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Is the Patent System the Way Forward with the CRISPR-Cas 9 Technology?

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Abstract

CRISPR-Cas9 technology is reshaping the way scientists conduct research in genetic engineering. It is predicted to revolutionise not only the fields of medicine, biology, agriculture and industry but, much like all revolutionary technologies of the past, the way humans live. Given the anticipated and already seen benefits of CRISPR-Cas 9 in different areas of human life, this new technology may be defined as a true breakthrough scientific discovery. The article presents several challenges connected with various dimensions of the CRISPR-Cas 9 patent landscape. The central argument is that today the biggest challenge is finding a intermediary way that ensures a balance between providing sufficient openness for the further progress of basic research in CRISPR-Cas 9 such as 'niche' areas of the latest genetic engineering and adequate intellectual property rights to incentivise its commercialisation and application. The article contends the endeavours by academic scientific institutions to arrive at short-term benefits of the new CRISPR-Cas 9 technology do not constitute such an intermediary way, especially when the CRISPR-Cas 9 patent landscape is viewed as part of a series of controversial bioethical discussions that have been underway for over 40 years.

Keywords: CRISPR-Cas9, intellectual property rights, patent litigation, biopatents, open innovation models

Introduction

CRISPR-Cas9 technology is a genome-editing approach that is changing the field of genetic engineering. This genome-editing tool is reshaping the way scientists conduct research, and is predicted to revolutionise not only the fields of medicine, biology, agriculture and industry but, much like all revolutionary technologies of the past, the way humans live. The CRISPR-Cas9 technology has reinvigorated research that lay dormant for years, importantly on stem cells, while stimulating drug discovery and novel biomedical therapies. Since CRISPR-Cas9 was discovered in 2012, applications based on it are found in the areas of diagnostics, creating complex animal disease models, drug resistance, DNA storage, etc. It is a powerful innovation anticipated to bring an unparalleled impact on the future of biomedicine. This new genome-editing technique will alter our understanding of disease mechanisms and provide a powerful tool for precisely and efficiently targeting diseases. It will revolutionise the treatment of genetically-transmitted human disease, correcting defective genes within diseased bodies, and potentially banishing genetic errors

from the germ line (EASAC Policy Report, 2017; National Academies of Sciences, Engineering, and Medicine, 2017; Egelie et al., 2016; Barrangou and Doudna, 2016).

Put simply, CRISPR-Cas9 works as a type of molecular scissors that can selectively trim away unwanted parts of the genome and replace it with new stretches of deoxyribonucleic acid (DNA). In more recent times, the popularity of this revolutionary technology has spread like wildfire. Many research labs around world dealing with genetic engineering are quickly adopting this new approach. Of course, today CRISPR-Cas 9 is not the only genome-editing technology. Researchers are still using other technologies, such as zinc finger nucleases (ZFNs) and transcription activator-like effector nucleases (TALENs). Still, CRISPR-Cas 9 is a special genome-editing approach because it is relatively simple to use compared to other approaches and also much cheaper and more efficient (Van Erp et al., 2015; Samy, 2018).

By virtue of the anticipated and already presented radical implications of CRISPR-Cas 9 for different areas of human life, this new technology may be defined as a true breakthrough in the progress of genetic engineering. The tremendous progress and applied potential of CRISPR-Cas 9 mean the financial and symbolic stakes surrounding it are enormous (Halilem et al., 2017). This largely explains why tensions concerning who holds the property rights to this revolutionary discovery are growing. In recent times, such tensions have been nowhere more evident than in the patent battle between Jennifer Doudna's research group (The University of California) and Feng Zhang' research group (The MIT/Broad Institute). In some respects, such tensions are not new in science. Considerable tensions in science were already described by Robert Merton (1973). What is especially interesting is that today's patent battles are characterised by the extreme mutual exclusivity of the parties involved. For example, in the most disreputable case of a patent battle between the University of California and the MIT/Broad Institute one of the parties had misrepresented the whole historical narrative of the discovery of CRISPR-Cas 9. (Namely, this revolutionary discovery did not entail any eureka moment, but was the result of research activities conducted over a decade or more). This was done as part of a public relations strategy to create the public impression that only the MIT/Broad Institute deserved to be registered as the owner of the patent for CRISPR-Cas 9. For example, in his essay "Heroes of CRISPR", Eric Lander, MIT/Broad Institute Director, publicly downplayed the scientific contribution of their competitors, writing that "Jennifer Doudna would call the world's attention to the important societal issues raised by the prospect of editing the human germline" (Lander, 2016: 24). The statement suggests that Jennifer Doudna should not be seen as the creator of this important scientific innovation! The aggressiveness of the tensions indicates the role of patents in the case of CRISPR technology is not only to protect an inventor's work, but to ensure big commercial benefits accrue to institutions when inventions emerge. Robert Merton (1973) already asserted the aim of scientific tensions is not simply (symbolic) recognition and reputation, but also money and profit.

The penetration of intellectual property rights (IPR) into the genome and other realms of biology forms part of a broader trend of expanding the ownership model in the public domain, which has "a spiralling effect" (Winickoff, 2015: 15). It is not only business enterprises, but also public academic institutions that do not like wasting time on monopolising their inventions with the help of IPR. They are increasingly using various other mechanisms to realise this goal, despite the fact such approaches could cause, through strict enforcement of patents and different licensing forms, a 'bottleneck' hindering any faster progress in basic academic science.

A clear indicator of the stronger tendency of academic institutions to commercially privatise their knowledge is patent litigation. In simple terms, patent litigation describes the legal processes that unfold when someone who owns the patent for a particular invention enforces their right by suing another person for manufacturing or selling the invention without permission. The extension and intensity of patent litigation is probably slowing down the progress of basic science because both business enterprises and academic institutions worry more about patent infringement and less about how beneficial the

improving of CRISPR-Cas 9 technology could be for the whole field of genetic engineering. We are even coming to the situation where patent litigations serve an offensive function.

Many IPR experts also believe the outcome of such patent litigations will affect control of the CRISPR platform and development of the technology. These experts contend we are in the middle of a fierce patent war, which is one reason that many promising scientific and technological fields are unnecessarily being forced to wait and see what will be the final result of this patent war. It is very important in every patent battle how the victors then assert their patent position. There is the threat that the still ongoing patent litigation concerned with CRISPR-Cas 9 will limit its use as a platform technology (Sherkow, 2017a; Sherkow, 2017b; Egelie et al., 2016). Such trends are leading us to the situation of the "tragedy of the anti-commons" (Heller and Eisenberg, 1998: 698).

However, one can also find opposite IPR expert views stating that the negative impacts of patent litigation on CRISPR-Cas 9 on the further progress of human genome-editing technologies would be marginal (Feldman, 2016; Graff and Johansen, 2016; Summerfield, 2015). Such experts do not regard such instances of patent litigation as a zero-sum game. They are seen as an opportunity to arrive at new solutions, e.g. cross-licensing agreements which ensure the global proliferation of CRISPR-Cas 9 technology. In many senses, those who support the use of various IPR mechanisms when it comes to the CRISPR-Cas 9 technology are mainly continuing the long visible 'philosophy' of academic entrepreneurship. In the context of academic entrepreneurship, the patenting of inventions in the academic sector was a critical factor in the development of modern genetic engineering (Etzkowitz, 2002).

To some forms of cross-licensing agreements are trying to come in the last times also University of California and the MIT/Broad Institute, i.e. the parties involved in the controversial patent litigation at the United State Trade and Patent Office (USTPO) and European Patent Office (EPO). Both academic institutions are involved in hotly contested patent disputes, but have at the same time created spin-offs through which they have formed a more complex cross-licence agreement mechanism.

When looking back at the history of genetic engineering, the patent landscape of CRISPR-Cas 9 raises many new challenges, although similar non-exclusive licensing approaches were already encouraged at the time of the emergence of recombinant DNA technology in the late 1970s. At that time, Boyer and Cohen had discovered a method to produce recombinant DNA in bacteria. Upon filing the Cohen-Boyer patent, Stanford University created a non-exclusive licensing programme that provided a predictable legal framework for using the discovery of the two scientists. Non-exclusive licences were made available to both the business sector and academic institutions. Such a non-exclusive licensing policy of Stanford University has been embraced by the academic world as a best-practice model for the commercialisation of biotechnology (Feldman et al., 2007).

Today, in the same way the discovery of CRISPR Cas 9 provides a revolutionary technology which also brings a series of novel challenges. As we attempt to show below, the situation is being made much more complex by several dimensions of the CRISPR patenting. Namely, the inconsistent decisions made by various patent offices, the establishment of surrogate companies at universities, patent claimers' interest in agreeing on broad patents, etc. It seems the academic sector has recently shown itself to be less prepared for the complex technological challenges at some points. If it may be said that at the time of the Cohen–Boyer recombinant DNA technology university licensing offices at American academic institutions were taking care of the balance between control and providing access for the multiple commercial applications and ongoing scientific studies that were relying on them, then "in the time of new CRISPR-Cas 9 technology it appears that the university licensing offices have already abdicated the possibility of playing such a role" (Egelie et al., 2016: 1031).

The central thesis of our contribution is that the biggest challenge facing the academic sector is how to find an intermediate way that ensures a balance between providing sufficient openness for the further progress of CRISPR-Cas 9 as 'niche'

areas of genetic engineering, while also giving sufficient support for intellectual property rights to retain incentives for academic innovators. The solution to this issue will impact the future progress of genetic engineering at large and may, in turn, generate proper responses to the increasing bioethical concerns. Our goal with this contribution is not to add to the stockpile of various views on institutional and policy regulation on newly emerging technologies. We instead seek to address the narrower question of how to find an intermediate way between the open and closed innovation models in the case of CRISPR-Cas 9 technology.

The problem with CRISPR-Cas 9 technology is not simply that the extremely wide scope of the claims made in bio-patent applications could halt the further progress of basic research. Concerns are also growing due to bioethical dilemmas arising from the patenting of CRISPR-Cas 9 technology. On one hand, we need to provide the necessary conditions for the successful development and use of CRISPR-Cas 9 across various fields of the life sciences, but also need to provide all the necessary safeguards that, in particular, no patents can be granted for CRISPR inventions, which could in any way offend human dignity and integrity. This does mean we need social rules which are flexible enough to provide the free flow of information on which the further progress of CRISPR-Cas 9 technology is based, but also which will take the ethical and moral implications into account.

Let us consider the use of CRISPR technology for germline interventions which could be aimed at altering a genome in a way that would affect not only the resulting child but potentially some of the child's descendants as well. Here, the question arises of whether the combination of germline intervention and patent protections could lead to forms of ownership that span an entire species (National Academies of Science, Engineering and Medicine, 2016). It will take some time for patent regulation to get up to speed with such a breakthrough technology like CRISPR-Cas 9. For that reason it is extremely important that all stakeholders involved in patent landscape dedicate attention also to ethical issues. In our article,I'll try to point out that ethical dilemmas surrounding biopatents, including CRISPR-Cas 9 patents, are not new. They appeared at the origins of modern genetic engineering. The history of genetic engineering clearly shows that diverging interpretations have always existed of how to use biopatents in practice. Of course, these interpretations have altered over time. Biogenetics has consistently progressed, for example, from small, biologically-active molecular compounds to complex proteins and molecules of DNA, including entire genes. It is expected that the rise of CRISPR-Cas 9 will see the ethical dimension of the patent landscape of biotechnology become ever more a subject of wider public interest.

The article has the following structure. In the following section, I highlight the negative implications of academic institutions' efforts to establish benefits of the new CRISPR-Cas 9 technology. Then, I move on to describe in more detail why the recent patent battles over the CRISPR-Cas 9 technology can be seen as part of the controversial (bioethical) discussions about biopatents that have existed for over 40 years. After that, the focus is on presenting models that advocate open access to knowledge in synthetic biology and other new technologies. Finally, some concluding words are provided.

Is the CRISPR-Cas 9 patent war a sign of academic research institutions' expectations of big short-term benefits?

Not since the early, heady days of recombinant DNA (rDNA) has a biogenetic technique so gripped the scientific imagination as CRISPR-Cas9 gene editing. Bioethicist Greely from Stanford University in California used the following analogy to stress the importance of the discovery of CRISPR-Cas 9 for modern society: CRISPR-Cas9 can be compared with the invention of the Model T Ford in the car industry. The Model T Ford was far from the first automobile to appear in the car industry, but it was its simplicity of production, dependability and affordability that transformed the society of the time (Specter, 2015). In the same way, CRISPR-Cas9 genome editing brings unprecedented ease and precision to genetic engineering.

It is currently difficult to forecast all the social and economic benefits flowing from the tremendous progress of CRISPR-Cas 9 genome editing. The range of potential uses of CRISPR is extremely huge. One consequence is the greater profit orientation seen in genome-editing science which »may very well signal a culture shift in academic research institutions from pure and translational research into profit-maximizing commercialization« (Sherkow, 2016: 29). The CRISPR technology is turning the ivory tower of biogenetics into a multibillion-dollar technological enterprise built on individual entrepreneurship, venture capital, start-ups, and wide-ranging university-industry collaborations (Jasanoff et al., 2015).

In this situation, the stakes for owning a patent in CRISPR technology are extremely high.

The speed at which this technology is developing has generated considerable optimism about short-term profit. The rapid growth of patent filings concerning CRISPR-Cas 9 started in 2012, essentially simultaneously with both of the leading research groups at Berkeley University and the MIT/Broad Institute that published their research breakthroughs. After that, the number of patents has continuously increased in the different aspects of the CRISPR technology landscape (it is divided into five main technology areas of high patent activity: CRISPR–Cas9 components, CRISPR–Cas activity, Vectors, Delivery, Application) (Egelie et al., 2016). Since the filing of the first patent claiming CRISPR as a gene-editing tool in 2012, the US Patent and Trademark Office (USPTO) has granted more than 1,000 patents pertaining to CRISPR in some way (Carson and Mulvaney, 2018).

Stakeholders from the university sector do not like wasting time to obtain patents to earn a profit from this revolutionary technology. This explains why some of them are entangled in prolonged and costly patent litigation. Patent litigation is a consequence of the aggressive patent 'policy' of the academic sector. In the last period, the most disreputable case of patent litigation involved two academic institutions from the United States, the University California and the MIT/Broad Institute. This case has attracted enormous public attention. It has spilled over from narrow expert and business circles to the front pages of popular media. Both parties to this 'interference proceeding'[1] at the USPTO are two groups of scientists. The first is a group led by Jennifer Doudna from the University of California who, together with Emmanuelle Charpentier from the University of Vienna, published the first results of CRISPR gene editing in prokaryotes. The second group is led by Feng Zhang from the MIT/Broad Institute who claims his team was the first to successfully implement CRISPR in eukaryotes.[2] The University California group filed a patent in early 2012 to cover the basic contours of CRISPR-Cas9. Its patent claim referred to the use of a genome-editing tool in any type of cell. Six months later, the MIT/Broad Institute group filed a claim for a patent where it was demonstrated that CRISPR-Cas9 can be used on eukaryotic cells. Zhang argued that his patent claim is sufficiently different from that of the University of California and therefore both parties, that is, the University of California and the MIT/Broad Institute, should be allowed to pursue their claims independently. This interpretation by the MIT/Broad Institute was not supported by the University of California. Zhang's patent claim to use genome-editing technology in any non-cellular or cellular setting (including in human cells) was opposed by the University of California, which retaliated by filing an application with the Patent Trial and Appeal Board at the USPTO to investigate interference. After quite a long process of interference proceedings, in 2017 the Patent Trial and Appeal Board at the USPTO declared that the patents granted to the MIT/Broad Institute do not interfere with the patent claims of UC Berkeley (Sherkow, 2017c; Ku, 2017). In September 2018, the US Federal Appeals Court also ruled in favour of the Broad Institute, confirming an earlier US patent board decision that patents from the lab of the investigator Feng Zhang did not "interfere" with those sought by the University of California. This should have meant that Zhang and his team had succeeded in obtaining the patent rights (United States Court of Appeals for the Federal Circuit, 2018). Yet the story did not end there with the grant of a patent to Zhang's group. The patent fight was merely entering the next rounds, with the University California asserting that the Federal Appeals Court had wrongly sided with the MIT Institute.

Even if we maintain the view that the bigger role for the ownership model at academic institutions will not threaten further progress in the basic science of genetic engineering, we must be aware of at least three threats likely to be strengthened by the uncompromising battles over patent rights:

1. The first threat is that the number of patent applications containing broad claims will grow in the extreme. Although certain studies concluded that scientists are optimistic about their ability to continue research despite the presence of broad patents (Nicol and Nielsen, 2003), it is generally accepted that the continuous requirement for patent breadth brings many negative implications. Patents connected with CRISPR-Cas 9 are typically drafted very broadly because this innovation falls into the category of "enabling technology", i.e. its use does not directly provide a product but enables a product to be made using other knowledge and probably technology (Sherkov and Greely, 2015; Grens, 2016; Nuffield Council for Bioethics, 2016). For example, Doudna and Charpentier's original patent application contained over 150 claims and was notably unspecific with respect to cell type (Sherkow, 2017a). Broad patents and patent thickets in fact already pose a big challenge to the whole field of genetic engineering (König et al., 2013; Van Zimmeren et al., 2011). A great challenge with patents of broad scope is that their claims may exceed what the inventor actually discovered. Broad patent claims are the key element in creating a legal monopoly over the ownership of inventions. They contain less detail than narrow claims, and therefore give the patent owner protection over a wider range of activities. Such owners seek property rights that extend beyond uses of their invention they originally anticipated or predicted, but also over any new uses that are developed (Singh, 2015; Nuffield Council for Bioethics, 2002). The big multinational pharmaceutical corporations have a strong interest in applying for extremely broadly worded patents on genetic engineering and in extending periods of exclusive patent rights over their innovations (Sampat and Shadlen, 2017).
2. The second threat is that the conditions of the global CRISPR patent landscape are uncertain and non-transparent. The prolonged and costly legal entanglements at various national and transnational patent offices are the main reason that many new players (venture capitalists, IP fund managers, patent auction houses, lawyers, etc.) are arriving on the scene. Myriad interested parties are pushing and pulling in different directions. In addition, patent offices are experiencing backlogs of unexamined patent applications, which generate legal uncertainty. The situation is sometimes extremely confusing. The last interference proceedings in which UC Berkley and the MIT/Broad Institute were involved have been interpreted differently by two leading patent offices in the world. As mentioned, in February 2017 the Patent Trial and Appeal Board at the USPTO declared that the CRISPR editing of eukaryotic genomes by the MIT/Broad Institute did not interfere with the University California's patent claims. It denied the University California an exclusive patent right to the technology concerning eukaryotes. However, contrary to the USPTO, only a few months later EPO revoked the first of several patents concerning CRISPR-Cas 9 technology obtained by the MIT/Broad Institute, citing a clear lack of novelty. It granted a broad patent jointly to the University of California (Jennifer Doudna) and the University of Vienna (Emmanuelle Charpentier) (Akst, 2017). The different positions held by the US and European patent offices reveal several disparities in the outcomes of international patenting. At the global level we are far from any harmonisation of the various patent practices concerned with genes and DNA sequences. The procedures for processing patent applications still vary considerably depending on the regulatory framework of a particular state or region. The Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement states that all World Trade Organisation (WTO) members should adopt a set of minimum standards on IPR, including pat-

ents and copyrights. At the global level, the TRIPS agreement does not oblige WTO member countries to make legal provision for the patentability of genes and DNA sequences (OECD, 2014; Van den Belt, 2013).

3. The third threat relates to the non-transparent role of 'surrogate' companies that are formed by academic institutions. Jorge L. Contreras and Jacob S. Sherkow (2017: 698) are very critical of this model of "surrogate licensing" in which universities seek to outsource the licensing and commercialisation of a valuable patent portfolio to university spin-offs.[3] They reviewed all of the CRISPR-Cas 9 surrogate licence agreements made publicly available in the USA. They found that in all principal surrogate licences the patent-holding institution has granted its surrogate companies the exclusive right to use CRISPR-Cas 9 to develop human therapeutics targeting any of the 20,000+ genes that comprise the human genome. Because no single company would be able to develop, test and market therapeutics on the basis of even a fraction of the entire human genome, the surrogate companies are authorised and expected to sublicense their rights to others. Despite this, it is still rare for any surrogate company to explore the possibility of such cooperation. In addition, as noted by Contreras and Sherkow the occupation of universities with forming a model of 'surrogate licensing' tends to make them withdraw from their usual cooperation with the academic world, "what could rapidly bottleneck the use of CRISPR-Cas 9 technology to discover and develop useful human therapeutics" (Contreras and Sherkow, 2017: 698).

As stated in the introduction to this contribution, opposite trends can also be detected, e.g. academic institutions are reconceptualising licensing policy. The general notion that no single company will invest in developing or commercialising the patented technology unless that company is guaranteed an exclusive license is slowly changing. In the USA, National Institutes of Health recommended that patents on research tools developed using federal funding be licensed non-exclusively so as to promote their greatest utilisation, commercialisation and public availability. In the case of CRISPR-Cas 9, the earliest programmes of non-exclusive licensing are being entered into by universities. This is important because it is a broadly applicable 'platform' technology that could enable innumerable specific applications.

Both of the leading academic institutions involved in the mentioned patent fight over CRISPR-Cas 9 technology have also formed "profit 'surrogate' companies to manage university licensing" (Sherkow, 2017c: 565). The University of California has delegated all of its licensing rights concerning CRISPR-Cas 9 technology to Caribou Biosciences, a profit-based 'surrogate' company which in turn has granted an exclusive licence to Intellia Therapeutics to develop human therapies. Meanwhile, the MIT/Broad Institute is using the company Editas Medicine as its surrogate for human therapeutics (Egelie et al., 2016; Van Erp et al. 2015).

Some differences exist between the approaches of the University of California and the MIT/Board Institute. Editas Medicine licenses CRISPR patents on a non-exclusive basis beyond its use in human therapeutics (Mathias et al., 2018; Döring and Lim, 2017). It has already granted 60 non-exclusive licences. It also makes part of CRISPR knowledge freely available to the non-profit community. Editas Medicine's strategy is to pool patents with other companies directed at developing CRISPR-Cas 9. In this regard, in 2014 Editas Medicine developed the inclusive innovation model. In this innovation model, Editas Medicine has the right for a pre-defined period to decide whether it intends to pursue the gene of interest and to commit to funding and launching a programme. If Editas Medicine chooses not to pursue a new programme within this period, the intellectual property becomes available to a third party, thereby facilitating greater public benefit.

The University California is more circumspect about its licensing plan for CRISPR-Cas 9 technology. Intellia Therapeutics has announced the Global Agreement on the Foundational Intellectual Property for CRISPR-Cas9 Gene Editing Technology. Under this agreement, Intellia Therapeutics is committed to maintaining and coordinating the prosecution, defence and enforcement

of the CRISPR-Cas9 foundational patent portfolio worldwide, and each of the co-owners of the intellectual property grants cross-consents to all existing and future licences and sublicences based on the rights of another co-owner. The main goal of such a patent pool is to protect the share of intellectual property rights among companies by approaching a global agreement (Samy, 2018; Mathias et al., 2018).

The strategy of non-exclusive licensing and cross-licensing pools used by Editas Medicine, Intellia Therapeutics and other 'surrogate' companies formed by the universities heralds a new policy in the IPR landscape of genetic engineering. However, even where such surrogate companies succeed in creating a set of such interlocking licence agreements, they cannot stop the risk of a slowdown in the advance of basic research because they are oriented to short-term profit rather than, say, the free flow of information and public access to knowledge. The last ones are ideals which should be lauded by academic scientists.

Why the recent patent litigation over the CRISPR-Cas 9 genome-editing technology may be seen as a continuation of the long-running debates on biopatents

The tendency to file the results of genetic engineering for patenting and other forms of IPR is not new. This issue has been the subject of critical and controversial discussions for more than 40 years. These controversial discussions have consistently had impacts extending beyond the economic domain. The question has arisen of why genes have ever been the subjects of patents. This question is changing into a (bio)ethical concern *par excellence*. The bioethical concerns of patenting inventions in genetic engineering have grown especially related to human genes and biomedicine. Van den Belt stated: "The legal and moral issues that synthetic biology and its medical applications are likely to raise with regard to intellectual property (IP) and patenting are increasing….. The problem becomes even worse if we have to zoom in on the medical applications of synthetic biology and the legal and moral issues they are going to raise with regard to intellectual property and patenting" (Van den Belt, 2013: 87). In that sense, we can also see the recent patent disputes over CRISPR-Cas 9 which are part of this wider issue of medical applications of synthetic biology as being a continuation of bioethical debates underway for 40 years.

If we look at history, the modification of living organisms with genetic engineering in the 1970s and 1980s opened up new possibilities for biotechnology to develop. This development soon led to appreciation of the commercial possibilities of genetic modification and the advantages of protecting developments by making claims in the patent system. This led to a situation where the emergence of new technology created new legal problems. Some kind of IPR revolution in genetic engineering first occurred in the USA. At the beginning of the 1980s, two parallel events facilitated this paradigm shift.

First, the attempt to assert ownership over biological components and entities became part of a much broader movement to transform living substances into marketable products. Early in the 1980s, the USA passed the well-known Bayh-Dole Act which assigned intellectual property rights over faculty discoveries from federally funded research to universities and emphasised the university's responsibility for commercialisation. The Bayh-Dole Act helped create whole new industries, such as biotechnology, where the USA holds a leadership role (Etzkowitz, 2002; Coriat and Orsi, 2002).

Second, the first patent application on any (man-made) living thing was imminent. After a lengthy series of lawsuits, the US Supreme Court awarded Chakrabarty a patent on Pseudomonas putida, a strain of bacterium he had transformed with several plasmids. It was the first patent application on a recombinant bacterium. The US Supreme Court held in 1980 that anything new under the sun that is made by man, whether living or non-living, can in principle be patented. This established a precedent for the patentability of living micro-organisms modified through human intervention. However, the Supreme Court did not set any boundaries on this new area of patentable material (Bhutkar, 2005).

During the 1980s, the patentability of living organisms was further extended from bacteria to multi-cellular organisms. This process then continued with the patentability of the first animal. In 1984, Harvard University filed for a patent on laboratory mice, i.e. a genetically-altered mouse. The mouse had been modified to be particularly susceptible to cancer. In other words, it was a strain of mouse developed in the laboratory with a predisposition to develop tumours. The case is known as the 'Harvard Oncomouse' (Jasanoff, 2005: 210). The USPTO awarded the patent for the oncomouse in 1988, being the first time a patent had been granted to a transgenic non-human mammal whose germ cells and somatic cells contain a recombinant activated oncogene sequence. The argument for granting the patent for the 'Harvard Oncomouse' was that in this case the isolation and purification of a particular DNA sequence from the body turns it into something radically different from its natural state.

Along with the advance of genetic sequencing the pressure to submit everything to patent rights grew. Such processes already then triggered concerns over the ethical issues of biopatents (on top of the fear the pressure to submit the discoveries made in biogenetics to patents would slow research and clinical tests for genetic disease). There was increasing dissatisfaction with the patent regimes' approaches to living organisms.

In this period, two kinds of arguments emerged against the patenting of genes of living organisms:

1. The first argument was used more with regard to human genes. It is clear that increasing access to the human genome held profound implications for a re-thinking of human dignity. It was said that human genes are the common heritage of humanity and that patents could violate the idea of the human genome as the common heritage of humankind. Based on the common heritage principle, this argument mirrors the language of UNESCO's Universal Declaration on the Human Genome and Human Rights (UNESCO, 2003), which refers to the concept of human dignity. It assumes that the dignity of each human individually and of all humanity would be affected if patents are sought for procedures or products claiming to alter the genetic identity of human beings. In that sense, the human genome is linked with human dignity and is by nature untouchable and non-patentable. Of course, underlying this basic argument against the patenting of human genes were deep concerns over a redefinition of life and their implications for human rights as well.
2. The second argument was based on the belief that the genes of all living beings (not only human beings) are naturally-occurring entities which are not invented but discovered.[4] In this circumstances, the so-called "patentable subject matter doctrine" (Sherkow and Greely, 2015: 164) has been again used. At the core of this argument was the question of whether genetic substances that are subjected to human manipulations are 'natural' or 'artificial'. This issue attracted wider political and public attention because from the outset important differences in the patent regimes of the EU and the USA started to appear. Although in the EU there has also been discord over the issue of gene patents between the European Parliament, EPO and specialist law reform advisory bodies (Rimmer, 2008), under EU patent law such ethical objections have more often been recognised as a reason not to grant patent rights (see, e.g. Parthasarathy, 2015; Cook-Deegan and Heaney, 2010; Jasanoff, 2005). One reason was that the European Parliament, after 10 years of debate, had accepted the European Biotechnological Directive on the legal protection of biotechnological inventions (European Biotechnological Directive, 1998). This was later implemented in the regulations of the European Patent Convention (EPC), an intergovernmental treaty that established a common legal framework for patent regimes in EU member states, Norway and Switzerland. It is also true that, although the European Biotechnological Directive was an important element of European patent law that binds national governments, the ethical consideration of biopatents has in particular EU member states many times followed a dif-

ferent course. Mostly they were free to judge for themselves whether to use a more or less strict bioethical approach in their patent regimes (Schneider, 2009; Gold and Gallochat, 2001; Mali, 2004). The same occurs today with the 'public order of morality' criteria. European patent law excludes from patentability any inventions whose commercial exploitation would be contrary to 'public order of morality' (OECD, 2014; Van den Belt, 2013).

The cases regarding the patenting of 'artificial life' are not explicitly addressed as something contrary to the 'public order of morality'. Put frankly, this requirement is difficult to satisfy not just in the USA, but in Europe as well. Let us take the example of synthetic biology, where physically 'isolating' the condition of the gene is not even necessary. It is entirely possible that one researcher could upload DNA sequences onto a computer, 'prints out' a copy of that DNA sequence and patents it as an invention or creates a novel DNA sequence with computer algorithms and inserts the sequence in an organism, and thus patents it.

In the USA, patent law has in some senses entirely avoided "the philosophical and ethical discussions" (Calvert, 2012: 172), even in the most controversial cases where the meaning of patent law was in most doubt. That was the practice at least until the well-known Myriad case in 2013. In the USA, unlike in the EU member states, the strengths of the patent courts have led to the weakness of the broader ethical reconsiderations of the function of biopatents. Courts are institutionally mandated to apply the law as they find it (Kleinman and Kinchy 2003). "Major legal disputes are disposed of as narrower questions of statutory interpretation, in accordance with technical criteria for granting patents, interpreted case-by-case by the courts" (Jasanoff 2005: 209).

It seems that the legal discourse in the USA called 'patent eligibility' (Sherkow and Greely, 2013: 1569), which ignores the ethical issues surrounding biopatents, was prevalent before the outcome of the Myriad case in 2013.[5] The decision in the Myriad case brought an important change in American legal doctrine concerning patent law (Singh, 2015; Winickoff, 2015; Calvert, 2012). The Myriad case was the first to reject "the isolated and purified doctrine as a lawyer's trick" (Van den Belt, 2013: 92). In this case the US Supreme Court did not confirm a patent claim that supposedly covered isolated genomic DNA, i.e. DNA fragments of various sizes that have simply been removed from the surrounding genome. It was declared that separation of the gene from its surrounding genetic material is not an act of innovation, which was contrary to former patent court practices in the USA. Before the Myriad case, in the USA thousands of genes had already been patented.

Today, in the context of the legal interpretation of the ownership of CRISPR-Cas 9 technology an extremely important bioethical issue that arises is its ability to power gene drives which alter normal patterns of inheritance such that engineered genes are always passed on to future generations (Esvelt, 2016; Sherkow, 2017a). We have noted that from the very outset of developing recombinant DNA technology in the 1970s it was necessary to clarify whether and under which conditions and to what extent inventions related to living matter should be eligible for patent protection. In the setting of the 'patentable subject matter doctrine', the patenting of CRISPR-Cas 9 technology as such does not pose any specific bioethical issue. CRISPR-Cas 9 cannot itself be patented because it occurs as a natural biological process. Finally, Cas 9 is a naturally-occurring protein and part of a naturally-occurring bacterial process. But, unlike the BRCA genes in the Myriad case, CRIPSR-Cas 9 technology is subjected to patenting because scientists are able to alter, control and modify this technology to function in animal and human cells, a cellular system in which CRISPR-Cas 9 does not naturally function (Ku, 2017; Beale, 2015).

This means that bioethical issues emerge when patents related CRISPR-Cas 9 technology are used which offend the dignity and integrity of the human being. Today the realistic prospect exists that the CRISPR-Cas 9 technology could be used for germline gene therapy in humans to prevent genetically inherited diseases. Such germline interventions could make genetic alterations in gametes or embryos, which are carried by all of the cells of the resulting child and passed on to subsequent generations as part of the human gene pool. The use of CRISPR-Cas 9 technology in

such 'gene drives' is extremely risky because they are forcibly heritable, making them difficult to control once put in place (Sharkow, 2017; Esvelt, 2016). In that sense, it is very important that CRISPR innovations intended to relate processes for modifying the germline genetic identity of human beings will not be rewarded by patents. In this situation, the deliberation about how, and by whom, the ownership of inventions using CRISPR-Cas 9 technology is to belong is extremely important.

Last but not least, CRISPR-Cas 9 technology has already been used for editing the genomes of animals. In the case of mosquitoes, CRISPR-Cas 9 was used to drive a cargo allele throughout the population that prevents the insect from acting as a vector for malaria. Alleles that prevent mosquitoes from acting as a vector naturally exist, meaning that a gene drive patent could not cover the allele itself. Yet, matters in patent practice are not as clear as seems at first sight. In the example of mosquitoes, it is possible to interpret the combination of CRISPR-Cas 9 with a natural allele intended to replace an existing one as either a composition of matter (nature) or as a new and useful improvement.

It will take some time for regulation to get up to speed with such a breakthrough technology like CRISPR-Cas 9 and thus, before then, it is important that all stakeholders involved consider the ethical issues

Today, one can see some differences in Europe and the USA in the evaluation of the new germ-line editing. The views held by American expert and policy actors on germ-line editing are much more pragmatic than those of their European counterparts. A report prepared by American academics states that human germ-line (heritable) genome editing should be allowed because, if regulated appropriately, the benefits for human health will outweigh the potential risks (National Academies of Sciences, Engineering, and Medicine, 2017).

Yet European academics who prepared a report on the risk of genome editing at practically the same time as their US colleagues had a much more precautionary view (EASAC Policy Report, 2017). While American experts support the idea of the science going forward before a general consensus based on deliberation that this approach is medically warranted, the academics from Europe suggest a worldwide moratorium on altering the genome to produce changes that could be passed on to future generations. It is clear these differences at the global level will probably also influence the prospects of future progress with the new CRISPR-Cas9 technology.

Efforts for open access to knowledge in the whole field of synthetic biology and their impact on the search for an alternative ownership model in CRISPR-Cas 9

CRISPR Cas 9 is an innovation which has revolutionised the entire field of synthetic biology. Synthetic biology (SB) may be seen as the part of genetic engineering with the most progress that is changing practically at an exponential pace. In the book *What's Your Bio Strategy?* (Cumbers and Schmieder, 2017), the opinions of dozens of leading academics and businessmen around the world are presented on what the further progress of SB will look like. Most interviewees assessed that SB, due to this new field, is slowly transforming into the next world-impacting technoscience.

In recent times we have often encountered the opinion that the transformation of biology into engineering science should fit well with the requirements of modern patent regimes. The biology began drawing on the engineering principles of standardisation, decoupling and abstraction with the aim to develop biological components that are interchangeable, functionally discrete and capable of being easily combined in modular fashion (see, e.g. Endy, 2005; Brent, 2004). Turning SB into some kind of engineering science would be proof that it is easier to submit inventions in SB to patenting (see, e.g. Oye and Wellhausen, 2010; Calvert, 2008). One example of the very aggressive use of IPR in synthetic biology is the efforts made by the John Craig Venter Institute to acquire extremely broad patent rights for new artificial life (Van den Belt, 2013). It is well known that Venter was at the centre of an attempt to patent genes already 30 years ago. One infamous example of such activity was a bid by the US National Institutes of Health, led by John Craig Venter, to patent thousands of short DNA

sequences called Expressed Sequence Tags (or ESTs) in 1991–1992 (Calvert, 2012).

In my contribution, I showed that the most efficient mechanism for encouraging the ongoing progress of CRISPR-Cas 9, which entails the most revolutionary step in the progress of genetic engineering (and synthetic biology[6]), is to find an intermediate way that ensures a balance between providing sufficient openness for further basic research, while also giving sufficient intellectual property rights to incentivise innovators. In that sense, the case of a patent war between the University of California and the MIT/Broad Institute based on the 'winner-takes-all' principle (Feldman, 2016: 392) cannot be the ideal paradigm for the future.

Due to the expanding body of various or even contradictory views and policy practices that has built up over the last decade around the protection and openness of innovations in the new and emerging technologies, it is sometimes difficult to characterise the issue in any definitive way. Still, with the invention of CRISPR – Cas 9 we must become ever more aware that we need to find a balance between different mechanisms that will not only encourage short-term profit in science, but its wider public benefits (Levin and Leonelli, 2017). CRISPR technology is in many regards so different from classical approaches in genetic engineering that it is entirely justified to find new solutions in the field of IPR as well. The idea that the same IPR models can be applied to all fields of technology for all times no longer holds (Van den Belt, 2013; Rutz, 2009).

When innovations in such advanced niches of synthetic biology like CRISPR-Cas 9 are moving despite the patent system, not because of it, perhaps it is time in the last part of our discussion to briefly consider the advantages of three models which proclaim free access to knowledge. They have their roots in a movement called 'access to knowledge' or "A2K" (Kapczynsky, 2010: 17). The A2K movement first came together in 2004 in response to the growing imbalance between privatised knowledge (that which is controlled by the intellectual property rights holder) and the knowledge commons (that which is 'owned' by the public). The A2K movement may be seen as a political reaction to the neoliberal agenda of intellectual property expansionism, but "it is also closely aligned with the rise of new emerging technologies that proved congenial to open-source approaches" (Krikorian, 2010: 57). The A2K movement raised fundamental questions about the production of ideas, goods and services created in the current knowledge-based economy, and about access to such ideas, goods and services. In order to avoid the further concentration of IPR and potentially adverse impacts on the progress of science, it suggested introducing complementary mechanisms for inducing innovation activity. Consistent with these basic principles of the A2K movement, various models of free access to information have been proposed for supporting the sharing of information in genetic engineering while maintaining incentives for innovation.

As noted by Jane Calvert (2012), since the idea of 'openness« is vague and interpreted in many different ways in the context of theory, one can identify at least three different general models of scientific and technological knowledge that offer the opportunity for the free flow of information: the open innovation model, the open science model, and the open source model. Since they were enacted in various settings and times, they usually require assessments on a case-by-case basis. Let us briefly look at them.

1. Open innovation model: the term 'open innovation' is used very broadly. It generally refers to major global changes in the behaviour of the business-enterprise sector. Created by Chesbrough to reduce the gap between industry and academia, the open innovation model is known as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough, 2006: 9). In such models, progress in innovativeness occurs on the basis of internal and external sources of knowledge and therefore in collaboration with several R&D actors (Bogers et al., 2018; West et al., 2014). It leads to stronger collaboration between companies with the aim of intensifying innovation and bringing in new resources not available internally. In the con-

text of open innovation, intellectual property plays a new role which no longer reflects the usual defensive mechanism adopted by companies (Enkel et al., 2009). More precisely, up until a few years ago most middle-cap companies made use of their patents to block competitors and to freely operate in the market. As several authors note, to deal with the possible constraints on knowledge transfer in open collaborative innovation there is primarily a need to develop adequate licensing strategies (Bogers et al., 2012; Grandstrand, 2011). In the open collaborative innovation model framework, cross-licences which represent less restrictive licensing strategies are especially important. In a cross-licensing agreement, the partners allow each other to use the knowledge they need for the collaboration. Alternatively, a less explicit 'umbrella agreement' is used which states that knowledge should and will be shared to the extent needed and the partners will only use this in relation to the collaboration and not internalise it privately. Although CRISPR technology holds tremendous innovation potential in agriculture, cross-licensing strategies are not regarded as the best way if they lead to the creation of a narrow oligopoly of a few interconnected multinationals. Such mega-merger waves (for example the Monsanto/Bayer merger transaction) could limit the disruptive potential of this technology.

Considering recent developments in human genome-editing technology, some authors suggest following earlier models developed by the licensing programmes of some universities. Such a positive case may be the licensing programme at Stanford University which created a pioneering licensing programme that provided a predictable legal framework for the use of its inventions. Non-exclusive licences were available to both companies and academic institutions, but on different terms (Egelie et al., 2016).

2. Open science model: This model is essentially non-pecuniary in the exchange of ideas although it clearly requires money for the production of ideas. It was described by Dasgupta and David already in 1994 (Dasgupta and David, 1994). Historically, in the early stages of several industries a similar model involving the free exchange of ideas and improvements was operative. Attention in the open science model is not given to IPR issues, but a great deal of effort is devoted to interoperability. For instance, ever more firms in knowledge-intensive sectors are participating in open science because it facilitates the disclosure of scientific discoveries through publications in academic journals (Jong and Slavova, 2014). Industry scientists even appear to have their internal career paths tied to publishing success and career ladders that resemble those in the academic science sector. This type of disclosure strategy encountered by certain firms is sometimes called the strategy of "patent-paper pairs" (Gans et al., 2017: 824). Many other initiatives connected with the open science model have emerged. One of the largest patent holders in the world (IBM) substantially altered its corporate policy on the management of patents already in 2006, especially in the areas of software and business method patents. Among other initiatives, the Open Collaborative Research (OCR) programme was established to support open-source software research between IBM and universities (Hall, 2010). Many recent initiatives refer to open data platforms. The EGI Open Data Platform, built on OneData technology, was developed to provide openly accessible data (Viljoen et al., 2016).
3. Open source model: It contains elements of both the private investment model (in which knowledge is appropriated privately) and the collective action model (with the emphasis on public knowledge). In that sense, it is some kind of "private-collective innovation model" (Von Hippel and Von Krogh, 2003: 210). Social actors in this model produce public goods, but also capture private benefits that exceed their participation costs (Gans et al., 2017). The open source model is interested in enabling certain legally binding forms of access. In fact, the term "open source" refers to information that can be modified because its design is publicly accessible. A good example is the Registry of Standard Biological Parts estab-

> lished by the International Genetically Engineered Machine (iGEM) Foundation (iGEM, 2017). This type of communal approach to property is seen as promoting "freedom to create" and the advancement of synthetic biology as one of the most revolutionary fields today (Hilgartner, 2012). The Registry runs and grows according to the "Get & Give or Share" philosophy. Users *get* in parts, samples, data and tools to work on their synthetic biology projects. They *give* back to this biobase the new parts they have made, as well as data and experience on new and existing parts. Finally, users *share* their experience and collaborate in the Registry's open community through their wikis, forums and other social tools.[7]

The BioBricks Foundation is an interesting proponent of an open-source synthetic biology community because its standardised transfer agreements contain ethical constraints (BioBricks Foundation, 2017). Enthusiasts from various academic institutions and industry who set up the Registry of Standard Biological Parts or BioBricks have articulated their open-source aspirations because they are explicitly attempting to follow the solutions seen in the computer sciences. They are inspired by the open-source movement in the development of computer software (Singh, 2015). In the case of computer software, copyright law was used based on the General Public Licence ('copyleft'). The General Public Licence ('copyleft') ensures that newly written software code is not privately appropriated but remains free for all to use. The main argument for using the BioBricks Registry was that the modular 'entities' produced by SB are ideal for open source because they can be worked on simultaneously by a large community of both users and producers, and this can speed up development of the field. A good example of such an 'entity' is the various types of bacterias producing biofuel. If the many parts of such bacterias were to be protected by different patents (which would probably be held by several rights holders), we would very quickly find ourselves faced with a 'patent thicket'. A patent thicket is a set of closely related and possibly overlapping patent rights to a certain technology, thereby requiring anyone wishing to use, build on or commercialise that technology to obtain licences from a number of patent holders (Shapiro, 2001). In some technologies, a 'patent thicket' is leading to an absurd situation. Joshua M. Pearce reported that "any innovator wishing to work on or sell products based on single-walled carbon nanotubes in the United States must wade through more than 1,600 US patents and then obtain multiple licenses to use any much of the basic and foundational information covered in those patents" (Pearce, 2012: 519).

The models of open science presented above allow the conclusion that the situation in reality is probably more complex than might be seen in theory. Namely, cases in practice oscillate between openness and closeness. The biggest challenge is therefore to strike the balance between providing sufficient openness for further scientific investigation and adequate policy instruments to provide incentives for innovation and commercial development. Last but not least, the whole field of genetic engineering has only recently considered open-source approaches. Here, efforts to establish an open-source community are still in their initial stages. Yet, within this open-source community there exist a vast array of possibilities. Or, to use the metaphors introduced by Drew Endy and further developed by Jane Calvert (2012), a diverse open-source-proprietary ecology is forming.

In our view, the open source model practised in the context of BioBricks could be of interest for CRISPR-Cas 9 technology. It could encourage the stakeholders involved from the academic and business-enterprise sectors to intend to provide more attention to free access to CRISPR-Cas 9 technology. In the BioBrick User Agreement (BUA), the inventors are required to publicly share their knowledge, leading to a productive relationship between private initiative and the public interest. Such a combination of the two interests holds significant implications for the further progress of CRISPR-Cas 9 technology, unlike the recent IRP situation regarding this revolutionary technology which is opaque due to the hubbub created by the never-ending patent battles. The BioBricks model is also of interest for another reason. Its standardised transfer agreements contain ethical constraints. The BioBrick User Agreement

contains ethical clauses which prohibit intentionally harmful uses of synthetic biology. Of course, critics who question the quality of BioBricks can also be found (Hilgartner, 2015). They criticise its design of a regime of openness as well as its parts-based approach to synthetic biology. Still, there is no doubt that the BioBrick model could be seen as a vanguard vision towards new solutions in the social regulation of new and emerging technologies at large whose benefits will be seen at some stage in the future.

Conclusion

This contribution had two aims. First, it tried to critically examine the risks emerging from the increased efforts of the business-enterprise and academic sectors to monopolise their inventions related to human genome editing technology with the help of strict forms of IPR. Second, another goal of the article was to point out that the stronger processes of privatisation and the use of strict forms of IPR also carry (bio)ethical implications. Of course, bioethical dilemmas did not begin with the emergence of the new human genome editing technologies. They have accompanied practically the entire history of biogenetics. In that sense, we see the recent patent disputes over CRISPR-Cas 9 as a continuation of the already long-running bioethical debates in biogenetics generally. Despite this, they have obtained new dimensions in recent times. As we aimed to highlight, the ethical risk to the dignity of human beings arises from the new CRISPR technology's ability to modify the germline genetic identity of human beings.

Concerning the strict enforcement of patent protection by the inventors of new human genome editing technologies, especially those coming from the academic sector, we saw that these processes could cause a 'bottleneck' hindering any faster progress of the whole field of biotechnology. What we especially attempted to emphasise is the threat of the brutal commercial and profit logic continuing to underpin the ownership models, including wide-scale litigation over patents, will destroy the concept of the free exchange of information in basic academic science. Namely, it seems that just in the case of the CRISPR technology, which is turning the ivory tower of biogenetics into a multibillion-dollar technological enterprise, the patenting regimes have started to too strongly dictate the behaviour of academic science. CRISPR research is a large field that attracts contributions from many talented scientists around the world. The US Patent and Trademark Office has issued more than 80 patents with claims to CRISPR and/or Cas9 to more than 300 inventors from nearly 60 applicant organisations. The European Patent Office has issued more than 20 such patents to approximately 30 inventors from about 10 applicant institutions. In addition, around the world more than 1,500 applications have been filed (but not yet granted).

The central thesis of my contribution is that the biggest challenge facing the academic research sector is to find an intermediate way that ensures a balance between providing sufficient openness for furthering the research into CRISPR as 'niche' areas of genetic engineering, while also ensuring sufficient intellectual property rights that give incentives for innovators. Namely, the solution to this issue will hold many positive consequences for the future progress of human genome editing technologies and may, in turn, generate proper responses to the increasing bioethical concerns. Patents are supposed to be a game of winner-takes-all in which the one who arrives first wins. In the article, I showed the clearest indicator of the increased tendency of academic institutions to commercially privatise their knowledge is patent litigation. Such uncompromising battles over patent rights bring many negative implications, some of which were presented in the article.

In view of the assessed negative implications, the patent system's structure stands in contrast to that of other intellectual property regimes in which society recognises the rights of multiple parties to the chase. Establishing alternative ways to a strict IPR regime is particularly important given the twofold tendency of the recent progress of human genome editing technology, i.e. its globalising tendency and its tendency to radically transform human beings and social life. Both tendencies are very realistic and very promising.

In the last part of our article, I presented various efforts made to ensure open access to scientific

knowledge. The three different general models of scientific and technological knowledge that offer an opportunity for freer flow of information are addressed, i.e. the open innovation model, the open science model, and the open source model. Models encapsulating a free approach to scientific knowledge especially in the domain of synthetic biology are underway. Notwithstanding this, as noted in the article, while these projects are only in their initial stages they have good prospects because they represent alternative ways to a strict IPR regime. Following the classification of some authors who distinguish different models of open science, I noted, also with reference to certain cases, that to ensure the further progress of CRISPR technology the open source model as practised in the BioBricks context might be interesting. It encourages the stakeholders involved from the academic and business-enterprise sectors to intend to provide more attention to free access to newly created knowledge in the domain of synthetic biology. Namely, lying in the centre of the BioBricks programme is a "Get & Give or Share" philosophy that entails reciprocal obligations to give something in exchange for a gift. In practice, while this is not always easy to manage, it could become a good case for the more balanced social regulation of all newly emerging technologies.

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Notes

1 If patents or patent applications overlap and the first person to invent is in dispute, then the patent office initiates what is called an interference proceeding, with intricate rules about deciding on the priority of invention. Interferences are more than twice as common in biotechnology patents than in any other patent class, and six times more frequent than patents on average (Merz and Henry, 2004).

2 The CRISPR system is the adaptive and inheritable immune system of certain bacteria and archaea, which are prokaryotes. Prokaryotes are simple single-celled organisms that lack a nucleus. Unlike prokaryotes, eukaryotic cells have many features such as a membrane-bound nucleus, which stores the cell's genetic information organelles, which are not found in prokaryotic cells. Animals and plants are eukaryotes.

3 Researchers recently suggest that licensing is no longer a uniform type of external knowledge-sourcing strategy. Namely, if a simpler or 'standardised' form of licensing gives the licensee the exclusive right to use the knowledge in exchange for money but without mutual interactions and resource sharing between licensee and licensor, then 'partnership-embedded licensing' embeds licensing in a broader partnership or an alliance that includes the mutual sharing of resources and joint R&D efforts (Klueter et al., 2017). The standardised form of licensing is dominant when it comes to cooperation between the academic sector and business-enterprise sector.

4 In our common use of the term, a 'discovery' is the acquisition of knowledge of a new but already existing fact about the world. An 'invention', on the other hand, is something that someone creates or develops which did not previously exist. "Thus, on the usual interpretation of the words, it seems apparent that the identification of a gene is a discovery, since genes exist in the world, in our bodies" (Nuffield Council for Bioethics, 2002: 23).

5 The case regards patent claims covering BRCA1 and BRCA2. The patent claim was made by the Myriad Genetics company. Both genes are critical to assessing early-onset breast and ovarian cancer risk.

6 According to some experts, synthetic biology is interpreted as a linear continuation of former developmental stages in genetic engineering. Other experts say that synthetic biology represents a "game changer" in progress of genetic engineering (Mali, 2014).

7 Despite its open-source credo, iGEM leaves open the possibility of filing patents on applications and combinations of their standardised biological parts. This means options exist to facilitate or expand intellectual property requirements in the iGEM research frame. As noted by D. Endy (2005), iGEM may therefore provide an ideal testing ground for experimentation on open and intellectual property schemes.

Public Discourse on Stem Cell Research in Russia: Evolution of the Agenda

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Abstract

This paper studies the evolution of the media discussion surrounding stem cell research in Russia from 2001 until the issuance of the first national law in 2016 and its impact on stem cell's 'social career' in the public discourse. It analyses how the interaction of different media frames stigmatized either the biomedical technology, or the expert community. It is argued that the regulatory framework in Russia lags behind technological developments in the country and mostly reacts to signs of fraudulent actions from drug makers or practitioners. Moral issues, in contrast to the international discourse, have been not the main reason in Russia.

Keywords: Russia**,** stem cell research, media discourse, agenda setting, framing, science and technology governance.

Introduction

Stem cell research ranks among the most controversially discussed topics in science (Nippert, 2002; Brown, 2003; Kitzinger, 2008). Therapies based on stem cells promise cures for a wide range of diseases, and for some give hope for eternal youth. Still, the thought of a scientist experimenting with human embryos or creating genetically modified human beings is as frightening today as was young Mary Shelley's creation of Frankenstein at the beginning of the 19th century. The trade-off between health benefits and fears of unrestricted science is the subject of a public debate, the outcome of which will shape institutional environments and legislation.

The example of such outcome happened in 2016, when the Russian Federation launched its first piece of legislation to regulate the use of stem cell research for medical applications. The law was issued mainly due to misuse and unethical practice in the field, which was attracting media attention and shaped public opinion. The media has a strong interpretive function in such public

discourses about scientific issues. Hence, this paper analyses the media coverage of stem-cell research and therapy and studies its impact on stem cell's 'social career' in the public discourse in Russia. The time frame of this study is marked by the first mentioning of stem-cell research until the issuance of the first national law in 2016. Russia provides a particularly interesting case as its institutional environment has developed independently from the Western settings. Furthermore, Russia has been the breeding ground for some of the most significant scientific discoveries in the past few centuries. This tradition of scientific excellence and well-rooted technocratic thinking provides an interesting example both for the perception of science and for the role of the media in the country. On the other hand, studies on Russia's critical media discourse around scientific hazards in general and stem cell research in particular are very scarce (see Astakhova, 2013; Kozhemyakin and Medkova, 2013).

A better understanding of such discourses is of great academic interest as they profoundly shape the future of certain fields in science and technology as they negotiate visions of the potential social benefits and risks of such scientific and technological advances. In other words, the future of science and technology builds on such contested claims and counterclaims over its potential (Brown et al., 2000). The public discourse on new scientific discoveries and emerging technologies is non-trivial as it is shaped by the historical experience, the dominant culture and the political system in a country (Gottweis and Prainsack, 2006) and, therefore, may significantly vary from one society to another. Differences in these discourses and their geneses are of great academic interest as they help to explain the social expectations and distinctive features of existing policy frameworks that deal with emerging controversies around recent scientific developments (see, for example, Kamenova and Caulfield, 2015; Petersen et al., 2017; Kamenova, 2017).

Role of the media in shaping public discourse

The dialogue between science and the greater society is mediated by a variety of communication channels, among which mass media play a crucial role in informing the wider audience with respect to the current policy agenda. However, in contemporary societies, where interactions between different groups of actors produce multifaceted discourses on highly knowledge-intense topics, the role of the media exceeds mere information diffusion. Through sectioning and filtering of information, it takes a very proactive role, which has long been a subject of academic research (Lippmann, 1922; Becker and Murphy, 1993; Dyck et al., 2013).

Extensive coverage of a particular topic alerts news recipients to an issue raised (McCombs and Shaw, 1972; Cohen, 1985; Elliott, 2012) and increases the importance of such a topic on the list of public priorities (for an overview see McCombs and Shaw, 1993). For example, Nisbet and Lewenstein (2002) showed that debates on stem cells in the US Congress and the White House received great media coverage, while discussions at a lower administrative level attracted attention of only small professional communities (Maynard-Moody, 1995). It has, furthermore, been recognised that the agenda set by the media greatly influences decisions by policy-makers (Caspi, 1982; Bennett and Entman, 2001; Nisbet et al., 2003; Schäfer, 2011). The way in which the media present a particular topic shapes the perception of recipients and sets the tone in which proposed solutions are negotiated (Gibbons, 1999; Nisbet et al., 2003; Holliman, 2004; Bauer, 2005; Kitzinger and Williams, 2005; Weingart et al., 2008; Schäfer, 2009; Haran and Kitzinger, 2009; Zajc and Erjavec, 2014). Thereby, the media might stigmatise certain scientific activities (such as human embryo research) or support the sentiments about future research (Frickel et al., 2010). Consequently, the media frame the public discourse around dominant narratives (Hall, 2006) and convert complex scientific findings into a sequential series of events (McComas & Shanahan, 1999; Boomgaarden and de Vreese, 2007)[1]. Due to the crucial role of public discourses in policy decision making, there is an increasing interest of factors that influence the course of the debate (Gregory and Miller, 1998; Weingart, 1998; Weingart et al., 2008; Rödder, 2009; Rödder and Schäfer, 2010; Schäfer, 2011; Hug, 2013; Saniei, 2013).

Specifics of the Russian Federation

Historically, though, the greatest attempts to influence the media came from national leaders. As such, the instrumentalisation of the media for political objectives has a long history in Russia and evolved from almost total control of all media channels in the Soviet period to a greater and more lasting freedom of the press after 1985, when Mikhail Gorbachev introduced principles of 'openness' and 'transparency' (Brooks, 2000). Journalists were given greater independence in choosing what to report on whilst still enjoying the economic security provided by subsidies (Hagstrom 2000; Ryabov 2004). For Yeltsin, freedom of the media was a baseline value (Gessen, 2000) as largely one means to an end: to replace the communist ideology. Nevertheless, the economic situation of independent media production started to deteriorate, as government backing broke away and advertising revenues were slow. Some newspapers fell into the hands of oligarchs, who pursued personal interests (Zassoursky, 1999, 2004; Belin, 2002; Fadin, 2002; Ledeneva, 2013; Pallin, 2017; Skillen, 2017). Putin strengthened central institutions in order to reestablish 'order'. Consequently, self-censorship became a growing phenomenon at privately owned media outlets (Belin, 2002; Schimpfossl and Yablokov, 2014). The state has ever since extended its hold over former independent media producers. See, for example, the case of NTV (Lipman and McFaul, 2001) coverage of politically and socially sensitive matters (such as the Chechnya war or the submarine Kursk), as well as issues pertaining to anti-terrorism regulations and state secrecies (Albats, 2001) and the annexation of Crimea (Zeveleva, 2018). In contemporary Russia, public discussions allow for vivid debates (McNair, 2000; Mickiewicz, 2000, Kosmodemyanskaya, 2014; Sologug and Yakimova, 2016; Kazun, 2017). This is especially true for the field of science, an area of great public interest in Russia.

Stem cell research and its regulation in Russia

For the purpose of this paper we consider stem cells as undifferentiated cellular elements with self-regeneration and differentiation abilities. Depending on the differentiation potential, the literature distinguishes between totipotent, pluripotent, and other types (multipotent, oligopotent and unipotent)[2] of stem cells. The pluripotent stem cells have the highest medical potential due to their capability of differentiating into any cell types. These are embryonic stem cells from blastocysts intracellular mass (obtained from in vitro embryo between the 4th and 7th days of development), as well as stem cells formed in the later stages: the primary embryonic germ cells (gonocytes) and the cells of embryonic tumors[3]. Besides human embryos, pluripotent cells can be derived from 'adult' specialized cells that have been genetically reprogrammed back into an embryonic stem cell-like state (induced pluripotent stem cells).

Up to 2001, the existing legislation of the Russian Federation did not cover any stem cell related activities. Stem cells were by then considered tissue transplants. The transplantation of human organs and tissues is regulated by the Federal Law № 41801 'On the transplantation of human organs and (or) tissues' (issued December 22, 1992 and edited June 20, 2000). However, according to its 2nd article, the regulation is applied neither to organs or tissues related to the human reproduction process, including reproductive tissues, nor to cord blood and its components. Furthermore, the law did not cover any stem cells derived from embryonic or abortion tissues, umbilical cords, or placentas.

Despite the absence of legal situation, stem cell researchers in Russia were very active and between 1996 and 2001, a total of 15 applications for a Russian patent in the field of stem cell research were approved. Russian researchers were developing stem cell technologies based on fetal tissues (which were subsequently viewed rather critically). In 1999, a patent was granted for an immune-corrective drug based on cell suspension that was obtained from natal cryo-preserved hematopoietic fetal liver cells and/or the human spleen. The drug was considered very promising for treating diabetes.[4] Another method was patented in 2000 for donor cell preparation from the fetal tissue of aborted fetuses at 17-21 weeks of fetal development.[5] Clinics (especially private ones) started successfully commercialising stem cell therapy programs (in particular fetal therapy).

Since 2001, a long period of legislation development has started. Table 1 provides informa-

Table 1. Key milestones of the public discourse on stem cells in Russia, 2001 – 2016

Period	Type	Events
2001-2002	Development of legislation	On August 29, 2001, the Russian Ministry of Health issued a new decree № 345 'On the establishment of the Advisory Council for the consideration of scientific research for cellular technologies and their introduction into practical public health'. In 2002 the Advisory Council issued the 'Temporary instruction on the order of research in the field of cellular technologies and their use'. The regulations limited the handling of stem cells to a list of specialised institutions.
2002-2003	The start of the first cord blood stem cell bank and first related legislation	In 2002, the first bank of stem cells of cord blood was established in Russia. On May 29, 2002 the Russian Academy of Medical Sciences launched the research program 'New cell technologies for medicine'. In 2003 the Russian Ministry of Health issued a new Act № 325 'On the development of cellular technology in the Russian Federation', which regulates (1) the formation of a bank of umbilical cord and placental blood for research proposes; (2) the separation and storage of placental blood concentrate; and (3) the formation of a bank for stem cells derived from umbilical or placental blood.
2004	Discussion of black market	In 2004 scientists and clinicians organized a round table discussion at the Sechenov Moscow Medical Academy about the legal aspects of stem cell usage with journalists participation.
2005	First fraudulent actions	In 2005 the sale of the 'anti-ageing' stem cell cosmetic 'Stvolamin' started.
2007	Further legislation	On January 22, a decree № 30 'On the regulation of medical activity licensing' was issued which required that each organization held a license to use cell technologies (including sampling, transporting and storage of hematopoietic stem cells, and the use of cellular technology).
2008	First public scandal	The manufacturer of 'Stvolamin' was blamed for fraud in production and selling.
2010-2011	First introduction of a specialised legal framework	On 6 December 2010, the first version of the federal law was published. The Article 9 Section 2 banned "the use of cells of human embryo or fetus for the preparation of cell lines intended for the biomedical cellular technologies development". This version was much criticized by experts because of the absence of clear definitions, rules and general illiteracy. After a public hearing the draft law was sent for the revision. In 2011, the Russian Academy of Medical Sciences and in the approved the revised version. However, it was not accepted.
2012	Second fraudulent action	Citizens found barrels with aborted human embryos in the forest near Nevyansk (a small town in the Sverdlovsk region of Russia).
2013-2016	Development of the specialized legal framework	In 2013, the Russian Ministry of Health published next version of the draft law 'On the circulation of biomedical cell products' and organized public hearings. The draft law did not pass the expertise too. In 2015, the Civic Chamber of the Russian Federation held public hearing with experts and public activists to discuss the next version of the draft law 'On Biomedical Cellular Products'. Following the discussion with the participation of the representative of the Ministry of Health, it was decided to create a working group, which would work on improving the draft law together with the department and the relevant committee of the Russian State Duma [the lower house of Parliament]. **In 2016, the law was finally accepted**.

tion on key changes and important events in the public discourse on stem cell research in Russia.

Over the course of years, researchers and clinicians had been acting in a legal vacuum. The results of our previous study (Polyakova, 2008, 2011) shed light on the main problems in stem cell research in Russia up to 2009, i.e. until the moment when the need for a specialised legal framework appeared on the political agenda.

In this research we studied social context and institutional organisation of stem cell research in Russia. We conducted 22 in-depth elite interviews with Russian scientists, clinicians and executives of private institutions, such as cord blood banks and biotechnology companies dealing with stem cells[6]. All experts agreed to participate in the research and to use the content of the interview anonymously. The list of experts is given in Appendix 1.

We discovered several interrelated internal and external problems in the field of stem cell research. The first one was the low level of the clinical trials culture in Russia:

> When these researchers talk about improvement, they take oncological patients at the last stage who will die anyway (usually homeless people, chronic alcoholics). They take the last stage of cirrhosis, and the person is kept alive on glucose and blood transfusions for 3-4 months. They administer these cells, and the patient shows improvement - maybe it is because (s)he does not drink in the clinic, or because of some vitamins. Supposedly two of seven patients lived 2 or 3 months longer. That's all based on empirical evidence'…When you start to investigate, then there is no paper trail. No protocols, no registration. This is very important. (Head of Laboratory, Novosibirsk)

The second one was the promotion of stem cells as a remedy for various diseases and the non-specific application of particular sources of stem cells:

> We began to use bone marrow cells for everything: cirrhosis, diabetes, everything. (Head of Laboratory, Novosibirsk)

> In the 1990s, the current director of the Institute X founded the department. They injected 'cocktails' of fetal tissues from placentas. This is not regulated… I asked one doctor: "Are you sure that you inject something that will show a specific result?" He answered me: "There are so many useful cells. We inject them all." (Clinician, National Medical Research Center, Moscow)

The third problem was the absence of strict rules and standards for stem cell research. It had several negative consequences.

Firstly, it created favourable conditions for the fraudulent schemes:

> There is no regulation for using stem cells... you just have to apply for a licence and you can administer the therapy to anyone who agrees to it. (Head of Laboratory, Moscow)

Secondly, it hindered the progress of biotechnology in Russia. Existed legislation and standards for work with pharmaceuticals and for the transplantation of human organs and tissues were unsuitable for stem cell research - which complicated the organisation and documentation of clinical trials:

> We have a license for the treatment of hematological diseases, to work with blood and bone marrow samples, for the isolation of stem cells from peripheral blood, etc. Such methods are legally approved. But if we want to use stem cells of bone marrow, for example, to treat liver cirrhosis, we are not allowed to do this, because legally we go beyond hematology - which is not a part of cell research. Therefore, the suggested method is not considered conventional and, therefore, should be licensed. Obtaining such a license, however, is not an easy task for bureaucratic reasons. (Deputy Director for Science Research Institute, Novosibirsk)

Thirdly, the lack of legislation had a negative effect on social status of stem cell researchers. The whole field of stem cell research was in the 'grey zone':

> It is now the third year that we work on state contracts and we conduct clinical trials that are not regulated. The state wants the product and the medical technology. So, what should we do? Refuse to work until there is a law protecting us? This will make the whole science stop. (Researcher, biotechnology company, Moscow)

By 2008 a market for medical technologies related to the use of stem cells had emerged in Russia. It included at least three areas. The first one was based on the use of 'classical methods' – those legally allowed in clinical practice (for example, bone marrow transplantations in the treatment of certain types of cancer). The second area targets experimental methods. Problems, described above, became particularly apparent in this area. The third area comprises fraudulent schemes. In such cases, stem cells were not used at all.

Methodology

This paper studies the media coverage of stem cell research in Russia over a 15-year period from 2001 until the end of 2016, when the law 'On the circulation of biomedical cell products' was came into effect (it entered into force on January 1, 2017). Its Article 3 Section 5 sets out "the ban on using cell products for development, production and application if the biomedical material was derived from the interruption or disruption of the development of a human embryo or fetus."

Media reports, as any other historic documentation, only reveals parts and aspects of how policies come into place or how they are acted upon. Also, not everything that took place in the time span of this paper was covered by the media. Furthermore, media reports cannot be taken at face value and require an independent source for triangulation. In this regard, we did secondary analysis of interviews with experts from science, technology and medicine (collected within the framework of specialized survey in 2008 (Polyakova, 2008, 2011).

The interviews provided very valuable contextual data, which was useful in interpreting specific events or scientific activities. The interviews were particularly helpful in identifying the early developments of stem cell research and applications in a legislative vacuum. At the same time, the narratives of the experts interviewed provided the background against which we could compare the integrity of media coverage (media discourse vs. expert discourse). Based on these interviews, we carefully approximated the key problems and controversies in stem cell research in Russia through content analysis.

The use of narratives to analyze historical sources in sociological research looks back on a long tradition (e.g. Franzosi, 1998). Such a methodological approach requires methodological rigor in order to meet scientific requirements in exposing generalizable patterns that inform beyond the setting of the present paper (e.g. Polletta et al., 2011; White, 1987). This rigor commands a careful organization and structuring of the material at hand in order to connect collected narratives and media reports to a chronologically presented line of events. The ultimate end of this paper is to reconstruct and conceptualize media coverage in order to understand policy action (the issuance of the piece of legislation in relation to these earlier events).

We made use of the Factiva database,[7] which contains over 32000 national, international and regional media sources from 200 countries in 28 languages. In particular, it covers all major Russian newspapers, journals, news feeds, leading news and business websites, as well as transcripts of broadcast news channels. A detailed description of the largest by coverage Russian offline and online media used in this research is provided in Appendix 2.

Factiva though only contains 21 transcripts of TV programs on stem cell research for the period from 2010 to 2016. We hence used in addition the online library of Russian language media 'Public.Ru'. We chose key federal TV channels that are broadcasted into all Russian regions: 'First channel' [Первый канал], 'Russia' [Россия], 'TV Center' [ТВ Центр], NTV [НТВ] and 'REN TV' [РЕН ТВ]. Those federal TV channels are key to transport the government's view on the subject matter.

The content analysis of media reports comprised of two stages. In the first stage, we studied the dynamics of the media coverage, using the keyword 'stem cells' and its derivatives ('stem cell' or 'embryonic stem cell' or 'fetal stem cell') for the period from 1997 to 2016 in the Factiva[8] and from 2005 to 2016 in Public.Ru. Thereby, we could estimate the scale of media coverage of stem cell research in Russia. In the second stage, we studied the controversial issues raised by the Russian media before passing the law that prohibited certain areas of stem cell research. To identify these articles, we developed the list of keywords and examined the articles' content. We compared all reports (total of 401) from 1997 to

2004 and compared them to the insights from the expert interviews. We focused on the content of the media communications and paid attention to specific terms or phrases, which would reveal a more critical stance towards stem cell research. This procedure revealed thematic differences between media coverage and the opinion of scientists. Thereby, we identified around 100 keywords and phrases associated with controversies in stem cell research. As the first keyword list was based on popular buzzwords, we further refined our keyword search and focused mainly on words that correlated strongly with negative views on stem cells. The final list included 385 keywords stressing four contested areas in the field of stem cell research in Russia:

- the absence of regulation in Russia (e.g.: uncontrolled and/or illegal use of stem cells in medicine, unregulated market);
- unethical behaviour of researchers or specialists, clinics or other institutions who offer stem cell therapy (e.g.: falsification, charlatan(s), unethical medical application, borderline bid);
- moral issues (e.g.: commercialisation of abortions, cannibalism);
- side effects (e.g.: risky method of treatment, stem cells of unknown sources or which provoke cancer).

Thereby we could identify the critical messages in media communications which built the basis for further analysis. The list of keywords is available upon request.

Findings

The growth of media attention to stem cells

The first publication on stem cells included in the database 'Factiva' appeared in 1997. Initially, the level of media attention to stem cell issues was very low (see Fig. 1). Often the term 'stem cell' appeared together with 'cloning'. As the number of messages regarding stem cell research increased, so did the share of such reports using both the terms 'stem cells' and 'cloning'. However, from 2010 onwards these publications did not exceed 10% of the relevant entries in the database 'Factiva'. The topic of stem cells has become an object of independent interest in the media.

Most of media stem cell coverage served an informative purpose only. They did not analyse this area and its problems. For example, 23% (4186 of 17906) of the analysed articles in the 'Factiva'

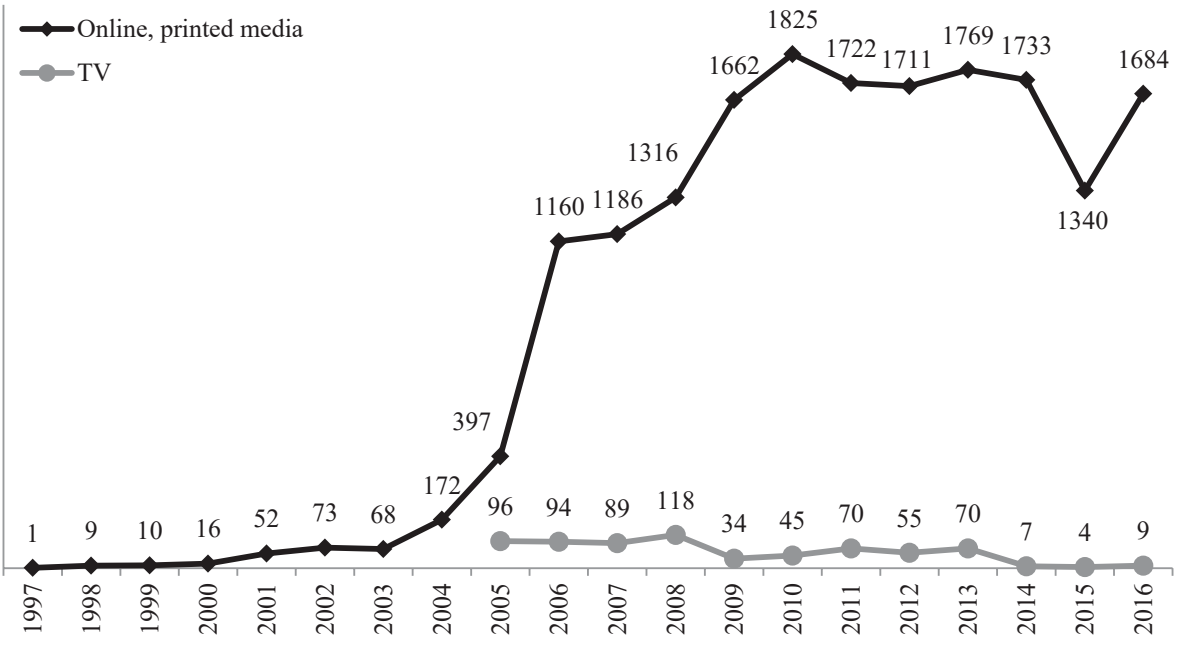

Figure 1. Media coverage of stem cell issues during 1997-2016 (messages per year)

database were devoted to scientific achievements or Nobel Prizes for discoveries related to stem cells, 15% (2623 of 17906) coveredindustrial applications, and 6% (1040 of 17906) – reported on the Russian Human Stem Cell Institute. In Public. Ru, 36% of entries about stem cells rcovered scientific achievements and 17% positive cases of treatment of incurable (or seriously ill) patients. Together with the 'naked' outline of the facts, these messages were embedded in the discourse of positive expectations and hope.

> The potential of cellular transplantology is enormous. Only 1% of normal cells, transplanted into a sick organism, can completely restore the functioning of damaged organs. (Independent newspaper [Независимая газета], 24.04.1998)

> (…) Moscow physicians have artificially grown stem cells and are ready to inject them. (...) All organs can heal. It restores memory, and heals neuroses and depressions, etc. Soon it will be possible to bank individual stem cells and, if necessary, inject them into the person who needs treatment. Theoretically, such cell therapy can prolong a person's life by 15-20 years. (Moscow Komsomolets [Московский Комсомолец], 19.11.2001)

> The market of stem-cell drugs should increase from $80-100 mln. in 2009 to $ 855 mln. in 2011. (Kommersant [Коммерсант], 13.09.2009)

> Israeli clinics use stem cells in the treatment of cancer and rare blood diseases. (Medical newspaper [Медицинская газета], 12.02.2016)

These reports stressed the potential of stem cells for medicine (treatment of incurable diseases, cultivation of tissues/organs, revitalisation/rejuvenation) and portrayed stem cell therapy as a 'panacea' for all imaginable diseases. Like the situation in other countries Russian media have rarely critically reflected on the hype surrounding breakthroughs in stem cell research, thus reinforcing the expectations about the future implication of this innovation (Frickel et al., 2010; Kamenova, 2017).

From 2004 to 2006, media coverage grew exponentially[9]. In 2004 the coverage of stem cell research and therapies more than doubled compared to 2003. In the next two years the number of contributions stayed constant. The growth in media coverage was linked to several approved legal documents regulating stem cell activities, as well as to the establishment of the first banks of stem cells of cord blood (in 2003-2004, see Table 1). Due to the increased media attention (Internet, newspapers and TV), by 2008 52% of the Russian population was aware of stem cells (Public Opinion Foundation, 2008).

Media coverage of stem cells issues in TV and other media indeed differ. While TV attention peaked between 2005-2008, the Internet and printed media attention to the topic reached its high only later (Figure 1). The topic has lost attraction for the official media (represented by TV) mainly in 2009 when Russian authorities announced the issue of a proposed law that would solve problems in current stem cells research.

Since 2010, the articles on stem cells have slightly decreased in numbers, most likely triggered by policy changes in this field to tackle controversial issues. A noticeable decline of interest can be seen in 2014, when attention shifted to the armed conflict in the east of Ukraine. From 2014 to 2015 media coverage was down substantially (by 23%), but then the level of media attention to stem cells grew up again.

Negative media frames

Science journalists often incline to accept an optimistic scientific agenda (Nisbet et al., 2003). Only 2% (311 of 17906) of the analysed online and printed media contributions in the time period covered by the present study were at least partly critical. The same indicator was slightly higher at 12% for TV coverage (86 out of 691), but low in comparison to results from other countries (Kamenova and Caulfield, 2015; Kamenova, 2017). We suppose that this very low level of attention to the controversies was one of the reasons why the authorities responded with such a time delay.

Most of the critical reports on TV (67%) were broadcasted in 2005-2008 (before the draft legislation), whereas 56% of the articles between 2009-2016 took a critical stance.

At the same time, the critical coverage of the Russian media became more diverse and did not focus exclusively on hESC (human embryonic stem cells) research but included its regulation and ethical positions (Maynard-Moody, 1995;

Brown, 2003; Brown et al., 2003; Nisbet et al., 2003; Saniei, 2013; Kitzinger and Williams, 2005; Gottweis and Prainsack, 2006; Lovell-Badge, 2008; Haran and Kitzinger, 2009; Elliott, 2012; Kamenova and Caulfield, 2015; Kamenova 2017).

In the next section, we will demonstrate that the media discourse on stem cells in Russia raised moral issues of hESCs research and fetal therapy, as well as issues with the professional community and commercialization practice in general. Critical articles contained information pertaining to problems in the field and controversial issues: 64% (or 200) on moral issues, 39% (or 119) on the challenges for professional expertise in terms of commercialisation of stem cells, and 37% (or 116) on the risk of side effects. The density of critical discourse in online and printed media vs TV programs is shown in Figure 2.

Ethical issues of stem cell therapy

hESCs research and fetal therapy was vividly discussed against ethical, moral, religious and legal backgrounds (Table 2). However, the ethical discourse, entirely or along with other contexts, remained dominant (90,5% of articles). Thereby, Russia's reports were in line with the international discourse (see for example, Kitzinger and Williams, 2005).

This direction of the critical discourse developed out of critical reflections on moral issues of the use of human embryos and fetal tissues in stem cell research and spanned the topic over to the commodification of human embryos and fetuses. Ethical arguments were based on the moral or religious discourse and were linked to the 'blastocyst', the same status as the 'living Baby' (Medical Post [Медицинская газета], 17.03.2006). The use of fetal stem cells was seen as inadmissible, as this would raise incentives for medical practitioners to conduct more abortions. "We will turn the killed children into spare parts for humans", was stated in the newspaper Profile([Профиль], 03.07.2006). Thus, the use of human embryos and aborted fetuses in stem cell research was presented as 'murder and cannibalism'.

Since 2001, the Russian media have started to raise questions with respect to the moral status of human embryos. Interest in the ethics and/or morality of stem cell research/technology in the Russian media echoed the coverage of similar public debates in the US and statements by the Catholic Church against the use of human embryos in stem cell research.

The peak of media coverage was reached between 2006-2010 in online and printed media and in 2007-2008 and 2012 on TV (Table 2). The media coverage of stem cell technologies became

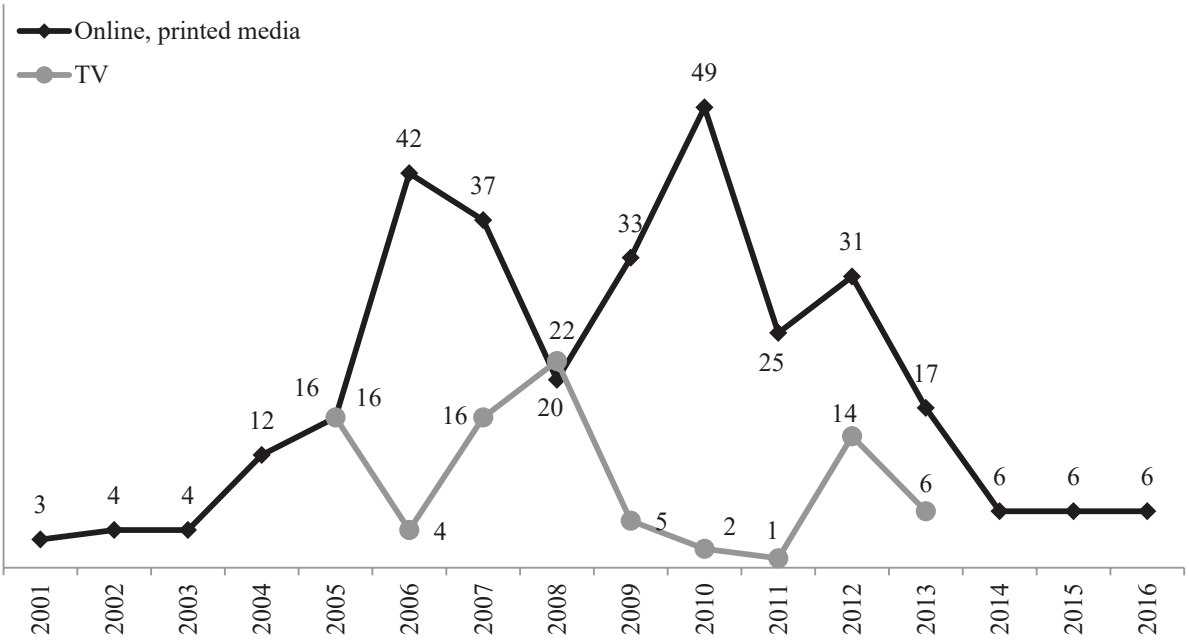

Figure 2. Media coverage of controversial stem cell issues during 2001-2016 (messages per year)

Table 2. Media coverage of controversial issues of hESCs research and fetal therapy during 2001-2016 (publications per year)*

1. Online, printed media
2. TV

Contexts	Frames	Topics	2001-2005		2006		2007		2008		2009		2010		2011-2012		2013		2014-2016		Total	
Moral/ ethical Religious	The use of human embryos and fetal tissues is murder and cannibalism Mixing man and animal is unethical	Moral status of human embryos	13	7	19	2	22	17	5	2	16	1	14		17	8	12	0	1	0	119	37
		Ethical issues in general without specification	4	0	6	0	3	0	6	1	4	0	7	0	5	0	3	0	0	0	38	1
		Moral estimation of fetal therapy	5	0	6	0	1	3	0	0	2	0	8	0	4	2	1	0	0	0	27	5
		Position of religious leaders	3	0	11	0	2	0	2	6	6	0	3	0	10	0	0	0	0	0	37	6
		The creation of hybrid embryos as a source of hESCs	0	0	2	0	3	1	1	8	0	0	1	0	0	0	0	0	2	0	9	9
Rational	The research on embryos is unnecessary because there are alternative way	Adult SCs VS. ESCs	6	0	3	1	6	3	1	0	2	0	1	0	3	0	2	0	2	0	26	4
		The discovery that mature cells can be reprogrammed to become pluripotent and further surveys	1	0	6	0	9	8	3	0	4	0	6	0	5	6	8	0	1	0	43	14
		A technique of generating hESCs without destroying embryos	0	0	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	2	2
International	Mixed frames	US debate	10	2	8	0	8	4	1	0	5	0	1	0	3	0	0	0	0	0	36	6
	Experiments with embryonic stem cells are illegal in many countries	Other countries	3	0	3	0	4	0	0	1	2	0	2	0	6	1	0	0	0	0	20	2
Legal	The use of human embryos (or hybrid embryos) and fetal tissues is illegal in Russia	The Russian State Duma [the lower house of Parliament] introduced a bill prohibiting the use human embryo or fetus as a source of stem cells	0	0	0	0	0	0	0	0	0	0	1	0	7	0	1	0	2	0	11	0
Other			3	4	2	0	5	0	3	1	3	4	1	1	1	0	3	0	1	0	22	10
Total number of articles per year			28	8	29	2	28	18	12	13	23	5	31	1	26	10	15	0	8	0	200	57

*Often one article combined several contexts and topics.

** In 2011, TV programs did not cover moral controversies in stem cell research.

more sophisticated. In 2006, the number of articles concerning stem cells in general almost tripled compared to 2005. In this year the ethical discussion in the media was triggered by four news topics: (1) the policy decisions of the then-President of the US, George W. Bush (he vetoed a bill that would have eased restrictions on federal funding for embryonic stem cell research), (2) the condemnation of the use of human embryos for research purposes by religious leaders, (3) the discovery of the IPSCs (induced pluripotent stem cells) technology which allows specialised adult cells to be genetically 'reprogrammed' to assume an embryonic stem cell-like state, which eliminated the need for human embryos, and (4) the emergence of alternative techniques for obtaining human embryonic stem cells (the creation of hybrid embryos as a source of hESCs and a technique of generating hESCs from single blastomeres without using embryos).

By the end of 2008, the media had stigmatized both embryonic stem cell research and fetal therapy as something immoral, non-essential and inacceptable in other countries. It is interesting that moral discourse was based on rather secular then religious argumentation (Table 2). Moreover, in this period journalists cited primarily foreign clerics.

In 2009, the need for a legal framework moved up high on the priority ladder of the policy agenda. In the next year, it was announced that obtaining stem cells from the human embryo or fetus would be banned (Table 1). Since 2011, the number of articles per year containing arguments against embryonic stem cell research has started to decline. In general, media coverage of hESC research (including positive and neutral articles) fell from 248 in 2009 to only 79 in 2016. Since 2012, this concept has completely disappeared from TV discourse. Thus, this field of research had been identified as especially problematic and had become a part of undone science or forbidden knowledge (Frickel et al., 2003)

Challenges for professional expertise

As mentioned before, biomedical research and stem-cell research in particular acted in an undefined space in Russia. The various commercialisation attempts of stem cell therapy under such conditions attracted attention of the media and triggered the discussion: 38% of online and print media, 47% of TV programs were devoted to the issues of legitimacy and professional ethics.

The media used terms like 'black market' and 'illegal activity' to describe these events. Almost half the articles (53 out of 119 articles and 19 out of 40 TV programs) were hyping the emergence of a black market for stem cells in Russia, whereas half the number of articles (20) compared the situation to other countries. Reports on the opening of criminal investigations and the revocations of licences in this field strengthened further the negative tone.

Stem cell therapy became a fashion medical service in different types of clinics and cosmetological centers. Media questioned the epistemic authority of such organisations and professionals and contested their technical capabilities to provide stem cell therapy.

> In Russia, there are no legal restrictions to work with embryonic stem cells. (…) Anyone who wants to offer cell rejuvenation/revitalisation can do it. (…) But what are these cells? (…) many cosmetological centres and clinics offer "tissue therapy" (a mix of fetal tissues)(…) If the procedure is carried out by non-professionals, then there is a big risk of infection. ("The price of eternal youth" Gazeta [Газета], 5 May 2004)

> There are hundreds of clinics and beauty salons across the country, which offer rejuvenation for 30 thousand dollars. This week, the Federal Service for Supervision of Health in conjunction with the Attorney General's Office checked 42 Moscow organizations that use stem cell technologies. As a result, almost all tested clinics had their licences for medical activity suspended. Only five public clinics have the right to work with stem cells. (REN TV, 7 April 2005)

Moreover, on the hype of stem cell technology and imperfect legal framework created favorable conditions for a fraud in Russia that triggered a vivid debate (38 out of 119 articles and 8 out of 40 TV programs) on stem cell therapy commercialization. For example, in 2005, the 'anti-ageing' drug 'Stvolamin'[10] had entered the market that allegedly contained stem cells. In 2008, the manufacturer of 'Stvolamin' was accused of fraudulent

action regarding production and commercialization of the drug. Media reported: "the many swindlers who began to treat people with God knows what" (Moscow News [Московские новости], 10.04.2012). Consequently, episodes of fraud in other countries appeared much less in the Russian media (12 articles).

Articles about the commercialisation of stem cell therapy were often based on investigative journalism with headings, such as "Buy cells cheap" (Ogonek [Огонек], 16 February 2004) or "Stem cells: hope or illusion" (Arguments and Facts [Аргументы и факты], 7 July 2004). They warned the population about potential risks and provided recommendations by experts on how to avoid swindlers. Often, journalists included information from conferences and other scientific events. For example, in an attempt by scientists to intervene and redirect the attention of society to the actual problems with respect to stem cell therapy, scientists and clinicians organised a round table discussion at the Sechenov Moscow Medical Academy at the end of 2004[11]. This event was widely covered in the media (though relevant reports are not included in the Factiva base) and became a starting point for a critical reflection initiated by the scientific community. Participants of the round table stressed that numerous organisations offering stem cell therapy did not have a licence.

The media attention was focused on the legal status of stem cell research in Russia so much so that other aspects were left out. For example, in the year 2012, barrels with aborted human embryos were discovered in the forest near Nevyansk (in the Sverdlovsk region of Russia). Most likely, it was a violation of the rules for the disposal of medical waste.

> Perhaps, the reason is the Russian negligence. There is an assumption that one health facility shipped the goods to another, which refused to accept it. And then the doctors decided to throw the embryos into the forest. (REN TV, 23 July 2012)

> This biological medical waste belongs to three hospitals at least. It seems that the organization that deals with the disposal of this medical biological waste has not met its legal requirements. (First channel ['*Первый канал*'], 23 July 2012)

This specific event was very provocative from both a legal and moral point of view. However, the media did not discuss the moral aspects of the behaviour of researchers and clinicians but instead journalists asked if the material has been used for illegal stem cell therapy: "Most likely, this is the concealment of criminal activity. It is possible that they were expecting an inspection, so they quickly got rid of the material evidences" (API-Ural [АПИ-Урал], 24.07.2012). The scandal in Nevyansk strengthened the notion of criminal wrongdoing in stem cell research.

Journalists questioned the legitimacy of organisations, which were offering stem cell therapy. For example, during an interview with the Russian Business Consulting (RBC) journal, the General Director of the Human Stem Cells Institute clarified that "as a rule, such organisations [that offer stem cells therapy] are licensed to work with cord blood, and not with the application of stem cell technologies" (RBC, 14.11.2012).

Controversies around the commercialisation of stem cell therapy proved to be a less popular topic (12 out of 119 articles, 0 TV coverage). Such media reports drew attention to the matters of the violation of the standards of good laboratory, clinical and manufacturing practice for business purposes in Russia: free participation in clinical trials and informed consent of the donors.

> Thousands of offers in the internet promise patients the treatment of the most severe pathologies and cardinal rejuvenation and do not explain what type and what sources of stem cells they use. Medical and scientific centers do not even hide behind the status of 'scientific research'. (GZT.ru, 06.12.2010)

> The texts of Russian authors virtually don't mention obtaining informed consent from the donors for the isolation of stem cells from cord blood (or other tissues) and their further use... Although hundreds of studies have already been conducted on the use of stem cells in the treatment of various diseases, the research literature contains no guidelines or best practices. Moreover, the therapies that are on offer in Russia stand in stark contrast to international rules. (Medical Post [Медицинская газета], 17.03.2006)

Media attention to the famous South Korean scientist Hwang Woo-Suk, charged with falsifying stem cell research the charge of falsification stem cell research, further discredited the credibility of stem cell researchers, but in broader context (13 articles and 7 TV programs).

This discourse surely affected the behavior of researchers and clinicians. This part of the media discussion discredited the credibility and standing of medical organisations and specialists, involved in clinical use of stem cells. In 2010, a documentary film 'Rejuvenation by death', aired by 'Ren-TV', reported on criminal activities in therapies with fetal stem cells.[12] This film was widely advertised in the media.

Articles devoted to the negative aspects of business activities with stem cells give the impression that the expert community was not able to enforce professional ethics. "Scientists ask to strengthen the laws and to control charlatans" (News World [Мир новостей], 25.07.2006). The weakness of the expert community and its disunity revealed itself in statements of the authorities published in the media as well:

> According to Deputy Minister of Health and Social Development of the Russian Federation, V. Skvortsova, due to the absence of a consolidated expert community minor studies become priority and often duplicate each other. (Medical Post [Медицинская газета], 06.04.2012)

Side effects of stem cell therapy

The risks and potential side effects of stem cell therapy was covered by 116 out of 311 online and print articles and 13 out of 86 TV-broadcasts . Almost half of the articles emphasised the cancer risk after stem cell therapy (49 out of 116).

> The influence of stem cells on the human body has not yet been properly studied. Stanislav Sadalsky [an actor] recently posted in his blog that his famous colleagues, who died of cancer, underwent treatment with 'miracle injections'. He says that Anna Samokhina, Alexander Abdulov, Lyubov Polishchuk and Oleg Yankovsky [well-known actors] rejuvenated with the help of stem cells and it prolonged their lives. (Evening Kazan [Вечерняя Казань], 11.05.2012)

> "The use of stem cells for rejuvenation can lead to serious complications. None of these technologies have been cleared in terms of safety. Stem cell injections at best threaten to intoxicate a healthy body, and at worst can lead to serious diseases. There are hints that stem cells can provoke the growth of cancerous tumours," said the head of the Pharmaceuticals Registration Department, Sergei Tkachenko. (TASS, 31.03.2005)

> Last year, dozens of laboratories that allegedly administered stem cell (and other cells) rejuvenators were shut down in Russia. Some of these creams and injections caused irreversible side effects, such as scars on the skin, cancer, etc. Soon a legislation on biomedical cellular technologies will be introduced to put an end to such practices. (Moscow Komsomolets [Московский комсомолец], 02.02.2011)

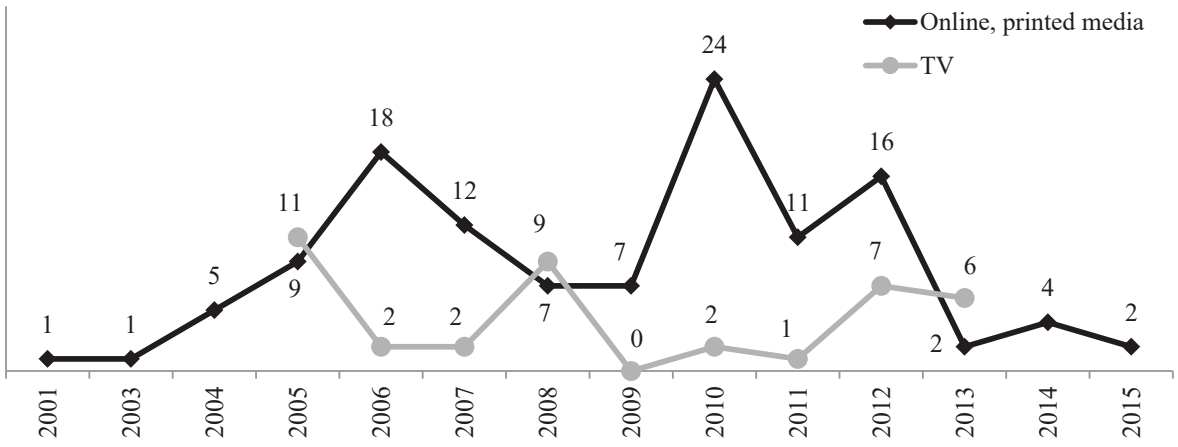

Figure 3. Media coverage of problems related to stem cell therapy commercialisation (messages per year)

Table 3. Media coverage of stem cell therapy risks during 2003-2016 (publications per year)

1. Online, printed media
2. TV

	2002-2005		2006		2007		2008		2009		2010		2011		2012		2013		2014-2016	Total	
Stem cells cause tumour growth and even cancer	3		0		6		1		3		12		2		5	3	1	3	0	33	6
Stem cells cause cancer	3		0		5		1		3		12		2		4	3	0	3	0	30	6
Embryonic and fetal stem cells cause tumour growth and even cancer	6		9		3		1		3		4		2		1		1		1	31	0
Embryonic and fetal stem cells cause cancer	5		5		1		1		1		4		1		0		1		0	19	0
Stem cells are dangerous (without specification)	6	2	7		3		4		1		3		0		2		0		2	28	2
Cancer stem cells	0		2		1		0	3	1		3		5		5		0		5	22	3
Stem cells of unknown sources are dangerous	3		2		0		0		0		4	1	1		2		0		0	12	1
Fetal therapy is dangerous	3	1	2		0		0		3		3		0		1		0		0	12	1
IPS cells can cause cancer	0		0		2	1	2		2		0		1		1		0		0	8	1
Efficiency is not obvious	1		0		0		1		0		2		0		0		1		0	5	0
Total articles per year	13	2	17		11	1	6	3	11		24	1	11		12	3	3	3	8	116	13

More than one third of articles about the cancer risk after stem cell therapy (19 out of 49) contain information about the cancer risk of ESCs and/or fetal stem cell rejuvenation and treatment. Such reports added to the moral stigma of ESCs and/or fetal stem cell research.

It should be noted, that journalists often mistakenly confused the term 'embryonic stem cells' with 'fetal stem cells'. Meanwhile, ESCs were not even the object of clinical trials either in Russia or other countries. This terminological confusion further discredited the work of researchers and painted a bleak picture of unscrupulous physicians using untested treatments.

> From the title it becomes clear that the 'donors' are unborn children. I saw refrigerators with 'material' in one of these laboratories - this is a ghastly sight. (Sobesednik [Собеседник], 28.04.2010)

> There is a peculiar modality of 'embryonic therapy' in Russia. Stem cells are isolated from the abortive material and injected into the patient. This method has two disadvantages. Firstly, there is a risk of infection if the material has been handled improperly. Secondly, there is a possibility of tumorigenesis due to uncontrolled cell division. (Itogi [Итоги], 23.11.2004)

> It is about the autologous cells and certainly not the embryonic cells obtained in abortions. (Culture [Культура], 18.09.2015)

Media activity thematising cancer risks related to stem cell therapy peaked in 2010 (Table 3), soon after the need for a specialised legal framework had been recognised in 2009. In 2010, the media honed in on the post of Russian actor Stanislav Sadalsky, who wrote in his blog, that several Russian movie stars had undergone rejuvenation treatment involving stem cells before they died of cancer. Also in 2010, the Russian Ministry of Health published the first version of the draft law 'On the circulation of biomedical cell products.' Since 2011, the issue of stem cell therapy's cancer risks has been disappearing from the media, and by 2014 it had disappeared altogether.

Interestingly, the majority of the articles (68%) on stem cells primarily focus on one specific issue,

leaving many others aside. Among the articles on ethical dilemmas in the field of stem cell research only 22% touch on the theme of the negative consequences of commercialising stem cell technologies and challenges for professional expertise, 28% focus on possible side effects. At the same time, more than a third (37%) of articles on the commercialisation of stem cells are concerned with moral issues and 43% discuss the negative effect of stem cell therapy on the human body.

The group of newspaper articles discussing side effects of stem cell therapy demonstrate a more comprehensive understanding of the situation regarding the use of stem cells at that time in Russia. Almost half (47%) of the publications refer to ethical debates concerning stem cells, too. In general, this is due to the fact that a large proportion of such reports are devoted to fetal stem cell therapy in Russia. Also, two-fifths (44%) of the publications cover the legal status of stem cell treatment in Russia.

In sum, media discussion surrounding stem cells started to decrease from 2011 onwards - after the first version of the draft law 'On the circulation of biomedical cell products' had been published in 2010. Official paperwork developed along with a growing level of the bureaucratisation of experts and their activities in the field of stem cell research and treatments. New technical details were regularly brought to the discussion by representatives of the scientific community and hampered the formation of a desirable consensus about basic terms and definitions, thus slowing down negotiation processes. Six years later, in 2016, the law 'On the circulation of biomedical cell products' was finally accepted. The law roughly reflects the development of the industry in the US 10 years ago and is close to the ideological position of the then-President of the US, George W. Bush. What a coincidence, given that the Russian media widely covered the US debate surrounding hESC research.

Nevertheless, the text of the law reflects all dominant narratives in the media. Firstly, it lifted an important area of medical technology out of the 'black market'. In particular, it regulates the development, research, expertise, state registration, production, quality control, sale, use, storage, transportation, import to / export from Russian, destruction of biomedical cellular products which are intended for prevention, diagnosis and treatment of diseases of the patient, as well as the donation of biological material for the production of biomedical cell products.

Secondly, the law drew attention to the role of professional expertise and prohibits the manufacture of falsified biomedical cell products (for example, like 'Stvolamin') and to violate the standards of good laboratory, clinical, and manufacturing practice (article 35, item 5).

Thirdly, the law removes the most problematic ethic challenge of human stem cell research. The Article 3 Section 5 sets out "the ban on using cell products for development, production and application if the biomedical material was derived from the interruption or disruption of the development of a human embryo or fetus."

Fourthly, the law provides a set of requirements for all manipulations with cell cultures intended for patients. Before passing of the bill, such procedures as genetic modification of cells, cell culture process, etc. were practically not controlled, which created risks for patients and contested the effectiveness of the treatment. The law establishes that medical staff needs specialized qualification to work with cell products, as well as it introduces the condition of compulsory life and health insurance for a patient participating in clinical trials. Contrary to the expert community, the media paid more attention to the ethical issues of hESC research and fetal therapy[13]. As a result, the media discussion framed the treatment with hESC and fetal stem cells as an illegal and unethical practice. It also showed, that the expert community was, at that time, not able to execute effective control over its members (professionals).

Discussion and conclusions

As previous studies have shown (Gstraunthaler and Day, 2008; Tateno and Yokoyama, 2013), media communication is increasingly becoming the medium of choice for the risk assessment associated with newly emerging technologies. Such perceptions are often shaped by collective experiences around major catastrophic events, among which the nuclear accidents in Chernobyl and on Three Mile Island, the disaster at Fukushima, as

well as Hurricane Katrina can serve as examples (Gamson and Modigliani, 1989; Triandafyllidou, 1995; Boomgaarden and de Vreese, 2007; Barnes et al., 2008; Greenberg and Truelove, 2011).

The fragile interplay between science, technology and society is especially easy to disrupt when a controversy is associated with a high level of uncertainty. In that case, different regulatory mechanisms can be applied before a consensus is achieved. In the case of the public debates on stem cells, we observe a variety of reactions. In the USA, scientists were for a long time almost cut off from public funding for ethical reasons (e.g. see CNN, 2009; Wadman, 2011). Other countries have gone as far as forbidding research in certain fields. While the UK approved research on embryonic stem cells derived in vitro (Lovell-Badge, 2008) and UK scientists has recently gained license to edit genes in human embryos (Callaway, 2016), Austria prohibits the use of human embryos for cell line production, but allows importing the cell lines, and Lithuania forbids any work with embryonic stem cells altogether (Mlsna, 2011).

This research contributes to the conception of 'forbidden knowledge' and 'undone science' (Frickel et al., 2010; Hess, 2007), demonstrating how the interaction of different media frames enhanced each other, stigmatizing either the biomedical technology, or the whole expert community (not only particular scientists and clinicians).

In this paper, we studied the evolution of the Russian media discourse on stem cell research and its correspondence to the key lines of the policy agenda. We focused on the role of the media in the overall framing of the public discourse about stem cells. The Russian community of scientists and clinical practitioners set the pace for the development of the public discourse, as they started first to patent and then to commercialise the newly developed technologies. The media drew the attention of both the public and policy-makers to controversial activities involving stem cell research and the commercialisation of stem cell therapy in Russia. First, media coverage led to the filling of the gaps in the present legislation and drew attention to the absence of strict and transparent rules for stem cell research and clinical practice. Next, the media highlighted the health risks linked to stem cell therapies. These concerns were both connected to commercialisation activities in a legal vacuum and the risks associated with the use of fetal tissues in stem cell therapy.

The scandal involving the drug 'Stvolamin' became a prime example of connecting the notion of 'stem cells' with criminal activities. Besides issues around commercialisation, the media covered ethical issues related to the use of human embryos and fetal tissues as a source of stem cells. In this case, such activity was framed as illegal despite the existence of a patented drug based on fetal tissue suspension and the method of preparation of cells transplanted from aborted fetuses. Once the topic had been framed in a negative way, there was no sensitivity towards such important details.

The subsequent ban was justified not so much by moral controversies but by fears of criminal activities. It helped to demarcate stem cell technologies from illegal and morally controversial medical activities.

The discourse on moral issues with respect to stem cells was also associated with criminal activity in research, except for coverage of international debate. Moral issues pertaining to the use of stem cell technology at no time played a crucial role in its legitimation / delegitimation. This puts the public discourse in Russia in contrast to most countries that have thus farbeen covered by academic literature. For instance, in the US, the government played a moderator role between the scientific community and mainly religiously oriented interest groups (Wertz, 2002). In Germany, public authorities and the scientific community worked closely together to convince German citizens of the positive outcomes of stem cell research (Rippe and Schöne-Seifert, 1991). The Australian experience demonstrated that the mobilisation of science and scientific knowledge in public debates on embryonic stem cell research led to the liberalising of regulation governing stem cell research (Lysaght and Kerridge, 2012).

Instead of shaping the way of development, the legislation was largely concerned with the prevention of criminal activities and to provide retrospective legitimacy to common practice.

This paper sheds light on the Russian discourse and thereby offers insights that stand in contrast

to the well-researched areas of stem cell discourses in other countries. It would be interesting to learn more about the public discourse and the role of policy-makers in other countries in a similar position as Russia.

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Notes

1 Media communication theory discusses the selective and polarising presentation of information under the concept of framing (Petersen, 2001; Scheufele and Tewksbury, 2007; Geels and Verhees, 2011).

2 The classification is based on the following sources: Stem Cell Classification // Source: Brown University Biology and Medicine URL from 13.09.2018 http://biomed.brown.edu/Courses/BI108/BI108_2002_Groups/pancstems/stemcell/stemcellsclassversatility.htm

3 Murnaghan I. Pluripotent Stem Cells // Source: the ExploreStemCells website. URL from 20.08.2018 <http://www.explorestemcells.co.uk/pluripotentstemcells.html>

4 Russian patents No. 2126260 RU, IPC A61K035/28 A61K035/407 A61K035/48 A61K035/54.Lekarstvennyj preparat immunokorregirujushhego dejstvia na osnove kletochnoj suspenzii i sposob lechenija saharnogo diabeta s ispolzovaniem etogo preparata (http://www.findpatent.ru/patent/212/2126260.html).

5 Russian patent No. 2160112, RU, IPC A61K35/48. Sposob prigotovlenija kletochnogo transplantata iz fetalnyh tkanej (Dismissed from 27.04.2012) (http://www.findpatent.ru/patent/216/2160112.html.)

6 The last five interviewees from 22 repeated the same concepts and themes are already discussed. Consequently, no additional interviews were needed.

7 https://global.factiva.com/sb/default.aspx?lnep=hp - subscription to the data source has been provided by the National Research University Higher School of Economics.

8 We got information from the database for 1997-2016 on 29 August 2017. Before 1997, there were no publications about stem cells in the library. Earlier reports are not included in Factiva.

9 Here we mean growth in percentage terms.

10 The name of the drug '**Stvol**amin' is consonant with the Russian word for 'stem' (**stvol**ovoi).

11 Osnovnye rezultaty 'kruglogo stola' v MMA im. Sechenova 23.11.2004, posvjashhennogo zakonodatelnym aspektam ispolzovania stvolovyh kletok, (http://www.mma.ru/events/44638/) (Accessed on 14.10.2014)

12 We are not sure how accurate the film is from a scientific point of view. Moreover, it contained technical mistakes (for example, in the classification of stem cells). Nevertheless, it contributes in framing the discourse around stem cells.

13 Unlike the media, experts did not give negative characteristics of ESCs. On the contrary they described their prospects in medicine.

Appendix 1. The list of experts

	Institution	Position	Gender	Scientific degree, title*
Novosibirsk				
1	Research Institute, Siberian Branch of the Russian Academy of Sciences	Head of Laboratory	Man	Doctor of Biology, professor
2	Research Institute, Siberian Branch of the Russian Academy of Sciences	Senior research fellow	Man	Candidate of Biology
3	Research Institute, Siberian Branch of the Russian Academy of Medical Sciences	Research fellow	Woman	Candidate of Biology
4	Research Institute, Siberian Branch of the Russian Academy of Medical Sciences	Deputy Director, Head of Laboratory	Woman	Doctor of Medicine, professor
5	Research Institute, Siberian Branch of the Russian Academy of Medical Sciences	Senior research fellow, clinician, Chief of Department, Deputy Director	Woman	Candidate of Medicine
6	Research Institute, Siberian Branch of the Russian Academy of Medical Sciences	Intern	Man	-
7	Research Institute, Siberian Branch of the Russian Academy of Medical Sciences	Director, Head of Laboratory	Man	Doctor of Medicine, academician, professor
8	Research Institute of the Ministry of Health of Russia	Neurosurgeon	Man	-
9	Biomedical Research Center of the Ministry of Health of Russia	Leading research fellow	Man	Doctor of Medicine, academician, professor
10	Center for Bone Marrow Transplantation, Siberian Branch of the Russian Academy of Medical Sciences	Director	Man	Doctor of Medicine, professor
11	Scientific and Clinical Center	Director	Man	-

	Institution	Position	Gender	Scientific degree, title*
Moscow				
12	Federal Research Center, Ministry of Health of the Russian Federation	Leading research fellow	Man	Doctor of Biology
13	Research Institute, Russian Academy of Sciences	Head of Laboratory	Man	Doctor of Biology, professor
14	Research Institute, Russian Academy of Science	Deputy Director	Man	Doctor of Biology, professor
15	Research Institute, Russian Academy of Science	Research fellow	Woman	Doctor of Biology
16	Research Institute, Russian Academy of Science	Head of Laboratory	Man	Doctor of Biology, professor
17	Research Institute, Russian Academy of Sciences; biotechnology company	Senior research fellow	Man	Candidate of Medicine
18	Biotechnology company	Director	Man	Doctor of Biology
19	Clinic	Deputy Director	Man	Doctor of Medicine, professor
20	Clinic	Executive Director	Man	
21	Biotechnology company	Director	Man	Candidate of Medicine
22	Research Center, Russian Academy of Medical Sciences	Clinician	Woman	Candidate of Medicine

* According to the International Standard Classification of Education (ISCED) 2011, Candidate of Biology/ Medicine belongs to ISCED level 8 – 'doctoral or equivalent', together with PhD, DPhil, D.Lit, D.Sc, LL.D, Doctorate or similar. Doctor of Biology/Medicine is a post-doctoral degree given to reflect second advanced research qualifications or higher doctorates in ISCED 2011.

Appendix 2. Description of key Russian newspapers used in media analysis

Name	Description and historical facts	Coverage	Print run	Audience	Audience size	Additional comments
Komsomolskaya Pravda (KP)	Soviet and Russian daily social and political newspaper. It was established in 1925 as the official organ of the Komsomol. The newspaper published many popular science and adventure articles. Young Soviet writers and poets were published in the newspaper. In the period of Perestroika the newspaper began to publish social-critical articles. In 1990 it reached print run the largest print run in the world (22,37 million copies). On August 21, the newspaper published the entire chronicle of the August Putsch as a historical document. After Perestroika the newspaper was privatized and changed its conception to entertaining. Since 1997 it has had an online version, since 2009 – radio station. In 2010 the TV channel 'Komsomolskaya Pravda' was launched, but it stopped broadcasting in 2014.	85 Russian regions and 47 countries	Daily KP – 655 ths. copies Weekly KP – 2.2 mln. copies	18+	Kp.ru – 44,5 mln. per month Printed projects – 9,9 mln. per week	№1 in the rating of favorite newspapers of Russians (OMI, 2014-2018)
Moskovski' Komsomolets (MK)	It was established in 1919 by the Moscow Regional and City Committee of the Komsomol. From the end of the 1970s till the beginning of the 1980s, it published articles devoted to semi-underground issues (informal youth movements, rock music, western cinema, etc.). After Perestroika the newspaper was privatized.		Daily MK – 700 ths. copies Weekly MK – 230 ths. copies Weekly MK-region – 1 mln. copies	16+	Mk.ru – 18 mln. per month Daily MK – 949 ths. per issue Weekly MK – 390,3 ths. per issue Weekly MK-region – 1,3 mln. per issue	№4 in the rating of favorite newspapers of Russians (OMI, 2014-2018)

Name	Description and historical facts	Coverage	Print run	Audience	Audience size	Additional comments
Nezavisimaya Gazeta (NG)	Established by the Moscow City Council in August 1990 and was registrated in the State Committee of the USSR. First editor-in-chief intended to create an independent newspaper. In 1995-2005 it was controlled by B. Berezovskiy (Soviet and Russian businessman, political figure, opponent of V. Putin since 2000). In August 2005 it was sold to K. Remchukov (in this period he was undersecretary of economic development Minister G. Gref). Journalists, politicians and public figures have repeatedly accused NG of publishing biased political articles. In March 2010 NG published the article of M. Hodorkovskiy "Legalized Violence" that criticised the Russian law enforcement system.		Daily NG (6 days per week) – 55 ths.	Web audience: 87% - men 47% aged 45+ and 31% 25-34 y.o. 29% - Moscow, 10% St.Petersburg 34% middle income, 51% upper middle income	Ng.ru – 650 ths. per week	
Rossiyskaya gazeta (RG)	Official newspaper of the Russian Government. It was established in 1990. Before taking a legal force state documents are published in RG.		Daily RG – 160 ths. copies Weekly 3,3 mln.	25-55 y.o. Higher education Middle and upper middle income	RG.ru – 29 mln. per month Daily RG – 760 ths. per issue	
Argumenty i facty (AiF)	The newspaper has been established in 1978. Initially it was a news-bulletin for lecturers, propagandists, political informers and agitators. Since 1988 it has become a newspaper. In May 1990, AiF entered into the Guinness Book of Records as the newspaper with the largest print run (33,5 mln. copies), the audience size was more than 100 mln. people. In 2014 the newspaper was bought by Moscow Government because of high level of indebtedness of publishing house AiF.		Weekly newspaper, 1,5 mln. copies		6,7 mln.	

What is 'Cosmic' About Urban Climate Politics? On Hesitantly Re-staging the Latour-Beck Debate for STS

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Abstract

While Bruno Latour's criticism of Ulrich Beck's cosmopolitanism helped set the stage 15 years ago for the highly productive research approach of cosmopolitics, including as concerns urban ecological politics, a nagging doubt remains that more blood was spilled than necessary in the exchange. In this short discussion piece, I re-stage the Latour-Beck debate as part of on-going inquiries into the more-than-human politics of climate adaptation in Copenhagen, exploring what exact senses of 'cosmos' might be helpful in making sense of this increasingly common-place situation. At issue, I suggest, is the question of what it means to say that 'natures', in the plural, are put at stake in such settings. Far from any synthesis, in turn, I conclude that scholars in STS and beyond might do well to extend a shared hesitation towards both sides of the debate - cosmopolitics, cosmopolitanism - and thus take the opportunity to share unresolved conceptual tensions in the service of posing better problems.

Keywords: Latour-Beck debate, cosmopolitics, cosmopolitanism, natures

Introduction: how to re-stage the Latour-Beck debate?

Why re-open what seems like a case closed? Back in 2004, some 15 years ago, science and technology studies (STS) eminence Bruno Latour (2004) exerted a bit of actor-network theory (ANT) force, in what he staged as a friendly criticism of sociologist Ulrich Beck's (2004) cosmopolitan proposal. While Latour lauded Beck for raising the issue of how diverse groups might find common ground in the face of ecological and other risky planetary disruptions, Beck's cosmopolitanism, Latour argued, was insufficient to the task. Instead of the humanist-multicultural problem of telling the culturally particular from the universally valid, which Latour saw Beck inheriting from previous cosmopolitan thinking all the way from Kant to the United Nations, we would need, Latour suggested, to pose a question of ontological multiplicity. Since we do *not* inhabit the same world, the same nature or cosmos, Latour asks, how might such a 'common world' eventually be build? How to take the nature of 'cosmos' as itself a question of politics?

In posing these questions, Latour set the stage for a research approach about to gain much influence in STS and beyond: the approach of cosmopolitics, a term itself traceable to Isabelle Stengers (see, e.g., 2015). In previous work, along with colleagues, I myself have benefitted greatly from this approach, not least in attempts to renew the sense of urban politics (Blok and Farías, 2016).

Yet, a nagging doubt remains for me that Latour's critical operation on Beck perhaps spilled more blood than necessary, particularly when it comes to grappling with present-day realities of ubiquitous ecological disruption. In any specific situation of urban ecological politics, I wonder, how readily can we tell just how many 'natures', in the plural, are put at stake in collective disputes, what they are and where they come from? How do we know, indeed, when practices and settlements pertain or not to one, common cosmos?

In this short discussion piece, I briefly sketch the key conceptual stakes of the Latour-Beck exchange and relate this to my empirical interest in urban ecological politics in times of worldwide climate crises, a domain I consider important for STS inquiry (Blok, 2013). I do so with a view to raising a few questions about the precise sense in which this politics is indeed 'cosmic', yet perhaps in ways not fully captured by neither Latour nor Beck.[1] My conceptual re-staging is fed by a limited, even parochial piece of quasi-ethnographic work into recent more-than-human politics in my native city of Copenhagen, focused on civic attempts to accommodate a climate-perturbed future of more and heavier rains. This increasingly commonplace state of urban affairs (see Blok, 2019), I believe, helpfully dramatizes the conceptual tensions at stake in the Latour-Beck debate and pose mutually unresolved issues.

Searching for new inspiration 'in the gaps' of the Latour-Beck debate, in the sense of how their abstract theorizing leaves many mutual blind spots behind, I argue that we may want to re-cast their approaches as disjunctive resources that might be put to more productive joint uses in STS and beyond. After all, as Latour (2004: 450) was frank to admit, his argument with Beck pertained to "a puzzle that has defeated, so far, everyone everywhere". My intuition is that this is still true, pace Latour's own subsequent efforts (e.g. Latour, 2017). For this reason, also, my intervention should in no way be read in the register of synthesis, as if somehow purporting to 'overcome' whatever deep-seated differences *and* to finally 'uncover' whatever deep-seated affinities that prompted Latour and Beck to engage in respectful dialogue. It is better to say that I want to mobilize both into a form of what Martin Savransky (2012) calls shared hesitation – whereby the exchange of puzzles might help us develop better problems.

The 'cosmic' in urban climate politics: a conceptual sketch

It is important to note that Latour's (2004) original criticism of Beck pertained centrally to the question of science, and therefore to questions that go to the core of STS as a research field. While Beck is right to search for a social science with global scope, Latour suggests, he inadvertently short-circuits the task ahead by prematurely assuming an ontologically unified cosmos. Beck does so, in turn, because he disregards those heterogeneous material-semiotic realities showcased in part by STS work on the techno-sciences. More specifically, Latour continues, Beck fails to realize that cosmopolitanism rests on an unquestioned faith in science "to know *the one* cosmos" whose "solid certainty could then prop up all efforts to build the world metropolis of which we are all too happy to be citizens" (Latour, 2004: 453).

By contrast to this *mono-naturalism* – a term borrowed from anthropologist Eduardo Viveiros de Castro – Latour advances his own version of de Castro's *multi-naturalism*, taken as largely co-extensive with constructivist ANT tenets. Put briefly, Latour (2004: 458ff) casts multi-naturalism as premised on protecting politics from a premature closure of 'cosmos', as the question of what human-nonhuman attachments and mediations constitute multiple and clashing *worlds*. Such ontological multiplicity, Latour suggests, is always and everywhere a political challenge. Hence, it is equally at work in the spectacular encounter of Amerindian animists with European colonialists in the 16th century as in the more humdrum ways that scientific fabrications shape public-political controversy. It thus also frames how one would think cosmo-politically about the Copenhagen climate case, to which I return later on.

Overall, Latour's has always seemed to me a well-taken and convincing criticism of Beck on this point of ontological multiplicity. It is debatable, however, just *how* far removed this actually is from what Beck (2004) presents as his *realistic* (and largely methodological) cosmopolitanism. Responding to Latour, Beck (2005: 3) draws a historical contrast: whereas first modernity indeed

rested on the regulative principles of Western rationalism and universalism, such certainties are now gone in the second, risk-prone modernity heralded by ecological disruptions since the 1960s. Instead, he continues, we today "experience the unity of the world but only in its threatened dismemberment", generating new conflicts over the loyalty and identity of persons, nation-states, "and even natures" (Beck, 2005: 5). To Beck, in other words, the core notion of global risk signals a new and ambivalent worldwide territory, torn in-between the breakdown of old affiliations and the prospect of a new, cross-boundary unity.

It is hard to know precisely what Beck intends by the plural form of 'natures'. Presumably, he means to signal that diverse (techno-)cultures around the globe understands 'nature' in different ways, shaping also diverse responses to new global risks such as climate change. In this multicultural sense, the plural form ('natures') stands in some tension, arguably, with Beck's general argument on the second modernity of risk society, which relies on the notion that global risks precipitate a new and *shared* condition of enforced transboundary enmeshments of collective fates across the planet (Beck, 2011). This is what he dubs the side-effect principle, according to which, for instance, ours is a world in which carbon emitted as part of high-consumption lifestyles in one region of the world, say Copenhagen, may return in the shape of intensified storms or floods in another, say Surat in India (Beck, 2010).

Side effects, in turn, constitute the core of what Beck (2011) dubs 'cosmopolitization', the realistic force of socio-natural change that is gradually precipitating a new sense of unity in world risk society. Simply put, the risks of climate change brings with them not only new types of catastrophes and new forms of collective vulnerability, but also a newfound sense of planetary interconnectedness and shared, worldwide fate. This is what Beck means, in other words, when speaking, as in the quote above (Beck, 2005), about the new twinning of (present) dismemberment and (future) risk-based unity characteristic of the ambivalences of our present, ecologically distressed age. Strictly speaking, then, and contra Latour's (2004) depiction, Beck's is less a theory of (philosophical) cosmopolitan*ism* and more a (sociological) theory of the gradual cosmopoliti*zation* of the world in the face of global ecological risks.

However, Latour's question of ontological multiplicity is still relevant to pose vis-à-vis Beck's theorizing of global risks. Amidst global risks like climate change, we should ask, how much of 'nature(s)' is in Beck's account shared at the level of ontological assumptions across diverse groups locally and globally, and how much is multiple and divergent? Even as climate change is surely backed up and carried by global science (including in famously controversial ways) (see Mahony and Hulme, 2018), how much does this scientific inscription-work (over-)determine more culturally rooted senses and practices of locally relevant 'nature(s)'? Conversely, to the extent that understandings of 'nature(s)' follow cultural lines, how are we to understand such differentiations in world risk society? In other words, what are the lines of cultural alliance and tension around 'nature(s)', locally, nationally, and globally?

Posing these questions may make it sound as if we do better by simply re-affirming the shift that Latour advocates, from Beck's cosmopolitan proposal to his own cosmopolitics, attuned as this latter approach is to these very questions. Yet, as I hope to unfold in what follows, conceptual tensions of a not-too-different kind *also* seems to me to haunt Latourian multi-naturalism, once we engage with the domain of urban climate politics. This becomes visible when reading across Latour's 20 years of pronouncing on the politics of nature, in ways that span from the clearly situated (ecology as a matter of *this* river, *that* landscape) to the more ambiguously planetary (ecology as a matter of facing Gaia as a new earthly condition), without any obvious way of bridging the two (see Latour, 1998; 2017).

Such a span raises questions, in a nutshell, pertaining to certain gaps that can be detected – in ethnographic work as well as in discussions on cosmopolitics in the socio-cultural sciences writ large – in-between notions of 'cosmos' and 'globe' or, as we might prefer, 'the planetary'. By this latter term, I mean simply to invoke the STS-informed sense in which, as Jennifer Gabrys argues (2018), climate change "is an event that comes into view through planetary computation", made knowable by global infrastructures. Yet, precisely for this

reason, climate change *also* raises questions about situated ways of knowing and living in common, including how to deal with multiple and sometimes incommensurate 'cosmic' attachments of human-nonhuman constituencies. Reconciling such tensions in turn poses questions, I believe, in equal measure to Latourian cosmopolitics and Beckian cosmopolitization.

In important ways, then, and despite popular meta-narratives of an Anthropocene era (see Blok and Jensen, 2019), just *how* the planetary of climate change comes to matter in any *specific* situation of ecological dispute, urban or otherwise, cannot be conceptually foreclosed through some notion of the common cosmos. To summarize on this note, the conceptual sketch set forth here is meant to suggest that, while both important and inspiring, neither Latour nor Beck quite resolve the issues they themselves pose (partly via their dialogue). Rather, Latourian cosmopolitics and Beckian cosmopolitization may usefully be deployed side-by-side in ways that acknowledge their mutually unresolved tensions. I turn next to rendering this point vivid and conceptually fruitful through an empirical illustration.

Urban cosmo-politics in action: setting the empirical scene

On July 2, 2011, a major cloudburst hit Copenhagen, leaving many streets and basements flooded. In the months and years to follow, climate adaptation would climb up the ladder of priorities for policy-makers, expert professionals and citizens alike, setting in train what at first glance appears a telltale version of Latourian-style urban cosmopolitics. Provisionally, following Latour's (2007) own elaboration, I take this to imply an agonizing sorting out of conflicting cosmograms of human and nonhuman co-habitation, and thus a search to reassemble urban common worlds of co-existence (see also Blok and Farías, 2016). Importantly, the common cosmos is cast here not as what precedes, but as what may follow from, a joint but antagonistic inquiry into an uncertain, heterogeneous, material-semiotic urban situation.

With Copenhagen sewage capacities exposed as grossly inadequate for the future, the local search was on for ways of handling excess rainwater on the urban surface, itself a translated version of a trans-locally mobile idea (see Blok, 2019). In the process, planners, engineers, and landscape architects would set about digging new rain-beds, park reservoirs, and much else besides. Meanwhile, civic groups joined in as well, adding their level of technical activism. Most importantly, a coalition of organized and grassroots civic voices emerged and gained momentum for their vision to excavate or, in the vernacular, to 'daylight' a stream of water, known as *Ladegaard*, nowadays running invisibly as a subterraneous canal underneath a traffic-heavy part of inner-city Copenhagen. Once excavated, the stream would once again meander on the surface of public space, as it had in the early 20th century.

Together with colleagues and students in anthropology and sociology practicing what we call teaching-based research, we sat out back in 2014 to trace these civic riparian aspirations and to similarly uncover or 'excavate' what kind of techno-politics of urbanized ecologies it engendered (Blok et al., 2017). In loosely multi-sited form, we would interview civic leaders, read through technical reports, join groups on social media, conduct walking ethnographies in the area and visit local history archives – all meant, in a clearly hyperbolic gesture, to attain a view of the city from the streams' point of view.

Now, to cut a long story short, these practices of ours lend themselves easily to the Stengerian-Latourian notion of cosmopolitics. Most obviously, we were latching our inquiry onto a proliferating set of civic explorations aiming – so it looked to us – to re-assemble, tooth and nail, all the ingredients making up this urban landscape, shaping a variety of socio-cultural, technical, and ecological relations into a new situated urban cosmogram (Latour, 2007), an emplaced instantiation of an encompassing world. Here, not only would the impinging reality of climate-induced rains meet with an accommodative gesture. Car-based infrastructures, moreover, would be dug down under ground, lessening air pollution; and the channelized stream would burst forth in a new green-blue urban landscape of recreation, bicycles, plants, insects, fish and other elements of a biodiverse, livable, more-than-human city.

If, as scholars like Adrian Franklin (2017) suggest, we associate the Latourian cosmopolitical proposal foremost with the enactment of such a multispecies city, where critter of all sorts become important companions to human urbanites, then all we had to do, it seemed, was to register carefully these civic-public explorations. In their critical questionings, the stream's proponents would articulate a cosmogram in which plural and more 'agentic' natures would now claim stronger cultural-political legitimacy, and stronger material presence, in the city. However, as we would soon realize, simply tacking along with these groups, and the way they sought to reconnect the ecologized city of the future to a pre-modernist past of water flowing openly through the urban fabric, was also to miss too much of how the planetary moment of climate change came to bear on the situation and influence its trajectory.

Hence, as Latour (2007) would be the first to predict, the issue of excavating the stream did not stay solely in its civic modality for long. Rather, once the civic coalition gained momentum in Copenhagen, a whole apparatus of formal knowledge and power kicked in, making visible the workings of the city's environmental technocracy. Engineering consultants, in particular, would come to play a key role. In the official 2016 pre-project report commissioned by the municipality, engineering experts took over the cost-benefit tool standardly deployed by the Danish Ministry of Finance. Excluded here, they duly noted, were many of the projects' assumed benefits, including those of biodiversity. Nevertheless, what stuck in the public imagination was the number itself: a so-called tunnel solution would cost in the range of 1 to 1.5 billion Euro, making it 'macro-economically unviable', as the report had it.

In subsequent years, *Ladegaard* became known as the popular stream that Copenhagen will never get – until recently, when a scaled-down version of civic ambitions to excavate the stream got re-entangled into the politics of a much-hated remnant of Copenhagen's high-modernist 1960's car infrastructure set for likely demolition. In this sense, the stream continued to offer itself up as a useful way of tracking the shifts and turns of urban techno-politics, and the grounds potentially generated for civic groups to democratize otherwise technically framed issues of more-than-human co-existence. Foremost amongst these issues, for present purposes, is the question of what happened to the planetary of climate change, or what Beck would call its global risks, in the situation: how was this latter entity mediated and translated, inside which alliances, and with what consequences for how events unfolded?

In the language of Latourian cosmopolitics, helped along by Noortje Marres (2007), the events just outlined might be summarized by saying that the collective experience of climate-induced rains had sparked a new critical urban public into being, oriented to a comprehensive search for a different, more-than-human city. This notion of publics stems from pragmatist John Dewey, for whom civic-public collectives arise from the shared experience of the indirect and troublesome consequences of political-economic decisions – and by way of their publicly articulating shared matters of concern. Interestingly, while less attentive than Latour to its more-than-human aspects, Beck (2011) would similarly invoke Dewey to articulate how the side-effects of industrial modernity's economic prerogatives here return, in the shape of global climate risks, to animate a critical public counter-response.

It is less clear, however, how either of these approaches – cosmopolitics, cosmopolitization – invites us to understand the key question of a possibly 'common' ground in-between the civic collective and the municipal bureaucracy in the case, and how climate change is or is not part of that commonality? For cosmopolitics, the question seems one of the extent to which a new situated urban cosmogram, one that accommodates climatic concerns alongside other human-nonhuman attachments, achieves gradual stabilization through a due process of inclusive inquiry (Latour, 2007). For cosmopolitization, in turn, the question is rather the extent to which global climate change indeed heralds a new urban-political situation whereby actors are forced to attend to, and seek to learn from, the risky trans-local connections and side-effects at work in this phenomenon (Beck, 2011). As I will argue next, neither expectation quite bears out in practice; yet, their intersection still proves analytically interesting.

How many 'cosmoses' did the *Ladegaard* events activate (and how do we know)?

In Latourian multi-naturalism, as noted, the common ground of cosmopolitics is conceptualized as the always-provisional end-point of a politics of multiple urban worlds, understood in ontological terms of heterogenous human-nonhuman assemblages. Here, unlike helpful post-colonial critiques already registered in these debates from scholars like Marisol de la Cadena (2010), my case lends itself to an interest in what Candea and Alcayna-Stevens (2012) call 'internal others'. That is, to differences and divergences *within* a Euro-American setting presumably marked by an official 'mono-naturalism' which, as work in ANT and STS has documented, nonetheless tends to enact natures of various kinds in multiple, divergent, and non-coherent forms (Law and Lien, 2018). This line of work, as noted, shaped our initial, cosmopolitics-inspired approach also to the *Ladegaard* case.

The cosmopolitical proposal is often mobilized in the first place towards *undoing* modernist exclusions, such as along nature-city, global-local and science-public boundaries (e.g. Franklin, 2017). However, as one instantiation of internal others, and as Beck would surely insist, various influential environmentalisms have arguably *already* been chewing away on some of those modernist exclusions at least since the 1960s. The very articulation by civic activists of the *Ladegaard* stream as a public matter of concern bears witness to such internal divergence, replete as this cosmogram is with non-polluted airs, plants and insects, extreme rains and changing climates. Such entities, we should note, hail from different moments of collective history and potentially constitute incommensurate attachments to diverse, more-or-less extensive ecologies. Their commensuration, in turn, should not be taken for granted, but rather analyzed *as* a mode of cosmopolitics.

Based on such a realization in my group, as hinted, we started asking ourselves just what was shared and what was divergent – what was the space of (in-)commensurabilities – between the two core 'cosmoses' or cosmogrammatic projects agonizing in our case, those of the civic collective and the municipal bureaucracy, respectively? In one sense, the divergence is initially radical, as it pertains to the difference between (future) existence and (current) non-existence of the excavated stream. In another sense, however, and even before the prospect of a compromise emerged, the substantive overlaps between the two world-building coalitions were striking. Notably, both projects recognized the strivings for a more-than-human city of biodiverse livability, and both took climate-induced heavy rains as a new and – importantly – non-negotiable entity with which to re-compose the city. They did so, even as they diverged on the question of which exact knowledges and techniques to rely on in going forward.

Put starkly, it thus turns out on closer inspection to be hard to tell whether this is a situation of mono-naturalism, the telltale sign of modernist ontology, or whether and if so *how* the situation had morphed into one of multi-naturalism, a clash of divergent nature-cultures. In particular, it proved harder than anticipated – by *us*, at least – to gauge what difference the new presence of a certain planetary entity, expressed in the climate-induced rains, made to this question in the situation at hand. Did this entity, we wondered, in fact move us closer to a situation of inclusive multi-natural inquiry, as Latour might envisage, in light of new radical indeterminacies in science and (urban) politics? Or, did it herald a situation of twinned experiential world unity and dismemberment, as Beck might predict, leading actors to seriously question their new trans-local risk interconnections?

This is where I want, hyperbolically perhaps, to link our own sense of ethnographic perplexity in the face of these questions to certain gaps, or unresolved puzzles and tensions, equally but differently at work in both Latourian cosmopolitics and Beckian cosmopolitization. Put abstractly, and borrowing again from Savransky (2012: 264f), this is the puzzle of how to bring worlds, urban and otherwise, "together in a way that attempts to take seriously the multiple modes of existence of the entities that compose them". In this context, the multiplicity I have in mind pertains, in only seemingly paradoxical terms, exactly to 'the planetary' or, more specifically, to the risky assemblages of climate crisis, itself a vast and multi-faceted set of spatio-temporalities

(Blok, 2010). Put concisely, it seems to me that this climatic entity *itself* potentially spans the cosmic and the planetary in multiple and non-coherent ways; ways not quite captured in either Latourian or Beckian terms. Moreover, I suggest that the *Ladegaard* situation made this apparent 'in the negative', as it were, by way of its exclusions and silences.

On this note, it is indeed striking to observe the highly particular, circumscribed, and exclusionary ways in which spatio-temporally far-flung and expansive climatic changes were allowed or rather *not* allowed, by civic and municipal agencies alike, to impinge on the search for common ground around the Copenhagen stream. Put bluntly, at no point was there any sense that this ground might, as it were, be shaken up in more thorough ways underneath the largely shared and hegemonic sense of urban nature-cultural ordering played out (see Law and Lien, 2018). Notably, for instance, seeing how cars would in no ways or numbers be expelled from the city when excavating the stream, but simply channeled through it differently and underground, civic actors failed to articulate any alliance or alignment between the stream proponents and proponents of low-carbon traffic transitions. The climates of these two civic groups, we might say, was equidistantly apart from that of the municipality; not to mention from those excluded and far-away others involuntarily suffering the climatic consequences (Beck, 2010).

Conversely, in a telling set of events to which Beck (2011) might well give the label of cosmopolitan risk community, civic activists and municipal planners alike would invoke their own creative sense of a newly globalized commonality when jointly pointing to Singaporean experiences of river daylighting as relevant to the Copenhagen situation. Lost from this set of far-flung translations, however, was any sense of those situated cosmic attachments to multiple ecologies presumably at work, quite likely in conflictual ways, in this Singaporean site. Rather than an inclusive moment of learning across divergence, then, such transboundary 'cosmopolitan' gestures were themselves reduced to their merely technical import, far from the sense of dismemberment to which Beck aligns climatic risks. Neither did such gestures lead to any inclusive, Latourian-style inquiry into divergent nature-cultures.

This is a situation, in short, in which the localized translation of the travelling planetary entity of climate change, as known not least through techno-scientific infrastructures, exerts effects that confound somewhat the expectations of Beck and Latour alike. Along Beckian lines, whatever planetary interconnectedness gets staged along with the risky climate-induced rains in Copenhagen hardly amounts to any encompassing, trans-local renegotiation of the city's nature(s). Conversely and relatedly, along Latourian lines, the open-ended search for new human-nonhuman attachments looks strangely foreclosed, given what we might think of as the local black boxing of an otherwise potentially unruly, globalized assemblage of climatic connections (Blok, 2010). In short, the Deweyan public, to which both protagonists subscribe, proved to be configured in rather more locally circumscribed, and rather more scientifically and politically conventionalized ways, than what cosmopolitics and cosmopolitization suggest.

While this may at first seem more of a challenge to Beck's cosmopolitan proposal than to Latour's more staunchly situated cosmopolitics, it is important to realize, as hinted, that Latour's own recent pronouncements on climate politics paints a different picture. Here, for all Latour's (2017) assertions that the figure of Gaia is not a 'God of totality', there is no escaping the observation, I think, that Latour's invocation of Gaiagraphy posits a new planetary condition, a new climatic regime, as *itself* the refigured common ground faced by collectives all around. However, to paraphrase Deborah Danowski and de Castro (2016), evident elisions between situated cosmic attachments and planetary exigencies raise the suspicion that planetarity *itself* may be assembled without due process (see Blok and Jensen, 2019). As Mike Hulme (2017: 29) puts it, socio-cultural analysis then must contend with how "people may increasingly encounter multiple climates"; or, as in my case, how such multiplicity is tamed.

While commonplace, the implications of such observations are far-reaching enough, I believe: just as Latour (with Hermant 1998) once suggested to think of urban life in Paris as partly a matter of the kinds of sociologies flowing through the city's streets, the same is surely true nowadays for the kinds of planetary geo-histories flowing

– and *not* flowing – through a city like Copenhagen. On our own part, as stream inquirers, we decided in fact to act as Gaia-graphers ourselves (Blok et al., 2017). Invoking the Latourian figure of an 'earthling', alongside a bit of science fiction, we attempted to intervene by way of public debate on the part of a differently figured cosmos, one in which *more* aspects of this entangled reality were allowed to bear on the ground. Our small piece of public imagination, however, mostly signal the gaps at work: the fact, that is, that earthlings remain here the people that are missing, as Danowski and de Castro (2016) would say, in the shape of those diverse human-nonhuman constituencies summoned by the exigencies of climate crisis yet rendered invisible on the ground in Copenhagen.[2]

STS sharing hesitations between Latour and Beck?

Be that as it may, I want to end here by briefly suggesting that gaps and elisions of this Latourian kind, pertaining to how we should think about our ecologically endangered (urban) worlds as both *one* and *many* at the same time, may be interestingly diffracted – although in no ways 'solved' – via a further detour through Beck's (2011) risk-induced cosmopolitization. More strongly than ('late') Latour, ironically, Beck was always attentive, I would argue (Blok, 2019), to how global risks like climate change would depend for their effects on a whole series of trans-local translations, semiotic *and* material, by which they would exert something like Doreen Massey's (1991) global sense of place. This would be a planetarity both local *and* extra-local, as it were, build up from the densification of ANT-style mediations across divergent registers of scientific, artistic, activist, and other ways of knowing together in public.

It is interesting here, I think, to return to Dewey's notion of publics as an important point of convergence. To Beck (2011), in particular, publics troubled by the risky side-effects of industrial modernity's routine operations nowadays question core principles of legitimacy, democracy and survivability, as ways of striving for a different common world. As for Latour, then, the question of the common ground is key. Except that, if we take seriously Beck's (2004) twinning of experiential world unity and dismemberment, the contemporary urban 'ground' would be one of an imaginative trans-local geography of shared-but-troubling risk affinities seriously rewriting what it means to pertain to a demanding collectivity. Arguably, this would be a progressively 'cosmopolitan' public whose precise contours escape also Beck's conceptual grid, raising instead a horizon of comparative trans-local inquiry yet to be filled in (see Blok, 2019).

This is where Beck's (2011) strictly *methodological* cosmopolitanism is in fact interesting also for STS, I believe, as a matter of searching for new tactics for studying trans-local and risky interconnections. While Latour (2004) is thus ultimately off mark, I think, in aligning Beck (2004) too squarely to a 'major' Kantian tradition of philosophical cosmopolitanism – although the tensions in Beck's oeuvre are real enough for sure – he is still on mark, I think, in critiquing Beck's too-early ontological unification of the one common world of global risks. Indeed, it is significant in this respect to note that Beck (2005: 2) concedes as much in his response to Latour: yes, Beck replies, the search for commonality in our disintegrating, high-risk world is ever ongoing, and as socio-cultural analysts, we must attend closely to how it unfolds. Moreover, he continues (Beck, 2005: 3), "we are very far from knowing how to conceptualize that situation", including when it comes to theories of nature-society relations (Beck, 2005: 7).

Beck's hesitation, I believe, is well taken and continues to be relevant. This is true, even as it also overlooks somewhat the specific ways in which Latourian cosmopolitics does indeed provide an inspiring and perpendicular approach to these very issues; only, as I have argued, to run up against its own version of rather similar conceptual tensions. Ultimately, I argue, this realization ought to instill in us, in STS and beyond, a hesitation *shared* and writ large towards *both* of their claims, when taken as unified conceptual registers. In other words, we may want to bend Latourian cosmopolitics *and* Beckian cosmopolitanism towards the *variable* urbanizations of *multiple* planetarities in the age of the (so-called) Anthropocene. Multi-naturalism and multi-culturalism must be swallowed at once, I argue, if we are to contribute to a much-needed re-mapping of urban socio-ecologies for a survivable future.

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Notes

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2 See http://turbulens.net/at-dromme-kobenhavn (in Danish).

The Corona Truth Wars: Where Have All the STS'ers Gone When We Need Them Most?

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The current corona pandemic disrupts the entire world like and threatens not only public health, but our economies, social relations, democracies, rule of law, mental well-being and more. While we may have more understanding of the Sars-Cov-2 virus than half a year ago, much of what it does and how to combat it is still uncertain, despite a dazzling amount of research on it. That may be logical when new issues arise, but the situation is complicated by the fact that this quest for truthful knowledge about the virus is entangled with various (geo)political dynamics, government policy pressures, media reporting, platform moderation and public understandings of it all. It is therefore quite unclear what information is reliable, which experts to follow and what (epistemic) authorities to trust. Science and Technology Scholars are perfectly equipped with concepts, theories and methods to help us understand these complex dynamics, and guide us through the fog of uncertainty and manipulation. Yet they seem remarkably absent in public *and* scientific debates. What is going on?

Leaning on established expertise? Or who else to trust?

Now that many European countries face rising numbers of Sars-Cov-2 infections and governments installed renewed lockdowns and other severe mitigation measures, public discussions about what to do gain much traction and urgency again. On one side of the spectrum we have people who regard Sars-Cov-2 as a highly dangerous 'killer virus' that needs to be contained as much as possible, while on the other side there are those who regard it as any other pathogen that we need to learn to live with, especially since the collateral damage of mitigation might be even greater. While there are several complex issues at stake here, the million dollar question that everybody seems to be concerned by is what strategy is best'' to deal with the spread of the coronavirus. Some countries, like Sweden and Brazil, took a radically different approach from most other countries, albeit for different reasons. Most other countries, however, compete with each other with more and more stringent mitigation measures to curb the spread of the virus. This has resulted in a remarkable global accordance never before achieved outside of wartime, perhaps in human history. But how should we assess and evaluate the various answers to this burning question? How do we compare the course of this pandemic across different contexts with different social, cultural, demographic and political characteristics that obviously influence the impact the crisis?

Governments in most countries lean heavily on their public health authorities, and in particular on their virologists and epidemiologists, for advice on how to deal with this crisis. While this appears

to make good sense—they are after all the most directly relevant experts and institutions—they also have rather specific ways of looking at the pandemic. The psychological, political, sociological, cultural and economic dimensions of this crisis are generally not part of their equations, while the implications and consequences of the pandemic play out in these domains as well. Even stronger put, disciplines such as epidemiology are myopic without social scientific understandings of how people behave (with the virus) in different contexts. If this pandemic has revealed anything, it is that mono-disciplinarity simply won't do to sufficiently tackle the complexities of this 'wicked problem' that affects so many domains of our lives and societies. In the meantime, fierce and often emotional debates on the justness of government strategies abound on daily talk-shows, newspapers and social media platforms alike. Aforementioned epidemiologists and virologists are omnipresent and rather dominant, but a multitude of other experts and actors, often with competing interests, fight in these arenas of public debate for their own position and (selectively) support their arguments with all kinds of facts, figures, and studies that would prove their points. But what to make of this all? Who is right? Whose knowledge and expertise to trust? And what is wisdom in this situation? Citizens are left with either trusting the (public health) authorities and the media that remarkably follows, or resort to alternative sources of information and expertise.

STS scholars could contribute greatly to such complex discussions between various publics, experts and authorities in which knowledge, politics and values are so intimately intertwined. They can help move public debate beyond prevalent simplistic oppositions between science vs politics, facts vs opinions, information vs manipulation, solidarity vs freedom, public health vs economy, lockdowns vs viral explosion. Realities are multi-layered and full of many shades of grey, efforts to reduce to such complexities to simple dichotomies are, in essence, political. They prioritize certain aspects over others. STS scholars can highlight such processes, address the ambiguity, and show what effects such reductions have. Moreover, they can put forward alternatives that do right to the complexity of the situation. Following Roger A. Pielke Jr. (2007) insightful work on the multiple roles to choose from as scientists depending on the degree of scientific and political consensus around a certain issue, STS'ers could take the role now of the "honest broker" given the high knowledge and value uncertainty of how to best deal with the current corona crisis. We would help public and political debate by clarifying and critically interrogating existing policy options and identifying new ones through the integration of various stakeholder concerns. Because the corona pandemic is far from a medical or public health issue alone, but instead affects *all* aspects of life, this would be an opportune and desirable strategy to take. But STS'ers seem nowhere to be found in current public and political debates on the corona crisis.

Conspiracy theories as STS research objects

One rather dominant stream of alternative information flows from the so-called conspiracy theory media outlets and actors that I research (Harambam, 2020a). Since the start of the corona pandemic, various suspicions, critiques, and allegations about what is *really* going on emerged. Questions arose about the (alleged man-made) origins of the virus, the way it makes people sick, the geopolitical games involved, the proportionality of the mitigation measures taken, the suspended civil rights, the possible connection with 5G, the rise of totalitarian policies and regimes, the way we measure corona infections and count covid-19 deaths, the politics of possible cures and medications, and of course, the sinister plans of Bill Gates, Big Pharma and the WHO in this all. Those variegated cultural expressions are indiscriminately labelled as conspiracy theories and the object of stigmatization and censorship (Harambam, 2020b). Various commentators in both media and science condemn those "blatant falsehoods" as bizarre, irrational, and dangerous ideas endangering public health. The WHO director-general Ghebreyesus argued in line that "we're not just fighting a pandemic; we're fighting an *infodemic*" (Zarocostas, 2020: 676). Social media platforms followed in an unique concerted effort to curb the spread of "covid-19 misinforma-

tion" by aggressively removing content and actors that deviate from WHO-guidelines. But does that do right to complexity of the situation we are in, where truthful knowledge of the coronavirus and especially about how to deal with it, is far from settled. WHO guidelines or not.

While *some* of those conspiracy ideas may indeed be clearly ludicrous, far-fetched, and dangerous, others qualify to be more intensively researched from an STS perspective. To give just a few of those examples: think of the politicization of potential cures, such as the way (research on) hydroxychloroquine is advanced by some, from Trump to "rogue" scientists such as Didier Raoult and Zev Zelenko, and suppressed by others (Sayare, 2020); the way public health authorities measure corona infections via PCR testing and how certain (arguable) cycle thresholds (ct) are chosen to indicate an infection or not (Mandavilli, 2020); what covid-19 deaths actually mean, did people die with *or* because of the coronavirus? And what incentive structures may influence their reporting (Hempton and Trabsky, 2020); how these numbers are uncritically and without meaningful context portrayed in media and inform official (lockdown) policies (Newton, 2020); the way scientific knowledge on the virus and treatments of Covid-19 is produced by certain (dubious) actors, leading to retractions in major medico-scientific journals (Davey, 2020); the way epidemiological models are (mis)used to predict the spread of virus and how that informs official public health policy (Rhodes et al., 2020); how respectable scientists going against the orthodoxy to eradicate the coronavirus by means of stringent lockdown measures are politicized, silenced and shunned in their efforts to point to the many adverse effects of such policies (Clarke, 2020) or the complex entanglement of philanthropic actors, pharmaceutical companies, (supra)national governments, and WHO in the long run for a working vaccine (McGoey, 2015). The global scientific knowledge production on Sars-Cov-2 and Covid-19 is a true battle ground on which (geo)political games, corporate interests, institutional dynamics, professional ideologies, media reporting and popular opinion influence the road to reliable information about the crisis we so desperately need to combat it. Looking at the major STS journals and STS associations shows no mentions of STS'ers working on the particular controversies of the contemporary corona truth wars described above. How can this be? Isn't the current corona "infodemic", in a new sense of the word, the perfect post-truth crisis on which various STS'ers can shine their lights?

Emerging corona STS research networks and infrastructures

There are, fortunately, some STS'ers working on the various implications and consequences of the corona crisis. Kim Fortun's Disaster STS Network is a wonderful initiative bringing scholars and research questions together to "follow and analyze COVID-19 as it plays out in different settings" [1]. Scott Knowles's *CovidCalls* podcasts are wonderful and span many different topics, from "Comedy in the Covid-19 Era" to "Medical Education in the Pandemic" [2]. The *Social Anthropology Special Forum* gives a great global oversight of various engagements with Covid-19, ranging from "creative writing to complex theoretical formulations, from deeply personal reflections to ethnographic accounts and political and economic analyses" (Soto Bermant and Ssorin-Chaikov, 2020: 2). Deborah Lupton's special issue in *Health Sociology Review* presents various intriguing perspectives on how the corona crisis manifests itself across our globe (Lupton, 2020). There is the 'COVID-19 Clinical Research Coalition', a global network of interdisciplinary "change makers building collaborative solutions in low-resource settings"[3], whose 'Social Science Working Group' (including STS journal editor Salla Sariola), supports and promotes social scientific research on various ethical issues, biomedical research, clinical trials, and public health responses across the globe[4]. She also wrote an insightful piece with two colleagues in the Finish journal of the Political Science Association on the multidisciplinary complexities of the pandemic and the situatedness of (successful) response dynamics (Butcher et al., 2020). Indeed, no one-size-fits-all solution will do.

And there is more: editors and presidents of STS journals (Sismondo, 2020), networks[5] and associations[6, 7] highlight the special role of STS to provide policy guidance, and urge individual STS'ers to step up since their expertise is crucial. Joan

Fujimura had an excellent subplenary with three other STS'ers on this topic at the 2020 4S/EASST conference arguing that "STS can help us understand and respond to the COVID-19 pandemic by offering accounts of the political ecologies of the virus that map how power relations till the social, spatial, and epistemological grounds over which it travels"[8]. Lastly, the EASST Twitter hashtag[9] is a great initiative to make visible the works/blogs of STS'ers on covid-19. Annalisa Pelizza shared many relevant tweets highlighting the issues I raise here, for example, this statement by the Nuffield Council of Bioethics urging the "authorities to take sensitive ethical and political covid19 decisions" through public deliberation and not just by expert groups[10]. Michela Cozza pointed to an article on the "Swedish Case" and paraphrased Sheila Jasanoff, "No single policy – and no corona strategy – is given by scientific knowledge, or evidence, alone"[11], and another to a "Covid-19 controversy attempt to close it" regarding claims of Nobel laureate Luc Montagnier "that the novel coronavirus is man-made and contains genetic material of HIV"[12]. Sarah de Rijcke shared a post with a repository of "resources for understanding fundamental perspectives and insights of the #COVID19 pandemic"[13].

Great potential, little action?

So there are STS initiatives and activities happening around the corona crisis, but is this it? Perhaps I have been overlooking certain public debate platforms where STS'ers are active, perhaps there are national public discussions that I am not aware of, perhaps I have missed articles or commentaries by STS scholars in the media, and perhaps I am just too impatient as some STS'ers may already be working on these issues. Indeed, STS scholars may have received "pandemic funding" as most national science foundations issued great amounts of research funding to stimulate corona research. #Covid19 has become the new scientific bandwagon to jump on (Fujimura, 1988). To give a good example, Roger Pielke Jr. received a (US) National Science Foundation Rapid Response Research (RAPID) grant to lead a comparative, international evaluation of the way science (advice) was able to influence how countries and their leaders have responded to the pandemic, and how that played out for its citizens[14]. While analyses from this project are, obviously, not to be expected soon, the blog [15] of this research project publishes relevant pieces on the entanglement of politics, technologies and science (advice). There may be many more new STS research projects starting at this moment, studying the complexities of the pandemic and how to best deal with it, but can we hear about them?

It remains remarkable, to say the least, that our community has been so silent in the public domain on arguably the greatest wicked problem instantly paralyzing our worlds. Where are the Collins' and Evans' who can help our various publics understand the value of experts and their role in society? Where are the Fuller's who can help us grasp the political games currently being played in the name of truth? Where are the Jasanoff's who can say more about how different political cultures and democratic societies influence how they tackle the crisis? Where are the Gieryn's who can explain us about how the boundaries of science are being stretched by certain actors and pushed back by others. Where are the Bowker's and Star's to help us through the various forms of classification and numerical manipulation? Where are the Latour's who can show us the complex entanglement of scientific knowledge production with other (commercial and state) actors? Where are the Mol's who can explain how the virus exists as multiple depending on its uptake in different socio-material constellations? I can go on with many more classic examples of what STS has to offer, but where are such analyses? And why are STS scholars working on these topics not visible?

From inward looking to taking center stage

The abovementioned initiatives and publications show that there are STS scholars attentive to the issues I raise in this commentary, but they are also rather *inward* looking, focusing on our fellow scholars. While it is important to stimulate academic discussions and productions on this topic, and we surely need more of that, we also need STS scholars to be present in public and political debates as they steer the course of history. Many

medical experts, predominantly virologists and epidemiologists of our public health institutes, take the center stage now in daily talk shows and parliamentary advisory groups alike. But where are we, my fellow STS'ers, in these important spaces to share our expert perspectives and provide the necessary contextualizations?

I can offer a few tentative explanations that may be helpful in order to achieve more impact of our discipline. First, there are several *internal* reasons why STS'ers are rather absent in public and political debates: STS'ers may study controversies as they unfold, but prefer to hold their analyses private until the action is over so that no rushed conclusions are drawn. STS'ers are often advocates of 'Slow Science', as Isabelle Stengers puts it (2018), arguing that the quality of scientific research benefits from diverging from the neoliberal logic of increasing performance and output. Following her line of thought, Stengers also argues that we must engage openly and honestly with the various publics we encounter about the promises and limits of scientific research. That may be a call to remember at this moment. Obviously, STS'ers are not one of a kind. And the internal tensions between different STS communities, or even between our own professional identities, may obstruct a clear STS sound in public debate as we still struggle to match conceptual analytical work and the desire to bring about societal change (Sariola et al., 2017). A related third internal reason may be the inaccessibility of much STS work. Despite upholding the democratization of knowledge of as virtue, STS can often turn rather esoteric: it's research output (books, articles, reports) are full of neologisms and unconventional use of words and their meanings. For the outside world, it is often hard to understand, let alone implement our insights in public health interventions or public debates without our concrete help. There may be good academic reasons for that, but it could explain the invisibility of STS'ers in public and policy debate. Should we think more about translation?

Next to such internal reasons, there are external explanations as well that may play a role here: first, many of us are struggling with the impact of the crisis on our daily (work) lives, trying to keep all the balls in the air. Think of the (burdensome) transition to online teaching, the redesigning of research projects now that empirical, and especially ethnographic, research is complex to arrange, and there is a fall-out of colleagues that either got sick due to Covid-19 or are simply burned out. More generally speaking, it is hard to expect that STS scholars can redirect their research focus as fast as a new issue arises, no matter how important that topic may be. Institutional and funding rigidity applies. There is a rat-race for Covid-19 funding, shifting our focus to writing research grants, instead of taking a stage in public debate. We can expect social and professional incentive structures that prioritize the scientific output over public engagement to have influence, especially when such may go against prevalent orthodoxies. The narrow medical focus dominating the discourse and policy of the pandemic may have impeded the interdisciplinary patchwork of STS to get through the right circles. Lastly, we simply may have not been as well-connected to political and media elites to allow for an easy entrance.

This absence of STS'ers in public and political debates is a serious missed opportunity for us not only to show the value of our expertise, but to contribute concretely to the course of this pandemic when we seem caught between the Scylla of lockdowns and the Charybdis of letting the virus just go loose. STS'ers are the perfect navigators in these troubled times: we understand the lure and danger of both monsters, but we can open ways and develop various means to steer clear from both disasters. Technocrats and detached political elites are pushing through policies that are de-politicized under the rubric of "there is no other way but lockdown", various information gatekeepers stifle democratic debate in the name of "suppressing harmful content", while populists, conspiracy theorists and outright demagogues tap on the fears and concerns of affected communities without offering viable alternatives. I have tried to intervene in public debates in The Netherlands, arguing several times that the science of the corona crisis is far from settled, that we need to explore and carefully evaluate multiple options out of the crisis, that a diversity of scientific perspectives should advice governments in their policies, and that the least

vocal and politically powerful communities that are hit the hardest by the crisis (the young, the lower social classes, the small business owners, the arts and culture) should have more say[16]. But I am a young scholar, without tenure nor much authority, and struggling with the impact of the crisis as well, so I could definitely need more support. Now that the corona truth wars are getting more fierce, and the stakes and undesirable consequences of current policies higher, we need STS scholars to connect, speak up and deploy their expertise and knowledge for the sake of our well-being and the future of our democratic societies. So let's start connecting and making ourselves more visible and part of both public and political debates.

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Notes

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13 https://twitter.com/sarahderijcke/status/1250542830419873808

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16 E.g.: http://theconversation.com/why-we-should-not-treat-all-conspiracy-theories-the-same-140022: https://www.volkskrant.nl/nieuws-achtergrond/socioloog-harambam-we-zetten-complotdenkers-te-gauw-weg-als-gekkies~b1942c88/; https://www.nu.nl/weekend/6053009/socioloog-harambam-complotdenkers-hebben-soms-gewoon-een-punt.html?redirect=1#coral_talk_wrapper; https://www.telegraaf.nl/nieuws/739300390/rutte-moet-eerlijker-zijn

Nelly Oudshoorn (2020) Resilient Cyborgs: Living and Dying with Pacemakers and Defibrillators. Singapore: Palgrave Macmillan. 350 pages. ISBN: 978-981-15-2528-5

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How one lives and dies with an implanted heart device is the topic of Nelly Oudshoorn's latest book, which mainly draws upon extensive fieldwork conducted in the Netherlands. While most STS research tends to focus on new and emerging technologies, Oudshoorn invites us to pay attention to older and more mundane technological objects of a particular kind: pacemakers and implanted cardiac defibrillators (ICDs). As she gives centre stage to technologies that are neither useable, handleable nor, in any case, detachable from their users, but rather implanted in their bodies until the end of life, Oudshoorn raises questions regarding the agency, vulnerability and resilience of people living with such technologies. Indeed, "what does it takes to keep hybrid bodies alive" is her main interrogation (p. 12). Still, in contrast to most work that focuses on life with, and of, technologies, be they usable, prosthetic or implanted, Oudshoorn is also concerned with the death of implanted heart devices and their wearers, that is, on the one hand, with how these technological objects affect how one dies with the device and, on the other hand, with what happens to pacemakers and ICDs after the death of their users. Doing so, she provides an original and welcome contribution to the field of STS and scholars interested in the agency and interactions with biomedical devices. Through 10 chapters grouped in 3 parts, Oudshoorn offers several heuristic tools for understanding the life and death of 'everyday cyborgs' (Haddow et al, 2015) or 'wired heart cyborgs' (p. 20). As they act on and modulate the heart's rhythm, pacemakers and ICDs aim to reduce their wearers' vulnerabilities. Yet, living with such devices introduces new vulnerabilities, which demands that one builds resilience to be able to cope with them. Besides adopting a constructive approach to vulnerability and resilience by drawing on recent STS scholarship and showing how vulnerability and resilience reside not with the individual but rather emerge and materialise in sociotechnical networks of human and nonhuman actants, Oudshoorn also builds upon Anselm Strauss' research to underline how living and dying with an implanted device requires work. The implant's disappearance under the skin does not amount to its disappearance from attention nor to a "seamless merging of humans and technologies" (p. 117). Rather, living with implanted heart devices and keeping hybrid bodies alive "involves an intensive trajectory of anticipating, monitoring, and adjusting the working of pacemakers and ICDs" (p. 117). It further "require[s] the active involvement of people having these implants, their close relatives, technicians, nurses and cardiologists, and the devices themselves" (p. 229). Through a fine-grained account of the dance of agency that takes place between technicians, wired heart cyborgs and implanted heart devices when adjusting and fine-tuning pacemakers and ICDs (chapter 3), Oudshoorn introduces the first heuristic tool that composes her sociology of resilient cyborgs, namely the conceptualisation of the

active engagement of everyday cyborgs in building resilience as work (p. 304). To draft her techno-geography of resilience, Oudshoorn also shows with great detail how living with a technology inside one's body transforms one's sensations. Here too, work is required to get used to the technology and the new sensations it induces. When ICDs and pacemakers produce beeping sounds that one has to learn to recognise, ICDs generate shocks as well, including inappropriate ones, that one must sense and tame in order to build resilience. Even though it does not directly engage with STS research on sensory experiences in the medical sphere (Rice, 2010; Harris, 2016), Oudshoorn's work resonates with it as it draws attention to the way sensations constitute a form of (practical) knowledge as well as to how being attentive to them plays a critical role in getting habituated to the technology and its agency (see also Dalibert, 2016 and Slatman et al, 2016). Accounting for this process (chapter 4), i.e. wired heart cyborg's expertise, by including sensory experience and resilience techniques constitutes the second heuristic tool of Oudshoorn's sociology of resilient cyborgs. Through attentiveness to their bodily feel and collaborative work with medical professionals and their close ones, people living with heart implants build resilience and a body-technology alliance. In contrast to most work on cyborgs and intimacy between bodies and technologies, one of the strengths of Oudshoorn's book is to show that the realisation of such alliance is not enough to be able to live well with a pacemaker or an ICD (chapter 5). If in high-income countries we live in environments filled with technological devices, the density and "the texture of [the] 'technosphere' within which we undertake our daily affairs," as philosopher of technology Don Ihde phrases it (Ihde, 1979: 7), is more intensely felt by people living with implanted and prosthetic technologies (see Dalibert, 2014). Becoming a 'resilient cyborg' thus demands 'disentanglement work' from humans and nonhuman actants alike (p. 118). Such work requires people to identify and anticipate potentially disruptive technologies, from airport security gates to induction plates, and people's behaviours, from strangers' intrusive gaze to loved ones' gestures, that might create harm to one's implanted body. The building of resilience through both the making of a body-technology alliance and disentanglement from disruptive actants thus demands particular efforts. It also entails conceptualising implanted technologies as 'body-companion technologies', which is Oudshoorn's third heuristic device (chapter 10). Oudshoorn draws upon Donna Haraway's notion to emphasise the reciprocal relationships between humans and technologies as well as the work needed to sustain such relationships. When body-companion technologies can be considered as 'co-travellers' (Haraway, 2003: 9), three reciprocal relations and interdependencies are involved in body-companion technologies and in making resilient cyborgs: mutual guarding, disciplining and domesticating. In these relations, attention to gender and age matters to understand life and death with implanted heart devices (chapters 6 and 7). While "gendered mismatches between devices and bodies and Western cultural norms about femininity and beauty […] all contribute to a techno-geography of resilience which delegates new responsibilities to women" (p. 49), such as mastering passing techniques regarding scars or articulating new forms of normalcy, "implants also affects the lives of younger and elderly people in very different way" (p. 49), the latter giving different meanings to their device, which creates different kinds of anxieties and demands different forms of emotional work. With sensitivity to difference the fourth heuristic tool offered by Oudshoorn to undertake a sociology of resilient cyborgs, the STS scholar insists on the necessity to account for the ways in which implanted bodies are subjected to different norms, expectations and work due to their particular position in power relations and axes of domination. The originality of Oudshoorn's book and proposal for a sociology of resilient cyborg also lies with her focus of life *and* death with and of an implanted heart device. Following the whole life-cycle of hybrid bodies is her fifth and last heuristic tool. Reviewing American, European and Dutch medical guidelines (chapter 8), Oudshoorn shows how "pacemakers and defibrillators shape the process of dying and who is granted the right to turn off these devices" (p. 230). These implants create 'dying trajectories' that involve particular anxieties and uncertainties.

In a direct call to medical professionals, Oudshoorn highlights how "the building of resilience to the emotional distress of the dying process" (p. 251) is hindered by the absence of clear medical guidance and information provided to people living and dying with an implanted heart device. Finally, Oudshoorn turns to the death of the device, or rather to 'the life' of the device after its wearer has died. Attending to the *Project My Heart Your Heart*, she describes how the refurbishment and reuse of pacemakers, hence the making of resilient 'second-hand' pacemakers, is an emergent practice that requires extensive work to meet regulatory standards, thus a particular path creation (chapter 9). In conclusion, this book reminds us that bodies and mundane implanted medical technologies deserve more attention from STS. Oudshoorn has done a remarkable job in following the life and death of people implanted with a pacemaker and an ICD, and of these devices. In the process, she offers several conceptual and heuristic tools that will certainly prove useful to researchers interested in questions of agency, vulnerability and resilience and, more generally, in understanding what it takes to live and die with technological devices inside bodies.

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Futures in the "Making": Multiple Ways of Engaging the Future

Kléber Ghimire (ed) (2018) Future Courses of Human Societies: Critical Reflections from the Natural and Social Sciences. Abingdon: Routledge. 274 pages. ISBN: 9781138488915

Robert Gianni, John Pearson and Bernard Reber (eds) (2018) Responsible Research and Innovation: From Concepts to Practices. Abingdon: Routledge. 314 pages. ISBN: 9781315457291

Gert Verschraegen, Frédéric Vandermoere, Luc Braeckmans and Barbara Segaert (eds) (2017) Imagined Futures in Science, Technology and Society. Routledge: Abingdon. 224 pages. ISBN:9780367890247

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The 2001 annual meeting theme for Society for Social Studies of Science, "Fashioning the Future: Science, Technology and Visions of Progress," characterized increasing scholarly interest in the concept of 'future' in the STS field. Since then, we have witnessed a flourishing of theoretical concepts and empirical analyses concerning the role of 'future' in the process of knowledge production and innovation (Brown and Michael, 2003; Jasanoff and Kim, 2009; Stilgoe et al., 2013). These three edited volumes published in 2017 or 2018 thus may mark a milestone for these scholarly efforts.

As shown in their titles, 'future' is the central theme of *Future Courses in Human Societies: Critical Reflections from the Natural and Social Sciences* (*Future Courses*) and *Imagined Futures of Science, Technology and Society* (*Imagined Futures*), albeit addressing the relationship between technoscience and 'future' in rather different ways. While *Future Courses* focuses on the assessment of long-term future of technologies and other social arenas, *Imagined Futures* pays more attention to how the imaginaries associated with the future impact and interact with the current development of technoscience. Meanwhile, 'future' also serves as the foundation of *Responsible Research and Innovation: From Concepts to Practices* (*Responsible Research*), a volume specifically about the implementation of the Responsible Research and Innovation (RRI) framework in the European Union policy context. As Robert Gianni and his colleagues point out in the introductory chapter, the emergence of the RRI framework came from the recognition that "it is now time to turn towards more positive processes in order to make

a co-construction of the future that we want and therefore decide what the right impacts are" (*Responsible Research,* p. 2). Juxtaposing these three edited volumes, this review aims to compare how three groups of scholars, with different theoretical groundings, engage with the idea of 'future' and its relationship with science and innovation. I differentiate the perspective of these three books as 'innovation in the future,' 'innovation with the future,' and 'innovation for the future.'

'Innovation in the future' refers to *Future Courses*, which aims to take a realist perspective to study how human future may look like in the long term. The book is written by scholars across natural and social sciences and has only limited connections with mainstream STS theories, judging by references cited. As the editor Kléber Ghimire articulates in the first chapter, the overall goal of this volume is "to comprehend the long-term evolution in human societies in their complexity and multi-dimensionality" (*Future Courses,* p. 5). While setting their primary focus as "the long-term future stretching towards coming centuries and even millennia" (*Future Courses,* p. 5), they also intentionally move away from the quantitative-based tools that, as Ghimire argues, are only suitable for predicting the coming future. Rather, they claim that a qualitative and exploratory methodology is better for the analysis of the distant future. Although these scholars stress that technology alone does not represent the human future, technology remains the primary focus of their inquiry. They analyze the potential development of different kinds of science and technology (physics, energy, nanotechnology, 3D Printing) as well as how technology may influence and interact with the future of other social arenas (such as human labor, economic modernization, democracy, and ethics). They make efforts to demystify overarching promises associated with innovations and counter popular skepticisms of emerging technologies. Overall, with a thoughtful methodological exploration, *Future Courses* nicely untangles the common belief that equates technological advances with the human future.

'Innovation with the future' refers to *Imagined Futures*, which explores a performative perspective of technological development. The book came out of a workshop held at the University of Antwerp and focused on the interaction between scientific imagination and the development of society. These researchers draw on the framework of 'sociotechnical imaginaries' (Jasanoff and Kim, 2009) and explore "how scientific and technological imaginations matter in the formation of human, ecological and societal futures" (*Imagined Futures,* p. 2) and "what various actors such as scientists, companies or states imagine the future to be like and how they act upon that imagination" (*Imagined Futures*, p. 2). Cases analyzed in this book are then organized into three main themes, including human (bioethics, epigenetics, functional food), technology (genetic engineering, sustainability science, electric car), and society (population census, science fiction, proactionary principle). These researchers approach various types of scientific knowledge or innovations with historical or comparative analysis and unveil the kinds of future imagined along with technoscientific development. In this sense, instead of treating 'future' as a potential reality, these researchers recognize 'future' as a discursive tool that possesses the power to impact advances of science and innovation in the present. Overall, *Imagined Futures* portrays how the current technoscientific development may be co-produced with various visions and projections of the future.

'Innovation for the future' refers to *Responsible Research*, which holds a prescriptive perspective of technological development. Written by European scholars, this book treats the European Commission's (EC) adoption of RRI in 2010 as the case for study and serves as a review and evaluation of the implementation of the RRI framework in the EU policy context. Since the EC is the most prominent promoter of the RRI framework in the international policy arena, this volume provides invaluable insights on how such a framework may work out in practice. While some researchers critically assess and clarity what the RRI framework entails and re-theorize its ethical implications, others consider how the framework may be modified or expanded and illustrate ways to avoid proceduralism and instrumentation when adopting the framework. Their analysis suggests that in contrast to traditional technological management and assessment in the EU policy context, the RRI framework foregrounds the issue of technolog-

ical uncertainty, promotes a proactive agenda to conquering "grand societal challenges" identified by the EC, and highlights the importance of responsibility. The critical issue then becomes how to define and create the kind of desirable future assumed underlying the RRI framework and how to take and distribute the responsibility amid the indeterminacy of innovations' future consequences. Overall, this volume unveils how the RRI framework favors and promotes innovations for achieving a particular version of the future.

These three collections speak to each other in multiple ways and shed light on each other's analysis. For example, while it is possible to see the RRI framework as a specific type of sociotechnical imaginary, the study of the European Commission's adoption of the RRI framework also demonstrates how particular versions of future may be realized and how relevant the imaginary of future may be. Additionally, the realist perspective and analysis provided by scholars in *Future Courses* not only help reveal the status quo of technological development without considering alternative or specific visions, but their methodological concern that projections of the future may be limited to the perspective of the present also serves as a reminder for any attempts to proactively anticipate the future. *Imagined Futures* and *Responsible Research* both point to one question that *Future Courses* ignores — What is the significance of comprehending the future and what implications follow? Eventually, the different focuses among these three volumes point to the thin line between anticipating and predicting or fore-telling and forecasting the future, especially in the policy planning context.

The other outstanding issue concerns the idea of technological 'uncertainty' toward the future. While these three collections all highlight 'uncertainty' as one key issue, they perceive uncertainty in different ways, which reflects their different engagement with the future. In *Future Courses*, 'uncertainty' is one of their discoveries after the analysis. As Ghimire mentions, "this uncertainty is all the more palpable when it comes to the consideration of distant and far-off periods (*Future Courses,* p.7); thus, "it is clearly impossible to affirm any specific future technological trajectory or outcome" (*Future Courses,* p. 8). In contrast, Gert Verschraegen and Frédéric Vandermoere argue in *Imagined Futures* that imaginaries of the future are "crucial in overcoming the uncertainty stemming from the inherent openness of the future" (*Imagined futures,* p. 6) and provide directions for collective actions. Similarly, some researchers in *Responsible Research* highlight the relation between the uncertainty of the future and responsibility at present as one of the significant challenges that the RRI framework needs to address.

Despite the theoretical and empirical richness of these three volumes, readers may find a gap remains in the literature — there are very few clues concerning the future-making of countries in the Global South. While RRI is mainly focused on the European policy context, most of the cases discussed in *Future Courses* and *Imagined Futures* are also advanced technologies or related policies in the Global North. More research may be required to explore how countries in different parts of the world engage with the 'future' and how innovations developed in the Global South interact with 'future-making' (Poonam et al., 2020).

The fact that these three volumes come from different academic communities not only indicates the popularity of the concept of 'future' but also entails that this concept — as a potential reality that society longs for — becomes a question that opens for debate and begs for answers. More importantly, these three volumes all suggest the responsibility and ability of the current generation to make the future a better reality than the present, while demonstrating multiple ways of engaging the future, particularly regarding the development of technoscience.

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