

Article



Speculative feminism and the shifting frontiers of bioscience: envisioning reproductive futures with synthetic gametes through the ethnographic method Feminist Theory
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### **Abstract**

Scientists are developing a technique called in vitro gametogenesis or IVG to generate synthetic gametes for research and, potentially, for treating infertility. What would it mean for feminist concerns over the future of reproductive practice and biotechnological development if egg and sperm cells could be produced in laboratory conditions? In this article, I take on the question by discussing the emerging technique of IVG through the speculative feminist analysis of ambiguous reproductive futures. Feminist cultural and science studies scholars have explored the transformative effects of biomedicine on reproduction through science fiction novels and other cultural products. I theorise the speculative and visionary in biomedicine in the context of ethnographic methodology by drawing on 'thought experiments' conducted with stem cell scientists as shared acts of future-oriented contemplation. I develop the figure of SF proposed by Donna Haraway to investigate how science facts and speculative fabulation together shape futurities of reproduction. I propose including shifting frontiers in feminist thinking of the SFs in bioscience. Biomedical research aims to shift the borders between what is known and not known in reproductive biology, subsequently raising new technical, ethical and political issues in terms of stratified reproduction. The article shows that synthetic gametes are anticipated to intensify selective procreation. Simultaneously, IVG is seen to forge new biogenetic relationships and possibilities for non-normative reproduction and kin-making. Following Haraway, I argue that by 'staying with the trouble' of these

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biotechnological visions, feminist speculative analytics on technoscience offers a valuable tool to envision more hopeful and equal futures together with scientists.

## **Keywords**

Bioscience, ethnography, in vitro gametogenesis, reproductive futures, speculative feminism, stem cells, synthetic gametes

## Introduction

The diagnosis of becoming is not the starting point for a strategy but rather a speculative operation, a thought experiment (Stengers, [1997] 2010: 12).

SF is practice and process; it is becoming-with each other in surprising relays[...] (Haraway, 2016: 3).

These cells are problematic, but they are not talked about, as people don't know about them yet (I3/2011).

The above quote is from a research scientist I met while carrying out ethnographic fieldwork in several European bioscience laboratories. In the study, I investigated the revolutionary technique of cellular reprogramming in stem cells and the implications of turning biology into technology in new ways (Meskus, 2018). The prospect of using cellular reprogramming to *craft synthetic gametes in the laboratory* was introduced by this researcher during our first encounter in her small office located between an IVF clinic and a stem cell laboratory at a university hospital. She offered me in passing a speculative scene of reproductive futures with an emerging method called IVG, in vitro gametogenesis. This method may enable the generation of synthetic gametes from somatic cells in laboratory conditions and open new options for treating infertility and involuntary childlessness in the coming decades. If successfully developed, IVG is also likely to shape our understandings of reproductive origins, biological relatedness and non-normative kin-making.

This article develops a speculative feminist analysis of ambiguous reproductive futures with new biotechnologies such as IVG. The latter involves the creation of entirely new reproductive material, derived from somatic cells, such as skin or blood, with the help of stem cells and cellular reprogramming (Saitou and Miyauchi, 2016). Drawing on my initial discussion with the researcher quoted above and interviews with other stem cell scientists, I explore the co-constitution of reproductive processes and technoscientific futures. How is biomedical science, through the envisioned technique of IVG, constitutive of reproductive futures that

matter to feminist concerns on social transformation in high-tech societies? Furthermore, how can we use the speculative approach to engage science with feminist analysis of biotechnological change and thus in collective deliberation on the forms and conditions of reproductive futurities?

Feminist scholarship on biotechnological shaping of procreation has focused on techniques operative in *the present*, exploring the modification of reproductive processes through, for instance, the slow freezing technique called cryopreservation (Radin and Kowal, 2017; Waldby, 2019) in social egg freezing to counter reproductive ageing (Brown and Patrick, 2018; Baldwin, 2019; Van de Wiel, 2020) and posthumous reproduction (Kroløkke and Adrian, 2013). Meanwhile, *not-yet-realised* materials, treatments-*to-be* and *imagined* experiences have received less attention, as they are challenging to approach empirically. It is difficult to grasp that which is only emerging, circulating through visionary discussions and tentative practices.

I investigate synthetic gametes as not yet realised biological material that borders on science fiction while also being an object of interest and action in biological research on stem cells. As it comes to the speculative and visionary in reproduction, this topic is often approached through art, fiction and poetry. Science fiction novels and other cultural products offer grounds to theorise reproduction and technoscientific futures, particularly through engaging with the transformative processes of biomedicine (Squier, 2004; Sheldon, 2013; Åsberg et al., 2015). Some feminist scholars have explored the future of bioscience by creating their own speculative stories (Benjamin, 2016; Haraway, 2016). I theorise the speculative and visionary in biomedicine through another route, namely the ethnographic method. I propose that as part of ethnographic fieldwork, a speculative feminist approach can prove useful in inviting and engaging scientists in the contemplation and assessment of biomedical shaping of the body and its processes.

'Reproductive futures', in my use, refers both to imagined technologically assisted ways of procreation and to reproduction as a means to strive for human futurity. The notion of reproductive future thus carries with it the duality of *technology* being regarded as a key signifier of the future in Western culture and the *reproductive process* as intensely implicated in the future (Franklin and McNeil, 1988). Following Marilyn Strathern (1992: 39), the reproductive process is understood here not merely as the making of persons but also as the making of the future. Through the dual focus on technology and reproduction, my use of 'reproductive future/futurity' departs from Lee Edelman's (2004) 'reproductive futurism', which arises from his critical queer theory analysis of the political order that deploys the image of the Child as futurity's emblem onto which social order and its exclusionary practices are built. Yet, the shifting frontiers of reproductive technologies re-invoke the question that Edelman posed about the complexities of imagining the future as always already entangled with the idea of (biological) offspring and related kin-making.

In exploring reproductive futures, I deploy the figure of SF proposed by Donna Haraway (2013, 2016, 2018) as a heuristic tool. The figure of SF denotes a feminist

approach in 'staying with the trouble' of technoscientific societies and 'becoming-with each other in surprising relays' (Haraway 2016: 3). I engage with Haraway's idea that thinking about *science facts* and *speculative fabulation* together is a way to investigate how bioscience shapes the conditions of possible futures. The speculative approach enables exploring IVG together with scientists before clinical application in humans. Speculation is thus a tool to trace linkages between science facts and acts of fabulation but also the *shifting frontiers* of bioscience. Shifting frontiers of bioscience provide, I contend, an entry point into the entanglement of technology and embodiment in the production of reproductive futures.

The source of synthetic gametes would be in the parental body but not in the gonads. The prospect of making gametes from somatic cells such as skin or blood raises questions about the intertwined orders of the 'natural' and 'artificial' and existing ideas about fertility and its control. Coming into existence from biological parents' skin cells through substantial technological modification is an origin story that begs wider discussion. Indeed, IVG has the potential to reconfigure the concrete material conditions of the continuity of life and extant understandings of what it means to be 'human', 'male' or 'female'. While acknowledging the multiple avenues an analysis of IVG could take, I focus here on IVG-induced effects for selective reproduction and the fundamental difficulty of differentiating between curing disease and enhancing embodied capabilities – a difficulty that is concomitant with much of biotechnological development.

# Speculative feminism operationalised in ethnographic fieldwork

Many have argued that the sciences offer a potential laboratory for the development of feminist theory (e.g. Holmberg, 2011; Roy, 2018). As an object of much interest in bioscience research, stem cells are, to borrow from Susan Squier, 'liminal lives' that 'hold rich potential for our ongoing biomedical negotiation with the paradigmatic life crises: birth, growth, aging, and death' (2004: 9). The proposed source of IVG is a cell line called the induced pluripotent stem (iPS) cell, which was first announced in humans in 2007. IPS cells are artificially created pluripotent stem cells, usually derived from a donor's skin biopsy or blood sample with the help of genetic manipulation (Takahashi et al., 2007). An existing form of liminal life, iPS cells can be differentiated into various tissue types in current experimental research. However, iPS cells are liminal living entities also in the sense that they could – in a possible future – be used in IVG to make the translation from somatic cells into germ cells, or into sperm and oocytes.

Following the participatory element in ethnographic interviews (e.g. Skinner, 2012), I decided to actively add a speculative element to my discussions on the iPS cell tool with informants. Assuming my informants would be aware of the prospects that the tool they were studying and using in their everyday lab work could become involved in attempts to craft synthetic gametes, I invited scientists to

conduct speculative envisioning on IVG together with me. Oftentimes the introduction of IVG into our discussions came through the theme of 'ethical issues' of the iPS cell technology. As this article illustrates, the speculative approach involved asking, inviting and guiding study participants to face the uncertainty of reproductive futures. Envisioning IVG also brought up a range of reactions and emotions in study participants, from open uneasiness with such a 'fictional' matter to affectively engaged, elaborate deliberation on possible lines of development.

A speculative approach requires the ethnographer-researcher to be self-reflexive about their own techno-preferences, ethical biases and affective stakes. During fieldwork, I declined the role of 'the bioethicist' that some informants offered me to help us out of the 'trouble' of uncertainty and to produce normative views on synthetic gametes. Explained in more detail later, I work with the idea of speculation as a thought experiment, as Isabelle Stengers ([1997] 2010) suggests, that does not aim to produce a unified 'truth' about the risks and promises of IVG. I also draw methodologically on ideas developed in the field of speculative design (Dunne and Raby, 2013; Tharp and Tharp, 2018), where technoscientific futures are studied through scenarios that are provocative, intentionally simplified and fictional. Often starting with 'what-if questions', design research uses collective speculation to open up spaces of debate and discussion. Notably, the aim in speculative design is not to pin the future down, to make it fixed and known, but to discuss the kinds of future that people envision and aspire to. Conducting collaborative speculation as part of the ethnographic interviews, I was likewise not interested in pinning the future down. Indeed, in Late Latin and Old French, the concept of speculation referred to 'intelligent contemplation', the 'act of looking' and the 'pursuit of the truth by means of thinking' (Online Etymology Dictionary, 2020). Embracing these ideas about speculation, I investigated what is at stake in the shifting frontiers of bioscience via IVG and the range of reproductive futures that would arise if it were taken into clinical use.

Haraway's (2016) figure of SF, with its multiple fecund meanings, speculative feminism, scientific facts, science fiction and speculative fabulation, is a useful conceptual figure for thought experimentation. Synthetic gametes are SF in multiple ways: the scientific fact of synthetic gametes has partly been shown and published. In humans, stem cell scientists have shown that primordial germ cells, which contribute to the formation of oocytes and spermatozoa, can be created by using either embryonic stem cells (Irie et al., 2015) or iPS cells derived, for instance, from women suffering from ovarian insufficiency (Panula et al., 2011; Leng et al., 2015). In mice, live births have already been achieved using gametes derived from pluripotent stem cells (Hayashi et al., 2012; Saitou and Miyauchi, 2016). Simultaneously, synthetic gametes remain in the realm of speculative fabulation since their clinical use is far from realisation. To derive viable gametes, particularly oocytes, from stem cells is extremely difficult and in humans, mature germ cells have not yet been achieved. Given this uncertainty, speculating about IVG helps to explore the shifting frontiers of bioscience and to direct the feminist gaze towards

epistemic, ontological and ethical stakes in remaking the borders between known and unknown and technological and biological in reproductive biology.

## Gametes through manipulated matter

The practice of in vitro gametogenesis is based on intensified knowing and modification of cellular material and its behaviour in different environments. Experimental stem cell research has induced primordial germ cells from iPS cells in cell culture, testing in which type of environments the complex developmental processes may be reconstituted in the laboratory. The goal is to identify and model in vitro how primordial germ cells develop stage-by-stage into spermatozoa and oocytes in the embryonic body. Studies have, however, suffered from inefficiencies in attaining the cell type and function wanted, undermining proper comparisons to processes in vivo. Furthermore, structural differences between mice and humans during early embryogenesis hinder the extrapolation of findings made in murine models to what may occur in humans (Saitou and Miyauchi, 2016; Yamashiro et al., 2018; Makar and Sasaki, 2020)

A recent ethnographic study on IVG has shown that scientists directly involved with IVG mainly consider it as a system for studying gametes' biological development and epigenetic mechanisms in cellular reprogramming, while being more cautious about its potential uses in future biomedicine (Merleau-Ponty, 2021). In my own fieldwork, study participants were not involved directly with IVG. However, some of them were studying supporting (gonadal) cells in testis and ovaries and all were experimenting with iPS cells for disease modelling. After observing and discussing the daily work with the new iPS cell technology, I often proposed some what-if questions about using the cell line to craft synthetic gametes. As a probing extension from the 'present' I was observing in the research laboratories, I began inviting study participants, even if initially reluctant because it was not their line of research, to talk about which kinds of reproductive futures – the co-constitution of technology and the reproductive process over time – could be envisioned with this new tool.

To begin with, investigating gametogenesis in vitro was regarded as part of what biomedical science *is and does*. Basic research on gamete maturation was considered similar to studying how, for instance, neural cells or cardiomyocytes develop: 'research-wise obviously interesting' (I27/2014). Concurrently, study participants speculated which cell culture and development stages need to be managed to turn iPS cells into germ cells that are functionally, genetically and behaviourally as they should be: chromosomally normal human gametes. Researchers I spoke with anticipated major challenges in standardising and controlling the starting material of synthetic gametes, meaning the iPS cell lines.

The main issues are epigenetic mechanisms at play in cellular reprogramming and the resulting genomic stability. Turning back 'the developmental clock' during reprogramming of somatic cells into iPS cells is a manipulative act in itself. If gametes are made from iPS cells, these must be as 'pure' and functional as possible.

Findings on epigenetic memory indicate that a reprogrammed cell might retain traces – a memory – of the cell type it used to be prior to reprogramming (e.g. Krupalnik and Hanna, 2014). Talking about the possibility of using iPS cells to derive gametes, Francesco, a post-doctoral researcher working in an Italian laboratory, told me that iPS cells tend to have 'imprinting problems' (I33/2014). He explained that 'the reprogramming is never complete; you have some printed part that is not complete. Maybe you can generate a complete person, but what will happen when he is going to reproduce?'. As a partial answer to this concern, stem cell scientists experimenting on IVG have established a foundation for resetting the epigenome in human primordial germ cells (Irie et al., 2015; see also: Merleau-Ponty, 2021). Nevertheless, the speculative futures of synthetic gametes are grounded in volatile biologies of the present in various ways. Understood as environment-genome interactions in a broader sense, the epigenetic challenges of IVG encompass a range of interventions to the reproductive processes: from establishing the primary cell lines to the prospective embryos created and – as Francesco pointed out – the life of a person born through IVG.

Investigating futures through the materialities of the present is crucial for speculative feminist analysis if we are interested in, as Haraway (2016) proposes, tracing new combinations of human and nonhuman lives. This raises the questions, where do the combinations emerge from and where will they take us? Growing human germ cells in a dish would subject cells to conditions where time and recurrent forced manipulation direct the outcome. In a prolonged cell culture, cells undergo a process my informants called *microevolution*, making some cells thrive better in their dish than others. Prolonging the timescale of cell culture was identified as a major problem if synthetic gametes were to be transferred from experimental research to clinical use. Catherine, the head of a research laboratory I visited in the UK, stated that she was initially critical of the idea of synthetic gametes because of the risk of 'genetic drift' in the cells (I23/2014). The cellular material would have to be cultured in the laboratory for several months, in effect generating genetic changes in the cells. Catherine concluded: 'it's very likely that the gametes that you would be making would not be very fit'.

The speculative ontologies of synthetic gametes represent liminal lives that, to borrow Squier (2004), escape categorisation and standardised scientific identities as cellular material. They appear partly as existing elements of stem cell science and partly as fantasies of new reproductive technologies. Speculating on the risks and promises of IVG, stem cell scientists made constant references to 'scientific facts' concerning the laboratory-induced biological processes to be harnessed in IVG. To derive synthetic gametes means overcoming major technical challenges with the knowledge that *full control* of the crafted yet living material cannot be achieved. Thus, we find ourselves in the liminal space between speculative fabulation and shifting frontiers of bioscience.

Synthetic gametes are envisioned as becoming entangled in long-standing debates about manipulating embryonic development (Franklin and Roberts, 2006; Franklin, 2013; Thompson, 2013). The validity and reliability of techniques

for deriving gametes from stem cells cannot be established without growing embryos to at least the blastocyst stage, usually reached at day five after fertilisation. This means that embryos are deliberately generated in vitro, solely for research purposes (Hinxton Group, 2008; Saitou and Miyauchi, 2016). Contemplating getting synthetic gametes to the clinic, my informants talked about the 'theory-driven generation of embryos' and 'making experimental individuals' (I18/2013). Several researchers stated, though, that it would be ethically more problematic to transplant the IVG-derived embryos directly into humans, to see whether the synthetic gametes functioned as expected, than to test the gametes with experimental embryos. 'That [testing the gametes directly on patients], my ethics won't allow', Sara, a head of laboratory in Sweden and a pioneer in both IVF treatments and stem cell research, told me. Referring to the European Convention on Human Rights and Biomedicine (Council of Europe, 1997), which would prevent the study of embryos derived from synthetic gametes in all the countries that have ratified it, Sara defended the importance of creating embryos for research purposes. How else, she asked, can we prove that laboratory-derived gametes yield 'normal embryos?' (I1/2010).

Futures are inseparable from and constituted in ambiguous ways by material practices and encounters of the present, as I have previously argued with Venla Oikkonen regarding the use of stem cells in biologically derived medicines (Meskus and Oikkonen, 2020). To make the speculative move from current use of iPS cells for disease modelling to deriving synthetic gametes for clinical purposes, the volatility of the source material and the biological stability of the would-be-gametes are crucial technical and ethical puzzles to be solved. While new biomedical futures may be offered with IVG, crafting synthetic gametes requires stringent alignment of a multitude of cellular (re)actions and human intervention. Let us nevertheless imagine that biomedical researchers do succeed in securing the quality, safety and efficacy of synthetic gametes and that they are brought into the clinic. What would this mean for reproductive futures?

# Selective procreation intensified

During my fieldwork, Charis Thompson (2013) published her book *Good Science*. In the book, she argues that stem cell science 'has ethics' in a different manner from many other fields of research because it intersects with controversial topics such as eugenics, commercialisation, genetic privacy and regeneration (Thompson, 2013: 27). Echoing this standpoint on ethics and stem cell technologies, Sara explained to me in a slightly agitated manner that even bioethicists tended to miss the ethical challenges created by the new iPS cell technology. Laura, her colleague in another university hospital, shared this view, saying that using iPS cells in the context of infertility treatment 'lies in wait in the future' (I3/2011), potentially complicating ethical discussions related to this cell line. Considering speculation as a thought experiment that does not aim at producing a unified truth about the plurality of worlds (Stengers, [1997] 2010), I seized these comments as a

cue to posing the questions: What if synthetic gametes did become a clinical option? What kinds of reproductive futures can we envision? What are the issues to be 'looked at' that bio scientists offer for feminist speculation?

My study participants regarded intentional manipulations of the embryonic genome as a major risk in bringing IVG into the clinic. They worried that iPS cell-derived gametes might be involved in attempts to, quoting Catherine, 'edit the genome of a prospective child'. Rapidly evolving genome-editing technologies have opened up the possibility of making precise, targeted changes to the genome. The clinical use of synthetic gametes could, they speculated, include trying to control and select a child's cognitive or physical characteristics. From a feminist perspective concerned about issues of stratified reproduction (e.g. Smietana et al., 2018), synthetic gametes abound with tensions between reproductive care and selective practices of procreation. If successful in human reproduction, IVG could become a further development in practices of selection, which have involved genetic screening (Franklin and Roberts, 2006), sex selection (Bhatia, 2018) and selective pronatalism (Thompson, 2005). In the context of preimplantation genetic diagnosis, Sarah Franklin and Celia Roberts (2006) show that the figure of the 'designer baby' is a paradigmatic case of unwanted biomedical development. It comes as no surprise then that visions about IVG are linked to reproductive futures becoming increasingly involved in practices of technologically conducted selection.

The following excerpt is from a discussion with José, a PhD student who was at the time of the interview working on a state-of-the-art PhD project involving both iPS cells and the then newly established genome-editing tool called CRISPR-Cas (see: Doudna and Sternberg, 2017). I asked José, 'is there some science fiction stuff [an expression offered by a previous informant] about which you think, ok, that's not for me?'. His response brings forward several SFs, speculative futures, scientific facts and shifting frontiers, as deeply enmeshed: 'Yeah, like, eugenics. We can try to repair the genome ... but this eugenics, like, we select that our children will be this way...no, no. But, of course, there now is this possibility also to select [using iPS cell and gene editing technologies]' (I16/2013). In a similar manner, several other study participants associated attempts to use IVG to select non-diseaserelated qualities or enhance future children's capabilities with what they termed 'eugenics'. This was an abhorred speculative future with IVG. However, repairing a flawed genome of a prospective child was simultaneously acknowledged as a possibility already in the present, a science fiction vision becoming scientific fact in the current moment.

Matteo, a laboratory head and distinguished participant in societal discussions on stem cell science, described iPS cells as perplexing because they herald *a new age of biological opportunities* (I30/2014). Using synthetic gametes to treat infertility and childlessness 'opens up a possibility to expand the domain of choice to an unprecedented level', he said. Matteo contemplated that making gametes in the laboratory can lead society towards the practice of 'in vitro eugenics', where stem cell-derived gametes are enrolled in selective breeding to produce individuals with a

desired genotype (cf. Sparrow, 2014). In other words, synthetic gametes were envisioned as allowing increased selection of one life over another at the level of a cell culture dish. This, Matteo said, generates 'a whole new space for political reflection on what we want as a society'. During our collaborative creation of what-if scenarios, he concluded that selection for the purpose of eliminating disease would feel acceptable for him: 'If you told me, do you want to endow your child with a copy of the receptor that makes him or her resistant to HIV, sure, why not'.

The point I want to make is that these issues of cure, selection and speculative futures do not arise in a void. Embedded in historical lineages of shaping human reproduction, speculating about IVG underscores sticky confluences of care-cure and enhancement-selection emblematic to current technoscientific societies. Here we are also reminded of how the reproductive process is understood not merely as the making of persons but also as the making of the future (Strathern, 1992). IVG has the potential power to radically remake biological conditions of fertility and thus the ways in which next generations come into being. It is a poignant case for speculating about reproductive futures because it involves not only the making of futures through the making of persons but also the making of persons through the making of gametes. My informants linked their thought experimenting with IVG specifically to the making of certain kinds of persons.

As it happened, these deliberations with stem cell researchers took place just before actors in the global scientific community began voicing concerns that editing the human germline – cells that pass on their genetic material to progeny – might be attempted. Prompting discussions on 'what we want as a society', national ethical and scientific committees in countries such as the US (National Academies of Sciences, Engineering, and Medicine, 2017) and UK (Nuffield Council on Bioethics, 2018) indicated that heritable germline editing was very likely to take place somewhere in the world. Not long after, in November 2018, biophysicist He Jiankui from the Southern University of Science and Technology in China announced that his group had used the genome-editing tool CRISPR-Cas9 to alter the embryonic DNA of twin girls. The stated aim was – as Matteo had anticipated – to prevent the babies from contracting HIV and thus pave the way for new disease prevention and disease-free family formation (He Laboratory, 2018). Creating the world's first gene-edited babies provoked national and international outery about unethical and premature human germline modification, landing He in prison for three years (Cyranoski and Ledford, 2018; Cyranoski, 2020). Nevertheless, as Eben Kirksey (2020) shows in his study of the case, science and technology corporations as well as research institutions in many parts of the world have continued working on this technology to 'remake the human condition'.

Similar to challenges brought up by He's gene-edited babies, IVG is deeply entangled with technical, ethical and political ambiguities surrounding reproductive modification. Consequently, it is increasingly difficult to determine what eugenics stands for in the age of reproductive modification. Speculative envisioning of futures with synthetic gametes foregrounds the fundamental difficulty created by biotechnological development in drawing the line between cure and enhancement.

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This, however, is not the end of the SF story on IVG. The speculative technology also opens up new opportunities for non-normative reproduction.

# The folded landscape of IVG

Feminist theorisation has sought to problematise, amongst other ontological dualisms, that of fact/fiction. Technological development and science fiction are mutually implicated rather than mutually exclusive (Haraway, 2016). Feminist speculative thinking, along with speculative design theorisation that I referred to in the beginning of the article, have further emphasised that thought experiments with science and technology are about 'creating possibilities' (Stengers, [1997] 2010) and 'pluriverses' where a future exists amongst other futures (Escobar, 2017). What could this mean in practice? Stengers proposes that 'learning to think is learning to resist a future that presents itself as obvious, plausible, and normal' ([1997] 2010: 10). In hindsight and as part of self-reflexive assessment of my speculative ethnographic approach, the discussions I invited study participants to join produced quite 'obvious' futures with IVG, including the way the technology was imagined to help treat involuntary childlessness. However, a point worth considering here is this: even with as potentially radical biotechnology as the IVG, envisioned futures arise from existing practices of technologically assisted reproduction.

Making the speculative move from the research laboratory to clinical use was often captured by stating 'as long as it is done in a regulated way and *just to treat infertility*', as Catherine put it. Synthetic gametes could be used in assisted reproductive therapy (ART) for 'infertile' patients and couples, understood primarily as individuals who have medical reasons for not being able to produce gametes. Medical indications for the use of synthetic gametes include infertility due to injury; exposure to toxicants or immune-suppressive treatments; and premature ovarian failure or azoospermia (the lack of sperm in seminal fluid) (Nikolic et al., 2016). Looking at IVG from this perspective, deriving gametes in the laboratory would be, José said, 'like an extension of IVF, a bit more complicated, involving reprogramming, but essentially it is the same' – in other words, a continuation of the ongoing and already routinised practice of assisted reproduction. Raili, a research group leader in a stem cell biobank, ended her speculative assessment of the new reproductive material by posing the question, 'why shouldn't we help you in this way, if other diseases can be fixed too?' (I18/2013).

For speculative feminist analysis, however, the landscape of future reproductive practices with synthetic gametes underscores the necessity of considering IVG also beyond the biomedical definition of infertility. Involuntary childlessness and 'reproductive needs' (Ishii, 2014) are not reducible to medical infertility. Existing ARTs are offered and used also for same-sex and solo parenting. If gametes could be made from skin cells, how is this prospect related to non-normative reproduction? What are the SFs of IVG-based procreation regarding single women and lesbian and gay would-be parents?

Coinciding with my study as well as early research on IVG with mouse models, bioethical discussion on general ethical principles for assessing clinical applications of IVG began to emerge. A central theme that bioethicists have debated for the past few years is the possibility for same-sex couples to have genetically related children. Ethical principles have been sought for and against the use of IVG to derive egg cells from somatic cells with XY chromosomes and sperm cells from somatic cells with XX chromosomes (e.g. Mathews et al., 2009; Cutas and Smajdor, 2015; Notini et al., 2020). Bioethicists have argued that if IVG is made clinically available, it would be 'unjust to exclude same-sex couples from using this technology based on their sexual orientation' (Segers et al., 2017: 688). Most importantly, synthetic gametes are seen to undo biogenetics-based objections to same-sex parenting because a child born with the help of IVG could be genetically related to *both* parents (Murphy, 2014).

Rather than searching for normative principles for IVG, my focus was on stem cells as liminal entities through which various open-ended *negotiations* take place on present and future forms of biomedical reproduction. Such negotiations illustrate the affectively charged dynamics of speculative fabulation, science facts and shifting frontiers of biological relatedness and imaginaries of displacing the centrality of heterosexuality and dimorphic gender relations. Indeed, if switching the sex of the germ cells became possible, IVG may reconfigure not only what fertility is and how it may be controlled but also our understanding and ideas about 'sex' and 'gender'.

Furthermore, the collaborative construction of speculative futures with study participants involved venturing into deliberations about intersecting differences and the question of who 'we' are or who the 'people' are who might profit or suffer from such technology. Whose futures are being talked about and by whom? With biotechnologies it is also often the case that producing speculative scenarios enforces questions about what is regarded as 'normal' and 'pathological'. This is where scenarios created in speculative contemplation may give rise to affective reactions such as resistance, bafflement and aversion.

Speculating on who could or should be allowed to derive synthetic gametes from their own somatic cells was a direction many of my informants were reluctant to venture further into. When I proposed that ethical discussion tends to lag behind biotechnological change and for that reason speculative discussions on possible futures serve a point, the answer was often 'it's so difficult to foresee what's coming' (I16/2013). Some of the study participants nevertheless reflected on the prospect of using IVG to derive eggs from chromosomally male cells or sperm from chromosomally female cells.

I had a lengthy discussion with Hanna, a post-doctoral researcher, who contemplated that:

changing chromosomes so that, for example, from two women you would take somatic cells from the other and differentiate, turn them into male cells by bringing the Y chromosome in and then differentiating these into sperm cells...which now sounds

pretty far-fetched and very challenging  $\dots$  I think that would not be normal or, that is not acceptable to me (I19/2013).

Hanna continued that she felt this would be 'too much manipulation' and favoured the existing practice of sperm donation. For this scientist, the 'sex change' conducted on the cellular level of gametes was a manipulative act that, in the context of the substantial cellular reprogramming required in IVG, crosses an ethical border. However, this ethical border proved difficult to put a finger on. Our discussion (like many other discussions with other scientists) ended with the informant pondering what form of technological modification could *not* be fitted into the existing landscape of ARTs. The gradual extension of in vitro fertilisation services to different social groups across countries provides, many informants thought, a self-evident context for IVG-related futures. Existing technological practices would justify further acts of reproductive modification.

For same-sex couples and individuals desiring solo parenting, synthetic gametes could multiply the range of choices for fulfilling reproductive wishes and thus be a means to alleviate reproductive injustices in the field of ARTs. From the perspective of lesbian pregnancy and parenting, Emily Owens (2019) argues that choices required in assisted conception are in an uneasy relation to the logics of genetic essentialism and the valences of biogenetic kin-making. Theorising through her own experiences about seeking familiarity in the choice of donor, she writes about 'the well-worn terrain of seeking legitimacy through biology' (Owens, 2019: 864). Arguably, the practice of IVG in same-sex reproduction could make intended parents less dependent on donated gametes if gametes could be made from one's own bodily material. Then again, the possibility of using genetically matching synthetic gametes may raise the value invested in biogenetic relationships. In my discussions with scientists, this ambiguity was expected to become even more complicated due to the envisioned high costs of IVG. Concomitant to existing reproductive justice issues with ARTs, it was predicted that offering IVG to facilitate non-normative reproduction would get caught up in arguments on 'cost reasons or the question whether it is supported by healthcare systems' (I29/2014).

To sum up, non-normative reproduction with the help of stem cell technology emerges as a reproductive future that biomedical scientists have varying views on. This indicates that the future landscape of IVG is rooted in present practices of stratified reproduction and the contested gender and sexuality politics of ARTs. Regarding the materialities of IVG, changing the chromosomal status of somatic cells may be considered a more invasive and ethically more challenging act of manipulation than the cellular reprogramming underlying IVG. The speculative feminist approach thus demonstrates that the affective and ethical stakes with switching the sex of the cells seem currently higher than with the invasive biotechnology that would enable synthetic gametes in the first place.

## **Conclusions**

This article has explored a speculative ethnographic approach to engage stem cell science with feminist theorisation on biotechnological change in order to envision emerging reproductive futures or the co-constitutive relations between technological development and reproductive processes. According to Cecilia Åsberg and others (2015: 155), speculation is at the very core of feminism, because feminism 'must open a terrain' from which it is possible to render different futures thinkable and imaginable. Futures that bestow responsibility, justice and equality are crucial aspirations for such scholarly work. Aligned with this thinking, I have developed a speculative feminist interrogation to trace the entangled regimes of SFs, that is, scientific facts, speculative fabulation and, as I proposed, shifting frontiers of bioscience. As part of ethnographic fieldwork, the speculative approach enabled probing into uncertain, hypothetical yet gradually emerging futures from the 'present' of stem cell laboratories. The approach involved exploring what-if questions with scientists who worked with the cellular technologies underlying the promise of IVG.

My aim is to show that speculative feminist thinking can elaborate ambiguous futurities not only in arts and cultural analysis but also in ethnographic research settings. Deployed in ethnographic interviews with scientists, speculation provides acts of 'looking' through *shared contemplation*. This means, as Noémie Merleau-Ponty (2021) writes quoting Sarah Franklin (2019) in *Nature*, that 'we must all be ethicists now'. New biotechnologies can be liberating and enabling, yet simultaneously they might reinscribe existing inequalities and produce novel ones. As the frontiers of biomedical research gradually shift how family- and kin-making can be conducted and understood, a speculative feminist approach is helpful in anticipating possible future implications of these developments. Carried out in ethnographic settings, this approach does not allow bio scientists to withdraw behind the shield of normative bioethics, that is, to relegate the contemplation and assessment of biotechnological development and reproductive modification to *other* fields of science. Rather, scientists are invited to conduct ethical deliberation 'on the go' while working with new technologies, such as the iPS cell line.

The case of IVG illustrates that the SFs of bioscience do not arise within a void. Rather, they emerge from and are rooted in historical lineages of modification and of previous and existing ways to justify the shaping of the human body. My discussions with stem cell scientists show that possible futures of reproductive modification are conceived as taking place in the name of preventing disease and suffering. This, however, raises the issue of whose suffering matters, and what new tensions arise in the politics of assisting reproduction. Who benefits from the new technology and at what cost? These are questions that a speculative feminist research setting can operationalise in the study of emerging futures. The approach can be used to insert a plurality of voices and viewpoints into visionary yet often biassed discussions and tentative practices in biotechnology development.

Clinical use of synthetic gametes might reinforce the preference for biogenetic relationships in human kin-making, that is, the value of one's genetically 'own' children. Yet one might ask if this kind of development is desirable. Current feminist debates on the future of human populations attempt to make sense of how reproduction links to earthly survival. They question pronatalist policies but also biological kin-making and suggest other, innovative ways to form families and kin relations (Clarke and Haraway, 2018). Others remind us that while new strategies of (non-)reproductive justice are needed, racial, ethnic, classed and gendered inequalities may be exacerbated in arguing for making kin, not babies. Historically and even today, reproductive restrictions have targeted population groups differentially (Lewis, 2017; Sasser, 2018). We can also return to Edelman's observations about the politics of 'reproductive futurism' (2004: 3) that conditions social order and generates exclusion. It is therefore worth considering whether the promise of a new method in technologically assisted procreation could not only create new reproductive futures but also feed into reproductive futurism as an oppressive political landscape.

If speculative feminism is indeed to engage in plural visions of reproductive futurities, kin-making and biotechnological change, staying with the trouble of *not* knowing what is right or wrong, who will benefit and who will be excluded from biotechnological developments, seems vital to keep the future open and ensure the on-going perceptiveness of critique. This does not mean, as the case of IVG shows, an inability to unpack potential implications of biotechnological change nor a relapse into nostalgia for technology-free life processes. At stake is not the biological basis or naturalness of reproduction – we are already past that point. Rather, attentiveness is needed to the contested yet intensive relations between technological development and the reproductive process in its increasing modifiability.

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#### Note

1. I interviewed researchers from various European biomedical research groups and laboratories between 2010 and 2016. The scientists' accounts analysed in this article form a total corpus of 33 in-depth interviews with stem cell scientists, clinical doctors and regulatory authorities (14 assumed women and 19 assumed men) conducted in Finland, Sweden, the United Kingdom and Italy. The interviews took place as part of fieldwork I conducted over ten months at a university-based stem cell laboratory in Finland in

2012–13, returning for a short period in 2014. The scientists represented all the major stages of academic careers, from laboratory staff, PhD students and post-doctoral researchers to research group leaders, laboratory heads and university professors. They worked in university- or hospital-based biomedical research laboratories that collaborated with other university laboratories and research institutions in Europe, North America and Asia (Meskus, 2018).

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