 2006). A través de la promoción de la desregulación ambiental y el fortalecimiento de la protección de la propiedad, en este caso en particular la propiedad intelectual, han sido los estados neoliberales los que más han impulsado la iniciativa científica privada para la generación de transgénicos. Por esta razón, el debate de los transgénicos no se agota en el debate científico, al igual que el debate en torno a la ciencia no se aísla de la crítica del modelo neoliberal del capitalismo. Como muchas de las historias de disidencia nos muestran, lo que está en juego son intereses comerciales interpenetrados con la ciencia, y ante un conflicto sobre la producción de conocimiento que también es político. Como lo demuestran varios estudios, la forma de los transgénicos no se disocia de los objetivos finales de la producción capitalista, donde la consolidación de los monopolios económicos requiere uniformidad ontológica (Kloppenberg, Garcia,2006, Harvey, 2003).

El paso del tiempo ha demostrado que el debate de los transgénicos continúa abierto y en él se contraponen tendenciosamente diferentes visiones del mundo y de la relación de la producción de conocimiento con la vida humana y el ambiente. Las alertas sobre los problemas de la privatización del conocimiento, de la relación preocupante entre industria, el complejo-militar del Estado (a veces sólo en sí mismo) con la ciencia, la supresión de científicos y las injusticias sociales, económicas y cognitivas que origina la disidencia, promueven también una comprensión más amplia de la forma en que la ciencia se ha subsumido progresivamente los modelos de producción capitalista.

La disidencia organizada denuncia que una cultura epistémica que permite la generación de transgénicos resulta de la subsunción de la ciencia bajo el capital. Esto configura una relación dialéctica donde la forma de producción específicamente capitalista interviene en las relaciones de producción de conocimiento precedentes. Este proceso se da en una primera instancia con el capital interviniendo en las relaciones de trabajo y luego en la organización y dirección específica de la producción de conocimiento (Marx, 2015 [1971] p.54-77; Kloppenburg, 2004). En otras palabras, la ciencia puede estar constituida por abstracciones, sin embargo, la ciencia es una práctica social que hoy sólo existe concretamente como práctica definida en su incorporación al proceso productivo de capital. En ese sentido, la subsunción de la ciencia al capital pasa por entender como un cambio cuantitativo del conocimiento (ej. identificación de los genes y de su organización en el genoma) llega a cierto estadio de desarrollo que se transforma a si misma de forma cualitativa, traduciéndose, por ejemplo, en una nueva forma de pensar el conocimiento genético, y/o una nueva ideología de la biología (Lewontin, 1998) que orienta un modelo económico de neoliberalismo molecular (Wynne, 2013).

3 - Modelo alternativo de producción de ciencia

No son sólo los científicos que publican estudios controvertidos, contra pericias y resultados divergentes de los intereses comerciales establecidos son objeto de intentos de supresión. Como demostró Brian Martin (1996), también aquellos que buscan modelos alternativos a la forma industrial de producción han sido excluidos y alejados de importantes círculos científicos y políticos.

Las alternativas surgidas a lo largo de las últimas décadas han promovido además un conjunto heterogéneo de prácticas productivas más éticas, justas y responsables (ej. agroecología), siguiendo un modelo epistémico que transforma de forma radical el entendimiento que tenemos sobre la ciencia y la producción de conocimientos frente al modelo hegemónico neoliberal.

Un aspecto fundador de estas alternativas es su recurrencia a posiciones de humildad (Jasanoff, 2003), es decir, buscan promover alternativas y nuevas objetividades comprometidas con la evolución del sentido de justicia y responsabilidad con el cuidado del mundo. En ellas, la responsabilidad se entiende como una postura de la producción que va más allá de la idea de responder, en el inmediato y de forma técnica, a problemas social urgentes y emergentes (o sea no siguen la visión miope de las decisiones capitalistas a corto plazo), sino que dialoga con las múltiples ontologías de los saberes del mundo en la construcción de sus preguntas y posibilidades de respuesta, sobre la base de una ética de cuidado y preservación. Es como diría Donna Haraway, una posición epistemológica capaz de responder (response-able) (Haraway, 2008, 2016).

Otro aspecto importante de las alternativas es que éstas no se circunscriben únicamente a los modelos productivos y a las formas de relación entre la ciencia y la sociedad. Por ejemplo, científicas como Lynn Margulis, autora de "On the Origins of Mitoses Cells" (1967) entendía que la teoría de la evolución darwinista era una brillante propuesta que, sin embargo, había sido transformada y usada como un dogma para servir a los intereses del capitalismo (Sagan, 2014). Contraria a la idea de que la evolución estaba orientada por la competencia, Lynn no se identificaba tampoco con el socialismo de Kropotkin y la ayuda mutua, a pesar de acercarse más a esta metáfora que la de la neodarwinista (Khalil, 2014 p.45-46). Para Lynn tanto la selección natural como la ayuda mutua posibilita la eliminación y/o la supervivencia, pero ninguna de ellas es creadora. Por eso ella presenta, a diferencia de Darwin y Kropotkin, una teoría que no se enfocaba en la vida ya en sí, sino en la creación de esa propia vida (Sagan, 2014). Activista antiimperialista y dura crítica de la política imperialista de los Estados Unidos de Norteamérica, Lynn nunca ahorró palabras para describir la forma en que el neodarwinismo no sólo estaba científicamente equivocado en sus interpretaciones capitalistas sobre la vida. Al encontrarse en Richard Dawkins uno de sus principales opositores, los debates entre ambos se reconocen como un gran momento de debate científico. Estos debates no libraron a Lynn, sin embargo, de severas acusaciones que buscaban minimizar su propuesta a través de formas de supresión que se enfocaban en su género. Si por un lado fue activamente ignorada por la comunidad científica, por otro, Lynn era acusada de ser demasiado ideológica, radical y a veces histérica. El hecho de ser una comunicadora de ciencia era también usado como argumento para no ser tomada en serio. Esta forma de descrédito de Lynn contrasta con el entusiástico que los científicos tienen ante comunicadores como Carl Sagan, ex marido de Lynn.

Las alternativas encuentran siempre resistencia, y por períodos esa resistencia puede ser disipada mediante la incorporación de una parte, o la totalidad, de las propuestas que construyen esas alternativas (Wynne, 2006). Una de las críticas permanentes a los transgénicos y a la ciencia generadora de estos organismos es que está orientada por los intereses de la industria. Los disidentes proponen así nuevos modelos de participación de ciudadanos en la decisión sobre el rumbo de la ciencia, en particular la aplicada. Como dije Einstein:

"[…] Sin embargo, la ciencia no puede crear fines y, menos aún, inculcarlos en los seres humanos; La ciencia, a lo sumo, puede proporcionar los medios para alcanzar ciertos fines. Pero los fines en sí están concebidos por personalidades con elevados ideales éticos y, si estos fines no nacen muertos, sino que son vitales y vigorosos, son adoptados y llevados adelante por esos muchos seres humanos que, inconscientemente, determinan la lenta evolución de la sociedad.[..] Por estas razones, debemos estar en guardia para no sobreestimar la ciencia y los métodos científicos cuando se trata de problemas humanos; y no debemos asumir que los expertos son los únicos que tienen derecho a expresarse sobre las cuestiones que afectan a la organización de la sociedad.” (Einstein, 2009 [1949] p.55-56 - traducción propia).

Esto abrió espacio al surgimiento de nuevas formas de comunicación de la ciencia basada en una participación horizontal de los ciudadanos y sus saberes (participación-acción, universidades populares, entre otros). Como Richard Levins (2015, p.25) ha identificado, a veces el conocimiento aparentemente contradictorio necesita encontrar formas de diálogo que permitan ver los errores asociados entre sí y, por otro, encontrar explicaciones para fenómenos que nadie puede describir y explicar con precisión. En resumen, ambos lados se equivocan, pero solo pudieren construir una explicación de un fenómeno a partir de la colaboración entre sus diferentes puntos de vista.

Estas propuestas no son, sin embargo, hegemónicas y conviven con una pluralidad de formas de organización de la comunicación y compromiso con los ciudadanos que recurren también a dispositivos clásicos, como el seminario, la conferencia, el foro.

De forma paradigmática estas formas de participación promueven también alternativas tecnológicas con base en una ética de cuidado y solidaridad donde la forma final del conocimiento no asume la forma de mercancía.

4 – Conclusiones

El momento político actual en que vivimos es de profunda confusión colectiva. Las elecciones de nuevos populismos en los Estado Unidos, Brasil, Italia, y otros, se alinean con viejos períodos negros de nuestra historia y dan lugar al surgimiento de nuevos discursos donde la coherencia ya no es punto central en la construcción de un argumento. Los acuerdos que parecían irrevocables demuestran su fragilidad (La salida de los Estados Unidos del Acuerdo de París, el Brexit, etc.) ante una nueva masa de populismo trumpiano. Las viejas certezas son cuestionadas y es abierto el espacio para un revisionismo histórico, donde los viejos capitales están en crisis y los nuevos luchan por nacer.

Un ejemplo de ese revisionismo histórico alcanza directamente el corazón del movimiento ambientalista de base científica. A pesar de las décadas que ya pasaron desde la publicación de "Primavera silenciosa" aún hoy se desarrollan campañas de desinformación sobre el trabajo de Rachel Carson, donde la acusan de ser la principal culpable de la muerte de miles de personas en el mundo por haber creado la base crítica que impide el uso de plaguicidas como forma de combatir vectores transmisores de enfermedad como la malaria. Dicen sus opositores que Rachel creó una falsa narrativa sobre los efectos nefastos de los insecticidas . Las falsas informaciones y las décadas de desprestigio que aún se abaten sobre "Primavera silenciosa" demuestran que el conflicto no se resolvió y que hablar hoy sobre Rachel Carson es luchar por una memoria colectiva sobre la ecología y la ética ambiental. La industria demuestra así que está activa en su intento de deslegitimar el pasado (viejos capitales) en el sentido de legitimar nuevas tecnologías (nuevos capitales) rodeadas de incertidumbre como ejemplifican los gene drives (genética dirigida) (Lebrecht et al., 2019).

Este revisionismo histórico que encuentra en las redes sociales es un terreno fértil para propagarse y utilizado para construir imágenes "ridículas" sobre los disidentes y sus propuestas.

En muchos de estos espacios se realizan comparaciones abusivas entre científicos disidentes y agentes conspiratorios, entre saberes y alternativas legítimas con productos originarios de la crisis de la realidad (ej. los Flat Earth Society). El objetivo final es siempre lo mismo obivamente, colocar alternativas creíbles entre ruidos confusos con el sentido de desacreditarlas.

Pero este momento de revisionismo oriundo de la crisis de la realidad, significa también una oportunidad. Por ejemplo, a través de una revisión crítica sobre la historia de la ciencia y la producción de conocimientos que adopta una óptica feminista. Quiero con esto afirmar que es posible, a través del análisis de las historias de mujeres en la ciencia complementar los estudios sobre controversias y disidencia científica con una perspectiva demostrativa de la evolución de las relaciones de género, y su función, en el seno de la ciencia.

Por ejemplo, a través de la historia de Marie Curie —científica dos veces laureada— y del rechazo a la propuesta de su entrada en la Royal Society (Rose, 1994, p. 145), es posible entender como el trabajo técnico de laboratorio, casi 200 años después de Lavoisier, era devaluado y reconceptualizado como mera práctica técnica de baja intensidad intelectual, lo que permitió ponerlo a la disposición del capital de forma barata. Hoy, el trabajo experimental – llamado básico - en un laboratorio, sigue exigiendo algún grado de especialización (por lo menos estar inscrito en un curso de nivel superior), pero es altamente precario o no pagado. El caso de Marie Curie revela también cómo formas antagónicas de ciertas relaciones sociales, pertenecientes a formas de sociedades anteriores a la capitalista, aparecen en el seno de ésta de forma disfrazada (Marx, 2017 [1975]).

La controversia de los transgénicos es un debate que no tendrá una resolución tan breve como nos gustaría. Y el aspecto más interesante de esta imposibilidad de resolución resulta no de la heterogeneidad que la compone, sino de la profunda contradicción que le origina. Me refiero a la profunda contradicción que existe entre la existencia de un espíritu científico desinteresado y universal con la forma de mercancía que el conocimiento adopta en el seno de la producción capitalista.

Las historias y las prácticas de la disidencia, en su heterogeneidad, promueven un modelo de producción de ciencia que al estar basado en postura onto-ético-epistemológica capaz de responder, escapa de la forma final de mercancía. El conocimiento pasa así a ser un bien común y no una fuerza de producción de plusvalía capitalista. Las tecnologías que vendrán a aumentar la producción o salvar trabajo, se harán de forma planeada, colectiva, y no servirán para disminuir el valor, ni desvalorizar para la fuerza de trabajo. Estas prácticas permitirán restaurar la legitimidad de la ciencia como productora de conocimiento y tecnologías que servirán a los intereses de una sociedad de valores morales virtuosos y no violentos. En ese camino, toda la ciencia libre (viva), es decir, no objetivada, enfrenta la furia violenta y mezquina de los intereses privados (Marx, 2017 [1975] p.9).

Se piensa la ciencia hoy como fuente de sabiduría, pero espantosamente la incorporación de la ciencia en el capital no resulta en una sociedad más culta científicamente, ni mucho menos en una clase dominante más inteligente. En realidad, para el trabajo científico la inteligencia está concentrada, bajo coerción, en la clase trabajadora de científicos impedidos de apropiarse directamente de su producto de trabajo. El estudio de controversias, como las de los transgénicos, por ejemplo, revela la existencia de una relación directa entre trabajo académico y producción de agnotologia (Proctor, 2008), estupidez (Graeber, 2015) y cretinismo. Por tal motivo, transitar hacia una forma diferente de hacer ciencia es y será un proceso lento y complejo. No obstante, el panorama actual no es un campo gris ausente de alternativas: la resistencia y la emergencia de nuevas prácticas de hacer ciencia, que se desarrollan desde de la comunidad (ej. los contra-laboratorios) y no del individuo o ser científico puro y aislado, han sido un claro ejemplo de que hay otra forma de comprender la realidad y nuestra existencia.

Transparencia

Irina Castro es miembro de la red europea ENSSER (European Network of Scientists for Social and Environmental Responsibility) y colabora periódicamente con la Plataforma Transgénicos Fora en Portugal. Irina Castro sigue siendo una activista feminista, ecosocialista, antirracista y antimilitarista.

Bibliografía

Álvarez-Buylla, E. R., Nelson, A. P.; Turrent, A., Wegier, A., Alavez, V., Milán, L., Traavik, T., Quist, D., Nieto-Sotelo, J. (2013) "Incertidumbres, riesgos y peligros de la liberación de maíz transgénico en Méxic" En E. Álvarez-Buylla & A.P. Nelson (Coords.) El Maíz en Peligro ante los transgénicos. Ciudad de México: UNAM, 111-163.

Arjó, G., Portero, M., Piñol, C., Viñas, J., Matias-Guiu, X., Capell, T., & Christou, P. (2013). Plurality of opinion, scientific discourse and pseudoscience: an in-depth analysis of the Séralini et al. study claiming that Roundup™ Ready corn or the herbicide Roundup™ cause cancer in rats. Transgenic research, 22(2), 255-267. DOI: 10.1007/s11248-013-9692-9

Barad, K. (2007). Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning. Duke University Press.

Bauer, M. W., Gaskell, G., & Durant, J. (Coord.) (2002). Biotechnology-the making of a global controversy. Cambridge University Press.

Ben Ali, S. E., Madi, Z., Hochegger, R., Quist, D., Prewein, B., Haslberger, A., & Brandes, C. (2014). Mutation scanning in a single and a stacked genetically modified (GM) event by real-time PCR and high-resolution melting (HRM) analysis. International Journal of Molecular Sciences, 15(11), 19898-19923. DOI: 10.3390/ijms151119898

Bowler, P. J. (2007) "Darwin, Charles Robert" En N. Koertge (Coord.) New Dictionary of Scientific Biography. Detroit: Charles Scribner's Sons, 242-247.

Camerota, M. (2007) "Galilei, Galileo" En N. Koertge (Coord.) New Dictionary of Scientific Biography. Detroit: Charles Scribner's Sons, 96-103.

Castro, I (forthcoming) What is a genetically modified seed? Implications for Science, Seeds and Cyborgs. Coimbra: Faculdade de Economia, Universidade de Coimbra.

Castro, I (2019). "Podemos salvar o clima no capitalismo?" En C. Principe & J. Mineiro (Coords.) ABC do socialismo. Um outro mundo não é possível, ele está a caminho. Lisboa: Parsifal, 32-39.

Cortessis, V. K., Thomas, D. C., Levine, A. J., Breton, C. V., Mack, T. M., Siegmund, K. D., & Laird, P. W. (2012). Environmental epigenetics: prospects for studying epigenetic mediation of exposure–response relationships. Human genetics, 131(10), 1565-1589. DOI: 10.1007/s00439-012-1189-8

Daintith, J. (2008). Biographical Encyclopedia of Scientists. London & New York: CRC Press, 171-172 & 273-274.

Delborne, J. A. (2005) Pathways of Scientific Dissent in Agricultural Biotechnology. PhD dissertation in Environmental Science, Policy and Management. University of California, Berkeley [fall 2005]

Einestein, A. (2009 [1949]) Why Socialism? Monthly Review, 61(1) pp 55-61

Elmore, R. W., Roeth, F. W., Nelson, L. A., Shapiro, C. A., Klein, R. N., Knezevic, S. Z., & Martin, A. (2001). Glyphosate-resistant soybean cultivar yields compared with sister lines. Agronomy Journal, 93(2), 408-412. DOI: 10.2134/agronj2001.932408x

Engels, F. (1974 [1883) Dialéctica da Natureza [trad. Joaquim ramos e Eduardo Nogueira]. Lisboa: Editorial Presença.

Ewen, S. W., & Pusztai, A. (1999). Effect of diets containing genetically modified potatoes expressing Galanthus nivalis lectin on rat small intestine. The Lancet, 354(9187), 1353-1354. DOI: 10.1016/S0140-6736(98)05860-7.

Fagan, J., Traavik, T., & Bøhn, T. (2015). The Seralini affair: Degeneration of science to re-science? Environmental Sciences Europe, 27(1), 19. DOI: 10.1186/s12302-015-0049-2.

Finamore, A., Roselli, M., Britti, S., Monastra, G., Ambra, R., Turrini, A., & Mengheri, E. (2008). Intestinal and peripheral immune response to MON810 maize ingestion in weaning and old mice. Journal of agricultural and food chemistry, 56(23), 11533-11539. DOI: 10.1021/jf802059w.

Fleck, L. (1986 [1935]) La génesis y el desarrollo de un hecho científico: introducción a la teoría del estilo de pensamiento y del colectivo de pensamiento. Madrid: Alianza.

Galeano, P., Debat, C. M., Ruibal, F., Fraguas, L. F., & Galván, G. A. (2010). Cross-fertilization between genetically modified and non-genetically modified maize crops in Uruguay. Environmental biosafety research, 9(3), 147-154. DOI: 10.1051/ebr/2011100.

Garcia, J. L. (2006) Biotecnologia e biocapitalismo global. Analise social, Vol: XLI (181), 981-1009

Gaskell, G., & Bauer, M. W. (Coords.). (2001). Biotechnology 1996-2000: The years of controversy. London: Science Museum.

Graeber, D. (2015) The Utopia of Rules: On Technology, Stupidity, and the Secret Joys of Bureaucracy. New York: Melville House Publishing

Gunning, R. V., Dang, H. T., Kemp, F. C., Nicholson, I. C., & Moores, G. D. (2005). New resistance mechanism in Helicoverpa armigera threatens transgenic crops expressing Bacillus thuringiensis Cry1Ac toxin. Applied Environmental Microbiology, 71(5), 2558-2563. DOI: 10.1128/AEM.71.5.2558-2563.2005.

Haraway, D. J. (2008) When Species Meet. Minneapolis: University of Minnesota Press.

Haraway, D. J. (1997) Modest_Witness@Second_Millennium.FemaleMan_Meets_OncoMouse. New York: Routledge.

Haraway, D. J. (2016) Staying with the trouble. Making kin in the Chthulucene. Durham & London: Duke University Press.

Harvey, D. (2003). The fetish of technology: Causes and consequences. Macalester International, 13(1), 7.

ISAAA (2017) Global Status of Commercialized Biotech/GM Crops in 2017. ISAAA Brief No. 53- ISAAA: Ithaca, New York.

Jagtap, U. B., Gurav, R. G., & Bapat, V. A. (2011). Role of RNA interference in plant improvement. Naturwissenschaften, 98(6), 473-492. DOI: 10.1007/s00114-011-0798-8

James, C; Krattiger A.F.(1996) Global Review of the Field Testing and Commercialization of Transgenic Plants: 1986 to 1995. The first decade of crop biotechnology. ISAAA Briefs No. 1. ISAAA: Ithaca, New York.

James, C (1997) Global Status of Transgenic Crops in 1997. ISAAA Briefs No. 5. ISAAA: Ithaca, New York.

Jasanoff, S. (2003) Technologies of Humility: citizen participation in governing science. Minerva, 41 (3).

Khalil, A. (2014) “Arriba y abajo” En D. Sagan (Coords) Lynn Margulis. Vida y legado de una científica rebelde (traducción Ambrosio García Leal). Tusquets Editores México. pp.33-46.

Kinchy, A. (2012) Seeds, Science, and Struggle: The Global Politics of Transgenic Crops (Food, Health, and the Environment). Cambridge & London: The MIT Press

Kleinman, D. L., Kinchy, A. J., & Handelsman, J. (Coords.) (2005). Controversies in science and technology: from maize to menopause. Madison: The University of Wisconsin Press.

Kloppenburg, J. R. (2004). First the seed: the political economy of plant biotechnology [2nd ed.] London: The University of Wisconsin Press

Krimsky, S. (2015). An illusory consensus behind GMO health assessment. Science, Technology, & Human Values, 40(6), 883-914. DOI: 10.1177/0162243915598381.

Kuhn, T. (2016 [1962]) The structure of scientific revolutions [3rd edition]. Chicago & London: University of Chicago Press.

Latham, J. R., Wilson, A. K., & Steinbrecher, R. A. (2006). The mutational consequences of plant transformation. BioMed Research International, VOL 2006. DOI: 10.1155/JBB/2006/25376.

Latour, B. (1987) Science in action: How to follow scientists and engineers through society. Cambridge: Harvard University Press.

Lear, L. (2009). Rachel Carson: Witness for Nature. New York: Mariner Books.

Lebrecht, T.; Wallace, H.; Castro, I. (2019), Social Issues, En Critical Scientists Switzerlan, European Network of Scientists for Social and Environmental Responsability, Vereinigung Deutscher Wissenschaftler (Org.), Gene Drive - A report on their science, applications, social aspects, ethics and regulations. Bern & Berlin: Holly Dressel, 159-214

Levins, R. (2015) Una pierna adentro, una pierna afuera. Ciudad de Mexico: CopIt-arXive & Editora C3

Lewontin, R. (1998) Biologia como Ideologia. A doutrina do ADN [trad. Margarida Amaral]. Lisboa: Relógio D'Água Editores.

Mackenzie, D. (1994) Transgenic tobacco is European first. NewScientist, n.1930, https://www.newscientist.com/article/mg14219301-100-transgenic-tobacco-is-european-first/?ignored=irrelevant, consultado el 17 de agosto de2020

Martin, B. (1996) Critics of pesticides: whistleblowing or suppression of dissent?. Philosophy and Social Action. 22 (3), 33-55.

Martin, B. (1997) Suppression Stories. Wollongong: Fund for Intellectual Dissent

Martin, B. (2010) How to Attack a Scientific Theory and Get Away with It (Usually): The Attempt to Destroy an Origin-of-AIDS Hypothesis. Science as Culture. 19 (2), 215-239. DOI: 10.1080/09505430903186088.

Marx, Karl (2015 [1971]) El capital. Libro I capitulo VI (Inédito): resultados del processo inmediato de produccion. [trad. Pedro Scaron] [6th edición] Ciudade de Mexico: siglo vientiuno editores.

Marx, Karl (2017 [1975]) El capital - Libro primeiro [Traducción Pedro Scaron]. [33th edicion] Ciudad de México: Siglo veintiuno editores.

McHenry, L. B. (2018). The Monsanto papers: poisoning the scientific well. International Journal of Risk & Safety in Medicine, Vol 29 (3-4), 193-205. DOI: 10.3233/JRS-180028.

Men, X., Ge, F., Edwards, C. A., & Yardim, E. N. (2004). Influence of pesticide applications on pest and predatory arthropods associated with transgenicBt cotton and nontransgenic cotton plants. Phytoparasitica, 32(3), 246-254. DOI: 10.1007/BF02979819

Merton, R. (1973) The sociology of science. Theoretical and empirical investigations. Chicago & London: The University of Chicago Press.

Myers, J. H. (2001) "Predicting the Outcome of Biological Control" En Charles W. Fox, Derek A. Roff and Daphne J. Fairbairn (Coords.) Evolutionary Ecology: concepts and case studies, New York: Oxford University Press, 361

Nelson, G. C. (2001). Genetically modified organisms in agriculture: economics and politics. Academic Press.

Nunes, J.A., Diego, C., Matias, M.; Costa, S. (2003) GMO and Public Policy in Portugal or How Not to Put GMOs into Politics, Research report, PubAcc Project. Coimbra: CES.

Piron, F., & Varin, T. (2015). El caso Séralini y la confianza en el orden normativo dominante de la ciencia. Sociológica (México), 30(84), 231-274.

Proctor, R. (2008) "Agnotology. A missing term to describe the cultural production of ignorance (and its study)" En R. Proctor & Schiebinger, L. (Coords) Agnotology: The Making and Unmaking of Ignorance. Stanford: Stanford University Press, 1-33.

Quarantiello, A. (2004) Rachel Carson. A biography. London: Greenwood Press.

Ribeiro, S. (2004) "Cultivos Transgénicos: Contexto empresarial y nuevas tendencias" En Rubio, J. M. (Coords) Alimentos transgénicos. Ciencia, ambiente y mercado: un debate abierto. Ciudad de México: siglo xxi editores, 67-87.

Rose, H. (1994) Love, Power and Knowledge: Towards a feminist transformation of the sciences. Cambridge: Polity Press

Rose, H., & Rose, S. (1974) "The Incorporation of Science" En H. Rose & S. Rose (Coords.) The Political Economy of Science. Ideology of/in the Natural Sciences. London & Basingstoke: the macmillan Press, 14-31.

Rubio, J. M. (Coord.) (2004). Alimentos transgénicos. Ciencia, ambiente y mercado: un debate abierto. Ciudad de México: siglo xxi editores

Sagan, D. (Coord.) (2014) Lynn Margulis. Vida y legado de una científica rebelde (traducción Ambrosio García Leal). Tusquets Editores México.

Sagan-Margulis, L. (1967) On the origin of mitosing cells. Journal of theoretical biology, 14(3), 225-274.

Sawasaki, T., Takahashi, M., Goshima, N., & Morikawa, H. (1998). Structures of transgene loci in transgenic Arabidopsis plants obtained by particle bombardment: junction regions can bind to nuclear matrices. Gene, 218(1-2), 27-35.

Shapin, S. (1999) A Revolução Científica [trad. Ricardo Afonso Roque]. Viseu: DIFEL 82.

Svitashev, S., Ananiev, E., Pawlowski, W. P., & Somers, D. A. (2000). Association of transgene integration sites with chromosome rearrangements in hexaploid oat. Theoretical and Applied Genetics, 100(6), 872-880.

Tabashnik, B. E., Van Rensburg, J. B. J., & Carrière, Y. (2009). Field-evolved insect resistance to Bt crops: definition, theory, and data. Journal of economic entomology, 102(6), 2011-2025.

Vazquez-Padron, R. I., Moreno-Fierros, L., Neri-Bazan, L., Martinez-Gil, A. F., De-la-Riva, G. A., & Lopez-Revilla, R. (2000). Characterization of the mucosal and systemic immune response induced by Cry1Ac protein from Bacillus thuringiensis HD 73 in mice. Brazilian Journal of Medical and Biological Research, 33(2), 147-155.

Waddell, C. (2000) "The reception of Silent Spring: An introduction" En C. Waddell (Coord.) And No Birds Sing. Rhetorical Analysis of Rachel Carson's Silent Spring. Carbondale & Edwardsville: Southern Illinois University Press, 1-16.

Watrud, L. S., Lee, E. H., Fairbrother, A., Burdick, C., Reichman, J. R., Bollman, M., & Van de Water, P. K. (2004). Evidence for landscape-level, pollen-mediated gene flow from genetically modified creeping bentgrass with CP4 EPSPS as a marker. Proceedings of the National Academy of Sciences, 101(40), 14533-14538.

Wynne, B. (2006) Public engagement as a means of restoring public trust in science–hitting the notes, but missing the music? Public Health Genomics, 9(3), 211-220.

Wynne, B. (2013) "Ciencia global, el maíz mexicano y el neoliberalismo molecular: cambiando los fundamentos de la ciencia, innovación y políticas para una alimentación y una agricultura sostenibles" En E. Álvarez-Buylla & A.P. (Coords.) El Maíz en Peligro ante los transgénicos. Ciudad de México: UNAM. 279-312

ANNEX 4

PODEMOS SALVAR O CLIMA NO CAPITALISMO?

Irina Castro

O modo específico de produção capitalista e a sua segunda contradição

O capitalismo verde, a sustentabilidade no quadro da produção capitalista e o ordenamento jurídico da natureza em torno dos direitos humanos são a mais recente retórica que o sistema capitalista encontrou para afirmar que pode resolver a crise climática e ambiental. Será que pode mesmo? Para podermos responder a essa pergunta há que responder primeiro como poderá o capitalismo salvaguardar o seu lucro resolvendo a crise climática, e se esta salvaguarda representa uma resolução dessa crise ou se na verdade a agrava.

Comecemos por explicar brevemente como se gera uma crise no capitalismo. Enquanto modelo de produção, circulação e consumo de valor, o capitalismo tem como finalidade a obtenção de lucro. Sendo a obtenção desse lucro um processo contínuo de expansão e acumulação de capital, o mesmo está exposto a situações de bloqueio ou interrupções. A isto também se chama crises, pois dá-se uma interrupção do seu processo de crescimento contínuo. Estas crises são maioritariamente geradas por contradições do próprio sistema capitalista.

Vejamos, por exemplo, a crise das matérias-primas. Consideremos que as matérias-primas, como o algodão, cereais, ferro, cobre, entre outras, são matérias extraídas da natureza através do trabalho humano, e que o petróleo e o carvão são as matérias-primas que alimentam o consumo de energia necessária à produção. Quando os custos destas matérias-primas aumentam, o sistema de produção capitalista enfrenta uma crise relacionada com os custos da sua produção. Mas como se pode gerar a crise dos custos de produção? De duas formas: extrativismo e poluição.

A crise dos custos de produção pode gerar-se pelo uso insustentável dos recursos naturais que são fonte das matérias-primas que entram no sistema de produção, por exemplo, uma crise do petróleo, do carvão ou o ferro, ou da sobre-exploração de outros recursos, como o solo e a água. A escassez gerada pela progressiva intensificação da extração e exploração e as dificuldades emergentes que representa originam um aumento dos custos produtivos, pois a extração destes necessita de mais trabalho, ficando assim mais cara. Paralelamente, a crise dos custos de produção gera-se também por impacto dos resíduos não-valorizáveis. Entenda-se resíduo, ou desperdício, como excrementos do processo de trabalho (ou consumo), que após a finalização do mesmo não se reconstituem como meios de produção e, portanto, não adquirem um novo valor de uso. Por exemplo, todos os resíduos industriais que são lançados nos rios e que resultam em poluição. Essa poluição restringe progressivamente o acesso a recursos naturais vitais, como a água e o solo. Isto tem impactos não apenas na produção, mas também nas sociedades humanas e em todos os outros seres. Mas isto não é novidade. O impacto da poluição na produção e comunidades humanas já era conhecido desde a era da revolução industrial.

Mas, então, como chegámos hoje a esta crise climática? A nossa experiência quotidiana com a poluição e degradação ambiental, quando é extraída da sua relação com a forma de produção capitalista, resulta na alienação da nossa relação com a natureza. Ocorre assim uma rutura das relações humanas com a natureza a que John Bellamy Foster designa de rutura metabólica. As relações existentes previamente são então substituídas por uma única relação, a capital-salário. Esta substituição tem como resultado imediato a alienação dos/as produtores/as e consumidores/as das condições objetivas da produção e do consumo. Passam assim a estar totalmente abstraídas das reais condições materiais da vida, ou seja, da natureza em si. Uma outra agravante desta rutura é que ela acontece não apenas entre nós e a natureza, mas também entre pessoas. A rutura metabólica reduz assim a nossa relação com a natureza à manutenção da nossa subsistência, possibilitando ao sistema capitalista a exploração intensiva e extensiva tanto do trabalho como da natureza.

Como já vimos, a crise dos custos de produção e a alienação das relações entre nós e a natureza estão na base da crise ambiental e climática. Falta-nos ver, no entanto, que respostas dá o capitalismo a esta crise.

Como a contradição é interna ao próprio sistema capitalista, os donos dos meios de produção não têm outra alternativa se não reorganizarem a produção e o trabalho. Isto passa ainda por reorganizar de forma espacial a natureza. Por exemplo, a forma capitalista de exploração agrícola resultou na progressiva destruição dos solos. Hoje, o capitalismo propõe uma solução de intensificação a que designa de sustentável. Mas essa intensificação passa necessariamente por uma reorganização da natureza e do trabalho de forma a que ambos permaneçam acessíveis ao capitalista sem que isto afete o seu processo contínuo de acumulação de capital. Isto significa que o conceito de sustentabilidade, que poderia ser entendido como um processo emergente de conflito entre capital e trabalho, passa a estar abstraído também das reais condições de produção, tornando-se assim um conceito vazio de noções de justiça e subsumido aos interesses do capital. É por este motivo que o capitalismo é uma perspetiva irracional de qualquer desenvolvimento humano sustentável.

Por outro lado, a superação da crise dá-se também pela criação de novos valores de uso. Por exemplo, da crise da sobre-exploração dos recursos e da crise do consumo de produtos poluentes, o capital avança com a proposta de reintroduzir os resíduos no processo produtivo. Isto apenas é possível porque, além do capitalismo continuamente revolucionar os meios de produção, também é pressionado socialmente para o fazer.

Um dos exemplos mais compreensivos é a reciclagem. A reciclagem é uma necessidade imediata para fazer frente ao massivo consumo de produtos que não podem ser valorizáveis pelo consumidor

Irina_Castro.indd 3 16/12/2018 21:53:58

final, e por isso se distingue da reutilização. No entanto, o potencial da reciclagem de fazer frente a uma produção e consumo desenfreado de produtos cujos resíduos resulta no seio da moral capitalista outra vez na alienação. Porquê? Para nós a reciclagem significaria, por exemplo, que a produção de plásticos seria reduzida perante uma contínua valorização das embalagens, que deveriam ser recuperadas ou transformadas e reintroduzidas novamente no sistema de produção. No entanto, alguns dados demonstram que apenas uma pequena percentagem dos resíduos que depositamos nos ecopontos são realmente aproveitados. Para os capitalistas continua a ser mais barato produzir novos plásticos do que reciclar os existentes. É por isso importante recusar uma abordagem da reciclagem enquanto sistema moralizante, que naturaliza as próprias condições de produção capitalistas e de hiperconsumo.

Outra forma de resolução da crise que o sistema capitalista encontra é mover-se no sentido de abandonar o circuito geral do capital e avançar para a especulação. Surgem assim os mercados de carbono, biodiversidade e de serviços ambientais, mas que não alteram de forma substantiva a forma de produção. Pelo contrário, fornecem ao capitalismo uma cara lavada de verde, salvaguardando a acumulação de riqueza. Resulta assim que o capitalismo parece ter a capacidade de salvar o seu lucro ao atuar sobre a crise climática, mas isso é mera especulação.

Apesar destas três formas de resolução da crise dos custos da produção – intensificação, surgimento de novos valores de uso e especulação –, nenhuma destas resolve a contradição fundamental do sistema. A intensificação dá seguimento à degradação, os novos valores de uso aumentam o consumo, e a especulação cria bolhas económicas que resultam em novas crises.

Assim, e respondendo à nossa pergunta se pode o capitalismo salvaguardar o seu lucro na crise climática? Sim, no entanto, não irá resolver a contradição viva que está na base da degradação ambiental e da crise climática. Pelo contrário, irá aprofundar essa crise e, por consequência, não existe salvação para o clima no quadro de um sistema de produção capitalista.

O ecossocialismo e o seu caminho

Perante a impossibilidade de salvar o clima no capitalismo, urge encontrar respostas alternativas. Respostas que permitam reabilitar a nossa relação com a natureza de forma a transcender a alienação produzida pela relação hegemónica capital-trabalho.

Várias ideias e alternativas têm surgido ao longo das últimas décadas, e podemos considerar que atuam em duas esferas: a individual e a coletiva. As alternativas individuais passam por uma mudança pessoal do nosso consumo. Procurar reutilizar embalagens, autogerir os resíduos orgânicos, reduzir o consumo energético, consumir produtos locais, etc. No entanto, estas opções, apesar de importantes, tem as suas próprias limitações. Por exemplo, muitas destas alternativas exigem um poder de compra superior à média salarial dos países, ou exigem que a pessoa disponha de tempo para as procurar e organizar, o que nem sempre é possível dentro do nosso modo de vida acelerado. É por isso que as experiências coletivas são tão importantes, pois tendem a distribuir o esforço individual e a abrir espaços de participação democrática. São exemplo as redes alternativas de comida que já existem em várias cidades do nosso país. Estas redes procuram romper com o circuito do capital ao retirar de cena o capitalista na organização da cadeia de distribuição. Muitas destas redes passam por uma articulação conjuntas entre produtores e consumidores auto-organizados.

Experiências semelhantes existem já em campos como a energia. Estas experiências, que procuram socializar setores estratégicos como o da energia, são formas de abandonar escolhas que dentro do sistema capitalista parecem inevitáveis. No campo da energia, uma transição para um sistema energético ecológico e socialmente justo passa pela descentralização e socialização do mesmo. Mas esta luta tem de ser feita de forma mais ampla do que apenas as iniciativas individuais ou coletivas de alteração de consumo. Necessita de mobilização popular e coordenação democrática que faça frente aos interesses privados do capitalismo, que na maioria das vezes são salvaguardados pelos próprios Estados. É por isso que movimentos, como os que temos hoje em Portugal contra a exploração de hidrocarbonetos, são tão importantes. Estes movimentos obrigam os Estados a dar respostas a interesses que não são os do capital privado e a tomar decisões políticas que refletem o interesse comum do nosso planeta.

As experiências coletivas estão assim na base de uma possibilidade de mudança. Elas rompem com as lógicas individualistas do capitalismo e abrem portas à construção de redes anticapitalistas de relações de produção, circulação e consumo de bens, fazendo igualmente pressão sobre os Governos para que atendam a políticas que defendam o bem comum e não apenas interesses setoriais. No entanto, o sucesso necessário destas experiências depende também dos conflitos que consigam abrir no seio da relação capital-salário. É, portanto, necessário que o quadro crítico da forma de produção capitalista usado para entender a crise climática e ambiental tenha em conta, na mesma consideração, o papel do trabalho nesta transformação.

É por isso que projetos políticos como o ecossocialismo defendem medidas como a redução do horário de trabalho mantendo o salário. Como vimos inicialmente, uma forma de fazer frente aos custos de produção por parte do capital passa pela intensificação da exploração dos meios de produção, e estes incluem o trabalho que é tendencialmente o primeiro a ser intensificado.

O ecossocialismo representa assim a base fundamental para o desenvolvimento de uma resposta ao capitalismo que une os elementos críticos do marxismo, do socialismo e da ecologia. Por ter na sua génese o envolvimento metabólico entre as pessoas e a natureza e a crítica da degradação ambiental dos regimes comunistas soviético e chinês, o ecossocialismo é um projeto político necessariamente anticapitalista e um socialismo despegado da lógica errónea das necessidades crescentes de produção e consumo. Apesar de ter origens no final do século XIX, é apenas durante os anos 70 que o ecossocialismo adquire forma como projeto político. Em particular, e desde o final da década de 1990, o ecossocialismo é ainda desafiado pelos emergentes movimentos antiglobalização e feministas expandir a sua crítica.

Além disso, o ecossocialismo reconhece que qualquer expressão de imperialismo é antiética, que ameaça a natureza e o trabalho. É por isso necessário um projeto de paz e solidariedade. Por ser uma política que combate a alienação, o ecossocialismo aprofunda as relações entre o movimento sindical e as lutas ecológicas. É uma consciência de classe ecossocial.

ANNEX 5

In Mestras e Mestres do Mundo: coragem e Sabedoria

Augusto Boal

Irina Castro

Publicado em 2021-06-15

https://alice.ces.uc.pt/mestrxs/?id=27696&pag=23918&id_lingua=1&entry=34600

Augusto Boal, o Mestre Perplexo

Inspiração

As histórias que fazem parte do Teatro do Oprimido (TO) e, em particular, as narradas pelo mestre Augusto Boal, tendem inevitavelmente a começar na história do camponês Virgílio. Não é por mero acaso que a história de Virgílio, habitualmente contada no início das sessões de Teatro Fórum (uma das múltiplas vertentes e técnicas do TO) é tão importante enquanto primeiro contacto com o legado deste mestre dramaturgo e pedagogo que nos ensina a ensaiar a revolução.

Mas lá chegaremos. Primeiro quero apresentar-vos Augusto[1], o jovem filho de Albertina Pinto Boal e do padeiro português José Augusto Boal, que vivia no Rio de Janeiro, Brasil. Diz a sua história[2] que foi por volta dos 15 anos que começou a escrever peças de teatro onde retratava as opressões de classe do proletariado brasileiro[3]. Perplexo com a inatividade dxs trabalhadorxs face às suas opressões, Augusto tinha para si que o privilégio da sua posição de artista lhe conferia uma certa imunidade face à opressão que tentava visibilizar nas suas obras. Até certa medida, esta ilusão do privilégio dx artista caracterizou a etapa inicial do Teatro Político durante a década de 50 do século XX. Tal como muitxs artistas da sua geração, Augusto acreditava ser capaz de ensinar aos oprimidxs a forma como deveriam lutar contra as suas opressões.

Esta fase da sua vida não deve, no entanto, ser desconsiderada. Augusto sempre foi um homem perplexo com a opressão, particularmente com a que ocorria no seu país natal, o Brasil. Foi este o motivo que o fez regressar, em 1955, dos Estados Unidos da América, onde estudou Teatro na Universidade de Columbia, para se juntar ao Teatro de Arena de São Paulo. Foi aí, na Rua Teodoro Bayma nº94, se não me falha a referência, que Boal aderiu a um recém-nascido projeto estético-político brasileiro que mudaria para sempre a história do Brasil e do Teatro.

Enquanto dramaturgo do Teatro de Arena, Augusto escreveu dezenas de peças e dirigiu outras tantas sob influência dos métodos de Constantin Stanislavski e Bertolt Brecht, cujas propostas procuravam criar um teatro mais realista e autorreflexivo. Comprometido com a ideia política de criar uma dramaturgia nacional brasileira, Boal adaptou textos internacionais como "A Mandrágora" de Maquiavel, e coassinou outros tantos, como "Revolução na América do Sul" (1960) e "Arena conta Zumbi"(1965)[4]. É, nas bases deste último, e no seguimento de outros espetáculos como "Arena canta Bahia" (1965) "Arena Conta Tiradentes" (1967), que desenvolve o seu compromisso com os princípios de conscientização e luta que o conduzirão a desenvolver uma nova estética-ética de Teatro que o afastará da dramaturgia realística e impulsionará a sua filosofia da perplexidade.

Em 1964, e em pleno início da Ditadura Militar Brasileira, Augusto destaca-se, uma vez mais na história do Teatro enquanto diretor do musical-político *Opinião*. Nove meses depois do golpe militar que instalaria no Brasil uma ditadura militar de 21 anos, o espetáculo juntou Nara Leão, João Vale e Zé Keti (e mais tarde Maria Bethânia) marcando o início de um movimento teatral contra a ditadura que procurava resistir através da prática artística, e das situações simbólicas e alegóricas da realidade política.

É também, por volta desta década, que Boal conhece Virgílio o camponês, e aprende que afinal não sabia mais do que xs oprimidxs. Um dia, quando trabalhava para a liga de camponeses do nordeste do Brasil, conheceu Virgílio, um camponês de verdade. No final de uma peça na qual falsos camponeses (atores/atrizes) encenavam uma revolta com o grito "*Temos de derramar o nosso sangue para salvar a nossa Terra*" Virgílio, entusiasmado com a peça e a sua mensagem, acerca-se de Augusto e dxs seus companheirxs com um desafio ontológico: "*Vocês pensam exatamente como nós, porque não pegam nas vossas armas?*", interrogou Virgílio. *"Porque não trazem as vossas armas, e vamos lutar contra os donos das terras que ocuparam as nossas terras. Nós temos de derramar o nosso sangue*".

Perplexo, Boal hesita, tentando explicar a Virgílio que, na verdade, as suas armas eram parte do cenário e que, embora a sinceridade deles fosse genuína não o poderiam acompanhar. Eram apenas artistas de verdade, e não camponeses de verdade. Desapontado, Virgílio reage às justificações de Boal: "*Então, quando um verdadeiro artista diz: vamos derramar o nosso sangue, vocês estão na verdade a falar sobre o NOSSO verdadeiro sangue, de verdadeiros camponeses, e não sobre o vosso*". Nasce assim em Boal um novo sentido sobre a perplexidade e com ele uma nova filosofia de teatro.

Mestre Perplexo

O que faz de Boal um Mestre do Mundo é a sua perplexidade. Não a perplexidade descrita no dicionário como aquela que indica o estado de se estar ou ser perplexo enquanto uma qualidade de hesitação, indecisão ou até de irresolução. A perplexidade de Augusto Boal inscreve-se no vocabulário do TO como a permissão para fazermos sentido teórico e prático do que aconteceu, imaginarmos o que não aconteceu, e ensaiarmos a possibilidade de outras coisas acontecerem (Boal, 1996). Ser-se perplexo é, pois, a filosofia das respostas infinitas às perguntas que nos procuram dominar pela racionalidade e pela técnica. Para Boal a pessoa perplexa é aquela que não toma como suas as certezas dadas pelas perguntas racionais, mas que partilha a perplexidade do infinito possível externo e interno a si[5].

A história de Virgílio é o início da filosofia da perplexidade de Boal, o resultado do desafio direto à noção de posições privilegiadas no seio dxs oprimidxs, e o traçar de um processo de solidariedade revolucionária que jamais terminaria para Boal, mesmo depois da sua morte em 2009.

Importa, neste momento, clarificar o que é o TO. Muitxs irão classificar o TO como um método dramatúrgico, outrxs como uma teoria revolucionária. Haverá aquelxs que ainda lhe atribuirão um carácter de terapia. No entanto, é necessário não esquecer que apesar do TO ser isso tudo e muito mais, a sua base é a filosofia da perplexidade. Quero com isto dizer que em Boal não existe propriamente um método ou uma teoria que não seja em si mesmo processo da nossa perplexidade na vida. O TO não é um método fixo, não é uma obra acabada ou uma teoria estabelecida. Não é uma receita que se prescreve, um protocolo que se segue à risca. É a prática da perplexidade de pensar o passado para no presente ensaiar o futuro. Neste sentido o TO não é a revolução, mas o ensaio da revolução. É a insurreição dxs oprimidxs das forças internas e externas que xs mantêm inativxs, é o transformar dxs espectadorxs passivxs em atorxs ativxs.

Rasgando de vez com as divisões espaciais, temporais e orgânicas entre atorxs e espectadorxs, o Teatro do Oprimido, em particular o Teatro Fórum - inicialmente apelidado de dramaturgia simultânea[6]- afirma-se como o espelho de Alice onde se refletem as opressões que se querem ver combatidas e se ensaia uma outra realidade.

No mesmo sentido, o surgimento do TO alterou também para sempre a forma como experienciamos o Teatro. Em todo o seu trabalho, Boal transmite-nos um sentido ético de Teatro falado e não ouvido, um Teatro-processo e não um Teatro-produto. Com uma forte visão crítica da sociedade do espetáculo, ou seja, da forma como a burguesia recorre ao uso do espetáculo para perpetuar as formas de dominação sobre a classe trabalhadora, Boal recorre ao Teatro como forma de revelar no espetáculo o que não é visível, o que não é consciente, mas que está presente como poder nas relações quotidianas (Boal, 2009).

Alice: Quanto tempo dura o eterno?
Coelho: As vezes apenas um segundo.
(Alice no País das Maravilhas, Lewis Carroll)

No final da década de 60, e em resposta à censura e ao controlo de informação exercido pelo ditador Emílio Garrastazu Médici, surge o Teatro-Jornal (1968) como técnica de dramatização da realidade das notícias manipuladas pela ditadura. Tal como descreve hoje o Centro de Teatro do Oprimido[7], organização que Boal funda no Brasil em 1986 após o seu retorno do exilio, o Teatro-Jornal "*é o grito das entrelinhas das notícias censuradas*", a encenação da realidade ocultada pela manipulação da informação. Esta técnica, que surge mais da necessidade do que da inspiração artística, é ainda hoje recorrentemente utilizada por diversos grupos de TO e movimentos estético-políticos para revelar através de imagens as realidades ocultadas pelas múltiplas formas de censura que persistem nas nossas sociedades.

Na altura em que se estabelece o Teatro-Jornal como forma de se dizer o que quem domina não quer ver dito, Boal é preso e na sequência exila-se na Argentina (1971). Sobre o tempo que passou na prisão, Boal relata que o tempo que passou encarcerado o transportou para uma outra conceção de espaço-tempo. Longe da auto evidência destas duas categorias, e não as tendo como adquiridas, Boal reflete sobre a forma como estas nos fornecem uma estrutura para determinarmos o que somos e como somos em sociedade. Debruçando-se de forma crítica sobre o que significa ser livre, Boal descobre na prisão que a liberdade ficcionada da rotina do seu corpo o encarcerava "*Quando somos livres no espaço estamos presos no tempo*"[8].

Para sempre marcado por Virgílio e por esta experiência na prisão, Boal abraça o forte sentimento Guevarista da solidariedade, e para sempre, ir-se-á inspirar nele ao dar corpo ao seu trabalho. Dez anos depois, em França e com a sua companheira Cecília, Boal inicia o caminho daquilo que viria mais tarde a ser designado como *Arco-íris do Desejo* (1996), um conjunto de técnicas que permitem trabalhar as opressões internalizadas. As que vivem dentro de cada um e cada uma. Foi da sua procura de um espaço estético-político, onde fosse possível dissipar a separação entre atorxs e espectadorxs, e onde a barreira do tempo fosse transposta pela coincidência do presente que se vive com a memória do passado e a imaginação do futuro, que surgiu a consciência sobre as opressões invisíveis que se perpetuam nas ideias e atitudes dxs próprixs oprimidxs (Polícias na Cabeça) (Boal & Epstein, 1988).

Cria-se assim uma importante noção no TO, a da tríade epistémica do espaço estético, isto é, a possibilidade que o TO e as suas técnicas têm para:

i) contrair e expandir o tempo e o espaço: no TO é possível encenar a forma como certos momentos experienciados e identificados como opressivos podem ser experienciados de formas distintas em termos de espaço e tempo.
ii) observar e conhecer na escala necessária a opressão: no TO é possível encenar sobre a mesma opressão em diferentes escalas, por exemplo, a forma como a opressão com base no género é exercida tanto ao nível do Estado como ao nível do corpo.
iii) criar a possibilidade de se ser tanto atorxs como espetadorxs da nossa própria ação: no TO tanto podemos interpretar a nossa opressão, como vê-la.

Esta tríade resultante da relação entre a vivência e a sua teorização permite então explorar a forma como o par dialético da opressão (subversão-submissão) atua internamente sobre xs oprimidxs. Desenvolvido no espaço estético, o TO assume o lugar onde o método artístico permite agir sobre o futuro e restaurar a ideia de democracia (Boal, 2009). É a exploração do pensamento sensível e do pensamento simbólico, a compreensão dos fenómenos e o revelar das forças escondidas por detrás de uma sociedade de espetáculo e de opressões. Combater essa sociedade, feita de consumo e contemplação obediente aos meios de comunicação hegemónicos, onde somos merxs assistentes, passivxs, inativxs, é combater o analfabetismo estético transformando essa sociedade de espetáculo numa *sociedade espetacular de um espetáculo de espectadorxs*. Esta proposta, formulada nos últimos anos de vida de Boal, é na verdade o devir do Teatro do Oprimido, e a defesa que o TO não é cultura, mas o desenvolver da própria cultura, tal como o Teatro não é consumo, mas "*é ser Humano*" (Boal, 2009). O Teatro não é algo que se compra, que meramente se contempla, que se assiste. O Teatro são as estruturas sociais, é a vida consciente, "*o Teatro é ser humano*".

Na sua obra *A estética do oprimido* (2009) Augusto Boal fala-nos desse Teatro composto de vidas conscientes e almas sencientes, onde a linguagem utilizada e pensada é tanto a palavra, como a forma, como o som, como a sombra. É estética em diálogo, onde todos os sentidos atuam – *sinestesia* – é onde se toma a consciência ética, se dá sentido às decisões. Em *Jogos para Atores e Não-Atores* (1998) Boal deixa-nos um conjunto de jogos e exercícios que permitem ir além do ato de *desmaquinar* o corpo, explorando coletivamente as opressões que sobre cada um e uma de nós são exercidas. Dota-nos da experiência coletiva de desconstrução e da capacidade criativa e criadora de mudarmos as nossas próprias histórias. No Teatro do Oprimido tudo existe em relação com os outros, os corpos com os objetos, o espaço com o tempo, o corpo com o corpo, com uma única missão, transformar!

A única forma de chegar ao impossível, é acreditar que é possível
(Alice no País das Maravilhas, Lewis Carroll)

Em 1992 Augusto Boal é eleito Vereador do Rio de Janeiro e nesta nova fase da sua vida também o TO entra numa nova etapa. Munido das técnicas que, durante anos, se desenvolveram nas múltiplas experiências de TO, Boal e a sua equipa parlamentar iniciam o caminho do Teatro Legislativo. Consciente de que o TO, e em particular o Teatro Fórum, nos confronta com as dificuldades e as complexidades dos momentos e das experiências imediatas, Boal organiza-as não apenas com o sentido de encenar os problemas e as soluções, mas dando-lhes também direção para a mudança que pudesse ocorrer através da ação legislativa. Um novo espectoatorx nasce nesse momento, aquele que não se coloca apenas no centro da ação dramática, mas que se coloca no centro da ação legislativa. O seu princípio: "*Todos podem fazer política, até os políticos*" (Soeiro, 2009).

Alterando para sempre a relação dxs cidadxs com a política, o Teatro Legislativo traz à democracia um novo fôlego. Relembra os seus objetivos e devolve-a ao povo. Com o Teatro dx Oprimidx os problemas concretos e os obstáculos às soluções são identificados, com o Teatro Legislativo muda-se a lei com base na construção de uma relação de forças que permite fazer frente às injustiças atuais. Desta forma a ação política é democratizada, a democracia é democratizada, e "o gosto pela política como discussão e ação coletiva, que dá uso à palavra e ao corpo, é recuperada" (Soeiro, 2009).

O Teatro dx Oprimidx não é, por isso, a revolução, mas o seu ensaio. Chamamos-lhe Teatro porque nele falamos todas as linguagens, nele dialogamos connosco e com xs outrxs deixando que a perplexidade trace o caminho para a emancipação. Quem por lá já andou sabe que o caminho é o das perguntas incertas. Onde se trocam experiências e situações vivenciadas na pele ou na ideia. Quem por lá andou já leu as entrelinhas das notícias e dos meios de comunicação que nem sempre deixam revelar a realidade dos factos acontecidos. Sabe que a opressão também vive de corpos, e dentro das nossas cabeças. Quem por lá andou deu corpo, estética, ação às pluri-histórias. O TO é, então, o juntar de todas essas histórias que formulam perguntas, perguntas que não se esgotam nas suas respostas, mas que partilham a perplexidade de todas as respostas possíveis e imaginadas. Quem por lá andou, sabe que os espaços de improviso suspendem o real e a sua imagem. Sabe que, de todas as vezes se ensaiam sempre possíveis soluções aos dilemas e aos desafios, e outros se geram. Quem por lá andou, sabe que, ao se pensar a perplexidade de forma coletiva é possível criar desfechos diferentes.

É por isso que Augusto Boal é um mestre, porque o teatro não é apenas um evento, mas forma de vida, é um processo onde se aprende e se ensina, onde se democratiza a política e se combatem polícias internalizados. É a revolução de dentro para fora, onde deixamos de ser merxs espectadorxs passivxs do que acontece e passamos a poder agir sobre a realidade, onde deixamos apenas de viver, passando a transformar sem nunca abdicar de pensar.

Referências

Boal, Augusto (1996) *O arco-íris do desenho: método Boal de Teatro e Terapia*. Rio de Janeiro: Civilização Brasileira

Boal, Augusto (2009) *A Estética do Oprimido*. Rio de Janeiro: Garamond e Funarte

Boal, Augusto & Epstein, Susana (1988) *The Cop in the Head: Three Hypotheses*. TDR 34, n.3 (1990): 35-42.

Soeiro, José (2009) "O Teatro como política contra a política como teatro", diversidades atuais blogspot, 4 de dezembro. Consultado a 10-12-2014 em URL: http://diversidadesactuais.blogspot.pt/2009/12/o-teatro-como-politica-contra-politica.html

---

Notas

1. Augusto Pinto Boal nasceu no Rio de Janeiro, Brasil, a 16 de março de 1931. É o criador do Teatro do Oprimido. Dramaturgo, escritor, político, sonhador e defensor da democracia e da liberdade. Um mestre da solidariedade prática. Faleceu a 2 de maio de 2009 no Rio de Janeiro depois de ter "vivido em quase todo o mundo". É talvez exagero meu dizer que tenha vivido em quase todo mundo, mas certo é que viveu todo o mundo, e hoje todo o mundo o vive. As suas obras estão traduzidas em mais de 20 linguas.
2. Augusto Boal numa entrevista a Amy Goodman do Democracy now! durante o mês de Junho de 2007. A entrevista pode ser vista em: https://www.youtube.com/watch?v=HOgv91qQyJc Para saber mais sobre a vida de Augusto Boal ver a entrevista ao programa Encontro Marcado com a Arte, disponível no youtube em: https://www.youtube.com/watch?v=03klL8GhIpw
3. Este texto é escrito segundo o Acordo Queerográfico. Coletivo Acordo Queerográfico (2012) Acordo Queerográfico. e-Cadernos CES, 18, consultado a 07 de Dezembro de 2014. URL: http://eces.revues.org/1539
4. *Arena conta Zumbi*, é uma obra de Augusto Boal e de Gianfrancesco Guarnieri que estreou no Teatro de Arena no 1º de maio de 1965. O musical procura colocar em cena as lutas e a resistência dos quilombolas de Palmares e inaugura um novo modelo dramatúrgico conhecido como o Sistema Coringa. Mais informações em: https://institutoaugustoboal.org
5. Boal define-se como um ser perplexo. Esta autodefinição é encontrada na entrevista que Augusto Boal dá ao Programa Encontro Marcado com a Arte, exibido pela TV Educativa. Essa entrevista encontra-se alojada na plataforma Youtube e pode ser vista através do link: **(Parte 1)** https://www.youtube.com/watch?v=03klL8GhIpw; **(Parte 2)** https://www.youtube.com/watch?v=1uk43Uy77ks; **(Parte 3)** https://www.youtube.com/watch?v=dsIa0B_eVIs
6. A dramaturgia simultânea é desenvolvida por Boal durante o seu período no Peru, em 1973, no âmbito do programa de alfabetização AFIN.
7. O Centro de Teatro do Oprimido está situado no Rio de Janeiro, Brasil. Mais informações em: http://ctorio.org.br/
8. Augusto Boal na mesma entrevista anteriormente referida a Amy Goodman, *Democracy now!* durante o mês de Junho de 2007.

Chapter 3

Social issues

Tamara Lebrecht, Helen Wallace, Irina Castro

1 Introduction

Gene drive organisms (GDOs) are a new biotechnological development that currently has no final product available to be assessed for its risks and benefits to society. In the first part of this chapter, we look at where investment in gene drive R&D is coming from, along with how conflicts of interest may arise. We examine the promises made about what products we can expect from this technology, especially in terms of claims about how they would benefit society and the economy. We also discuss how such promises influence public understanding of the technology and help to secure research funding. We then examine gene drive patent applications. In the second part of this chapter, we examine how issues such as consent and risk assessment have been tackled by existing projects using genetically modified (GM) mosquitoes (currently without gene drive, but with some plans to include it in the future) and discuss liability and the Precautionary Principle. Finally, we discuss what more meaningful public engagement about these issues would require.

2 Gene Drive science in context: science in society

Research and development of gene drive organisms (GDOs) is taking place in different social and economic contexts across the globe. For gene drive organisms (GDOs), the initial investment in R&D occurs mainly in rich economies (notably in the USA, Australia, the UK and some other European countries). In contrast, some of the first open releases of GDOs are planned in resource-poor countries, with the claim that they will tackle diseases of poverty such as malaria. For example, Beisel and Boëte note that the transfer of genetically modified (GM) mosquitoes from lab to field, potentially including GDOs in future, "also involves a transfer from North to South, from laboratories in high-tech knowledge economies to (often) resource-poor developing countries" (Beisel and Boëte 2013, 47).

In wealthy OECD countries, the idea of the knowledge-based economy[1] has become a key driver of research investment. The 'knowledge' embedded in a product is seen as adding value to it. Compared to physical goods, knowledge is less tangible and hence more difficult to value, trade and control. Thus, industries depending on knowledge want to pin it down and build walls around their own knowledge, in order to control and protect it from competitors. Intellectual property rights became these walls. They give value to this knowledge and allow it to be traded rather than freely used (Gold et al. 2008, 17).

With the general decline in public structural funding during the last decades, universities have experienced increasing pressure to diversify their

1 The term 'knowledge-based economy' (KBE) was first coined by the Organisation of Economic Co-operation and Development (OECD) in a 1996 report which argued that the OECD economies were increasingly based on knowledge, information and technological innovations, underpinned by scientific research and development and patents (OECD, 1996).

financial sources and to rely more on competitive funds (Geuna and Nesta 2006, 791). In theory, patents act as a reward for invention that is supposed to stimulate investment, creativity and economic growth. While originally inventions made with public funding in the USA belonged to the federal government, the adoption of the Bayh-Dole Act in 1980 made it possible for universities to own and commercialise publicly-funded, in-house inventions, and to license their intellectual property to private firms (see Section 6.1, Box 2) (Tofano, Wiechers, and Cook-Deegan 2006, 54). With this change in policy, which has since been copied elsewhere in the world, huge amounts of private capital have been invested in certain types of R&D. As a result, researchers started to think about commercial uses of their work and pressure to file patents rose, with some researchers even being bound by contract to tell their funders about any invention that could be patented and commercialised (Tofano, Wiechers, and Cook-Deegan 2006, 57).

In this context, it is not surprising that 'hype', or exaggerated promises about valuable future commercial applications and social benefits, started to appear in scientific research studies, in an effort to help secure research funding. Additional issues arising from this development relate to conflicts of interest and transparency; for example, ties to industry and the incentive to patent may be problematic for the independence and autonomy of researchers (Geuna and Nesta 2006, 796). Patent applications are often not declared in scientific papers (Mayer 2006). Scientists who are named as inventors on patents will in some cases have a direct financial interest in promoting the claims of 'industrial applicability' made in the patent. In other cases, the patent may not confer a direct financial reward, but defending the claims made in it may still be important for the scientist's career and future funding.

Biotechnology is an important part of this fundamental change to science. For example, Joly notes that the privatisation of agricultural research and development is related to economic policies and to reductionism in science, i.e. to "the promises associated with the biotechnology revolution, and specifically the 'molecularisation' of life sciences, which prompted major changes in research and development (from the experimental field to the research laboratory, increasingly disciplinary and reductionist research and development, concentration of research in a small number of institutions), and the patentability of life forms…" (Joly 2005, 619).

Commercial biotechnology emerged at the same time as the above-mentioned change to US and international patent policy (Tofano, Wiechers, and Cook-Deegan 2006, 54). Biotechnology became a business when the knowledge emerging from scientific research became classified as intellectual property (IP) that was valued and could be bought and sold (Pisano 2006). Many countries followed suit and brought their IP laws in line with those of the US, in order to benefit from the biotechnology boom (Gold et al. 2008). A watershed moment was when venture capitalists learned that IP could be bought and sold independently of the final product (Pisano 2006, 142). This has allowed hype around new technologies to influence both public and private R&D investments, and allowed money to be made from simple promises, even when useful final products are often not delivered and when there is no net benefit to society or the economy.

More recently, philanthropic donations have begun to play an increasing role in the research and development of new technologies, for example in the case of GM mosquitoes, including those with gene drive. Thus, Beisel and Boëte argue that "GM mosquitoes render the mosquitoes themselves as a commercial product; a commercial product in a political economy funded by philanthropic initiatives, shaped by private university spin-offs and characterized through economic inequalities" (Beisel and Boëte 2013, 54).

3 Funding for Gene Drive research and development

The biggest investments into gene drive research and development (R&D) come from the US military, large philanthropic donors and government-funded research agencies. In the following sections, we will look at who the main gene drive funders are, what they are funding and how this may be relevant for public engagement exercises.

3.1 Military and intelligence agencies

The U.S. Defence Advanced Research Projects Agency (DARPA) announced in 2017 that it will invest $65 million over four years in the 'Safe Genes' programme that funds seven major research projects focusing on gene drive and genome editing R&D. (DARPA 2017). The *Gene Drive Files*, a trove of documents and emails obtained by civil society investigators through a Freedom of Information request, reveal that the total amount DARPA invests into the 'Safe Genes' programme is $100 million, likely making them the largest single funder of gene drive R&D (Gene Drive Files 2017a, 1). One of the 'Safe Genes' projects, led by Keith Joung at the Massachusetts General Hospital, receives $11 million from DARPA, and part of the project funding goes to Target Malaria investigators, at Imperial College in London. The team at Imperial College for the first time achieved complete population suppression of caged mosquitoes using gene drives (Kyrou et al. 2018). That research was funded not just by DARPA, but by the Bill & Melinda Gates Foundation and the UK Biotechnology and Biological Sciences Research Council (BBSRC) as well (Kyrou et al. 2018, 1066).

Other military and intelligence organisations involved in gene drive R&D are the Intelligence Advanced Research Projects Activity (IARPA) and the US Army Corps of Engineers (ACE) (Gene Drive Files 2017b).

3.2 Philanthropic foundations

The Bill and Melinda Gates Foundation (BMGF), the largest philanthropic foundation in the world (Belluz 2015), has long had a leading role in funding GM mosquito research (Enserink 2010). Beisel and Boëte (2013, 47) note that: "Before the establishment of the Gates Foundation, research on genetic manipulation of insects was a small niche field…" They also highlight how one of the foundation's strategic aims now focuses explicitly on developing insect technologies, thus accelerating the development and testing of GM mosquitoes. BMGF provides the core funding, $75 million so far, for the Target Malaria project (Regalado 2016a). Target Malaria is a research consortium that aims to control the spread of malaria by releasing genetically modified gene drive mosquitoes. Target Malaria has progressed R&D on gene drive mosquitoes further than other groups and is currently operating in Burkina Faso, Mali and Uganda (Target Malaria n.d.a).

The Open Philanthropy Project (OPP), whose major funders are the couple Cari Tuna and Dustin Moskovitz (co-founder of Facebook and Asana), is another major philanthropic donor that has awarded an additional $17.5 million to Target Malaria (Dunning 2017). OPP has also awarded $1.2 million to the Foundation of the National Institutes of Health (FNIH) to form a working group of approximately twenty experts tasked with developing a consensus pathway for field-testing gene drive mosquitoes (Open Philanthropy Project 2016).

The FNIH itself is another key actor supporting the development of gene drives. In collaboration, again with the Bill and Melinda Gates Foundation, along with numerous research institutions around the world, the FNIH managed the *Vector-based Control of Transmission: Discovery Research (VCTR) programme* (Foundation for the National Institutes of Health n.d.). The VCTR programme supported Target Malaria's R&D on gene drive mosquitos (see for example Eckhoff et al. 2017, E264 and Hammond et al. 2016, 82).

In addition to the funding from such philanthropic organisations, Target Malaria has also received direct governmental funding from the European Commission, the UK Department of Environment, Food and Rural Affairs (DEFRA) and the Ugandan Ministry of Health (Target Malaria n.d.b).

Tata Trusts are among the top philanthropic organisations in India and have awarded $70 million to create the Tata Institute for Active Genetics and Society (TIAGS), in collaboration with the University of California, San Diego (UCSD). UCSD announced they would match the trust's award with a further $70 million. The institute aims to develop mosquitoes that are unable to propagate malarial parasites using gene drives (Philanthropy News Digest 2016).

Other philanthropic organisations that fund gene drive R&D include, among others, the Wellcome Trust (UK), the Burroughs Wellcome Fund (US), the Rainwater Foundation (US), the Greenwall Foundation (US), the Alfred P Sloan Foundation (US), the WM Keck Foundation (US), the Kinship Foundation (US), the Pew Charitable Trusts (US), the David and Lucile Packard Foundation (US) and the Paul G. Allen Frontiers Group (US) (Esvelt 2018a, 8; Gantz et al. 2015, E6742; Grunwald et al. 2019, 109; Sculpting Evolution n.d.a; Target Malaria n.d.b).

3.3 Governmental science and research agencies

The Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a partner in the DARPA-funded 'Safe Genes' project that aims to develop and test a mammalian gene drive system in rodents (Godwin 2017). According to the *Sydney Morning Herald*, CSIRO has allocated $3.5 million for "community research related to synthetic biology" to secure "social licence" for its gene drive ambitions (Wilson 2018). The goal of this social engagement seems be securing social acceptance, rather than fostering true democratic decision-making (see Section 10). According to an email obtained by a Freedom of Information request, CSIRO has also been promoting the rodent gene drive technology to various government agencies and other stakeholders (Wilson 2018).

Furthermore, the UK Biotechnology and Biological Sciences Research Council (BBSRC) is funding mouse and rat gene drive research at the Roslin Institute at the University of Edinburgh as well as mosquito gene drive research at Imperial College (BBSRC 2017; Kyrou et al. 2018, 1066).

The US National Institutes of Health (NIH) awarded $1.5 million to Kevin Esvelt for the development of 'daisy' gene drives (National Institutes of Health 2017; Sculpting Evolution n.d.a). With support from DARPA and the Bill & Melinda Gates Foundation, NIH and FNIH sponsored the National Academies of Sciences, Engineering, and Medicine (NASEM) gene drive report "Gene Drives on the Horizon: Advancing Science, Navigating Uncertainty, and Aligning Research with Public Values" (2016), that intended to "…create a consensus committee to summarize current understanding of the scientific discoveries related to gene drives and their accompanying ethical, legal, and social implications" (National Academies of Sciences, Engineering, and Medicine [NASEM] 2016, viii & 1). NIH further support Target Malaria (Target Malaria n.d.b) and various gene drive studies (see for example DiCarlo et al. 2015, 12; Gantz et al. 2015, E6742; Gantz and Bier 2015, 444; Grunwald et al. 2019, 109).

Other governmental science and research agencies involved in gene drive funding include the Uganda National Council for Science and Technology (UNCST) (Target Malaria n.d.b) and the National Science Foundation (NSC) (see for example DiCarlo et al. 2015, 12; Dhole et al. 2017, 806; Min et al. 2018, S60).

3.4 Guiding principles for the sponsors and supporters of Gene Drive research

As a response to the US National Academies of Science, Engineering and Medicine Report that provided recommendations directed at researchers, funders and policy-makers (NASEM 2016, 106, 128, 142, 170-172, 177-178), Emerson et al. (2017, 1136) published five guiding principles for sponsors and supporters of gene drive research:

1.) advance quality science to promote the public good;

2.) promote stewardship, safety and good governance;

3.) demonstrate transparency and accountability;

4.) engage thoughtfully with affected communities, stakeholders and publics;

5.) foster opportunities to strengthen capacity and education.

These guiding principles have been endorsed by prominent gene drive funders, including the Bill & Melinda Gates Foundation, Tata Trusts and the US FNIH. Such a pledge to ensure safe and responsible gene drive research is laudable; but can we conclude that further development of the technology will always follow these guidelines and be in the best public interest? Boëte (2018) argues that the list of Guiding Principles is a "voluntary undertaken code of ethical and scientific conduct" (Boëte 2018, 18), which is not legally binding. This means that the signatories cannot be held accountable for actions that do not honour the code.

While governmental funding is, at least formally, accountable to the public, philanthropy is still largely free from public accountability mechanisms and democratic control. The Bill and Melinda Gates Foundation, for example, is only accountable to its three main trustees, that is, Bill and Melinda Gates, alongside Warren Buffet. Although philanthropic and charitable organisations, by definition, aim to serve the public interest, foundation trustees are the ones to decide a.) what the public interest is (e.g. global health), b.) what a problem is (e.g. malaria), and c.) how they want to fix it (e.g. with gene drives) (Barkan 2013).

Today, more and more funders have preconceived notions about social problems and their solutions. In an approach called "strategic philanthropy", they develop specific policy or outcome agendas to be fulfilled by their grantees; thereafter, the grantees seem to take on the role of contractors (Rourke 2014, 2). Academic experts have questioned the Bill and Melinda Gates Foundation's global health research priorities. Some in particular critique the emphasis on technology and technological fixes (Belluz 2015). The growing influence wealthy philanthropic organisations, such as the Bill and Melinda Gates Foundation, have on funding for global health (Belluz 2015) and the lack of real public accountability, raises the question of whether, and how, the public can be truly involved in the discourse on gene drive R&D.

As the *Gene Drive Files* have revealed, the principle on transparency, which is key to the guiding principles, has already been violated by important signatories. They have been officially named as having engaged in coordinated "closed door" efforts to influence UN agencies' support of gene drives, and also in avoiding media engagement (Boëte 2018; Gene Drive Files 2017c). This gives the impression that instead of genuine stakeholder engagement, which could theoretically result in the rejection of the gene drive approach, the aim of these signatories is simply to gain acceptance for their agenda.

Another issue is that DARPA, as probably the largest funder of gene drive R&D, is missing from the list of signatories. There seems little interest on the part of DARPA to engage thoughtfully with stakeholders and the public in discourse on gene drive R&D. At the first public meeting of the Committee on Gene Drive Research in Non-Human Organisms, Col. Daniel Wattendorf stated: "...we may not have the time in this case to actually wait for, and make calls for, certain scientific actions and communities to deliberate. We actually may need to be working on technology solutions right now. And the alacrity of our [DARPA] institution to be able to do that is at hand" (Wattendorf 2015).

Lastly, while the five guiding principles could become very important for responsible R&D, they currently do not allow for discussion about how a problem should be tackled and what research is being done in the first place. As we discuss under consideration of the Precautionary Principle (PP) later (Section 8), and as the European Environment Agency has noted, thorough practice of the PP would always include inter alia assessment of what may be the multiple alternative trajectories which could meet the same social goals and needs as the prevailing trajectory. Thus, even a thorough enactment of the five guiding principles would fail to meet the internationally established Precautionary Principle requirements.

4 Conflicts of interest in science

Conflicts of interest may play a major role in what is communicated about a technology, what research is conducted, and how the results of scientific studies are communicated and used in practical investment and regulatory decisions.

It is well established that commercial conflicts of interest in science can jeopardise the independence of research. The discussions in this area have focused on the field of medicine, where compromises have repeatedly occurred in research participants' well-being, research initiatives, publication of results, interpretation of research data, and scientific advancement, all because of industry funding for research (Tereskerz et al. 2009). Industry funding can also skew the research agenda, with major implications for what kind of research gets funded and how this is communicated and used (Wallace 2009). Adverse effects, among many others, may include biasing the research and associated policy agendas towards false or ineffective solutions to a problem, potentially leading to major negative impacts on public health (Wallace 2009; Kearns 2016).

Conflicts of interest are not limited to scientists working in the commercial sector. Krimsky (2003) describes how university science is now entangled with entrepreneurship, and investigates the effects of modern, commercialised academic science. Vallas and Kleinman describe how "the structural reconfiguration of academic science generates an increasing tension between the 'ideal' culture of academic science and the 'real' culture of market-oriented logics governing the pursuit of capital in one or another form" (Vallas and Kleinman 2008, 306). Patents held by academic scientists are also a recognised source of conflicts of interest (Mayer 2006). In relation to GDOs, Brossard et al. note that "relevant conflicts of interest can go beyond the financial ones and can include how the topic at hand relates to our worldviews, the success of our next grant proposal, or the positive views of our administrators and colleagues" (Brossard et al. 2019, 5).

In addition, bias is not limited to commercial interests. Scientific bias has been well studied in the medical research literature, where several types of interpretative bias (bias in the analysis of data, rather than in the measurements themselves) have been identified (Kaptchuk 2003). These also include "confirmation bias" – evaluating evidence that supports the scientist's preconceptions differently from any evidence that challenges these convictions (Kaptchuk 2003, 1454).

A major problem is scientists 'over-promising' in order to secure research funding, which is now almost routine (Gannon 2007). Hype and 'over-promising' are discussed further below. Other impacts of conflicts of interest in GM insect research are discussed further in Section 7.

5 The role of hype in the Gene Drive discussion

5.1 The role of hype in securing research funding (for Gene Drive research)

Hyperbole or "hype", in terms of scientific research, means "extravagant or exaggerated promotion" of whatever one protagonist is attempting to sell to another. Promises about future benefits play an important role in securing (competitive) investments in R&D. In some cases, the grant being sought is corporate or venture capital investment, underpinned by intellectual property (IP). In other cases, funding for research, whether academic or private, may be coming from governments, philanthropic organisations or a combination of the above.

Writing more than a decade ago, Gannon (2007) argues that "hype" in science is spreading for several reasons, including: the increasing pressure on institutions and researchers to secure funding from diverse sources; the requirement that scientists explain the relevance of their work to the general public; and the fact that many grant applications require the applicant to explain the impact of their work on society. Scientists are in a fierce competition to maintain and increase public as well as private support and funding, and therefore, "…scientists over-promise by sending messages of being close to their goals, even if this is not true" (Gannon 2007, 1087). Gannon notes that the promise that a cure is just around the corner, if only a few million more in funding is forthcoming, more often than not is an exaggeration. However, when it comes to scientific publications and grant applications, reviewers do not usually comment on the credibility of the claims made for future benefits that might arise from the research. Furthermore, they do not ask for the same level of proof for these speculations as they do, for example, for speculations on a step in scientific methods. This has led to overstretched expectations of what science and technology can achieve, both among the public and among funders.

Future releases of GDOs have been claimed to bring tremendous benefits to society, for example the end of malaria or Lyme disease. Even though R&D is still in its infancy and far from any field trials, gene drive researchers have informed potential philanthropic funders that "gene drive research has the potential to make enormous positive impacts on global human health" (Darrow et al. 2016, 3). Whilst this recommendation comes with extensive caveats about the need to also fund "gene drive safety and control", little doubt is expressed about the ability of open releases of GDOs soon being able to play a major future role in tackling serious infectious diseases. In some academic journals, in contrast, numerous doubts are expressed about the potential of GDOs to deliver on any of these promises.

One issue is the likely evolution of resistance to the introduced trait. For example, Brossard et al. note that most of the public discussions of gene drives relate to one type of gene drive, where the release of a small number of individuals could, in theory, cause the spread of the gene drive through entire populations of the engineered species worldwide. They state that "It is important to recognize that this is only one type of gene drive and that it will be very difficult to develop such a gene drive to function indefinitely without pests evolving resistance to it" (Brossard 2019, 2). They also note that an alternative approach involves the use of a GDO which produces many unviable offspring; but this would theoretically require enough individuals to be released so that the engineered individuals are initially more than 25% of the total population. In practice, there might be significant practical difficulties in achieving this, in addition to the complexities of how ecosystems might respond.

In relation to GM mosquitoes, including those incorporating gene drive mechanisms, Beisel and Boëte ask "How might a control strategy that is embodied in the mosquito genome play out in the face of ecological complexity, adaptability and resistance? Which risks might the strategy entail and how are risks and benefits distributed?" (Beisel and Boëte 2013, 40). They also raise the question of "how to think about biological adaptability of GM mosquitoes in relation to the coexistence of mosquitoes, parasites and humans over time?" (Beisel and Boëte 2013, 42). The same authors also note that the basic relationship between the density of mosquitoes, human infection and disease is poorly understood. More than 450 species of *Anopheles* mosquitoes are known worldwide; around 70 are malaria vectors (of which 41 are thought to be dominant vector species or species complexes), and the rapid reproduction and evolution of mosquito populations makes them dynamic and adaptable (Beisel and Boëte 2013, 46; Sinka et al. 2012, 1). Moreover, new species continue to be identified with the aid of molecular techniques (Coetzee et al. 2013). Hybridisation occurs between major vector species, with hybrids typically occurring at rates of about 1% in most areas, but up to 24% in others, for reasons that are not fully understood (Lee et al. 2013; Mancini et al. 2015). This poses a risk of gene flow between species, if gene drive *Anopheles* mosquitoes were to be released. However, the fact that hybridisation is limited also implies that releasing one species of gene drive mosquito is unlikely to suppress the population of another species, which may therefore expand its range and continue to transmit malaria. This multi-species challenge is rarely discussed in public.

5.2 The role of hype in framing the public discourse

Public support is a very important factor contributing to the success of a technology and its capacity to become economically viable (Esvelt 2018a, 5). Since the 1990s, when there were major concerns amongst policy, commercial and scientific elites about indiscriminate public mistrust in science, cultivation of public acceptance of science-based innovation of almost any kind has become a policy and industrial mantra. For example, the perceived worth and benefit of potential applications have always played an important role in public acceptance of biotechnology. "The relatively low levels of public support for a variety of gene transfers change dramatically when a gene transfer is tied to achieving a specific goal that is deemed worthy" (Amin et al. 2007, 42).

Media, including scientific media, often overemphasise the potential future benefits of any given technology while downplaying the risks. While the media's desire to tell an interesting story may be partially responsible for reporting exaggerated promises, journalists are not always the source of such exaggerated claims. Bubela and Caulfield (2004, 1399) found that the majority of 627 analysed newspaper articles accurately reflected the claims made in scientific and medical journals. Although media sources can be at fault as well, pressure by industry and funding entities may lead researchers to make claims about future benefits of gene drives in order to secure research funding. Picked up by media journalists, these claims may then also frame public understanding of the technology and what it might do long before it is ready to be applied. In the end, it is important to note that researchers, media and industry all play a role in framing the public discourse of gene drives.

In the following sections, we will have a closer look at some examples of exaggerated and overly optimistic promises made about this technology in newspaper articles, as well as in scientific journal articles and patent applications; and we will discuss how erroneous descriptions and perceptions contribute to framing the public discourse.

5.2.1 Headlines

Headlines are a source of information for the many people who do not have the time to read full articles. Of course, headlines tend to exaggerate and use catch-phrases in order to gain the reader's attention. Gene drive-related headlines often include exaggerated and sometimes quite unsubstantiated promises, for example making claims about being able to offer public health or conservation benefits:

- The CRISPR machines that can wipe out entire species (Ryan 2019).

- Argument builds around a genetic tool that can erase an annoying species (Meador 2016).

- Genetically modifying Zika virus out of existence (Flam 2016).

- Powerful 'Gene Drive' Can Quickly Change an Entire Species (Stein 2015).

Since to date no open releases of gene drive organisms have taken place (nor are such releases planned), it is too early to say what GDOs "can" do, or that they will be able to predictably wipe out a species. The gene drive research currently being done is lab and modelling work. As Oxitec's failed open release experiments with GM mosquitoes in the Cayman Islands have shown (GeneWatch UK 2018), results from the lab or models can be insufficient predictors what will happen in the field. However, much confidence was invested by the scientists in those partial methods. Using a headline that strongly implies what the technology can do once ready to be applied may be less of an informative description and more of a mechanism for influencing public understanding of the technology.

5.2.2 Terminology

In a subtler way, the language and terms used to describe gene drives can themselves convey promises which influence how the technology is perceived. Different terms are being used to portray what gene drives are supposed to be able to do: *modification drive, suppression drive, sensitising drive, global drive, local drive or daisy chain gene drive, reverse drive or daisy restoration drives*, etc. Some of these terms, especially "local drive" or "reverse drive", intentionally convey a promise of safety, containment, control, reversibility and redress, even though none of these concepts has ever been proven. Kevin Esvelt has often publicly stated that he opposes closed-door science and that gene drive research must be open and transparent (see for example Esvelt 2016; 2018b). Therefore, he wants to inform the public about the experiments his research group is planning to do before they are actually conducted. As a result, before actually successfully developing them, Esvelt's 'Sculpting Evolution' research group has presented its concept of so-called 'daisy chain gene drives' and what different versions could do. By doing so, they helped to establish many of the above-named terms, although all are hypothetical. Not only do we not know whether these theoretical concepts will behave as intended and promised in the field, they have not even been demonstrated in a lab.

Nevertheless, many speculations have already been made, for example: that the daisy drive system will "return power to the hands of local communities" (Sculpting Evolution n.d.b), who, once (and if) it is operational, will be able to decide whether or not to use gene drives to solve local ecological problems; or that they could be used to restore a population to its original genetic state (Sculpting Evolution n.d.c). While these researchers find it problematic to release GDOs that are designed to "spread indefinitely" (Sculpting Evolution n.d.b.), they see no problem in releasing daisy drives, which are intended to have a limit to their spread. In their patent application on daisy chain gene drives (see Section 6.2) they promise: "Daisy chain gene drives designed using methods provided herein can be used to address otherwise intractable ecological problems, with a level of safety inherent in their design, that reduces or eliminates a likelihood of global effects as occurs for conventional gene drive organisms that are released into the wild", and: "Unlike previous global gene drive system, methods of the invention provide designs for daisy chain gene drives that can be safely tested in field trials" (Esvelt, Min, and Noble 2017, 55-56).

A side-effect of this supposed open and transparent approach to research is that a.) promises about future benefits of a hypothetical, untested concept are made very early in development; b.) the language and terms conveying these promises, as if they were already-proven reality, are already established in society well before a technology actually exists.

5.2.3 Application promises

As discussed above, a specific goal or application perceived perhaps as dangerous but also as *worthy*, for example in saving human lives, can increase public support for that technology. Therefore, it is important to show the public how they personally, or the world as a whole, can directly benefit from this technology: "Although many questions about this technology remain unanswered, we are optimistic about the potential of gene drives in strengthening the public health arsenal and reducing worldwide human suffering" (Darrow et al. 2016, 2).

Although any form of gene drive technology is far from being tested in the field and further yet from its promises of beneficial applications becoming reality, a lot of emphasis has already been placed on future beneficial applications being delivered once the technology is made available. For example, the following quotes paint an overoptimistic picture of the potential health, environmental and agricultural applications of gene drives: "The ability to edit populations of sexual species would offer substantial benefits to humanity and the environment. For example, RNA-guided gene drives could potentially prevent the spread of disease, support agriculture by reversing pesticide and herbicide resistance in insects and weeds, and control damaging invasive species" (Esvelt et al. 2014, 1); "…it could be used to conserve threatened or endangered species, combat invasive species, or control agricultural pests. It is particularly tantalizing as a potential weapon against vector-borne infectious disease" (Abbasi 2016, 483); "Effective gene drives may enable us to control invasive species, re-sensitize organisms that have developed resistance to insecticides and herbicides, and reduce or eliminate many types of vector-borne diseases, all at a low cost" (Champer, Buchman, and Akbari 2016, 147).

As the examples above show, three areas of applications of gene drives are most prominent: public health, conservation and agricultural applications, with hoped-for eradication of vector-borne diseases currently being the most commonly hyped potential application of gene drives. In addition to these direct benefits promises about the results of gene drive R&D, it is sometimes argued that the gene drive approach might actually be the more sustainable alternative for other already applied technical solutions, for example by decreasing the numbers of GM mosquito releases: "To date, trials [with GM mosquitoes] have used a self-limiting approach, requiring repeated mass release of GM males. But a self-sustaining control would be possible using a gene drive system, eliminating the need for ongoing releases…" (Piaggio et al. 2017, 102); or by decreasing the use of toxic pesticides: "For example, a gene drive to suppress non-native rodent populations on remote islands could reduce the need for alternative forms of control such as the use of rodenticides. The cost of administering rodenticides is estimated to be in the millions of dollars and rodenticides may also harm non-target species" (NASEM 2016, 5). Not mentioned is the question of whether gene drives will work in mammals at all, and what practical and social implications the release of gene drive rodents on these islands might have: for example, how many GDOs would have to be released to efficiently control the island population, how long would that take and what damage could the GDOs cause in the meantime?

Furthermore, it has even been argued that Gene Drives "could make the world a more just place", thereby adding a moral, ethical component. According to the MIT technology review, Esvelt considers evolution a blind, amoral process, whose only goal is to survive, comparing it to a "larger failing of the universe". This should be rectified with gene drives and the ability of experts like himself to "fine-tune the battle for survival" (Regalado, 2016b). This shows the immense confidence of some gene drive researchers that they are not only able to alter organisms and eventually populations, but the evolutionary process itself. Fittingly, Esvelt called his research group at the MIT media lab in Massachusetts "*Sculpting Evolution*".

Below we will take a closer look at the specific promises made in these three sectors.

Public health promises

Where biotechnology is concerned, human medical and health applications are generally better accepted by the public than are agricultural applications (Amin et al. 2007, 40). In the gene drive discourse, a great deal of emphasis is being put on potential public health benefits. The most common promise is that gene drives, once applied, will have the potential to eradicate vector-borne diseases such as malaria, dengue fever or Zika, either by suppression of the vector population or by rendering the vector population resistant to the parasite, virus or bacteria. This is illustrated with the following quotes: "With gene drives, it may be possible to kill off a mosquito population or make the population resistant to malaria parasites" (Wade 2015a); "Gene Drive mosquitoes have tremendous potential to help eliminate malaria, and multiple gene drive approaches have recently shown promise in laboratory settings" (Eckhoff et al. 2016, E255); "These findings could expedite the development of gene drives to suppress mosquito populations to levels that do not support malaria transmission" (Hammond et al. 2016, 78); "In the U.S., scientists are racing to develop similar genetic suicide vests for mosquitoes that spread Zika and dengue fever" (Regalado 2016b).

When gene drives are proposed as potential solutions for public health concerns, the proponents build their narrative by citing the large numbers of people suffering and dying each year from specific illnesses: "Malaria alone kills over 650,000[2] people each year, most of them children, while afflicting 200 million more with debilitating fevers that economically devastate their societies. Dengue, yellow fever, trypanosomiasis, leishmaniasis, Chagas disease, and Lyme disease are caused by other pathogens that spread using vectors. All of these can potentially be reduced or even eliminated by driving changes in the vector that prevent transmission" (Esvelt and Smidler 2015, 28-29); "A large region, at least in principle, could be freed from malaria, which kills almost 600,000 people a year" (Wade 2015b).

Sometimes the promises are highly specific and ambitious: "Such genes, if successfully propelled throughout a wild mosquito population, would render a region free of the malarial parasite, which could no longer spread via mosquito bites" (Wade 2015a); "the inserted genes are expected to *spread rapidly and take over a wild population in as few as 10 generations, or a single season*" (Wade 2015b, emphasis added). Another, equally optimistic one states: "Although all vector species must be targeted in a given area in order to stop transmission, the disease will be permanently eradicated if the newly vacated ecological niches are filled by competing non-vector species. Significantly, this strategy requires little or no understanding of the vector's molecular biology, but *unavoidably entails the local or possibly global extinction of the vector species*" (Esvelt and Smidler 2015, 29, emphasis added).

Such statements convey the impression that once this technology is applied, it will work predictably, as intended, and also that it will work rapidly, thereby being a sensible or the only solution to combat vector-borne diseases. Missing are all the varied caveats about what might go wrong if the technology doesn't work as intended; for example, when the mosquitoes develop resistance to the gene drive. Anyone conversant with biology knows that there is no guarantee that the vacated ecological niche will be filled with a non-vector species, as Esvelt and Smidler (2015) suggest, and not by another mosquito species (Wilke et al. 2018, 5-7). Furthermore, potential ecological problems arising if an ecological niche is filled with a species that previously played a minor role in that particular ecosystem are not brought up. In the case of genetically modified Bt crops, we have seen that reducing the numbers of a specific pest in an area often leads to the establishment of secondary pests that may be just as destructive (Lu et al. 2010; Wang et al. 2008; Wu et al. 2002; Zhao 2011). In the case of mosquitoes which transmit dengue, the former Chief Scientific Officer of GM insect company Oxitec, Luke Alphey, has stated: "Since *Ae. aegypti* and *Aedes albopictus* are known to compete…it is possible that the successful implementation of…gene drives could lead

2 The World Health Organisation's World Malaria Report 2018 speaks of 435,000 deaths in 2017.

an existing *Ae. aegypti* population to be displaced by *Ae. albopictus* where it would not otherwise have been. This would likely hamper efforts to eliminate viruses such as dengue since *Ae. albopictus* are also competent vectors…" (Edgington & Alphey 2018, 21-22).

Conservation promises

It is often promised that synthetic biology and especially gene drives could make a significant contribution to conservation efforts. In 2017, Piaggio et al. published a paper called "Is it Time for Synthetic Biodiversity Conservation?" in which they claim that synthetic biology might be the long-desired solution for many conservation problems. They state: "The field of synthetic biology, which is capable of altering natural genomes with extremely precise editing, might offer the potential to resolve some intractable conservation problems…", adding: "It has become apparent that synthetic biology holds tremendous potential across numerous fields, including conservation biology" (Piaggio et al. 2017, 97).

One promise often mentioned is that gene drives could help control invasive alien species, such as rodents on islands, resulting in protection for the endangered species threatened by them. Although this is highly theoretical and far from any experimental validation, gene drives are already being treated by some science reporters and gene drive researchers as known working tools in the conservation toolbox: "What's more, the technology also offers a new way to delete invasive species from islands like Hawaii, something that could rescue native birds at the edge of extinction" (Regalado 2016b). As seen above with promises about public health, proposals to use gene drives as solutions often portray the severity of the situation and then propose gene drives as potential technical fixes, without appropriate time or research going into whether they will work as intended, what could go wrong on the ground, how we would deal with that and especially, what the alternatives are: "One of the most environmentally damaging consequences of global economic activity is the transport of invasive species, which often causes ecological disruption and the extinction of native species. Isolated ecosystems such as those on small islands are especially vulnerable. Cas9 Y-drives have tremendous potential to promote biodiversity by controlling or even eradicating these species from individual islands or possibly entire continents" (Esvelt and Smidler 2015, 29).

Another promise is that gene drives could immunise endangered species, such as amphibians, against pathogens: "Although not yet developed, other payload genes of great practical importance may immunize threatened or agriculturally important organisms against pathogens, such as…genes that render amphibians immune to the killer Chytrid fungus, which is responsible for the decline of amphibian species all over the world" (Champer, Buchman, and Akbari 2016, 147) or "Such RNA guided Cas9 gene drives may be used to quickly spread protective alleles through threatened or soon-to-be-threatened species such as amphibians" (Esvelt and Smidler 2015, 28).

The extremely speculative nature of such statements is rarely highlighted, and readers (the public and the funding bodies) are likely to infer the scientists' excitement and confidence reflects imminent breakthroughs, rather than what is more likely, a desire for public approval and further funding. Statements about the practical implementation of these approaches are mostly lacking. Grunwald et al. (2019), for example, indicate that there might be additional technical hurdles to develop efficient gene drives in mammals, compared to insects, stating "… it appears that both the optimism and concerns [that gene drives could be used to reduce invasive rodent populations] are likely to be premature" (Grunwald et al. 2019, 108). Moreover, alternative methods to control invasive species that are, or with better understanding, could be available to society, may be equally cost-effective and much more within the realm of predictability and control than these as yet non-existent technical fixes. But this basic dimension of responsible democratic social appraisal and choice seems largely ignored. Gene drives are portrayed as an added or even only possible solution to different conservational issues in the above mentioned statements, although many of the species mentioned have never even been tested in the lab.

Agricultural promises

Gene drive patent applications also include many potential agricultural applications. In his 2003 patent application, Burt already stipulated that gene drives could be used to control pest populations or to render pest and weeds that have developed resistances to certain pesticides susceptible again, stating: "The method may also be used to interrupt other, non-lethal genes, e.g. a gene that confers a pesticide resistance onto a crop, thus making the pest susceptible to the pesticide again" (Burt 2003, 31). Nevertheless, agricultural applications, such as gene-drive mediated pest control, are less widely discussed in the media than potential health or conservation related applications (Courtier-Orgogozo et al. 2017, 878). As stated above, human medical and health applications are generally better accepted by the public than agricultural biotech applications. Potential agricultural applications being mentioned – mostly gene drive-mediated pest control, or the reversal of pesticide resistance, using so-called "sensitising drives"- are portrayed as sensible or sustainable solutions to current agricultural problems: "Additionally, the versatility of RNA-guided endonucleases may allow for other suppression approaches, such as the reversal of resistance to pesticides or herbicides by specifically targeting resistance alleles and replacing them with sensitive ones — a process that could be repeated if resistance is reacquired" (Champer, Buchman, and Akbari 2016, 147), or: "Compared to other pest management techniques, it [gene drive-mediated pest control] is cheaper, more precise, and, so far, less controversial as, say, the use of pesticides", adding that gene drive-mediated pest control may "easily eradicate a species" (Courtier-Orgogozo et al. 2017, 878). However, these are still approaches within the prevalent industrial agricultural system, likely to be attractive to major agrochemical companies (further discussed in Section 6.2). Moreover, gene drives so far have not been tested and might not work in plants. For example, the cell repair mechanism predominant in plants[3] might prevent the gene drive element to be copied to the damaged chromosome (see Chapter 1 for more details). As for other GDOs, ecosystem responses may also be complex and unpredictable.

5.3 Implications of hype for alternatives

Hype about new technologies can undermine existing or more practicable alternatives, by diverting resources from promising approaches. For example, Beisel and Boëte note that "beyond the question of whether or not GM mosquitoes can work, we should be asking what other kinds of techniques they replace or marginalize by directing resources away. As a tool of transfer and an instrument of eradication, they entangle malaria in institutional and economic calculations—between companies, philanthrocapitalist endeavours, macroeconomic models and global health agendas. At the same time, GM mosquitoes disentangle malaria from more local forms of control—the low-tech labour-intensive forms of management that belong to place" (Beisel and Boëte 2013, 47).

However, the body organising public engagement in new technologies is often the same one that has developed and/or invested in the technological fix being promoted. As such, it does not have proper incentives to explore alternatives as part of any public engagement exercise. Although alternatives are often mentioned, this is usually in a way which highlights their limitations and diminishes or dismisses the role that they can play. In the agricultural GM crops domain, Vanloqueren and Baret (2009) have explained in detail how this anti-scientific lock-in to a particular technology occurs, and how it correspondingly locks out what may well be more sustainable, more ethical, and more acceptable, alternative technical, scientific and social trajectories.

For example, for dengue control, the GM mosquito company Oxitec restricts discussion of alternatives to GM mosquitoes to the use of larvicides and adult spraying, with most focus on adult spraying (which is widely recognised to be ineffective), although they do mention wearing a long-sleeved shirt and using mosquito repellent (Parry 2012).

3 Called Non-Homologuous End Joining (NHEJ)

They do not discuss existing methods of control, such as destruction of breeding sites by government-employed inspectors or local communities; or social and environmental measures, such as improving water and sewage systems and shredding waste tyres (which provide potential breeding sites). Absence of a tap water supply is correlated with an increased incidence of dengue, because water storage containers used by households without tap water supply provide mosquito breeding sites (Schmidt 2011, 6), and the presence of a good primary health care system can significantly reduce the incidence of dengue (Roriz-Cruz et al. 2010). World Health Organization research has also focused on utilising new non-insecticidal intervention tools (such as rectangular water container covers in India, sweeping nets or dragon fly nymphs in Myanmar, and copepods and screen covers for earthen jars in Thailand), and on engaging local communities in these methods (TDR 2013).

Reis de Castro and Hendrickx (2013, 121) use the concept of 'ordinary treasure' to describe how releases of Oxitec's GM mosquitoes in Brazil were characterised as both ordinary (and hence unproblematic) on the one hand, and as valuable treasures (embedding hopes and expectations of tackling disease). Reis de Castro and Hendrickx (2013, 123-124) describe a 'rhetoric of hope', in which arguments about the possible negative effects of releasing GM mosquitoes in Brazil are perceived as a threat to the economy, and moreover, in the case of new technologies designed to tackle disease, as equivalent to not caring for people who are suffering. Reis de Castro and Hendrickx note (2013, 123) how the GM insect technique "follows a deep-rooted logic that focuses on the mosquito, rather than analyzing and improving social conditions, health care or medical interventions" and conclude (2013, 124) that "In this sense, the case of the transgenic mosquitoes in Brazil evidences a technological fix that proposes to overcome not only a problem in the individual attitude [to mosquito control] or the government's actions, but an entire deficient infrastructure". This analysis raises questions about the wisdom of spending time and money on unproven technology, rather than fixing the social structures that caused the problems in the first place.

The same rhetoric is now evident in claims about GDOs, including the potential use of gene drive in mosquitoes to tackle diseases such as malaria, as detailed above.

Failure to properly include alternatives can lead to significant opportunity costs, especially if large sums of money - and other resources, as well as time - are wasted on unrealistic future promises rather than implementing existing interventions effectively and conducting more cost-effective, diverse, and appropriate R&D. For example, Beisel and Boëte argue that "Funding silver bullet solutions such as GM mosquitoes diverts resources away from more low-cost and local measures in malaria control like mosquito nets, larviciding, or increasing health systems capacities in order to improve access to malaria treatment" (Beisel and Boëte 2013, 54).

5.4 Implications of hype in current public engagement exercises

There are no current open releases of gene drive organisms. However, there have been open releases of genetically modified (GM) insects on an experimental scale, conducted by the commercial company Oxitec, which is now owned by the US company Intrexon (Intrexon n.d.). In Burkina Faso, the research consortium Target Malaria aims to begin experimental open releases of GM mosquitoes over the next year, with a view to beginning open releases of gene drive mosquitoes in five to ten years' time. In the US, MIT researchers are proposing releasing hundreds of thousands of GM mice into the environment of Nantucket Island. This project is also seen as a possible step towards releasing gene drive mice in the future: however, the researchers say they do not intend to build gene drives in this organism until field trials of non-drive mice are completed and local communities request a drive system (Esvelt n.d.). Genetic Biocontrol of Invasive Rodents (GBIRd) is another research consortium, focused on developing gene drive organisms in rodents, with a view to releasing them into the environment to attempt to eradicate pests (GBIRd n.d.).

Since no GDOs have yet been released into the environment, it is worth examining some of the proposals to release GM insects – which have taken place, or are imminent – in order to compare the rhetoric of the relevant institutions with what happens in reality. This is particularly important in the case of Target Malaria, which plans to release GM mosquitoes in the next year, followed by gene drive mosquitoes in 5 to 10 years' time.

On its website, Oxitec describes its GM *Aedes aegypti* mosquitoes as "the solution" to the diseases spread by this species of mosquito (including dengue, Zika, chikungunya and yellow fever) (Oxitec n.d.a). In contrast, Wilke et al (2018, 5) note that the ecology of GM mosquitoes is not completely understood, and their supposed interaction with particular biomes and non-target species is mostly theoretical. That's just one of the reasons why environmental and ecological variations may alter the expected outcome of suppression strategies based on GM mosquito releases, which will possibly result in failure to suppress targeted mosquito vector populations, or in other surprises. Reis de Castro and Hendrickx state, "Even from a 'technical' viewpoint it is by no means clear when the mosquito technology can be said to work: does it mean diminishing the prevalence of dengue? To what extent? Does "working" mean suppressing the population of wild mosquitoes – if so, by how much, for how long? Further research will be necessary to see how the mosquitoes are made to work, under what sort of geographical and economic conditions, and with what types of political alliances" (Reis de Castro and Hendrickx 2013, 127).

To date, all Oxitec's open releases of GM mosquitoes have been experimental; there is no evidence of any reduction in the target diseases; and claims for successful suppression of mosquito populations have been highly exaggerated (GeneWatch UK 2018). Nevertheless, public engagement exercises undertaken by Oxitec take the claimed benefits of open releases of their GM mosquitoes as fully established and undisputed. For example, in Brazil, Oxitec's public engagement included a jingle claiming that Oxitec's GM mosquitoes are "the solution" to dengue, "Let him into your house, He's the solution, He fights dengue and won't bite anyone, Protect your health, He's the good mosquito" (Bevins 2012).

In 2018, the Environmental Health Minister in the Cayman Islands confirmed that trials of Oxitec's GM mosquitoes there did not work and would be abandoned (Cayman News Service 2018). Trials in Panama and Malaysia had already been abandoned by this time, and in Brazil, a totally new version of the technology was undergoing early trials. Thus, this claim that the GM mosquitoes that had already been released were a "solution" was not supported by any evidence.

Similarly, Oxitec's website describes its GM crop pests as "the solution" to pest control problems involving four different pest species affecting crops such as brassicas, soft and stone fruits, maize, rice, sugarcane, cotton and more than 250 kinds of fruits, nuts and vegetables (Oxitec n.d.b). However, Oxitec has not yet demonstrated that any of their Genetically Modified pests could suppress a wild pest population in the field. Further, the trait engineered into these GM pests is female-killing "late acting lethality", i.e. the female offspring of the release GM males die mainly at the late-larval or pupal stage (Fu et al. 2007, 354). This raises concerns about the damage they would do to crops during the repeated mass releases that would be needed to attempt to suppress a wild population (Benedict et al. 2010, 26); and about the contamination of crops with GM larvae (many of which may die inside the crop) (Reeves and Phillipson 2017). These issues are likely to limit the practical application of this technology in real-world situations, but are not mentioned in the company's publicity material.

Target Malaria's website does not claim it has an existing "solution", but does say it is aiming to develop one. It states: "Target Malaria is an innovative project aiming to reduce the population of malaria-transmitting mosquitoes in sub-Saharan Africa. By reducing the population of malaria mosquitoes, we aim to reduce the transmission of the disease" (Target Malaria, n.d.c) and "We aim to develop a technology that can be complementary to other mosquito control methods and which offers a solution that is long term, cost-effective and sustainable as it tackles the problem at the source" (Target Malaria n.d.d). Nevertheless, Target Malaria's technology is excessively promoted considering it is something which does not yet exist in a form even close to being ready for experimental release, even in the lab. On the BBC in October 2018, one of the project's researchers stated that "The benefits that this technology can have in terms of human lives is massive" (BBC 2018), although the proposed open release of GM mosquitoes he is discussing is a small-scale release of a different technology, which the researchers expect to have no impact on malaria at all (ACB et al. 2018). A report published by the New Partnership for Africa's Development (NEPAD) of the African Union expresses near certainty about future benefits when it states "It will certainly take many years before actual outcomes are ready for field deployment, but potential benefits for African countries against malaria will almost certainly be extensive" (NEPAD 2018, 2). Even though they may include caveats about the technology, press articles include headlines such as "Here's the plan to end Malaria…" (Molteni 2018); "A swarm of mutant mosquitoes is out to eradicate malaria" (O'Mahoney 2018); and "A genetically modified organism could end malaria and save millions of lives — if we decide to use it" (Matthews 2018).

Target Malaria's proposal to release up to 10,000 GM mosquitoes over the coming year is a training exercise for the researchers; Target Malaria says that these GM mosquitoes will not be used for malaria control. This is because repeated large releases would be needed to seek to suppress the wild population of mosquitoes, which, even if successful, would be prohibitively expensive (Hayes et al. 2015, 7). Thus, there is no justification for making these releases in terms of "anticipated benefit" to public health. It is clear that the only benefit is to the researchers themselves.

A news report on the proposal to release GM mice on Nantucket describes the idea of genetically engineering mice that are immune to tick-borne diseases, such as Lyme disease, called "Mice against Ticks", and states: "the hope is to flood Nantucket with enough of these genetically engineered mice, that they would pass the immunity gene down to their offspring for multiple generations" (Boston 25 News 2017). However, the article also states that the researchers have only "identified the genes necessary" and does not mention if they actually have any evidence that the plan would work. A year later, another article asks "Will Nantucket vote to allow genetically altered mice to control Lyme disease?" (Mullin 2018). This could be taken to imply that mice containing traits that can control Lyme disease actually exist, and also suggests that their future ability to control disease is not in any doubt.

The GBIRd website asks: "Could we create a self-limiting gene-drive modified mouse that biases future generations to be male (or female) only, thereby achieving eradication by attrition? If so, should we do it? Under what conditions?" (GBIRd n.d.). Whilst GBIRd appears somewhat more cautious about making claims of benefit than the other projects discussed here, it nevertheless implies that once the technical challenges are overcome (the creation of the genetically engineered mice) this will inevitably lead to eradication of the population. Elsewhere on the same website a similar implication is made by stating "Researchers are exploring a technique of editing rodent genes in order to produce either all-male or all-female offspring, which, once released onto an island, would effectively self-eliminate the rodent population" (GBIRd 2018). Basic practicalities, such as how many GM mice would need to be released (perhaps many times the existing mouse population, in order to successfully mate with all the mice already there) and the damage the released GM mice would do on the island during the releases, are not discussed at all.

To date, public engagement exercises by Oxitec, Target Malaria and GBIRd have been led by these companies and research programmes, all of which have vested interests in promoting high expectations of future benefits and downplaying any risks. It is hard to see such engagement exercises as independent or unbiased. For credible public engagement to take place, uncertainty about what can be delivered needs to be openly acknowledged and unrealistic promises should be avoided. These issues are discussed further in Section 10.

5.5 Summary of findings regarding claims of benefits

Promises about the future benefits of new biotechnologies are often unrealistic, due to the unacknowledged complexity of real world biological, ecological and social systems. As Chapter 4, page 219 (Ethics and Governance) of this Report notes: "these desirable consequences and benefits in welfare only obtain if 1.) gene drives can be made dependably operational, 2.) they do not come with accompanying or hidden costs to human or environmental health, and 3.) they offer a real, long-term solution". In the case of GM mosquitoes without gene drive mechanisms it has been shown that claims of benefit, based on laboratory results and computer modelling, were not delivered in the field. In the case of gene drives, R&D is still in its infancy and far from any field trials. Many claims about future benefits of gene drives portrayed in media, scientific publications and patent applications seem farfetched. Public discussion is often limited to speculative health and conservation applications, with the aim of focusing on claimed benefits more likely to attract public support.

Framing public engagement exercises in a way that implies tremendous benefits are likely (or even inevitable), if and when open releases of gene drive organisms take place, is clearly problematic. For example, it limits the space for discussion of the usually poor success rates of so many biotechnological innovations thus far (Wallace 2010), the complexity of the approach and its dependence on numerous unverified assumptions. It also does not address the issue of the opportunity costs associated in investing in any approach that might not deliver the claimed outcomes. Further, over-hyped claims of future benefits may prevent concerns about negative impacts on human health from being included in the framing of the discussion. That is because, by definition, the still theoretical success of the gene drive organism in achieving its aim of disease reduction is assumed. It also prevents concerns about other impacts from being taken seriously because harm to ecosystems may be seen as less important than saving human lives.

Looking at biotechnology in medicine, Martin and Morrison (2006, 16) argue that in order for effective public policy to be developed, two things need to change: first, a more realistic set of expectations about the speed and scale of innovation needs to be adopted; and secondly, a different model, which views biomedical innovation as a slow and incremental process, should be used to inform public discussion and policy-making.

Similarly, McKelvey and Bohlin point out that decision-making in R&D has to be made under conditions of uncertainty about 'what will work' as well as about 'what will raise capital and what will sell'. If uncertainty is wide-spread, then the best course of action may be to invest in a set of diverse possible directions of technological development. They note that, "Certainly, biotechnology as an area of concern for basic science, small entrepreneurial firms and huge pharmaceutical companies has been one which holds out enormous promise - yet has also absorbed large amounts of resources with apparently few results in terms of direct industrial development" (McKelvey and Bohlin 2005, 98).

There is a danger that investors, policy makers and the public are being misled by unrealistic promises about what will be delivered through gene drive research and development. There may be significant opportunity costs if investments are diverted from more effective existing tools and R&D trajectories by these unrealistic promises.

6 The role of patents

As discussed above, promises about future benefits are an important means of securing research funding. Promises of potential future applications of new technological inventions or concepts are often voiced in intellectual property claims, the most stringent of which is the patent.

A patent gives its holder the right to exclude others from the reproduction, use, sale and distribution of his or her invention for a limited amount of time, generally 20 years (World Intellectual Property Organization [WIPO] n.d.). Requirements for patentability usually are: novelty, inventive step ('non-obviousness' in US patent law) and industrial applicability ('usefulness' in US patent law) (Art 52(1) European Patent Convention 2019, 27; 35 U.S. Code §§ 101-103, 2017).

The patent system is an artificial legal construct, established as a means of compensating inventors for their investments in R&D. The idea was that offering the possibility of gaining a reward would act as an incentive to create inventions and thereby foster innovation, economic growth and ultimately benefits to society. Today, however, the role of patents is controversial (see below).

In the next section, we give an overview of patents on gene drives and related technologies. We discuss what these patents cover, who the patents belong to and who they have been licensed to. Finally, we discuss whether patenting gene drive technology could be a means of regulating their use, as well as how patents on gene drives may influence innovation, research priorities and social benefits.

6.1 CRISPR-based patents

In 2014, Esvelt et al. were first to suggest using CRISPR/Cas9, a so-called genome editing technique, to build gene drive systems. This greatly boosted gene drive R&D as previous chapters of this Report have demonstrated. The CRISPR/Cas9 technology, which had been hailed as the "biggest biotech discovery of the century" (Regalado 2014), had started a flood of patent applications[4]. According to IPStudies, an IP consulting firm based in Switzerland, more than 2230 families of CRISPR-based patent applications had been filed by January 2018, 60% of which were filed by institutional applicants. The rest were filed by industrial applicants, individual inventors or were co-filings between industrial and institutional applicants (IPStudies 2018). The number of CRISPR-based patent applications increases monthly, with an average of 3 new patent publications per day.

The foundational CRISPR patents (Charpentier et al. 2013 and Zhang et al. 2014) have started a huge patent war between the institutional applicants and their researchers, Jennifer Doudna of the University of California, Berkeley and Emmanuelle Charpentier, then of Umeå University, Sweden, on the one hand, and Feng Zhang of the Broad Institute (affiliated with the Massachusetts Institute of Technology and Harvard University) on the other hand (see Box 1).

Box 1: War over CRISPR patents in the U.S.: UC Berkeley vs. Broad Institute

In 2012, Jennifer Doudna, University of California Berkeley and Emmanuelle Charpentier, then of Umeå University, Sweden, showed that CRISPR/Cas9, which is used by prokaryotes (bacteria and archae) as defence mechanisms against viral infections, can be reprogrammed to cut isolated DNA at a chosen site. On May 25, 2012, they filed a patent application for their invention in the US. A couple of months later, in December 2012, Feng Zhang of the Broad Institute and the Massachusetts Institute of Technology (MIT) in Cambridge also filed a patent application for the CRISPR/Cas9 technique in the US. Zhang's team reported that CRISPR/Cas9 also works in more

4 As of January 2019, the average pendency time (the time between filing of a patent application and the grant of the patent or abandonnement of the application, respectively) was approximately two years in the US. For individual patent applications, the pendency time might be much longer, especially if a an application is being appealed and needs a decision by the Board of Patent Appeals and Interferences (BPAI) (United States Patent and Trademark Office n.d.). With a pending patent application, the applicant can, however already begin to exploit their invention (Erickson Law Group n.d.).

complex living eukaryotic cells, including plant, mice and human cells that do not have an endogenous CRISPR system. Although filed later, Zhang's patent was granted in 2014, while the Doudna-Charpentier patent application remained under review. This led the UC Berkeley group to request an interference procedure with the US Patent and Trademark Office (USPTO). This procedure, unique to US patent law, is a means of examining whether the claims of two patents overlap and, if this is the case, who was the first to invent a commonly claimed invention. During the interference procedure, which started in January 2016, both parties filed hundreds of pages of documents with the court. The procedure moved beyond scientific argumentation and became unusually hostile, with allegations of impropriety and accusations of bias. The UC Berkeley team argued that Zhang's application to eukaryotic cells was obvious to a "person of ordinary skills" and hence lacks 'non-obviousness', a condition for a patentable invention. (Ledford 2016 a, b, c; Reardon, 2016; Sherkow 2017a)

The hearing, which received a lot of international attention, took place on 6 December 2016 at the USPTO. In February 2017, the US Patent Trial and Appeal Board (PTAB) ruled that there was no interference between the two inventions, which means that the Broad Institute will be able to keep its US patents. This ruling, which would give the Broad Institute control over the potentially most lucrative applications of CRISPR/Cas9 in plants, animals and humans, led to a rapid increase in the stock price of Editas Medicines, which has an exclusive licence from the Broad Institute to develop treatments for rare diseases using CRISPR, while the stock prices of its direct competitors Intellia Therapeutics and CRISPR Therapeutics, which have exclusive licence agreements to use UC Berkeley's patent application, fell by 10 and 15 percent, respectively (Regalado 2017; Ledford 2017).

UC Berkeley subsequently filed an appeal to the US Court of Appeals for the Federal Circuit, claiming "fundamental errors of law"; but on 10 September 2018 the US Court of Appeals upheld the previous decision by the USPTO. UC Berkeley could now still decide to appeal the decision to the US Supreme Court (Ledford 2018).

Although some were surprised about the hostile turn this patent fight has taken, a settlement was not to be expected, due to the huge commercial interests involved on both sides. The institutions behind the patents had already entered into a series of exclusive licence agreements with commercial companies founded by the institutions and one of their respective researchers. Zhang and Doudna founded Editas Medicine. Doudna, who has since cut ties with Editas Medicine, is involved with Caribou Bioscience and Intellia Therapeutics, while Charpentier has co-founded CRISPR Therapeutics with Rodger Novak and Shaun Foy (Ledford 2016a). These spinout companies had already further licenced the respective patents to other companies, including Bayer-Monsanto, DowDuPont and Novartis (Contreras and Sherkow 2017, 699) and invested millions of US Dollars in the patent fight. This system of surrogate licensing (see Box 2) of course may not be in the public interest. Editas Medicine, Intellia Therapeutics and CRISPR Therapeutics are publicly traded companies. Their duty is to maximise the profits of their shareholders and not to advance scientific knowledge in the public interest. Moreover, patent fights, where university turns against university, can complicate interinstitutional research agreements and impair the culture of scientific collaboration (Sherkow 2017b).

Box 2 University Intellectual Property Transfer

The 1980 adoption of the Bayh-Dole Act in the US allowed universities to own and commercialise patents arising from in-house inventions. Many other countries followed suit. This shift in policy reflected the growing acceptance of patenting academic research, along with the idea that social benefit could be created by licensing university patents to private firms, which would then develop commercially valuable products and services. It is now common for universities to seek to commercialise intellectual property by transferring their patent rights to private companies (sometimes co-founded by the inventors themselves), which then take on the role of further sublicensing and commercialising the invention. Contreras and Sherkow (2017) call these companies "surrogates for the institutions". They take on the role and responsibility of the patent owner, keeping a major share of the profits. The universities, often having a substantial equity interest in the surrogate company, still receive a substantial share of the profits, while minimising their risk. In 1988, Oxford University, for example, formed Isis Innovation (now called Oxford University Innovation), a wholly-owned subsidiary designed to help the university exploit intellectual property. Intellectual property created at Oxford became generally assigned to Isis, which transferred the technology to industry through licensing agreements. In this "surrogate licensing model", research tools developed with public funding, instead of being licensed as widely as possible by universities operating in the public interest (as recommended inter alia by the US National Institutes of Health - NIH), are exclusively licensed to a number of "surrogate companies" that then control their further use. In addition to contradicting the conventional understanding of science as universally shared knowledge, this can have a negative impact on innovation, by decreasing competition (and information-sharing) in the respective fields (Contreras and Sherkow 2017; Tofano, Wiechers, and Cook-Deegan 2006, 54). This also gives a university a vested interest in promoting the technology, which might further undermine the supposed impartiality of science.

6.2 Gene Drive patents

In 2003, the first patent application describing a gene drive was published internationally (Burt 2003) The difference between national and international patent applications is described in Box 3. Therein, a method is described that has the intention of transforming a population or entire species, either for population suppression or for establishing a desired characteristic in that population. This is to be achieved by introducing a sequence-specific drive element, such as a gene with an increased inheritance ratio, e.g. a homing endonuclease gene (HEG), into the germline of an organism, thereby disrupting or knocking out a selected gene and subsequently introducing the then modified organism into the whole target population.

Box 3: National and international patent applications

The first step to secure a patent is to file a patent application. This can be done at the national patent offices in the respective countries where an inventor seeks a patent. If an inventor seeks protection in several countries, it may be more convenient to simultaneously request patent protection in multiple countries by filing the application at regional or international patent offices (WIPO n.d.). This way, filing several separate patent applications can be avoided. The European Patent Office (EPO) is a regional patent office with 38 member states. Once the patent has been granted by the EPO, it still has to be individually validated in the designated states. The new Unitary Patent system, which has yet to come into effect, would avoid individual validations (European Patent Office 2018). The Word Intellectual Property Organisation's (WIPO) Patent Cooperation Treaty (PCT), is an international patent treaty with more than 150 contracting states. The WIPO does not grant any patents, but rather forwards them to the competent patent office in the respective countries where a patent application is filed. Each state still autonomously decides whether or not to grant the patent within its borders. This is called the "national phase" (WIPO n.d.).

The first two letters of a patent publication number indicate the country or organisation in which the patent application was filed or granted. The prefix WO, for example, is short for WIPO and the prefix EP, for European Patent Office.

Long before the invention of CRISPR/Cas9 for genome editing, this patent application already described the idea of a two-component system to cut DNA at a specific target sequence and introduce the HEG at the cleavage site.

It also already described the various potential applications of gene drives, still being promised today: malaria control (either by mosquito population control or by conferring resistance to the malarial parasite); eradication or control of unwanted or colonising species which are detrimental to a previously-established ecosystem (for example rodents or goats); altering the balance of insects or microorganisms (for example those associated with food crops or livestock); or rendering pests susceptible to appropriate pesticides (for example insects, nematodes or fungi).

Its inventor, Professor Austin Burt, is now a member of the 'Gene Drives for Vector Control' group at Imperial College, which is one of the partner institutions of Target Malaria, and is Target Malaria's Principal Investigator. As well as patents on CRISPR technology or gene drives, academic institutions may also hold related patents on particular applications. Other members of the 'Gene Drives for Vector Control' group at Imperial College, for example, have applied for patents to genetically modify insects, particularly malaria-transmitting anopheline mosquitoes (see Box 4). These are relatively old patent applications that may not apply to gene drive organisms, but they illustrate how GDOs developed in the future might also be patented, along with how academic scientists and institutions may already have (or may develop) commercial interests in particular technologies.

Box 4. Related patent applications from the 'Gene Drive for Vector Control' Group

In 2000, Crisanti et al. applied for a patent to genetically modify insects, particularly anopheline mosquitoes, by introducing foreign genes in the *Anopheles* genome. Therein, they provided a.) a method to delay the hardening process of the chorion, the rigid structure around the insect embryo, after oviposition so as to facilitate DNA injection; and b.) a DNA delivery vector capable of successful transposition in anopheline mosquitoes. They suggest either introducing a gene to control the transmission of malaria-causing parasites or producing sterile males intended to be released as a means of genetic control.

In 2004, Kafatos et al. applied to patent a method to render anopheline mosquitoes, in particular *Anopheles gambiae*, resistant to malaria-causing parasites.The method describes how to enhance or suppress mosquito proteins, that are either hostile or beneficial for parasite development, by application (feeding, spraying or injection) of a compound that interferes with the expression or activity of the protein. It further describes how to identify compounds that trigger an immune response in a mosquito of the genus *Anopheles* against *Plasmodium* (the parasite). For suppression of the protein expression, their suggestion is to use antisense-technology, or RNA interference (RNAi) in order to knock out the described genes.

With the discovery of the CRISPR/Cas9 technology, a dozen gene drive patent applications have followed, most of which either belong to Harvard University or the University of California (Table 1).

A key gene drive patent application, called "RNA-Guided Gene Drives" and filed by Harvard University (Esvelt and Smidler 2015), claims the ability to develop a method for targeted population suppression or extinction via the release of an RNA-guided genetic load drive into the targeted population, thus biasing the sex ratio of the population. The patent application describes the utility of this gene drive in the eradication of infectious diseases, the control of invasive species and the protection of threatened species, such as amphibians. However, the major part of the patent description is dedicated to "Agricultural Safety and Sustainability" and what they call "sensitising drives". Sensitising drives are gene drives meant to render the progeny sensitive to an external stimulus. This means that exposure of a weed or pest to a compound, for example a specific chemical, should result in a harmful reaction. The idea is to make pesticide-resistant weeds or pests susceptible to the original pesticide again - a major commercial 'rescue operation' for what have been failing markets for chemicals like glyphosate, due to the pests developing resistance. Subsequently, hundreds of weeds, crop pests and pesticides became covered by the patent, including glyphosate, 2,4-D and Bt toxins produced by CrylA.105, CrylAb, CrylF, Cry2Ab, Cry3Bbl, Cry34Abl, Cry35Abl, mCry3A, or VIP (Esvelt and Smidler 2015, 34-51). The same weeds, crop pests and pesticides are covered in a 2017 patent application, also by Harvard University (Esvelt and Min 2017, 42-60). In these ways, using and adapting the patenting system, academic science has been further integrated into the global agrichemical and GM industries. Along with other important domains, and with little democratic attention, gene drives have also become a driver of this transnational social and political change.

This shows that gene drives may be able to attract lucrative investors in the agricultural field of genetically modified (GM) crops. The most widely commercialised GM crops engineered to be resistant to herbicides, such as glyphosate and different insecticidal toxins derived from *Bacillus thuringiensis* (Bt), have suffered major setbacks with the development of glyphosate-resistant weeds and insect pests that are now resistant to Bt toxins (Bohnenblust 2016; Peralta and Palma 2017), something long predicted by those opposing this technology. Alternative GM crops, such as those resistant to the herbicides dicamba and 2,4-D, have led to huge problems with

Table 1: Gene Drive patent applications

WIPO Number	Publication Date	Applicants	Inventors	Title	
WO/2003/038104	5/8/03	Imperial College	Burt, A.	Methods for genetically modifying a target population of an organism	
WO/2015/105928	7/16/15	Harvard College	Esvelt, K.M., Smidler, A.L.	RNA-Guided Gene Drives	
WO/2016/073559	5/12/16	The Regents of the University of California	Bier, E., Gantz, V., Warren, W.L.	Method for Autocatalytic Genome Editing and Neutralizing Autocatalytic Genome Editing	
WO/2017/049266	3/23/17	The Regents of the University of California	Bier, E., Gantz, V., Hedrick, S., Warren, W.L.	Method for Autocatalytic Genome Editing and Neutralizing Autocatalytic Genome Editing And Compositions Thereof	
WO/2017/058839	4/6/17	Harvard College	Esvelt, K.M., Min, J.	Dependent Component Genome Editing Gene Drives	
WO/2017/132207	8/3/17	University of California	Akbari, O.S.	Use of *Medea* Elements for Biocontrol of *D. suzukii* Populations	
WO/2017/160689	9/21/17	University of Massachusetts	Sontheimer, E.J.	Anti-CRISPR Compounds and Methods of use	
WO/2017/196858	11/16/17	MIT, Havard College	Esvelt, K.M., Min, J., Noble, C.	Methods to Design and use Gene Drives	
WO/2018/035300	2/22/18	University of California	Bier, E., Gantz, V., James, A.A.	Split Trans-Complementing Gene-Drive System For Suppressing *Aedes Aegypti*	
WO/2018/049287	3/15/18	MIT, Harvard College	Esvelt, K.M., Min, J., Noble, C.	Methods and Compounds for Gene Insertion into Repeated Chromosome Regions for Multi-Locus Assortment and Daisyfield Drives	
WO/2018/053457	3/22/18	Joung, J.K.	Joung, J.K.	Methods of genetically alterning yeast to produce yeast variants	
WO/2018/071892	4/19/18	Joung, J.K., Gehrke, J.M.	Joung, J.K., Gehrke, J.M.	Epigenetically Regulated Site-Specific Nucleases	

herbicide drift when these crops are treated with their very toxic corresponding products, resulting in millions of acres of incidental crop and non-crop injuries in the US (Bohnenblust 2016; Bradley 2017; 2018). Moreover, multiple weed resistances to glyphosate, dicamba and 2,4-D are already seen today (Dellaferrera et al. 2018). Recently, hybridisation between two major agricultural pest insects (*H. armigera* and *H. zea*) has been confirmed, raising additional concerns about increased insecticide resistance problems in the future (Anderson et al. 2018).

Any technology that claims to be able to reverse these resistances is likely to attract the attention of the major biotech companies, many of which already have license agreements for using CRISPR/Cas9 (see above). In 1993, when applying for non-regula-

State	Also published as
International publication: A1 National phase entry: US, Canada, Australia, Japan Withdrawn: Japan (25.05.2006)	AU2002339086 (B2) CA2466129 (A1) US2005120395 (A1)
International publication: A1 National phase entry: Japan, Canada, EPO Published: EPO (16.11.2016)	EP3092310 (A4) CA2936312 (A1) JP2017511685 (A) SG11201605550Q (A) WO2015105928 (A1) AU2015204784 (A1) CN106133141 (A) SG10201805815Y (A) US2016333376 (A1) WO2015105928 (A9)
International publication: A1	US2018291382 (A1)
International publication: A2 National phase entry: EPO Published: EPO (25.07.2018)	WO2017049266 (A3) CA2998894 (A1) EP3350315 (A2)
International publication: A1	N/A
International publication: A1	N/A
International publication: A1	N/A
International publication: A1	N/A
International publication: A1	N/A
International publication: A2	WO2018049287 (A3)
International publication: A1	WO2018053457 (A9)
International publication: A1	N/A

tion status of the first genetically modified Roundup Ready (glyphosate tolerant) soybeans, Monsanto claimed incorrectly that it was "highly unlikely that weed resistance to glyphosate will become a problem as a result of the commercialization of glyphosate-tolerant soybeans" (Monsanto 1993, 56). With the development of yet more genetically modified crops, allowing spraying of more and higher levels of herbicides, we face a form of herbicide intensification termed 'the transgenic treadmill' (Binimelis, Pengue, and Monterroso 2009, 9; Schütte et al. 2017, 7). In the case of gene drives, scientists now agree that resistance could eventually evolve again, but discard the whole problem by saying this technology could be used *repeatedly* to make weeds and pests susceptible again and again (Champer, Buchman, and Akbari 2016, 147). It seems evident that this would lead to a new level of treadmill, whose purpose is not to prevent diseases or pests, but to maintain the prevalent chemically-dependent industrial agricultural system.

Another fundamental gene drive patent application, this one filed by the University of California and called "Method for Autocatalytic Genome Editing and Neutralizing Autocatalytic Genome Editing", mentions applications for combatting malaria, HIV and cancer and in reducing or eliminating immunogenicity, as well as in controlling agricultural pests and invasive species (Bier and Gantz 2016). It further includes hundreds of cancer types and model organisms, many of which are agricultural pests, thereby also covering potential lucrative applications in the health and agricultural sectors.

In 2017, MIT and Harvard University applied for a patent on daisy chain gene drives, a type of gene drive that is not yet functional, but would be "…designed to permit controlled, local gene drive activity." and claims to have "the ability to confine the gene drive organisms, such that they only affect local populations and do not risk global gene drive activities" (Esvelt, Min, and Noble 2017, 33). According to the patent, daisy chain gene drives may be used to reduce vector-borne and parasitic diseases, as well as to control or eliminate populations of agricultural pests or invasive species. Non-limiting examples of organisms which a daisy chain gene drive may be delivered to, or included in, according to the patent, are: "insects, fish, reptiles, amphibians, mammals, birds, protozoa, annelids, mollusks, echinoderms, flatworms, coelenterates, and arthropods, including arachnids, crustaceans, insects, and myriapods" In 2018, MIT and Harvard University applied for another patent on daisy chain gene drives, covering the same non-limiting examples of organisms (Esvelt, Min, and Noble 2017, 52; Esvelt, Min, and Noble 2018, 48). This kind of comprehensive patent ownership is not uncommon in patenting of genetic research. The fact is that most of the domains listed have never been tested even in a preliminary way for the effectiveness of the gene-drive; they have simply been imagined by the researchers as possible domains. This illustrates how institutions and academic researchers try to foresee and legally cover any potential future commercial exploitation of their invention.

The idea of using locally confined gene drives might seem more responsible, reducing ethical concerns about potentially eradicating entire species along with safety concerns about unintended and unforeseeable consequences. It means the prospect of developing daisy chain gene drives could increase public support for the technology. Along with funding, public understanding plays an important role when it comes to governance and regulation of new technologies (Mitchell et al. 2018, 3), so the development of "local gene drives" would also likely attract more private investment. A technology that potentially spreads to an entire population or species after an initial release is not as likely to develop a huge commercial market, hence the return on investment might be limited. With the possibility of spatially and temporally confining the spread of a gene drive organism, however, multiple subsequent releases at multiple locations are imaginable (Mitchell et al. 2018, 4). Going back to the theory of "sensitising drives", as explained above, a private company might be able to sell a package of a compound (such as a pesticide) and a corresponding gene drive organism (such as a crop pest) that has been rendered sensitive to said compound, each and every year to farmers around the world. These kinds of strategic and competitive business models, should in principle require democratic appraisal, since they have far-reaching and often unpredictable social, environmental, and economic consequences.

6.2.1 Regulation of Gene Drive patents

Esvelt has suggested that the patent system could be used to ensure gene drives are used ethically and responsibly. Those wanting to purchase a patent license would first have to disclose their proposed use to the patent holder before carrying out any experiments. The goal would be to ensure openness and also to limit licenses only to users ensuring ethical use (Regalado 2016c; Sherkow 2017b). Although this seems like a noble suggestion, this would mean that Esvelt himself and Harvard University, or any other scientist and their employer-institution which had been granted a gene drive related patent, would be able to decide how gene drives should be used or *what constitutes an ethically justifiable purpose*. In so doing, they would take on the role of gene drive regulators, gaining legal control over not just the technology disclosed in their patent, but its distribution and use.

This would inevitably fragment the larger social regulation of the entire technology. A societal responsibility like gene drives (or any other technology) governance should not be placed in the hands of a research institution or individuals, most especially those who have a direct financial interest in its promotion. Those with vested interests in the technology cannot also be the ones overseeing its governance and use. How could it be ensured that the foundational gene drive patents, covering many potentially lucrative applications in the health and agricultural sector (see above), are not licensed to a few surrogates that are really part of larger companies, as has happened to the related CRISPR/Cas9 patents? In the end, society would have to put its trust in the patent holders alone to ensure that the technology is used (or not used) in the best public interest.

Instead, Parthasarathy (2018, 488) argues that transparency and political legitimacy would increase if government institutions, which are explicitly charged to represent the public interest, were to use patent systems to help regulate new technologies such as gene editing. The patent system would have to be linked to explicitly relevant laws for the purpose of regulation. In the US, this was already done in the Atomic Energy Act of 1946/1954, to reduce the development and commercialisation of atomic weaponry by private actors. This Act, for example, prohibits the patenting of any invention or discovery that would be "useful solely in the production of fissionable material or in the utilization of fissionable material or atomic energy for a military weapon" (Newman and Miller 1947, 750). If a patent for a production device could be obtained, the inventor would not be allowed to manufacture the device without a license from the Atomic Energy Commission, nor could they license its use to anyone except the government. If an intergovernmental regulatory framework for reviewing and awarding patents for their ethical and responsible use was set up, the patent system might indeed add another layer of protection from misuse of the technology. It cannot, however, be left to the patent system alone to regulate gene drives.

6.3 Social benefit implications of patents

The intent of the patent system is to increase innovation and enable the development of commercially valuable products and services, in order to create economic growth and ultimately social benefits. However, today the role patents play in fostering social benefits is ambiguous. As noted by the OECD, research and innovation thrive on collaboration and knowledge sharing (Gold et al. 2008, 16). Patent holders are required to publicly disclose the details of their inventions so that others can build on it by undertaking further research and development. At the same time, a patent, by definition, is the right to exclude others from commercially using the given invention. It has often been claimed that industry manipulates patent law to thwart rivals and block research, as well as to direct it away from humanitarian goals towards goals that maximise profits (Jenkins and Henderson 2008). In the health field, for example, despite increasing use of intellectual property patents, a decline in innovation has been observed (Gold et al. 2008, 7). As the example of CRISPR/Cas9 has shown, the commercial interests behind patents on biotechnological inventions often foster secrecy and hamper transparency and collaboration, thus interfering with overall innovation dynamics.

Kevin Esvelt, who openly opposes closed-door science, agrees that the current competitive approach to scientific enterprise doesn't promote open and transparent science: "It is a prisoner's dilemma. The benefits come from cooperation by everyone. But by participating you risk being exploited by people who steal your idea, get it working before you do, and claim the credit." (Esvelt 2016, 153). Gene drive research, however, would, according to Esvelt, offer a way out: "The field is new and small, and many of us have already worked together to publish a joint recommendation calling for future experiments to use multiple stringent confinement strategies. Several groups already disclose proposed and ongoing gene-drive research and invite feedback, and active discussions between researchers and funders seek ways to ensure that everyone will be similarly forthcoming." (Esvelt 2016, 153). In 2016 he and his colleagues initiated the project "Responsive Science", intended to further this vision.

While the efforts of Esvelt and colleagues, to disclose their research ideas and foster open discussion (even before the experiments are performed), is very laudable, it is unfortunately questionable whether all gene drive researchers will follow Esvelt's call, as all he is doing is appealing to the individual scientists' sense of responsibility. He suggests no means of enforcing participation or controlling whether or not the rules he discusses are being followed. Furthermore; (1.) the appropriate rules would need lengthy negotiation amongst relevant parties; and (2.) those relevant parties would have to include institutions as well as individual scientists, and it is well-attested that institutions behave in ways which cannot be modelled from individual behaviour.

Patent rivalry between universities is not the only reason that scientists don't want to disclose their research ideas. Disclosing an idea to the public at an early stage may itself affect later patentability of related innovations. This in turn may decrease the likelihood of finding the funding that can translate the idea into reality (Fass et al. 2011, 11). Esvelt suggests that gene drives should be a non-profit technology (Esvelt 2018b), even if it would mean repercussions for his personal benefits from his patents. The same, however, cannot be expected from others, and it is questionable if everyone involved in gene drive R&D would agree (and could afford) gene drives to be a non-profit venture. Moreover, it has to be noted that the motive behind Esvelt's suggestion is unlikely to be free access to the technology (see Section 6.2.1. Regulation of gene drive patents) but rather public acceptance and the avoidance of a moratorium on gene drives. In a 2018 article titled "Gene drive should be a non-profit technology" Esvelt states: "When people know you will benefit financially from a proposal, they're less likely to trust your judgment", adding: "Gene drive and other ecotechnologies depend on popular support. Since they involve the genetic engineering of wild populations, that support is by no means guaranteed, especially if there is for-profit involvement." (Esvelt 2018b). However sincere his personal beliefs might be in terms of this technology bringing social benefits, such statements leave the impression that Esvelt's engagement for openness and transparency in science is as much a strategic choice to gain public acceptance, in order to move forward quickly, as it is a willingness to foster true public engagement. A lack of the latter in practice could delay or even lead to the rejection of the technology: "The primary danger posed by CRISPR-based gene drive is social. Given widespread scepticism of genetic engineering, any unauthorized release of a gene drive system could lead to a strong social backlash and serious damage to public trust in science and governance when society can least afford it. In addition to institutional damage, such backlash would almost certainly delay efforts to use gene drive to prevent vector-borne and parasitic diseases such as malaria and schistosomiasis, possibly resulting in millions of otherwise preventable deaths." (Esvelt 2018a). Furthermore, the issues described in this chapter also apply to non-profit enterprises, which have their own in-built social biases and assumptions, and which may also wield significant power over others.

Another important social issue highlighted by the increased use of patented technologies, one which has been less widely discussed, is the effect that patents have on research priorities. The role of patents is not straightforward and is often difficult to disentangle from the other factors influencing R&D investments and innovation. However, possible negative impacts of university patenting include diverting research resources (researchers' time and equipment) away from research questions that may not to be suited to the development of patents, but which may well offer potentially greater social benefits (Geuna and Nesta 2006, 799). As numbers of patent applications and income from intellectual property have become measures of university and industry success and funding, patentable inventions will be given a higher priority over other types of research that might have greater social benefit. It is thus not only access to biological knowledge and discoveries that is controlled and shaped by the patent system, but also *what constitutes scientific knowledge itself* (Wallace and Mayer 2007).

With the rise of biotechnology, patents were legalised for living organisms for the first time in 1980 in the US (see Diamond v. Chakrabarty), and globalised in the 1995 Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement. The possibility of patenting genetically modified organisms in turn was a major incentive to further invest in genetic engineering, as it allowed patent owners to control and exploit genetic material that farmers previously freely replanted and exchanged amongst themselves[5]. Although it is clearly not the only factor driving research agendas, the commodification of genetic inventions via patent claims therefore plays a key role in the 'geneticisation' of both health and agriculture.

As mentioned, gene drive R&D is accompanied by promises of many beneficial applications. However, open releases of gene drive organisms have the potential of altering and interacting with ecosystems in new, complex, unpredictable and unforeseeable ways. Whether or not the deployment of gene drive organisms will in fact create social benefit one day is still very hypothetical. Nevertheless, gene drive technology hype and patents may help attract further investment in gene drive R&D and possibly divert resources from potentially more sustainable alternatives.

7 Fully informed consent

In this section, we consider issues related to the need for individuals to provide prior, fully informed consent to open releases of GDOs.

7.1 Fully informed consent for projects not involving medical research

For medical research such as releases of gene drive mosquitoes, fully informed consent is already an ethical requirement under the Helsinki Declaration (see Section 7.2). However, for other gene drive organisms, which are intended to alter ecosystems but not to impact on human health, the situation so far has been less clear. This changed in 2018 with the adoption of a decision by Parties to the Convention on Biological Diversity (CBD), as discussed in Chapter 5. This requires the consent of potentially affected indigenous peoples and local communities to be sought or obtained to the release of GDOs "where applicable in accordance with national circumstances and legislation". The CBD Decision is an important acknowledgement of the importance of consent to the release of any GDO; however, for medical experiments, any release will also have to comply with the more stringent and well-established requirements of the Helsinki Declaration, as discussed below.

7.2 Fully informed consent to medical research

In the case of releases of gene drive mosquitos with the goal of affecting tropical diseases such as dengue fever or malaria, the requirement for fully informed consent is enshrined in international principles for medical research.

The Declaration of Helsinki outlines the internationally agreed ethical principles for medical research involving human subjects (World Medical

5 The subsequent rise of a few agrochemical companies that today control a major share of the global seed and pesticide markets, and its impact on farmers' and consumers' choice, is still subject of controversy today. Others critique the patenting of life altogether (see for example the German and European initiatives "Kein Patent auf Leben!" and "NO PATENTS ON SEEDS!", respectively).

Association 2013). It includes the requirement that: "Medical research involving human subjects may only be conducted if the importance of the objective outweighs the risks and burdens to the research subjects" (Article 16).

The Declaration of Helsinki builds on the Nuremberg Code, adopted as a code of medical ethics to condemn the practices of doctors working for the Nazis (Fischer 2006). It also states that: "In medical research involving human subjects capable of giving informed consent, each potential subject must be adequately informed of the aims, methods, sources of funding, any possible conflicts of interest, institutional affiliations of the researcher, the anticipated benefits and potential risks of the study and the discomfort it may entail, post-study provisions and any other relevant aspects of the study…" (Article 26).

Thus, the Helsinki Declaration requires that research participants are adequately informed about the risks and anticipated benefits of the study. In theory, this allows potential participants to weigh up the potential risks and benefits, as part of the process of informed consent.

Resnik (2012) explores a hypothetical field trial of malaria-resistant GM *Anopheles* mosquitoes and highlights the fact that field trials should not be implemented unless research indicates that overall public health benefits are likely to be greater than public health risks (Resnik 2012, 5). He further notes that, "In a study taking place in a developing nation, it is likely that many of the subjects will be vulnerable, due to poverty and lack of access to health care" and notes that, "To protect these subjects, measures should be in place to ensure that consent is free from coercion and undue influence" (Resnik 2012, 7). Resnik also states that, "Individuals may be exploited if they are harmed in research when there is little expectation that they will benefit, or they do not provide consent" and that, "Exploitation of a community may occur when the community is placed at risk without the expectation of significant benefits" (Resnik 2012, 7).

Macer (2005) also considers ethical issues in relation to the release of genetically modified (GM) insects with the aim of controlling human disease. He notes that "Informed consent requires information to be provided, so disseminating information about the plans and progress of the project, and obtaining the consent of any person potentially affected by the release of transgenic insects, is important for the ethical conduct of research trials, whether or not national guidelines require this, or even exist" (Macer 2005, 653). Macer also highlights that if a study involves humans, oversight by an ethics committee or institutional review board (IRB) is also necessary (Macer 2005). He goes on to argue, "To consider the issue at a local level, as required for obtaining appropriate informed consent, it is essential that a local ethics committee (and/or IRB if associated with an institution) open to the communities involved is established" (Macer 2005, 654).

This raises issues about how these risks and benefits are determined and communicated, and how different value-judgements, unknowns and uncertainties are dealt with in this process. Aspects of these issues are covered by national and international agreements and regulations covering genetically modified organisms (GMOs). However, these regulations may be absent, contested, or not properly enforced. Below, we consider how risks have been dealt with to date during the process of obtaining consent for projects wishing to release GM mosquitoes (currently without gene drive). We highlight that in practice participants may not be fully informed by developers about the risks of new technologies and that power asymmetries may affect who has information, what choices people are able to make, and whose voices are heard. Hype about benefits will also substantially affect whether people are genuinely fully informed before they are asked for their consent.

7.3 Absence of adequate environmental risk assessments

The previous section highlighted the problems associated with the ethical requirement upon scientists to obtain fully informed consent from all potentially affected parties before they begin any environmental releases. For "fully informed" to be a meaningful condition for the public, scientists involved also have to be fully informed about all possible harms that may result from their actions. This is a problematic normative condition. As Chapter 4 (Ethics and Governance) notes, risk assessments inherently involve making value-based judgements; for example, deciding what constitutes a hazard or an environmental protection goal, and what constitutes quality in safety science. This involves being explicit not only about imprecisions in knowledge of salient measures and relationships ("uncertainties"), but also about lack of knowledge ("ignorance"), and untested assumptions ("ignorance"), as well as about unanticipated contingencies (also ignorance, e.g. variable conditions in the environment which may affect validity of assumed extrapolations to broader conditions). Risk management decision-making also inevitably requires a determination of what constitutes an acceptable level of risk.

Both Oxitec's and Target Malaria's GM mosquitoes have been exported from European Union (EU) countries for open release into the environment elsewhere. Under EU law, the exporter should provide prior notification, including a publicly available environmental risk assessment that meets European standards, before exporting GM insect eggs for open release to foreign countries. This legal requirement arises because GM insect eggs are live, genetically modified organisms (living modified organisms or LMOs) covered by the Cartagena Protocol on Biosafety (CPB) to the Convention on Biological Diversity. The relevant legal requirements for export are implemented in the EU through the European Regulation (EC) 1946/2003 on transboundary movement of genetically modified organisms. This Regulation requires that the environmental risk assessment (ERA) provided by the exporter meets the EU standards on risk assessment contained in EU Directive 2001/18/EC. Regulation (EC) 1946/2003 is important because it requires the exporter to provide a comprehensive, publicly available risk assessment that meets EU standards for GMOs intended for release into the environment. The Precautionary Principle (discussed in Section 8) must be taken into account when applying this Regulation.

Avoidance of transboundary notifications has been a major issue with the commercial GM insect company Oxitec, which has never published a risk assessment which meets EU standards prior to undertaking any of its open releases of GM mosquitoes into the environment (GeneWatch UK 2014). Reeves et al. note that there were "significant omissions" (Reeves et al. 2012, 8) in the information made publically available prior to open releases of GM mosquitoes in the Cayman Islands and Malaysia, and that "Without the pre-release publication of complete risk assessment documents detailing all the potential hazards analyzed, it is often impossible to establish which have been considered (and by whom) and if any obvious hazards have been overlooked for rigorous consideration" (Reeves et al. 2012, 9). They also highlight that the Cayman Islands had no enacted legislation relating to living GM organisms at the time of the first open release of GM mosquitoes there (Reeves et al. 2012, 8).

Target Malaria has claimed to be holding itself to higher standards. However, it is currently arguing that it is not required to make a transboundary notification that includes such a risk assessment for its proposed release of male-sterile GM mosquitoes in Burkina Faso, because the GM mosquitoes were exported for an initial period of contained use (for which a notification is not required under EU law) before release (ACB et al. 2018). Instead, Target Malaria has commissioned its own risk assessment, without reference to the required standards, which omits some of the relevant issues, and relies heavily on 'expert elicitation' and unpublished data (Hayes et al. 2018).

In September 2018, Target Malaria announced that it had received regulatory approval for its first proposed open release of GM mosquitoes in Burkina Faso (Target Malaria 2018). However, there is no published environmental risk assessment (ERA) other than one published by Target Malaria itself, and there has been no public consultation, apart from "public engagement" activities conducted by Target Malaria, the organisation proposing the release. This is despite the fact that the Cartagena Protocol requires Parties, including Burkina Faso, to make available summaries of the risk assessments generated by its regulatory process to the Biosafety Clearing House (paragraph 3(c) of Article 20), as well as to consult the public in the decision-making process (paragraph 2 of Article 23) (see also Chapter 5, Regulation).

According to the Helsinki Declaration, people must be fully informed about the potential risks of a study in order for their consent to meet ethical requirements. This cannot be the case until a comprehensive risk assessment has been published that meets the necessary standards and opened for public consultation. Because the idea of releasing GM insects into the environment is relatively new, best practice would be for specific guidance on how to do such risk assessments first be developed by the regulators, not the proponents, and for this guidance to be subject to public consultation, such as has happened in the EU (EFSA Panel on Genetically Modified Organisms 2013). Provided conflicts of interest can be avoided, this could help prevent the developer having too much influence over the risk assessment process, including how unknowns and uncertainties will be handled.

In addition, under the Cartagena Protocol, Parties are allowed to take into account socio-economic considerations that arise from the impact of GMOs on biological diversity when they make decisions about importing GMOs. Under national laws, socio-economic considerations or assessments may also be required as part of decision making on GMO applications

ERAs published to date for GM insects have not included any discussion of socio-economic aspects. The summary of the risk assessment commissioned for Target Malaria's proposed release of GM mosquitoes on Burkina Faso states, "The report is not a complete evaluation of all potential risks. Some potential risks, such as the risks to social endpoints identified in Burkina Faso's legislation, are not addressed in this analysis" (Hayes et al. 2018, 2). This sidesteps the question of where these missing social risks have been evaluated or how the public will be informed about any such assessment, as well as if they will be engaged in any decision-making (see Section 10). This issue will remain relevant for future proposed releases of GDOs (whether proposed by Target Malaria or others).

It should be noted that open releases of GDOs would challenge the regulatory system further, requiring updates and adaptations to GMO risk assessment methodologies as well as a precautionary approach (discussed in Section 8).

7.4 Power asymmetries

As noted above, power asymmetries may be particularly evident when technologies are transferred from wealthy to poor countries, and when the people affected may be vulnerable, not only because of their poverty, but because the state and related infrastructures are typically much weaker in poor countries.

In African countries, there have been a few studies of public and scientific attitudes to the release of GM mosquitoes which would potentially include gene drives. Preliminary research conducted in Burkina Faso concluded that "the community's acceptance of GMM [GM mosquito] release could be affected by the fact the citizens interviewed did not appear to completely understand either the possible negative aspects of GMMs in the environment or the detail of how GMMs operate" (De Freece et al. 2014, 265). In a small study of perspectives of people in Mali toward GM mosquitoes for malaria control, 62 participants said they would support a release of GM mosquitoes that satisfied their conditions, 14 said they would not support a release under any circumstances, and four were unsure (Marshall et al. 2010, 7). Conditions were wide-ranging and included requirements for evidence GM mosquitoes will not cause human health or environmental concerns and that there would be no costs to the community (Marshall et al. 2010). However, it is not at all clear how these conditions might be implemented and enforced.

Notably, Marshall et al. reports that, "The main concern expressed by participants in all groups, but particularly amongst those from rural areas, was that the strategy of releasing GM mosquitoes will not work" (Marshall et al. 2010, 7). This is an important issue in view of the general over-optimism concerning the technology discussed above, as well as the untested claims of efficacy that are often made by GDO developers. To what extent can claims of efficacy (as well as risks) be contested in debate about new technologies? How can potential participants, who may lack resources and technical expertise, raise concerns about efficacy that are not dismissed by the scientists who have a vested interest (financial, or otherwise) in promoting such technologies? Finally, can people have any influence on research investments and the exploration or implementation of alternatives? These issues are discussed further in Section 10.

In some cases, power imbalances may occur not only between 'experts' and local people, but also between the relatively well-funded scientists promoting an open release of GDOs and local scientists or medical experts. Okorie et al. (2014) interviewed 164 scientists selected from academic and research institutions in Nigeria and found that a majority (83.5%) of the local scientists who participated in their study were sceptical about a potential release of GM mosquitoes in Nigeria. Further, 92.7% of these scientists would require contingency measures to be available to remove the GM mosquitoes "should a hazard become evident during the course of the release" (Okorie et al. 2014, 1).

Looking beyond debate about the benefits and risks of the experiment itself, Marshall et al. noted that some of their interviewees in Mali seemed to accept the proposed GM mosquito project for reasons unrelated to their actual feelings about the technology, in this instance "based on the expectation that they will get a hospital in return" (Marshall et al. 2010, 11). They also noted the limited participation of women in their study.

In the case of Target Malaria, concern about the process of informed consent is exacerbated by evidence that the company is paying 400 CFA francs (approx. 70 cents US) per hour to people collecting biting female mosquitoes from their own bodies (Flanagan 2018). Volunteers are required to sit for 6 hours in a room at night with the lower part of their leg exposed up to the knee, so that the mosquitos land and they can collect them with a suction tube (Target Malaria Burkina Faso and IRSS 2017). The use of a financial incentive to induce individuals to expose themselves to biting female mosquitoes, that is, potentially to contracting malaria, is ethically very questionable, and highlights a power imbalance between the researchers and research participants underpinned by great financial inequalities.

An independent report from Burkina Faso has detailed further concerns. It found that many people in the country are concerned about the potential impacts of Target Malaria's project and about the absence of risk assessment by the regulators, and are unaware of many of the details of the project, including where the funding for the project comes from (Fuhr 2018).

Target Malaria's lead funder, the Gates Foundation, is one of the largest on earth and extremely influential. Whilst its generosity has been widely praised (it spends more on global health every year than most countries), it has also been criticised for unknown efficacy, since the process is answerable only to the Gates family and therefore lacks accountability and transparency. This foundation has also been accused of what some regard as questionable priorities, in particular, too much emphasis on technology and technological fixes. It also supports strong intellectual property (IP) protections within these supposedly philanthropic projects. Finally, few people involved are willing to speak on the record about any concerns in these and other regards because they are being funded by the foundation (Belluz 2015). Emails released as a result of Freedom of Information requests and published as the *Gene Drive Files* reveal that a previously undisclosed gene drive "advocacy coalition" was run by a private PR firm, which received $1.6 million in funds from the Bill and Melinda Gates Foundation. The firm is on record at the UN for employing covert lobbying tactics to influence expert UN discussions (Gene Drive Files 2017c).

There is little public information regarding the consent process used by Target Malaria. However, NGOs and journalists have reported concerns about other power imbalances, including from a woman highlighting her difficulties from within the community asked to give its consent, who told Le Monde "In any case, we do not have our say, it is the men who make the decisions here" (Dossou 2018; Douce 2018; Noisette 2018).

Power imbalances can also influence regulatory processes. In 2012, a group of NGOs published a report detailing how Oxitec had infiltrated decision-making processes around the world with a view to influencing regulations, guidelines and decision-making about the release of genetically modified insects (GeneWatch UK 2012). Subsequently, the European Ombudsman found that one of the experts involved in developing guidance for the risk assessment of GM insects in the EU had failed to declare relevant conflicts of interest (European Ombudsman 2015).

Thus, power imbalances may affect the regulatory framework and who is asked for their input to decisions, as well as influencing whose voices end up being heard and, ultimately, what decisions are taken.

8 Precautionary Principle

8.1 The need for a precautionary approach

A precautionary approach involves adopting a cautious attitude towards risk that takes pre-emptive measures to avoid harm (see Box 1 in Chapter 4: Ethics and Governance). It is an explicit commitment for all signatories to the UN Convention on Biological Diversity (CBD) and its Cartagena Protocol.

8.2 Brief history of the Precautionary Principle

Although the Precautionary Principle was originally anchored in the concept of prevention used in medicine, it has expanded its intrinsic notions of prevention into a general rule of public policy action and participation in matters that represent potential threats to health and the environment. According to Harremoës et al. (2001), writing on the history of the Precautionary Principle, the concept arises from the German *Vorsorgeprinzip* first introduced in 1974 by the German Clean Air Act. Since this date, the principle has been progressively integrated in political agendas and international agreements, expanding not just the scope and range of the principle, but also its names, which has resulted in a sometimes confusing discussion over terminology.

Wynne (2002, 469) argues that scientific risk discourse wrongly implies that risk analysis identifies all significant future consequences of the relevant actions. It thus ignores (or "deletes") ignorance and the unanticipated consequences – lack of control – lying beyond the reach of existing scientific knowledge. Wynne (2002, 465) argues that the dominant risk discourse also excludes many other questions, which he distils into three general types: 1.) other issues and interconnections, such as driving purposes, intended social benefits, and conditions (e.g. of ownership, implementation, investment and control, regulation and accountability); 2.) what is meant by 'the technology' as putative 'cause' of possible impacts; and 3.) are the consequences or questions even answerable, and if not, what then?

Stirling highlights that, "precaution is not simply about acting to stop something, but introduces instead a responsibility for more careful and explicit reasoning over what kinds of action might be appropriate" (Stirling 2016, 5). Further, "In particular (and unlike idealised notions of 'sound scientific' risk assessment), it embodies an awareness of the asymmetries and inequalities of the power relationships that bear on processes of regulatory appraisal and help to shape the fabrics of the knowledges produced within them" (Stirling 2016, 5). Therefore, "the Precautionary Principle requires more explicit, scientifically rigorous and socially sophisticated attention to the implications of incomplete knowledge, than is routinely provided in the conventional regulatory assessment of 'risk'" (Stirling 2016, 6).

According to Harremoës et al. "The precautionary principle is an overarching framework of thinking that governs the use of foresight in situations characterised by uncertainty and ignorance and where there are potentially large costs to both regulatory action and inaction" (Harremoës et al. 2001, 192). Harremoës et al. describe twelve 'late lessons', based on an analysis of case studies, which highlight the importance of heeding 'early warnings' and taking a precautionary approach. Their case studies include examples of harm caused by X-rays; lead (and lead substitutes) in petrol; asbestos; poorly managed fisheries; 'mad cow' disease (BSE); radiation; and various chemical pollutants. The lessons drawn by the editors of the report are:

1. Acknowledge and respond to ignorance, as well as uncertainty and risk, in technology appraisal and public policymaking.

2. Provide adequate long-term environmental and health monitoring and research into early warnings.

3. Identify and work to reduce 'blind spots' and gaps in scientific knowledge.

4. Identify and reduce interdisciplinary obstacles to learning.

5. Ensure that real world conditions are adequately accounted for in regulatory appraisal.

6. Systematically scrutinise the claimed justifications and benefits alongside the potential risks.

7. Evaluate a range of alternative options for meeting needs alongside the option under appraisal, and promote more robust, diverse and adaptable technologies so as to minimise the costs of surprises and maximise the benefits of innovation.

8. Ensure use of 'lay' and local knowledge, as well as relevant specialist expertise in the appraisal.

9. Take full account of the assumptions and values of different social groups.

10. Maintain the regulatory independence of interested parties while retaining an inclusive approach to information and opinion gathering.

11. Identify and reduce institutional obstacles to learning and action.

12. Avoid 'paralysis by analysis' by acting to reduce potential harm when there are reasonable grounds for concern. (Harremoës et al. 2001, 168–169)

The most frequent argument coming from opponents to the application and expansion of the Precautionary Principle has been that it slows or even interrupts the innovation and development process. But as the editorial team from "Late lessons from early warnings: the precautionary principle 1896-2000" (Harremoës et al. 2001) has demonstrated, there is no empirical evidence to support such an argument. On the contrary, according to the editorial team and based on the fourteen case-studies that are the basis of their argument, the Precautionary Principle will only restrict innovation in some questionable technologies, while creating the space to foster innovation in other directions. These favoured technologies are often ones which may not be under the control of, or are otherwise not favourable towards, global industrial interests and their particular investments. This has demonstrated that curtailment of a particular option may actually serve to foster and intensify innovation, but in other areas (Harremoës et al. 2001, 182). The actual objection to applying the Precautionary Principle really seems to be that the technological pathways developed under it may not be the ones endorsed today by corporate and private interests. Stirling (2016) argues that precaution is about steering innovation, not blocking it, as innovation can take many different pathways. He concludes "In the end, precaution is identified to be about escaping from technocratic capture under which sectoral interests use narrow risk assessment to force particular views of the world. What precaution offers to enable instead is more democratic choice under ever-present uncertainties, over the best directions to be taken by innovation in any given field" (Stirling 2016, 2).

8.3 Application of the Precautionary Principle to research

The dominant linear and reductionist approach to risk assessment is problematic, especially because of the many ambiguities, complexities and indeterminacies inherent in human knowledge. The twelve lessons above, highlighting problems which can occur due to the lack of application of a precautionary approach (Harremoës et al. 2001), have in fact demonstrated that science may be insufficiently reflexive and critical about the potential good and harm caused by its activities. The optimistic aura surrounding the promises of science and technology along with the excessive expectations that aura has fostered, has perhaps obscured the capacity to accept the fact that ignorance, uncertainty and risk are part of the scientific system. The current atmosphere accompanying any new technology (which is "hyped" in order to stimulate acceptance and funding), has created a distinction between how scientific uncertainty and change are accepted within the scientific community, compared with how they are downplayed outside it. These true descriptions of how science works tend to disappear when scientific researchers seek to provide society with unrealistic certainties in order to gain funding.

Stirling details how "various forms of the precautionary principle serve, in many specific ways, to help foster more transparent and deliberate democratic decision making concerning the steering of alternative directions for innovation" (Stirling 2016, 17). He concludes that, "By contrast with the technocratic procedures of risk assessment, precaution is about greater democracy under uncertainty" (Stirling 2016, 17).

The application of the Precautionary Principle at the level of project design may discourage some pathways of development, but it would provide researchers with the ethical and responsible principle of channelling alternative routes to scientific innovation and discovery, covering gaps in knowledge and fostering new discoveries. As a necessary stage to responsible technological development, it not only represents a strong commitment to the well-being of the population and systems affected, it also prevents the waste of resources on expensive interventions, lukewarm mitigation strategies and unnecessary and non-useful data gathering, that typically follow when technologies are adopted without due regard to the need to make precautionary decisions in a context of uncertainty. It promotes a scientific pathway that embraces complexity and uncertainty with more humility and less hubris.

The impact of the application of the Precautionary Principle on all technological research would not only favour science and policies regarding health and the environment. It has the potential of reinforcing democratic principles, by rebuilding trust between politicians, scientists and the public. When it comes to gene drives, this implies that alternative trajectories of innovation must be part of the debate, and that consideration of alternatives must occur not only at the point at which GDOs might be released into the environment, but also at very early stages, when research priorities are being set.

8.4 Precautionary Principle for GDOs

When GDOs are the subject of debate, the Precautionary Principle is often invoked, but rarely developed. An example may be drawn from the 2016 National Academies of Sciences, Engineering, and Medicine (NASEM) report "Gene Drives on the Horizon: Advancing Science, Navigation Uncertainty, and Aligning Research with Public Values".[6] Although the report mentions the Precautionary Principle a few

6 This report was requested by the National Institutes of Health and the Foundation for the National Institutes of Health to the Board on Life Sciences of the National Academies of Sciences, Engineering, and Medicine.

times, it gives more attention to its technical aspects rather than its ethical, philosophical and political dimensions. For example, it sometimes focuses on the principle as being useful at the stage of testing and environmental release, stating that uncertainties in the case of GDOs are structural to this phase of the technology development. In this matter, the experts contributing to the report promote the idea that a step-by-step assessment is necessary; however, they never question the necessity of developing such technologies in the first place, through applying the Precautionary Principle to research.

The authors also refer to the asymmetries among countries regarding the Precautionary Principle and the instruments available to regulate and govern GMOs. These may pose a barrier when it comes to national cooperation on research and assessment of GDOs, and also create asymmetries of power when it comes to definitions of ethical standards.

Beisel and Boëte note that regulation of GM mosquitoes with self-spreading genetics (such as GDOs), "is considered almost impossible, or at the very least extremely difficult" (Beisel and Boëte 2013, 50). Further, "GM mosquitoes and other public health measures to control malaria will not be able to coexist", because this strategy actually *relies on people fostering the survival and spread of the GM mosquitoes*, rather than avoiding and killing them as would normally be the case with other public health measures, such as using bed nets or removing breeding sites (Beisel and Boëte 2013, 53). Beisel and Boëte note that GM mosquito strategies are "particularly vulnerable to unforeseen effects and ecological uncertainties", (Beisel and Boëte 2013, 53) for example:

- it is unknown how (and how quickly) mosquito and parasite populations would react to the introduction of GM mosquitoes;
- it is unknown how many species would need to be transformed in order to interrupt the transmission of the malaria parasite;
- significant ecological uncertainties are inherent to the complex and shifting disease ecologies of malaria.

These concerns will also apply to other GDOs, not just mosquitoes, due to the intention that they spread and replicate in the environment. In effect, the open release of GDOs is intended to re-engineer whole ecosystems, and therefore the role of the Precautionary Principle is particularly important.

9 Who is liable if anything goes wrong?

Issues of liability are covered by the Nagoya-KL Supplementary Protocol on Liability and Redress, and, in addition, individual states have a responsibility under international law to not cause harm to the environment of another State. However, liability and redress is a critical if still deficient component in the regulatory toolbox. Deficiencies include the long term, irreversible nature of potential harm, and the difficulties in establishing proof of any damage and its source.

In releases of GM insects to date, one concern has been the use of in-country partners (by both Oxitec and Target Malaria) to make the applications to regulators, and the absence of transboundary notifications published by the exporter (see Section 7.3). Depending on whether the developer or the in-country partner is defined as the 'operator' in national law, this could mean that the in-country partner is held liable if anything goes wrong, allowing the developer (usually based in a rich country) to walk away and not take the responsibility or bear the costs of any future harm.

The difficulties in establishing liability may be exacerbated by gene drives spreading across national boundaries, with potentially long-term effects.

10 Public engagement

There is recognition by academics working in the field, such as Brossard et al. that "Deciding to use gene drives to control and suppress pests will involve more than a technical assessment of the risks involved, and responsible decision-making regarding their use will require concerted efforts from multiple actors" (Brossard et al. 2019, 1). They recognise that "technical expertise is not enough to address the complexities surrounding a scientific issue that has not only technical but also social, ethical, and legal dimensions" (Brossard et al. 2019, 1). They further note that "Editing pernicious genes to make a disease-causing mosquito, or a pathogen-carrying rodent, less harmful sounds like an appealing idea. But there are serious questions about the ethics of engineering a wild species and about potential environmental consequences that might change ecosystem dynamics or spread well beyond the specific targeted location" (Brossard et al. 2019, 2). Brossard et al. also argue that "Engagement about gene drives should aim to foster open, substantive dialogue between all interested and affected individuals in areas where the technology may be used" (Brossard et al. 2019, 4).

The history of Public Engagement of Science (PES) is vast and it has gone through several changes since it was first proposed by an official scientific/political body at the turn of the millennium (House of Lords Science and Technology Committee 2000). Today, PES is no longer just the ethical responsibility that scientists owe society; it is part of basic research design, expected to bring benefits to scientists' careers as well as to society. Some argue this is a win-win situation, with the optimistic claim that its theoretically two-way communication between publics and scientists generates mutual understanding and greater trust.

However, because the theory of PES is rooted in a process of sharing and mutual learning, any experience of engagement must be anchored on the premise that society (in its forms of organisation) has "ways of knowing" and also deep concerns that may differ substantially from those of science. In other words, society has methodological and epistemic resources that sometimes may diverge from those used by scientists.

10.1 Alternatives to a 'pathway for acceptance'?

For a long time, institutions have been defining the wrong questions and making the wrong assumptions when it comes to public engagement. Rather than seeing engagement as a democratic right, most of the initiatives taking place approach the provision of information to the public as primarily an attempt to create a system will does not generate controversy or resistance to scientific and technological outcomes. This means that the goal of public engagement as we know it is not democratic, but simply a 'pathway for acceptance', which does not allow for the option of rejecting a particular technology or approach and instead choosing alternative approaches.

This bias of public engagement in science is reflected in some of the initiatives already implemented. For example, it's not rare to find that the feedback from those engaged in deliberative forums often reflects feelings of disappointment, loss of time and feelings of impotence (PSx2 2008). One of the main reasons people experience these negative feelings regarding their engagement with science is that the apparatus for participation rarely reflects how most people would wish to approach the actual use of the technology. Others may even report exhaustion, especially when people are enrolled in a continuous process of participation that doesn't produce any achievable outcomes relevant to their own interests.

Stirling (2014) argues that if public engagement exercises around innovation, including gene drives, are to be credible and robust, they should not be restricted to issues of risk or safety alone, nor confined merely to the ways in which a new technology 'should' or is expected to work; nor should they assume that the technology will be introduced in any case, whatever the outcome of the public engagement.

Stirling et al. (2018) discuss risk, participation and democracy in the governance of new synthetic biology and gene drive technologies. They argue (Stirling et al. 2018, 44) that genuine empowerment of all affected parties actually interested in making better choices differs from 'instrumental' participation, which is simply about engineering pre-existing aims (such as: fostering trust; providing justification; securing acceptance; and managing blame). Stirling et al. (2018, 44) therefore consider how regulatory assessment of gene drives can move from a purely risk-based analysis to diverse and more substantive processes of 'social appraisal'.

This same article also emphasises that appraisal should devote symmetrical attention to all practical alternatives and offer a balanced picture of associated pros and cons as seen by the affected stakeholders – particularly those having no commercial interest in the technology under consideration (Stirling et al. 2018, 46). Questions around benefit and harm must be directed to the potential pros and cons associated with a diverse array of alternative policy options. These pros and cons would highlight the importance of embedding risk-based assessment in a broader social appraisal that includes public participation. Real participation must recognise: a.) that some level of ignorance will always exist with a new technology; and b.) that a substantive social appraisal entails value-based judgements that probabilistic risk assessment techniques are not designed to address (Stirling et al. 2018, 48).

Leach et al. (2010) point out that technological fixes frequently fail to work and create further problems because they are most often modelled in labs or on computers, methodologies which do not reflect the complexity of real world situations. These authors argue in favour of offering a broader range of options at such participatory sessions, described as "multiple potential pathways to sustainability". Such an approach draws attention to the contrast between "dominant" and "alternative" narratives. For example, for infectious disease epidemics, the dominant narrative is that outbreaks are threatening humanity and need to be controlled through surveillance and technological solutions. An alternative narrative might be that "underlying causes need to be tackled, requiring a rethink of surveillance and diverse social, cultural, ecological and technological responses" (Leach et al. 2010, Table 7.3). According to Leach et al. (2010), that would lead to greater recognition of uncertainty and would empower approaches more rooted in local needs that feature more equitable, socially distributed outcomes. They list five key principles for appraisal for sustainability:

- Include a diversity of types of knowledge through participatory engagement;
- Extend scope and enable choice;
- Take a dynamic perspective, accept incomplete knowledge;
- Attend to rights, equity and power; and
- Be reflexive (Leach et al. 2010, Table 5.3).

The dominant versus alternative narrative is clearly visible in the case of GDOs, for example in proposals to release gene drive mosquitoes as a proposed technological solution to tackle malaria, as there are many other approaches that might work better with less risk. Leach et al.'s (2010) five key principles are therefore essential requirements for public engagement to be meaningful.

Ely et al. argue that technology assessment practices can serve to unjustifiably 'close down' debate, "failing adequately to address technical uncertainties and social ambiguities, reducing scope for democratic accountability and co-ordination across scales and contexts" (Ely et al. 2013, 1). They note that "existing efforts in technology development and wider innovation are typically most strongly steered by incumbent interests, which often do not match those of the most vulnerable groups, and frequently fail fully to account for social, technical and ecological complexities and uncertainties" (Ely et al. 2013, 1). They argue in favour of "broadening out" and "opening up" technology assessment. By 'broadening out', they mean including a variety of options, policies, methods of analysis, uncertainties, and so on (Ely et al. 2013, 2). By 'opening out', they mean communicating the results of the analysis more widely and in a way which allows for different interpretations, rather than giving a single answer (Ely et al. 2013, 2).

Campos et al. (2017, 14) describe how the multiple programmes of 'community engagement' undertaken during the open field releases of Oxitec's GM mosquitoes in Brazil served primarily to 'publicise' the releases, rather than to examine the fundamentally political choice about whether to pursue a biotechnological strategy of vector control, or whether to explore the conditions of public acceptability prior to a decision to deploy this technology. Campos et al. note that the processes of 'community engagement' promoted by the sponsors of Oxitec's GM mosquitoes in Brazil "neither encouraged inclusive deliberation nor gave rise to opportunities for responsiveness to public concerns on the part of innovation actors" and also note, "At the same time, the regulatory system never explicitly reviewed public expectations or concerns in its assessment of OX513A mosquitoes" (Campos et al. 2017, 3). Campos et al. argue that "the complex and conflict-ridden trajectory" of GM mosquitoes in Brazil "serves to highlight the role that political accountability must play in any effective implementation of the principles of Responsible Innovation" (Campos et al. 2017, 2). By political accountability, they mean "a set of mechanisms, institutional or otherwise, that render open to public scrutiny and debate the rationales that actors in positions of political authority draw on to support certain innovation trajectories", including, but not limited to, regulatory approval and community consent (Campos et al. 2017, 3).

Below, we consider some aspects of this problem.

10.1.1 Need for engagement in the definition of a problem and for 'broadening out' societal appraisal

Several aspects of today's current paradigm of engagement are responsible for the frustrations described above. One is the fact that participation intended to generate acceptance does not engage people in the first place in a clear definition of what the problem actually is for which their assessment is needed. For example, holding a public consultation, as part of gaining authorisation to market new genetically modified crops, may allow farmers to expose their concerns regarding the impact of these technologies in their production but it never asks the farmers what actual problems they're facing in the first place. Problems are, in public engagement of science and technology, defined *a priori* by the consultation, participation or deliberation spaces, and by the scientists and promoters who have already decided on what they are. The reason for this is that the hegemonic paradigm of participation or engagement sees citizens as objects and not as subjects of the discourse. As Wynne (2003) has described, in contemporary policy culture, it is problematically not ordinary public citizens, but scientific experts who are assumed to be the proper authors of "public meanings" (the accepted meaning of public issues, especially those involving 'science', for policy to manage).

This problem has led Civil Society Organisations to call for opportunities for participation to be provided from *the very beginning* of the process, which would then include the question of how funding for scientific research is allocated (PSx2 2008, 31). In the case of GDOs, this would mean opening up the question of research priorities to much earlier, more in-depth, discussions.

Unfortunately, most of the institutions that fund research promote only a limited forum for engagement. Discussion of what kinds of projects should be considered for a funding call is currently rarely open to the engagement of the affected public. There is a need to recognise that public engagement should be a fundamental part of the preliminary phases; that is, when the whole complex of funders, innovation stakeholders and researchers engage in an exclusive and elite process in which they pose and develop a question for R&D.

Engaging society in debates about GDOs has many challenges, as does any initiative trying to include public engagement with scientific innovation. These challenges have been identified within the recurrent debates over the impact of new technologies with effects that are highly uncertain. One example, which is also stressed in the NASEM (2016) report, is: which groups should engage in the participatory initiatives of GDOs risk assessment? It is widely recognised that people affected by the technology have a strong interest in being able to join engagement initiatives; but the communities engaging in this participatory process are often vulnerable, that is, at serious disadvantages compared to the researchers and promoters. In the case of GDOs seeking public approval for release that promise to reduce or control an infectious disease, that vulnerability is constructed around the fact that they are the ones being affected by this disease. This fact may of course make such a public more liable to accept technologies that promise to eliminate the disease than those who are not affected. This may not mean they desire the technology, only that they are too vulnerable to oppose it.

Although the idea of public engagement in decision-making is accepted by most of the scientists and experts working in risk assessment with human communities, there is a fundamental bias in their vision of how this should work. They often assume that these communities are *inactive* regarding the disease concerned. This is often not true, which represents a challenge to mainstream strategies of engagement that mostly begin from the false premise that there are no local risk assessment strategies already being implemented, or that those in existence are based in ignorance and therefore do not serve to address the problem. When considering the engagement of communities, we should not only take into consideration the condition of the scientific research, we also need to engage in debates concerning value and power relations.

Discussing releases of GM mosquitoes intended to tackle dengue, Nading notes that, "Ethics that appeal to risk calculated in nested regulatory institutions, a standardizable body or an idealized 'nature', prevent us from asking, 'What if resources were put toward changing the conditions that make the environments of Grand Cayman, Bahia, Kuala Lampur and Key West (not to mention less research-ready spaces such as Managua and Manila) dengue-endemic in the first place?' In other words, these discourses divert our attention from the fact that dengue the disease, like the GM organism that would be its cure, is a product of uneven, though by no means unchanging, political and economic relations" (Nading 2015, 41).

When addressing the scientific questions regarding GDOs, rather than enquiring whether GDOs may cause unintended effects, we should ask ourselves at the earliest stages: 'How well do we know the diseases we are targeting? How well do we understand the complexity of the ecology of the target populations? Are these diseases *only* transmitted by certain vectors? Which disciplines do we need to engage in the development of such technologies?'

For example, according to the Target Malaria project, it seems that medicine and public health professionals are not included when these outreach teams are constituted. As we see from their website, the team mostly consists of biologists, geneticists and engineers, with a clear absence of health professionals. Such a team composition seems an odd choice, considering the promises made about these GDOs primarily concern improved human health. Furthermore, as is stressed in the NASEM (2016) report, communities also have their own 'ways of knowing' when it comes to these scientific questions, which means we should not only promote the exchange of knowledge, we should incorporate their knowledge in the apparatus of participation, the definition of the questions, the project design and its implementation and periodic review. We should also be prepared to fail; that means that engagement must not be conducted within the premise that the technology will be accepted, that it only needs some small modification and technical instruments for assessment to achieve that invariable goal. We must be prepared to reject these technologies, not just in favour of alternatives that may already exist, but also in favour of alternative paths of development for the future.

10.1.2 The need for problem-led engagement

A related issue is the need for engagement to be problem-led, not technology-led. One of the major critiques of today's methods of scientific production of knowledge is that they are mostly oriented in order to serve their internal technological apparatus, rather than to seriously consider a problem or scientific challenge that needs to be addressed.

For example, the NASEM (2016) report reflects this problem. This report, which tried to "create a consensus to summarize the current understanding of the scientific discoveries regarding gene drives" (NASEM 2016, vii), not to mention its subtle contradictions, assumes that problems regarding the impacts that could conceivably be caused by gene drives are mainly to be solved by adapting new versions of the same technology. For example, it's often highlighted in the report that one possible solution regarding the impact of gene drives is to introduce *another* genetically modified mosquito (with the as yet non-existent "reversal drives"), even when the authors accept that these, even if eventually perfected, may create impacts of their own.

In contrast, problem-led research is based on posing fundamental questions about a given problem. If we accept uncritically that a technology is the best (or only) solution to complex phenomena such as famine or disease, we will be trapped in the current socio-technological apparatus. As Kloppenburg (2005) has argued, this bias generates a scientific contradiction. The contradiction is simple: the socio-technological bias of modern society (and consequently of modern science) is based on the desire to continuously revolutionise the means of production and consumption. Project applications for funding reflect this essentially economic goal.

Researchers have all faced that blank space in grant application forms, which requires an answer to questions such as: What is the novelty of your approach? Which new products does your research generate? What is the intrinsic value of your project? To these questions only a few will risk answering with "old", non-technological approaches (such as traditional, indigenous and local knowledge). Researchers tend to ignore them; they are no longer in fashion. The choices we are led to make by a technology-oriented approach makes us ignore tested methodologies built by our own communities. With time, and because research tends to move in the direction of innovation, some of this important knowledge is forgotten. This represents a creative form of destruction of memory and experience, opening a gap of open enquiry within the fabric of the scientific enterprise.

A broader approach would begin with different definitions of the problem that is being investigated (such as the challenge of tropical disease), especially to those problems involving social actors, and a serious consideration of all the alternatives that could be used or developed in order to tackle it, including social measures such as alleviating poverty or lack of access to clean water. In the context of GDOs, this means that public engagement should never begin with the promotion of a claimed technological 'solution'.

10.1.3 The need to avoid unrealistic promises

As noted above in Section 5, unrealistic promises distort public engagement in debates about new technologies. For credible public engagement to take place, uncertainty about what can be delivered needs to be openly acknowledged and unrealistic promises must be avoided.

If public engagement exercises are framed in a way that implies tremendous benefits are likely (or even inevitable) if open releases of GDOs are permitted, this limits the space for discussion of the complexity of such an approach and its dependence on numerous unverified assumptions. It also does not address the issue of the opportunity costs associated with investing in any approach that might not deliver the claimed outcomes. Over-hyped claims of future benefits may also prevent some concerns from being included in the framing of the discussion (because, by definition, the gene drive organism is pre-supposed to be successful and therefore any harms associated with its failure are excluded from debate).

Addressing the issue of unrealistic promises also requires new approaches to the governance of science in order to regulate the 'political economy of promise' currently shaping scientific culture in the public interest. This has not even been posed as a problem to be addressed, let alone been subject to collective analysis and deliberation.

10.1.4 The need for inclusiveness and responsiveness

Civil Society Organisations have argued that the innovation process needs to be opened up so that all stakeholders have enough time to consider the implications of a new technology (PSx2 2008, 30-32). Everyone should be able to participate at some level and in some capacity; this would necessarily include Civil Society Organisations. Participation needs to be on an equal footing in order to address unequal power relations, and public concerns must be listened to and taken into account (i.e. the process must be responsive).

Due to issues with power imbalances, there is a particular need to include marginalised groups. Furthermore, 'inclusiveness' must not mean a simple invitation to speak, but a genuine opportunity to shape agendas, including research agendas, and to affect decisions. This should include *a right to refuse to take part in a particular project, and to propose and explore alternative approaches.*

The challenges of engagement in debates regarding GDOs are particularly great, due to this technology's potentially invasive, international and irreversible effects.

10.1.5 Role of scientists and 'counter-expertise'

Suppression of dissenting scientific voices has long been the norm in science (Martin 1999; Delborne 2016). The goal of this suppression is not just a defence of the rationality of the scientific system. It is equally a professional defence of the curtain of authority and power that separates science from society. That curtain makes sure that the roles for engagement are decided by the field of the "Us", that is, the protagonists for an innovation, and that the "Others" are the ones who need to adapt in order to participate.

Civil Society Organisations have argued that 'counter-expertise' plays an important role in exposing bias and enabling alternative perspectives to be heard (PSx2 2008, 31). However, there cannot be counter-expertise without funding and resources. Transparency and two-way exchanges of information, open-mindedness and genuine engagement are also essential for societal knowledge-development and learning. Debates both within and about science should involve different opinions/viewpoints and a plurality of expertise and recognition of other types of knowledge that take into account minority experiences and voices.

This means that another model of engagement is needed. Some alternatives have been initiated by groups of critical scholars in an interdisciplinary way (e.g. Nunes et al. 2014). These initiatives take into account many facets of society and of its communities and groups, including economic, social and cultural aspects. When a researcher approaches engagement from a critical and self-reflective perspective, mutual learning can take place; the movement of knowledge then becomes a flux and not a linear process. The tools and the apparatus for participation are both built on the people's forms of organisation and in their values and concerns. However, this effort requires time and resources.

11 Conclusions

In this chapter, we have considered the political economy of GDOs, including how research is patented and funded, and how funding concerns lead to unrealistic claims about what researchers can deliver. Gene drive R&D is still in its infancy and far from any field trials. Many claims about future benefits of gene drives portrayed in media, scientific publications and patent applications thus at best seem premature. Public discussion is often limited to speculative health and conservation applications, with the aim of focusing on those claimed benefits which appear more likely to attract public support.

We have explored how exaggerating effectiveness can lead to opportunity costs when alternative solutions are neglected, and how it can close down public debate about the best ways of developing salient knowledge collectively in order to tackle societal problems.

We then considered how issues such as obtaining prior informed consent have been undertaken by existing projects wishing to release genetically modified (GM) mosquitoes (currently without gene drive, but with some plans to include it in the future); and we noted serious limitations in these approaches. We discussed how power imbalances may affect the regulatory framework and who is asked for their input to decisions. We discussed liability and the Precautionary Principle and finally considered the issue of public engagement in decisions about research and development involving GDOs.

Public engagement has to take place at the very beginning of the process, when funders, innovation stakeholders and researchers define what a problem is and set R&D priorities. We conclude that social issues regarding GDOs can only be addressed by broadening the processes of public engagement with prevailing R&D and commercial interests, and by taking a properly precautionary approach. It is essential to acknowledge the extent of the ignorance and uncertainty embodied in the best of scientific understanding of the complexities of ecosystem and human health responses to the release of GDOs, and thus the unpredictability – and irreversibility – of the future effects of GDO releases. Alternative approaches to tackling problems must be part of public engagement with the scientific, regulatory and science policy debates, including questions about what kinds of research should be funded. Public debate should not be framed by unsubstantiated and unrealistic claims about what gene drives can deliver. Genuine empowerment of all affected parties in the interests of making better choices must not be conducted with the premise that the technology will be accepted and that it only needs some small modification and technical changes to achieve that goal. Society must be prepared to reject these technologies, not just in favour of alternatives that may already exist, but also in favour of alternative paths of development for the future.

References

Abbasi, Jennifer. 2016. "National Academies Hit the Brakes on Gene Drive–Modified Organisms." *JAMA* 316 (5): 482–83. https://doi.org/10.1001/jama.2016.8830.

ACB et al. 2018. "GM Mosquitoes in Burkina Faso: A Briefing for the Parties to the Cartagena Protocol on Biosafety." African Centre for Biodiversity, Third World Network, GeneWatch UK. http://www.genewatch.org/uploads/f03c6d66a9b354535738483c1c3d49e4/GM_mosquito_report_WEB.pdf.

Amin, Latifah, Jamaluddin Md Jahi, Abd Rahim Md Nor, Mohamad S. Osman, and Muhammad Mahadi Nor. 2007. „Public Acceptance of Modern Biotechnology". *Asia-Pacific Journal of Molecular Biology and Biotechnology* 15 (2): 39–51.

Anderson, Craig J., John G. Oakeshott, Wee Tek Tay, Karl H. J. Gordon, Andreas Zwick, and Tom K. Walsh. 2018. "Hybridization and Gene Flow in the Mega-Pest Lineage of Moth, Helicoverpa." *Proceedings of the National Academy of Sciences of the United States of America, PNAS* 115 (19) 5034-5039. https://doi.org/10.1073/pnas.1718831115.

Barkan, Joanne. 2013. "Plutocrats at Work: How Big Philanthropy Undermines Democracy". *Dissent Magazine*. https://www.dissentmagazine.org/article/plutocrats-at-work-how-big-philanthropy-undermines-democracy (accessed February 27th 2019).

BBC. 2018. "Village Gets Ready for 'Hacked' Mosquitoes." BBC World Service - Newsday. October 19, 2018. https://www.bbc.co.uk/programmes/p06p2x6w (accessed March 31st 2019).

BBSRC 2017: "Experts are to investigate how genetic techniques could be applied to help control pest species." https://bbsrc.ukri.org/news/research-technologies/2017/171205-n-gene-experts-set-to-tackle-pest-control/ (accessed January 30, 2019).

Beisel, Uli, and Christophe Boëte. 2013. "The Flying Public Health Tool: Genetically Modified Mosquitoes and Malaria Control." *Science as Culture* 22 (1): 38–60. https://doi.org/10.1080/09505431.2013.776364

Belluz, Julia. 2015. "The Media Loves the Gates Foundation. These Experts Are More Skeptical." *Vox*, June 10, 2015. https://www.vox.com/2015/6/10/8760199/gates-foundation-criticism (accessed February 27, 2019).

Benedict, Mark, Michael Eckerstorfer, Gerald Franz, Helmut Gaugitsch, Anita Greiter, Andreas Heissenberger, Bart Knols, Sabrina Kumschick, Wolfgang Nentwig, and Wolfgang Rabitsch. 2010. "Defining Environment Risk Assessment Criteria for Genetically Modified Insects to Be Placed on the EU Market." EFSA Supporting Publications 7 (8): 71E. https://doi.org/10.2903/sp.efsa.2010.EN-71.

Bevins, Vincent. 2012. "Dengue, Where Is Thy Sting?" *Los Angeles Times*, November 1, 2012.

Bier, Ethan, and Valentino Gantz. 2016. "Methods for Autocatalytic Genome Editing and Neutralizing Autocatalytic Genome Editing." WO/2016/073559, issued May 13, 2016. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2016073559&redirectedID=true

Binimelis, Rosa, Walter Pengue, and Iliana Monterroso. 2009. "'Transgenic Treadmill': Responses to the Emergence and Spread of Glyphosate-Resistant Johnsongrass in Argentina." *Geoforum* 40 (4): 623–33. https://doi.org/10.1016/j.geoforum.2009.03.009.

Boëte, Christophe. 2018. "Letter: Gene Drive and Trust in Science: " in *GeneWatch: a bulletin of the Committee for Responsible Genetics*, 31 (1): 18-19.

Bohnenblust, Eric W., Anthony D. Vaudo, J. Franklin Egan, David A. Mortensen, and John F. Tooker. 2016. "Effects of the Herbicide Dicamba on Nontarget Plants and Pollinator Visitation." *Environmental Toxicology and Chemistry* 35 (1): 144–51. https://doi.org/10.1002/etc.3169.

Boston 25 News. 2017. "MIT Researchers Propose Release of Genetically Engineered Mice on Nantucket." MIT Media Lab. October 18, 2017. https://www.media.mit.edu/articles/mit-researchers-propose-release-of-genetically-engineered-mice-on-nantucket/ (accessed March 31st 2019).

Bradley, Kevin. 2017. "A Final Report on Dicamba-injured Soybean Acres." *University of Missouri, Integrated Pest Management*. October 30, 2017

Bradley, Kevin. 2018. "July 15 Dicamba injury update. Different Year, same questions." *University of Missouri, Integrated Pest Management*. July 19, 2018.

Brossard, Dominique, Pam Belluck, Fred Gould, and Christopher D. Wirz. 2019. "Promises and Perils of Gene Drives: Navigating the Communication of Complex, Post-Normal Science." *Proceedings of the National Academy of Sciences of the United States of America*, January. https://doi.org/10.1073/pnas.1805874115

Bubela, Tania M., and Timothy A. Caulfield. 2004. "Do the Print Media 'Hype' Genetic Research? A Comparison of Newspaper Stories and Peer-Reviewed Research Papers." *CMAJ: Canadian Medical Association Journal = Journal de l'Association Medicale Canadienne* 170 (9): 1399–1407.

Burt, Austin. 2003. Methods for Genetically Modifying a Target Population of an Organism. WO/2003/038104, issued May 9, 2003. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2003038104

Campos, André Sica de, Sarah Hartley, Christiaan de Koning, Javier Lezaun, and Lea Velho. 2017. "Responsible Innovation and Political Accountability: Genetically Modified Mosquitoes in Brazil." *Journal of Responsible Innovation* 4 (1): 5–23. https://doi.org/10.1080/23299460.2017.1326257.

Champer, Jackson, Anna Buchman, and Omar S. Akbari. 2016. "Cheating Evolution: Engineering Gene Drives to Manipulate the Fate of Wild Populations." *Nature Reviews*. Genetics 17 (3): 146–59. https://doi.org/10.1038/nrg.2015.34.

Charpentier, Emmanuelle, Jennifer A. Doudna, Martin Jinek, Krzysztof Chylinski, James Harrison Doudna Cate, Wendell Lim, and Lei Qi. 2013. "Methods and Compositions for Rna-Directed Target Dna Modification and for Rna-Directed Modulation of Transcription." WO/2013/176772, issued November 29, 2013. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2013176772&redirectedID=true

Cayman News Service. 2018. "Minister Claims GM Mosquitoes Didn't Work," November 23, 2018. https://caymannewsservice.com/2018/11/gm-mosquitoes-didnt-work/ (accessed March 31st 2019).

Coetzee, Maureen, Richard H. Hunt, Richard Wilkerson, Alessandra Della Torre, Mamadou B. Coulibaly, and Nora J. Besansky. 2013. "*Anopheles Coluzzii* and *Anopheles Amharicus*, New Members of the Anopheles Gambiae Complex." *Zootaxa* 3619: 246–74.

Contreras, Jorge L., and Jacob S. Sherkow. 2017. "CRISPR, Surrogate Licensing, and Scientific Discovery." SSRN Scholarly Paper ID 2993190. Rochester, NY: Social Science

Research Network. https://papers.ssrn.com/abstract=2993190

Courtier-Orgogozo, Virginie, Baptiste Morizot, and Christophe Boëte. 2017. "Agricultural Pest Control with CRISPR-Based Gene Drive: Time for Public Debate: Should We Use Gene Drive for Pest Control?" *EMBO Reports* 18 (6): 878–80. https://doi.org/10.15252/embr.201744205.

Crisanti, Andrea, Catteruccia Flaminia, and Tony Nolan. 2001. "Transgenic Insect." WO/2001/044483, issued June 22, 2001. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2001044483&redirectedID=true

DARPA 2017. "Building the Safe Genes Toolkit." https://www.darpa.mil/news-events/2017-07-19 (accessed January 30, 2019).

Darrow, Mack, Eric Gastfriend, John Min, and Alex Sakatos. 2016. "Gene Drive Research Funding Recommendation Report for the Philanthropy Advisory Fellowship." Organized by Harvard University Effective Altruism Student Group on behalf of Thomas Mather. https://static1.squarespace.com/static/55f47404e4b06b1754d1df07/t/56d76c7a9f7266eea24f164b/1456958587552/PAF+GeneDriveFundingReport.pdf

De Freece, Chenoa, Léa Paré Toé, Fulvio Esposito, Abdoulaye Diabaté, and Guido Favia. 2014. "Preliminary Assessment of Framework Conditions for Release of Genetically Modified Mosquitoes in Burkina Faso." *International Health* 6 (3): 263–65. https://doi.org/10.1093/inthealth/ihu035

Delborne, Jason A. 2016. "Suppression and Dissent in Science." In *Handbook of Academic Integrity*, edited by Tracey Bretag, 943–56. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-287-098-8_30.

Dellaferrera, Ignacio M., Eduardo Cortées, Elisa Panigo, Rafael De Prado, Pedro Christoffoleti, and Mariel G. Perreta. (2018). "First Report of Amaranthus hybridus with Multiple Resistance to 2, 4-D, Dicamba, and Glyphosate." *Agronomy*, 8(8), 140. https://doi.org/10.3390/agronomy8080140

Diamond v. Chakrabarty, 447 U.S. 303 (1980).

DiCarlo, James E., Alejandro Chavez, Sven L. Dietz, Kevin M. Esvelt, and George M. Church. 2015. „Safeguarding CRISPR-Cas9 Gene Drives in Yeast". *Nature Biotechnology* 33 (12): 1250–55. https://doi.org/10.1038/nbt.3412.

Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the Deliberate Release into the Environment of Genetically Modified Organisms and Repealing Council Directive 90/220/EEC - Commission Declaration. 2001. 106. Vol. OJ L. http://data.europa.eu/eli/dir/2001/18/oj/eng

Dhole, Sumit, Michael R. Vella, Alun L. Lloyd, and Fred Gould. 2018. „Invasion and Migration of Spatially Self-Limiting Gene Drives: A Comparative Analysis". *Evolutionary Applications* 11 (5): 794–808. https://doi.org/10.1111/eva.12583.

Dossou, Modeste. 2018. "Burkina: des moustiques OGM contre le paludisme créent la controverse." *Benin Web TV* (blog). October 23, 2018. https://beninwebtv.com/2018/10/burkina-des-moustiques-ogm-contre-le-paludisme-creent-la-controverse/

Douce, Sophie. 2018. "Des moustiques OGM contre le paludisme: le projet qui fait débat au Burkina," June 29, 2018. https://www.lemonde.fr/afrique/article/2018/06/29/des-moustiques-ogm-contre-le-paludisme-le-projet-qui-fait-debat-au-burkina_5323380_3212.html (accessed March 31st 2019).

Dunning, Hayley 2017. "Malaria elimination project wins $17.5m funding boost." *Imperial College London*. https://www.imperial.ac.uk/news/179689/malaria-elimination-project-wins-175m-funding/ (accessed: January 30, 2019).

Eckhoff, Philip A., Edward A. Wenger, H. Charles J. Godfray, and Austin Burt. 2017. "Impact of Mosquito Gene Drive on Malaria Elimination in a Computational Model with Explicit Spatial and Temporal Dynamics." *Proceedings of the National Academy of Sciences* 114 (2): E255–64. https://doi.org/10.1073/pnas.1611064114.

Edgington, Matthew P., and Luke S. Alphey. 2018. "Population Dynamics of Engineered Underdominance and Killer-Rescue Gene Drives in the Control of Disease Vectors." *PLOS Computational Biology* 14 (3): e1006059. https://doi.org/10.1371/journal.pcbi.1006059.

EFSA Panel on Genetically Modified Organisms (GMO). 2013. "Guidance on the Environmental Risk Assessment of Genetically Modified Animals." *EFSA Journal 11* (5): 3200. https://doi.org/10.2903/j.efsa.2013.3200.

Ely, Adrian, Patrick Van Zwanenberg, and Andy Stirling. 2013. "Broadening out and Opening up Technology Assessment: Approaches to Enhance International Development, Co-Ordination and Democratisation." *Research Policy* 43 (January). https://doi.org/10.1016/j.respol.2013.09.004.

Emerson, Claudia, Stephanie James, Katherine Littler, and Filippo (Fil) Randazzo. 2017. „Principles for Gene Drive Research". *Science* 358 (6367): 1135–36. https://doi.org/10.1126/science.aap9026.

Enserink, Martin. 2010. "GM Mosquito Trial Strains Ties in Gates-Funded Project." *Science | AAAS*, 2010. https://www.sciencemag.org/news/2010/11/gm-mosquito-trial-strains-ties-gates-funded-project (accessed March 31st 2019).

European Patent Office. 2018. "How to get a European patent. Guide for applicants." European Patent Office, Munich, Germany. ISBN 978-3-89605-211-7

Erickson Law Group. n.d. "How long does it take to get a patent?" Erickson Law Group, PC. http://www.ericksonlawgroup.com/law/patents/patentfaq/how-long-does-it-take-to-get-a-patent/ (accessed 27 February, 2019).

Esvelt, Kevin M. n.d. "Current Research - Sculpting Evolution." http://www.sculptingevolution.org/genedrives/current (accessed February 27, 2019).

Esvelt, Kevin M., Andrea L. Smidler, Flaminia Catteruccia, and George M. Church. 2014. "Concerning RNA-Guided Gene Drives for the Alteration of Wild Populations." *ELife* 3. https://doi.org/10.7554/eLife.03401

Esvelt, Kevin, and Andrea Smidler. 2015. "Rna-Guided Gene Drives." WO/2015/105928, issued July 17, 2015. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2015105928&redirectedID=true

Esvelt, Kevin. 2016. "Gene Editing Can Drive Science to Openness." *Nature News* 534 (7606): 153. https://doi.org/10.1038/534153a

Esvelt, Kevin M., and Jianghong Min. 2017. "Dependent Component Genome Editing Gene Drives." WO/2017/058839, issued April 7, 2017. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2017058839&redirectedID=true

Esvelt, Kevin, Jianghong Min, and Charleston Noble. 2017. "Methods to Design and Use Gene Drives." WO/2017/196858, issued November 17, 2017. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2017196858&redirectedID=true

Esvelt, Kevin M. 2018a. "Gene Drive Technology: The Thing to Fear is Fear Itself." URI: http://hdl.handle.net/1920/11337

Esvelt, Kevin M. 2018b. "Gene drive should be a nonprofit technology." STAT. https://www.statnews.com/2018/11/27/gene-drive-should-be-nonprofit-technology/ (accessed 7 January, 2019).

Esvelt, Kevin, Jianghong Min, and Charleston Noble. 2018. "Methods and Compounds for Gene Insertion into Repeated Chromosome Regions for Multi-Locus Assortment and Daisyfield Drives." WO/2018/049287, issued March 16, 2018. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2018049287&redirectedID=true

European Ombudsman. 2015. "Decision of the European Ombudsman Closing the Inquiry into Complaint 346/2013/SID against the European Food Safety Authority ('EFSA')." European Ombudsman. January 30, 2015. https://www.ombudsman.europa.eu/en/decision/en/58868

European Patent Convention (2019). "Art. 52. Patentable inventions." Convention on the Grant of European Patents (European Patent Convention) of 5 October 1973 as revised by the Act revising Article 63 EPC of 17 December 1991 and the Act revising the EPC of 29 November 2000.

Fass, Josh, Arjun Athreya, Jackie Niu, Yanzhi Yang, and Yong Wu. 2011. "Managing Innovation: A Social Benefit Analysis of Patents and Alternatives." *University of Virginia*. 1-20

Fischer, Bernard A. 2006. "A Summary of Important Documents in the Field of Research Ethics." *Schizophrenia Bulletin* 32 (1): 69–80. https://doi.org/10.1093/schbul/sbj005

Flam, Faye. 2016. "Genetically modifying Zika virus out of existence." Commercial appeal. https://eu.commercialappeal.com/story/ opinion/analysis/2016/02/13/genetically-modifying-zika-virus-out-of-existence/90442282/ (accessed October 17, 2018).

Flanagan, Jane. 2018. "Malaria Trial Pays Africans to Be Bitten." *The Times*, December 1, 2018, sec. World. https://www.thetimes.co.uk/article/malaria-trial-pays-africans-to-be-bitten-n9znctk97 (accessed March 31st 2019).

Foundation for the National Institutes of Health (n.d.). "Vector-based Control of Transmission: Discovery Research." https://fnih.org/what-we-do/programs/vctr-discovery-research Accessed: January 30, 2019

Fu, Guoliang, Kirsty C Condon, Matthew J Epton, Peng Gong, Li Jin, George C Condon, Neil I Morrison, Tarig H Dafa'alla, and Luke Alphey. 2007. "Female-Specific Insect Lethality Engineered Using Alternative Splicing." *Nature Biotechnology* 25 (3): 353–57. https://doi.org/10.1038/nbt1283

Fuhr, Lili. 2018. "Burkina Faso's Mosquito Controversy: Consent, awareness and risk assessment in Target Malaria's gene drive project." November 20, 2018. http://klima-der-gerechtigkeit.de/2018/11/20/burkina-fasos-mosquito-controversy-consent-awareness-and-risk-assessment-in-target-malarias-gene-drive-project/

Gannon, Frank. 2007. "Hope, Hype and Hypocrisy." *EMBO Reports* 8 (12): 1087. https://doi.org/10.1038/sj.embor.7401129

Gantz, Valentino M., Nijole Jasinskiene, Olga Tatarenkova, Aniko Fazekas, Vanessa M. Macias, Ethan Bier, and Anthony A. James. 2015. „Highly Efficient Cas9-Mediated Gene Drive for Population Modification of the Malaria Vector Mosquito Anopheles Stephensi". *Proceedings of the National Academy of Sciences of the United States of America* 112 (49): E6736-6743. https://doi.org/10.1073/pnas.1521077112.

Gantz, Valentino M., and Ethan Bier. 2015. „The Mutagenic Chain Reaction: A Method for Converting Heterozygous to Homozygous Mutations". *Science* 348 (6233): 442–44. https://doi.org/10.1126/science.aaa5945

GBIRd. n.d. "GBIRd." *Genetic Biocontrol of Invasive Rodents*. https://www.geneticbiocontrol.org/ (accessed February 27, 2019).

GBIRd. 2018. "Managing Invasive Species around the World - Successes, Failures, and Hope for the Future." *Genetic Biocontrol of Invasive Rodents* (blog). February 7, 2018. https://www.geneticbiocontrol.org/managing-invasive-species-successes-hope-future/

Gene Drive Files. 2017a. "AS notes on DARPA Safe Genes rollout San Diego May 2 2017." Obtained by Edward Hammond / Third World Network from North Carolina State University by North Carolina Public Records Law request of 7 August 2017. http://genedrivefiles.synbiowatch.org/as-notes-on-darpa-safe-genes-rollout-san-diego-may-2-2017/ (accessed: January 30, 2019).

Gene Drive Files. 2017b. "Gene Drive Files Expose Leading Role of US Military in Gene Drive Development." Obtained by Edward Hammond / Third World Network from North Carolina State University by North Carolina Public Records Law request of 7 August 2017. http://genedrive-files.synbiowatch.org/2017/12/01/us-military-gene-drive-development/ (accessed: January 30, 2019).

Gene Drive Files. 2017c. "Gates Foundation paid PR firm to secretly stack UN Expert process on controversial extinction technology." Obtained by Edward Hammond / Third World Network from North Carolina State University by North Carolina Public Records Law request of 7 August 2017. http://genedrivefiles.synbiowatch.org/2017/12/01/gates_foundation_pr/ (accessed: January 30, 2019).

GeneWatch UK et al. 2012. "Genetically-Modified Insects: Under Whose Control?" Testbiotech, Berne Declaration, SwissAid, Corporate Europe Observatory. http://www.genewatch.org/uploads/f03c6d66a9b354535738483c1c3d49e4/Regnbrief_fin2.pdf

GeneWatch UK. 2014. "Failures of the transboundary notification process for living genetically modified insects". GeneWatch UK. http://www.genewatch.org/uploads/f03c6d66a9b354535738483c1c3d49e4/CPB_insects_sub_Aug14_v2.pdf (accessed February 12, 2019).

GeneWatch UK. 2018. "Oxitec's GM Insects: Failed in the Field?" GeneWatch UK. http://www.genewatch.org/uploads/f03c6d66a9b354535738483c1c3d49e4/Failed_in_the_field_fin.pdf (accessed February 12, 2019).

Godwin, John. 2017. "NC State Receives DAPRA Funding to Develop, Test Gene Drive System." NC State University. https://research.ncsu.edu/ges/2017/08/nc-state-receives-darpa-funding-gene-drive-system/ (accessed January 30, 2019)

Gold, E. Richard, Wendy A. Adams, Louise Bernier, Tania Bubela, Luc Cassivi, David Castle, Ghislaine Cleret de Langavant, et al. 2008. "Toward a New Era of Intellectual Property: From Confrontation to Negotiation - A Report by the International Expert Group on Biotechnology, Innovation and Intellectual Property." SSRN Scholarly Paper ID 1260099. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=1260099

Grunwald, Hannah A., Valentino M. Gantz, Gunnar Poplawski, Xiang-Ru S. Xu, Ethan Bier, and Kimberly L. Cooper. 2019. "Super-Mendelian Inheritance Mediated by CRISPR–Cas9 in the Female Mouse Germline". *Nature* 566 (7742): 105–9. https://doi.org/10.1038/s41586-019-0875-2

Geuna, Aldo, and Lionel J. J. Nesta. 2006. "University Patenting and Its Effects on Academic Research: The Emerging European Evidence." *Research Policy*, Property and the pursuit of knowledge: IPR issues affecting scientific research, 35 (6): 790–807. https://doi.org/10.1016/j.respol.2006.04.005.

Harremoës, Paul, David Gee, Malcolm MacGarvin, Andrew Stirling, Jane Keys, Brian Wynne, and Sofia Guedes Vaz. 2001. "Late Lessons from Early Warnings: The Precautionary Principle 1896-2000." Publication 22. Environmental Issue Report. Copenhagen: European Environment Agency. https://www.eea.europa.eu/publications/environmental_issue_report_2001_22

Hammond, Andrew, Roberto Galizi, Kyros Kyrou, Alekos Simoni, Carla Siniscalchi, Dimitris Katsanos, Matthew Gribble, et al. 2016. "A CRISPR-Cas9 Gene Drive System Targeting Female Reproduction in the Malaria Mosquito Vector *Anopheles Gambiae*." *Nature Biotechnology* 34 (1): 78. https://doi.org/10.1038/nbt.3439

Hayes, Keith R., Simon Barry, Nigel Beebe, Jeffrey M. Dambacher, Paul De Barro, Scott Ferson, Anders Goncevalves de Silva, Geoffrey R. Hosack, David Peel, and Ronald Thresher. 2015. "Risk Assessment for Controlling Mosquito Vectors with Engineered Nucleases: Sterile Male Construct. Final Report." Target Malaria/CSIRO. https://targetmalaria.org/wp-content/uploads/pdf/target-malaria-risk-assessment-sterile-males-plus-executive-summary.pdf

Hayes, Keith R., Geoffrey R. Hosack, Adrien Ickowicz, Scott Foster, David Peel, Jessica Ford, and Ronald Thresher. 2018. "Risk Assessment for Controlling Mosquito Vectors with Engineered Nucleases: Controlled Field Release for Sterile Male Construct: Risk Assessment. Final Report." Target Malaria/ CSIRO. https://targetmalaria.org/wp-content/uploads/target-malaria-independent-ecological-risk-assessement-small-scale-release-sterile-male-executive-summary.pdf

House of Lords Science and Technology Committee. 2000. "Science and Society." 3rd Report HL 38. House of Lords Science and Technology Committee. https://publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm

Intrexon. n.d. "Intrexon: Better DNA." https://www.dna.com/ (accessed February 27, 2019).

IPStudies 2018. CRISPR Patent Landscape. Sample. https://www.ipstudies.ch/wordpress/wp-content/uploads/2018/06/2018.01-CRISPR-Patent-Landscape_SampleV2.pdf

Jenkins, Russel, and Mark Henderson. 2008. "Medical research is 'hindered by out of date laws'." *The Times*. 5 July 2008. https://www.thetimes.co.uk/article/medical-research-is-hindered-by-out-of-date-laws-575xsksb5m7 (accessed March 31st 2019).

Joly, Pierre-Benoit. 2005. "Resilient Farming Systems in a Complex World — New Issues for the Governance of Science and Innovation." *Australian Journal of Experimental Agriculture* 45 (6): 617–26.

Kafatos, Fotis, George Christophides, and Mike Osta. 2004. "Use of Pgrp, Lrrp and Ctl Proteins to Trigger an Anti-Plasmodium Immune Response in Anopheles Species." WO/2004/075912, issued September 11, 2004. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2004075912&redirectedID=true

Kaptchuk, Ted J. 2003. "Effect of Interpretive Bias on Research Evidence." *BMJ* 326 (7404): 1453–55. https://doi.org/10.1136/bmj.326.7404.1453.

Kearns, Cristin E., Laura A. Schmidt, and Stanton A. Glantz. 2016. "Sugar Industry and Coronary Heart Disease Research: A Historical Analysis of Internal Industry Documents." *JAMA Internal Medicine* 176 (11): 1680–85. https://doi.org/10.1001/jamainternmed.2016.5394

Kloppenburg, Jack Ralph. 2005. *First the Seed: The Political Economy of Plant Biotechnology*. Univ of Wisconsin Press.

Krimsky, Sheldon. 2003. *Science in the Private Interest: Has the Lure of Profits Corrupted Biomedical Research?* Rowman & Littlefield.

Kyrou, Kyros, Andrew M. Hammond, Roberto Galizi, Nace Kranjc, Austin Burt, Andrea K. Beaghton, Tony Nolan, and Andrea Crisanti. 2018. „A CRISPR–Cas9 Gene Drive Targeting Doublesex Causes Complete Population Suppression in Caged Anopheles Gambiae Mosquitoes". *Nature Biotechnology* 36 (11): 1062–66. https://doi.org/10.1038/nbt.4245

Leach, Melissa, Ian Scones, and Andrew Stirling. 2010. Dynamic Sustainabilities: Technology, Environment, Social Justice. Routledge. https://www.researchgate.net/publication/272085745_Dynamic_Sustainabilities_Technology_Environment_Social_Justice

Ledford, Heidi. 2016a. "Bitter Fight over CRISPR Patent Heats Up." *Nature News* 529 (7586): 265. https://doi.org/10.1038/nature.2015.17961.

Ledford, Heidi. 2016b. "How the US CRISPR Patent Probe Will Play Out." *Nature News* 531 (7593): 149. https://doi.org/10.1038/531149a.

Ledford, Heidi. 2016c. "Titanic Clash over CRISPR Patents Turns Ugly." *Nature News* 537 (7621): 460. https://doi.org/10.1038/537460a.

Ledford, Heidi. 2017. "Broad Institute Wins Bitter Battle over CRISPR Patents." *Nature News* 542 (7642): 401. https://doi.org/10.1038/nature.2017.21502.

Ledford, Heidi. 2018. "Pivotal CRISPR Patent Battle Won by Broad Institute." *Nature*, September. https://doi.org/10.1038/d41586-018-06656-y.

Lee, Yoosook, Clare D. Marsden, Laura C. Norris, Travis C. Collier, Bradley J. Main, Abdrahamane Fofana, Anthony J. Cornel, and Gregory C. Lanzaro. 2013. "Spatiotemporal Dynamics of Gene Flow and Hybrid Fitness between the M and S Forms of the Malaria Mosquito, Anopheles Gambiae." *Proceedings of the National Academy of Sciences* 110 (49): 19854–59. https://doi.org/10.1073/pnas.1316851110.

Lu, Yanhui, Kongming Wu, Yuying Jiang, Bing Xia, Ping Li, Hongqiang Feng, Kris A. G. Wyckhuys, and Yuyuan Guo. 2010. "Mirid Bug Outbreaks in Multiple Crops Correlated with Wide-Scale Adoption of Bt Cotton in China." *Science* 328 (5982): 1151–54. https://doi.org/10.1126/science.1187881.

Macer, Darryl. 2005. "Ethical, Legal and Social Issues of Genetically Modifying Insect Vectors for Public Health." *Insect Biochemistry and Molecular Biology* 35 (7): 649–60. https://doi.org/10.1016/j.ibmb.2005.02.010.

Mancini, Emiliano, Maria Ida Spinaci, Vasco Gordicho, Beniamino Caputo, Marco Pombi, José Luis Vicente, João Dinis, et al. 2015. "Adaptive Potential of Hybridization among Malaria Vectors: Introgression at the Immune Locus TEP1 between Anopheles Coluzzii and A. Gambiae in 'Far-West' Africa." *PLoS ONE* 10 (6). https://doi.org/10.1371/journal.pone.0127804.

Marshall, John M, Mahamoudou B Touré, Mohamed M Traore, Shannon Famenini, and Charles E Taylor. 2010. "Perspectives of People in Mali toward Genetically-Modified Mosquitoes for Malaria Control." *Malaria Journal* 9 (1): 128. https://doi.org/10.1186/1475-2875-9-128.

Martin, Brian. 1999. "Suppression of Dissent in Science." *Research in Social Problems and Public Policy* 7: 105–35.

Martin, Paul, and Michael Morrison. 2006. "Realising the Potential of Genomic Medicine." London: Royal Pharmaceutical Society of Great Britain. https://pharmacyresearchuk.org/wp-content/uploads/2012/11/Realising_the_potential_of_genomic_medicine.pdf

Matthews, Dylan. 2018. "GMO Mosquitoes: How CRISPR and Gene Drives Could Help End Malaria" Vox, September 26, 2018. https://www.vox.com/science-and-health/2018/5/31/17344406/crispr-mosquito-malaria-gene-drive-editing-target-africa-regulation-gmo (accessed March 31st 2019).

Mayer, Sue. 2006. "Declaration of Patent Applications as Financial Interests: A Survey of Practice among Authors of Papers on Molecular Biology in Nature." *Journal of Medical Ethics* 32 (11): 658–61. https://doi.org/10.1136/jme.2005.014290.

McKelvey, Maureen, and Erik Bohlin. 2014. "Conclusion: Conditions for Innovation in Biotechnology and Telecommunications." *Innovation* 7 (1): 96–104. https://doi.org/10.5172/impp.2005.7.1.96.

Meador, Ron. 2016. "Argument builds around a genetic tool that can erase an annoying species." Minnpost Earth Journal. https://www.minnpost.com/earth-journal/2016/09/argument-builds-around-genetic-tool-can-erase-annoying-species/ (accessed October 18, 2018).

Min, John, Andrea L. Smidler, Devora Najjar, and Kevin M. Esvelt. 2018. „Harnessing gene drive". *Journal of Responsible Innovation* 5 (sup1): S40–65. https://doi.org/10.1080/23299460.2017.1415586.

Mitchell, Paul D., Zachary Brown, and Neil McRoberts. 2018. "Economic Issues to Consider for Gene Drives." *Journal of Responsible Innovation* 5 (sup1): S180–202. https://doi.org/10.1080/23299460.2017.1407914.

Molteni, Megan. 2018. "Here's the Plan to End Malaria With Crispr-Edited Mosquitoes | WIRED," September 24, 2018. https://www.wired.com/story/heres-the-plan-to-end-malaria-with-crispr-edited-mosquitoes/ (accessed March 31st 2019).

Monsanto. 1993. "Petition for Determination of Nonregulated Status: Soybeans with a Roundup Ready™ Gene" Monsanto# 93-089U. http://www.aphis.usda.gov/brs/aphisdocs/93_25801p.pdf (accessed 26 February 2019).

Mullin, Rick. 2018. "Will Nantucket Vote to Allow Genetically Altered Mice to Control Lyme Disease?" *Chemical & Engineering News*, August 27, 2018. https://cen.acs.org/biological-chem istry/genomics/Nantucket-vote-allow-genetically-altered/96/i34 (accessed March 31st 2019).

Nading, Alex M. 2015. "The Lively Ethics of Global Health GMOs: The Case of the Oxitec Mosquito." *BioSocieties* 10 (1): 24–47. https://doi.org/10.1057/biosoc.2014.16.

National Academies of Sciences, Engineering, and Medicine (NASEM). 2016. "Gene Drives on the Horizon: Advancing Science, Navigating Uncertainty, and Aligning Research with Public Values." Washington, DC: *The National Academies Press*. doi: 10.17226/23405.

National Institutes of Health. 2017. "NIH Director's New Innovator Award Recipients." https://commonfund.nih.gov/newinnovator/AwardRecipients17 (accessed January 30, 2019).

NEPAD. 2018. "Gene Drives for Malaria Control and Elimination in Africa." https://www.nepad.org/publication/gene-drives-malaria-control-and-elimination-africa (accessed March 31st 2019).

Newman, James R., and Bryon S. Miller (1947). "Patents and Atomic Energy" *12 Law & Contemporary Problems*, 746-764

Noisette, Christophe. 2018. "Burkina Faso – 10 000 moustiques OGM bientôt disséminés." Inf'OGM. September 24, 2018. https://www.infogm.org/6631-burkina-faso-10000-moustiques-ogm-bientot-dissemines (accessed March 31st 2019).

Nunes, João Arriscado, Daniel Neves Costa, Júlio Borlido Santos, and Irina Castro. 2014. "Novos envolvimentos da Ciência com a Sociedade: As Oficinas de Ciência na intersecção das Ciências da Vida, as Ciências Sociais e os seus Públicos., Coimbra: CES." PTDC/CS-ECS/108011/2008-FCOMP-01-0124-FEDER-009237. Coimbra, Portugal: Centre for Social Studies, University of Coimbra. https://www.researchgate.net/publication/289819325_Novos_envolvimentos_da_Ciencia_com_a_Sociedade_As_Oficinas_de_Ciencia_na_interseccao_das_Ciencias_da_Vida_as_Ciencias_Sociais_e_os_seus_Publicos_Coimbra_CES

OECD. 1996. "The Knowledge-Based Economy." OCDE/GD(96)102. Paris: Organisation for Economic Co-operation and Development. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=OCDE/GD%2896%29102&docLanguage=En.

Okorie, Patricia N., John M. Marshall, Onoja M. Akpa, and Olusegun G. Ademowo. 2014. "Perceptions and Recommendations by Scientists for a Potential Release of Genetically Modified Mosquitoes in Nigeria." *Malaria Journal* 13 (1): 154. https://doi.org/10.1186/1475-2875-13-154.

O'Mahony, Jennifer. 2018. "A Swarm of Mutant Mosquitoes Is out to Eradicate Malaria." *Wired UK*, September 21, 2018. https://www.wired.co.uk/article/mosquitos-crispr (accessed March 31st 2019).

Open Philanthropy Project. 2016. "Foundation for the National Institutes of Health – Working Group on Malaria Gene Drive Testing Path." https://www.openphilanthropy.org/focus/scientific-research/miscellaneous/foundation-national-institutes-health-working-group (accessed January 30, 2019).

Oxitec. n.d.a. "Friendly Mosquitoes." Oxitec (blog). https://www.oxitec.com/friendly-mosquitoes/ (accessed February 27, 2019).

Oxitec. n.d.b. "Crop Protection." Oxitec (blog). https://www.oxitec.com/crop-protection/ (accessed February 27, 2019).

Parry, Hadyn. 2012. "Re-Engineering Mosquitos to Fight Disease." *TED talk*. November 2012. https://www.ted.com/talks/hadyn_parry_re_engineering_mosquitos_to_fight_disease (accessed March 31st 2019).

Parthasarathy, Shobita. 2018. "Use the Patent System to Regulate Gene Editing." *Nature* 562 (7728): 486-488. https://doi.org/10.1038/d41586-018-07108-3.

Peralta, Cecilia, and Leopoldo Palma. 2017. "Is the Insect World Overcoming the Efficacy of Bacillus Thuringiensis?" *Toxins* 9 (1). https://doi.org/10.3390/toxins9010039.

Philanthropy News Digest. 2016. "Tata Trust Awards $70 Million to UC San Diego for Genetics Institute." https://philanthropynewsdigest.org/news/tata-trusts-awards-70-million-to-uc-san-diego-for-genetics-institute (accessed January 30, 2019).

Piaggio, Antoinette J., Gernot Segelbacher, Philip J. Seddon, Luke Alphey, Elizabeth L. Bennett, Robert H. Carlson, Robert M. Friedman, et al. 2017. "Is It Time for Synthetic Biodiversity Conservation?" *Trends in Ecology & Evolution* 32 (2): 97–107. https://doi.org/10.1016/j.tree.2016.10.016

Pisano, Gary P. 2006. *Science Business: The Promise, the Reality, and the Future of Biotech*. Boston: Harvard Business School Press.

PSx2. 2008. "Participatory Science and Scientific Participation: The Role of Civil Society Organizations in Decision-Making about Novel Developments in Biotechnologies. PSx2 Project Final Report." http://www.genewatch.org/uploads/f03c6d66a9b354535738483c1c3d49e4/PSX2_final_20report_1.pdf

Regulation (EC) No 1946/2003 of the European Parliament and of the Council of 15 July 2003 on Transboundary Movements of Genetically Modified Organisms (Text with EEA Relevance). 2003. OJ L. Vol. 287. http://data.europa.eu/eli/reg/2003/1946/oj/eng

Reeves, R. Guy, Jai A. Denton, Fiammetta Santucci, Jarosław Bryk, and Floyd A. Reed. 2012. "Scientific Standards and the Regulation of Genetically Modified Insects." Edited by Michael J. Lehane. *PLoS Neglected Tropical Diseases* 6 (1): e1502. https://doi.org/10.1371/journal.pntd.0001502.

Reeves, R. Guy, and Martin Phillipson. 2017. "Mass Releases of Genetically Modified Insects in Area-Wide Pest Control Programs and Their Impact on Organic Farmers." *Sustainability* 9 (1): 59. https://doi.org/10.3390/su9010059.

Reardon, Sara. 2016. "CRISPR Heavyweights Battle in US Patent Court." *Nature News* 540 (7633): 326. https://doi.org/10.1038/nature.2016.21101.

Regalado, Antonio. 2014. "Who Owns the Biggest Biotech Discovery of the Century?" MIT Technology Review (accessed 21 October, 2018).

Regalado, Antonio. 2016a. Bill Gates Doubles His Bet on Wiping Out Mosquitoes with Gene Editing. MIT Technology Review. https://www.technologyreview.com/s/602304/bill-gates-doubles-his-bet-on-wiping-out-mosquitoes-with-gene-editing/ (accessed January 30, 2019)

Regalado, Antonio. 2016b. "Meet the Moralist Policing Gene Drives, a Technology That Messes with Evolution." MIT Technology Review. https://www.technologyreview.com/s/601634/meet-the-moralist-policing-gene-drives-a-technology-that-messes-with-evolution/ (accessed 21 October 2018).

Regalado, Antonio. 2016c. "Stop "Gene Spills" Before They Happen." MIT Technology Review. https://www.technologyreview.com/s/602633/stop-gene-spills-before-they-happen/ (accessed 21 October, 2018).

Regalado, Antonio 2017. "Patent Office Hands Win in CRISPR Battle to Broad Institute." MIT Technology Review (accessed 21 October, 2018).

Reis-Castro, Luisa, and Kim Hendrickx. 2013. "Winged Promises: Exploring the Discourse on Transgenic Mosquitoes in Brazil." *Technology in Society*, Biotechnology, Controversy, and Policy: Challenges of the Bioeconomy in Latin America, 35 (2): 118–28. https://doi.org/10.1016/j.techsoc.2013.01.006.

Resnik, David B. 2012. "Ethical Issues in Field Trials of Genetically Modified Disease-Resistant Mosquitoes." *Developing World Bioethics*, December. https://doi.org/10.1111/dewb.12011.

Roriz-Cruz, Matheus, Eduardo Sprinz, Idiane Rosset, Luciano Goldani, and Maria Gloria Teixeira. 2010. "Dengue and Primary Care: A Tale of Two Cities." *Bulletin of the World Health Organization* 88 (4): 244–244. https://doi.org/10.2471/BLT.10.076935.

Rourke, Brad. 2014. „Philanthropy and the Limits of Accountability: A Relationship of Respect and Clarity". Kettering Foundation. 29. Oktober 2014. https://www.kettering.org/catalog/product/philanthropy-and-limits-accountability-relationship-respect-and-clarity

Ryan, Jackson. 2019. „The CRISPR machines that can wipe out entire species. CNET." https://www.cnet.com/news/the-crispr-machines-that-can-wipe-out-entire-species/ (accessed 24 February, 2019).

Schmidt, Wolf-Peter, Motoi Suzuki, Vu Dinh Thiem, Richard G. White, Ataru Tsuzuki, Lay-Myint Yoshida, Hideki Yanai, et al. 2011. "Population Density, Water Supply, and the Risk of Dengue Fever in Vietnam: Cohort Study and Spatial Analysis." *PLoS Med* 8 (8): e1001082. https://doi.org/10.1371/journal.pmed.1001082

Schütte, Gesine, Michael Eckerstorfer, Valentina Rastelli, Wolfram Reichenbecher, Sara Restrepo-Vassalli, Marja Ruohonen-Lehto, Anne-Gabrielle Wuest Saucy, and Martha Mertens. 2017. "Herbicide Resistance and Biodiversity: Agronomic and Environmental Aspects of Genetically Modified Herbicide-Resistant Plants." *Environmental Sciences* Europe 29 (1). https://doi.org/10.1186/s12302-016-0100-y.

Sculpting Evolution. n.d.a. "Kevin M. Esvelt." Sculpting Evolution. http://www.sculptingevolution.org/kevin-m-esvelt (accessed January 30, 2019).

Sculpting Evolution. n.d.b. "Daisy Drive Systems". Sculpting Evolution. http://www.sculptingevolution.org/daisydrives (accessed December 11, 2018).

Sculpting Evolution. n.d.c. "Daisy restoration drives". Sculpting Evolution. http://www.sculptingevolution.org/daisydrives/restoration (accessed December 11, 2018).

Sherkow, Jacob S. 2017a. "Inventive Steps: The CRISPR Patent Dispute and Scientific Progress." *EMBO Reports* 18 (7): 1047–51. https://doi.org/10.15252/embr.201744418.

Sherkow, Jacob S. 2017b. "Patent Protection for CRISPR: An ELSI Review." *Journal of Law and the Biosciences* 4 (3): 565–76. https://doi.org/10.1093/jlb/lsx036.

Sinka, Marianne E., Michael J. Bangs, Sylvie Manguin, Yasmin Rubio-Palis, Theeraphap Chareonviriyaphap, Maureen Coetzee, Charles M. Mbogo, et al. 2012. "A Global Map of Dominant Malaria Vectors." *Parasites & Vectors* 5 (1): 69. https://doi.org/10.1186/1756-3305-5-69.

Stein, Rob. 2015. "Powerful 'Gene Drive' Can Quickly Change An Entire Species." NPR: https://www.npr.org/sections/health-shots/2015/11/05/451216596/powerful-gene-drive-can-quickly-change-an-entire-species?t=1539162385985 (accessed October 18, 2018).

Stirling, Andrew. 2014. "Towards Innovation Democracy? Participation, Responsibility and Precaution in Innovation Governance." STEPS Working Paper Series. STEPS Centre, University of Sussex. https://steps-centre.org/wp-content/uploads/Innovation-Democracy.pdf

Stirling, Andrew. 2016. "Precaution in the Governance of Technology." SPRU Working Paper Series. Science Policy Research Unit (SPRU), University of Sussex. https://www.sussex.ac.uk/webteam/gateway/file.php?name=2016-14-swps-stirling.pdf&site=25

Stirling, Andrew, K. R. Hayes, and Jason Delborne. 2018. "Towards Inclusive Social Appraisal: Risk, Participation and Democracy in Governance of Synthetic Biology." *BMC Proceedings* 12 (Suppl 8): 15. https://doi.org/10.1186/s12919-018-0111-3.

Target Malaria. n.d.a. "Where We Operate". https://targetmalaria.org/where-we-operate/ (accessed February 27, 2019).

Target Malaria. n.d.b. "Who We Are". https://targetmalaria.org/who-we-are/ (accessed January 30, 2019).

Target Malaria. n.d.c. "Target Malaria." https://targetmalaria.org/ (accessed February 27, 2019).

Target Malaria. n.d.d. "Our Work: Target Malaria." https://targetmalaria.org/our-work/ (accessed February 27, 2019).

Target Malaria. 2018. "Target Malaria Welcomes the Decision of the National Biosafety Agency of Burkina Faso to Approve a Small-Scale Release of Genetically Modified Sterile Male Mosquitoes." 2018. https://targetmalaria.org/wp-content/uploads/pdf/statement_authorisation_nba_bf.pdf (accessed March 31st 2019).

Target Malaria Burkina Faso, and IRSS. 2017. "Information Form on Volunteers Involved in the Capture of Mosquitoes on Their Persons." In English: https://acbio.org.za/sites/default/files/documents/Consent%20form%20Target%20Malaria%20ENG.pdf In French: https://acbio.org.za/sites/default/files/documents/doc04065120180719114656.pdf

TDR. 2013. "Dengue Control Support through Eco-Bio-Social Approach." WHO. February 20, 2013. https://www.who.int/tdr/news/2013/dengue_control/en/ (accessed March 31st 2019).

Tereskerz, Patricia M., Ann B. Hamric, Thomas M. Guterbock, and Jonathan D. Moreno. 2009. "Prevalence of Industry Support and Its Relationship to Research Integrity." *Accountability in Research* 16 (2): 78–105. https://doi.org/10.1080/08989620902854945.

Tofano, Daidree, Ilse R. Wiechers, and Robert Cook-Deegan. 2006. "Edwin Southern, DNA Blotting, and Microarray Technology: A Case Study of the Shifting Role of Patents in Academic Molecular Biology." *Genomics, Society, and Policy* 2 (2). https://doi.org/10.1186/1746-5354-2-2-50.

United States Patent and Trademark Office. n.d. "Data Visualtization Center" USPTO. https://www.uspto.gov/corda/dashboards/patents/main.dashxml?CTNAVID=1004 (accessed February 27, 2019).

U.S. Code. 2017. "Title 35. Patents. Part II. Patentability of Inventions and Grant of Patents. Chapter 10 – Patentability of Inventions §§ 101 – 103."

Vallas, Steven Peter, and Daniel Lee Kleinman. 2008. "Contradiction, Convergence and the Knowledge Economy: The Confluence of Academic and Commercial Biotechnology." *Socio-Economic Review* 6 (2): 283–311. https://doi.org/10.1093/ser/mwl035.

Vanloqueren, Gaëtan, and Philippe V. Baret. 2009. "How Agricultural Research Systems Shape a Technological Regime That Develops Genetic Engineering but Locks out Agroecological Innovations." *Research Policy* 38 (6): 971–83. https://doi.org/10.1016/j.respol.2009.02.008.

Wade, Nicholas. 2015a. "Gene Drives Offer New Hope Against Diseases and Crop Pests." The New York Times. https://www.nytimes.com/2015/12/22/science/gene-drives-offer-new-hope-against-diseases-and-crop-pests.html (accessed 18 October, 2018).

Wade, Nicholas. 2015b. "Engineering Mosquitoes' Genes to Resist Malaria." The New York Times. https://www.nytimes.com/2015/11/24/science/gene-drive-mosquitoes-malaria.html (accessed 18 October, 2018).

Wallace, Helen M., and Sue Mayer. 2007. "Scientific Research Agendas: Controlled and Shaped by the Scope of Patentability." In *Intellectual Property: The Many Faces of the Public Domain*. Northampton, USA: Edward Elgar Publishing.

Wallace, Helen M. 2009. "Big Tobacco and the Human Genome: Driving the Scientific Bandwagon?" *Genomics, Society, and Policy* 5 (1). https://doi.org/10.1186/1746-5354-5-1-1.

Wallace, Helen M. 2010. "Bioscience for Life?" GeneWatch UK. http://www.genewatch.org/uploads/f03c6d66a9b354535738483c1c3d49e4/Bioscience_for_life.pdf

Wang, Shenghui, David R. Just, and Per Pinstrup-Andersen. 2008. "Bt-Cotton and Secondary Pests." *International Journal of Biotechnology* 10 (2–3): 113–21. https://doi.org/10.1504/IJBT.2008.018348.

Wattendorf, Col. Daniel. 2015. "Statement on Behalf of the Defense Advanced Research Projects Agency at the First Public Meeting of the Committee on Gene Drive Research in Non-Human Organisms: Recommendations for Responsible Conduct." Video: Welcome & Perspectives of NIH, FNIH, DARPA, & Gates Foundation, min 32:21 – 32:42. http://nas-sites.org/gene-drives/2015/08/04/first-public-meeting/ (accessed 22 February, 2019).

Wilke, André B. B., John C. Beier, and Giovanni Benelli. 2018. "Transgenic Mosquitoes – Fact or Fiction?" *Trends in Parasitology*, March. https://doi.org/10.1016/j.pt.2018.02.003.

Wilson, Katherine. 2018. "Could WA be the genetic testing ground for 'synthetic mice' to end mice?" The Sydney Morning Herald. https://www.smh.com.au/environment/conservation/could-wa-be-the-genetic-testing-ground-for-synthetic-mice-to-end-mice-20180221-h0wev9.html (accessed January 30, 2019).

World Intellectual Property Organization (WIPO). n.d. "What is intellectual property?" WIPO Publication No. 450(E), ISBN 978-92-805-155-0

World Medical Association (WMA). n.d. "Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects." https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/ (accessed February 27, 2019).

Wu, Kui M., W. D. Li, Hongqiang Q. Feng, and Y. Y. Guo. 2002. "Seasonal Abundance of the Mirids, Lygus Lucorum and Adelphocoris Spp. (Hemiptera: Miridae) on Bt Cotton in Northern China." *ResearchGate* 21 (10): 997–1002. https://doi.org/10.1016/S0261-2194(02)00080-7.

Wynne, Brian. 2002. "Risk and Environment as Legitimatory Discourses of Technology: Reflexivity Inside Out?" *Current Sociology* 50 (3): 459–77. https://doi.org/10.1177/0011392102050003010.

Wynne, Brian. 2003. "Seasick on the Third Wave? Subverting the Hegemony of Propositionalism: Response to Collins & Evans (2002)." *Social Studies of Science* 33 (3): 401–17. https://doi.org/10.1177/03063127030333005.

Zhang, Feng, Le Cong, Patrick Hsu, and Fei Ran. 2014. Engineering of Systems, Methods and Optimized Guide Compositions for Sequence Manipulation. WO/2014/093712, issued June 20, 2014. https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2014093712&redirectedID=true

Zhao, Jennifer H., Peter Ho, and Hossein Azadi. 2011. "Benefits of Bt Cotton Counterbalanced by Secondary Pests? Perceptions of Ecological Change in China." *Environmental Monitoring and Assessment* 173 (1–4): 985–94. https://doi.org/10.1007/s10661-010-1439-y.