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In vitro gametogenesis: just another way to have a baby?

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ABSTRACT

Advances in science have made possible the derivation of reproductively viable gametes *in vitro* from mice. The research on human cells suggests that *in vitro* gametogenesis ("IVG") with reproductive potential may one day be possible with humans. This technology would allow same-sex couples to have children who are biologically related to both of them; allow single individuals to procreate without the genetic contribution of another individual; and facilitate "multiplex" parenting, where groups of more than two individuals procreate together, producing children who are the genetic progeny of them all. IVG could also make prenatal selection a much more refined and comprehensive process than it is today, allowing for the selection of embryos on the basis of multiple factors. Evaluating IVG under a relational autonomy framework, this article argues that the potential benefits or harms of IVG depend on the social, scientific, and legal context in which it is situated and how it is used. It concludes that IVG is preferable to some forms of assisted reproductive technologies in certain instances and substantially more problematic in others. Finally, it suggests that its capacity to "perfect" prenatal selection in many ways exacerbates the problematic aspects of increasingly expansive prenatal selection.

KEYWORDS: Assisted reproductive technologies, equality, gametogenesis, genetics, prenatal selection, relational autonomy

INTRODUCTION

In the first few years of this century, researchers made headlines after deriving *in vitro* gametes—reproductive cells—from mice.[1] Further work produced live offspring,

[1] See eg, Nicholas Wade, *Pennsylvania Researchers Turn Stem Cells to Egg Cells,* New York Times, May 2, 2003, at A28; Sylvia P. Westphal, *Embryonic Stem Cells Turned into Eggs,* New Scientist (May 1, 2003),

demonstrating the reproductive viability of these cells.[2] While not nearly as advanced, the research on human cells suggests that *in vitro* gametogenesis (IVG) may one day be possible with humans.

These scientific advances raise important questions about what IVG might mean for human procreation. In some ways, this technology is just another method to allow infertile individuals to have genetically related children. In other words, it is one of many forms of assisted reproductive technology (ART). On the other hand, it potentially allows for methods of procreation that have never been possible before. With IVG, same-sex couples may be able to have children who are biologically related to both of them. In addition, IVG could facilitate 'multiplex' parenting, where groups of more than two individuals (whether all male, all female, or a combination) procreate together, producing children who are the genetic progeny of them all.[3] And finally, single individuals may be able to procreate without the genetic contribution of another individual,[4] what I refer to as 'solo IVG'. IVG also presents the possibility of 'perfecting reproduction', by greatly improving the ability to screen for undesirable diseases or even traits.

IVG potentially offers some of the same benefits as many other types of ART, which help infertile individuals, same-sex couples, and single people participate in the procreative process. It also raises a host of legal and ethical issues similar to those presented by existing and future technologies—such as *in vitro* fertilization, preimplantation genetic diagnosis (PGD), prenatal testing, germline gene transfer, mitochondrial replacement, genetic enhancement, and reproductive cloning. Among these issues are concerns about the 'unnaturalness' of the means of procreation, the difficulties of determining parentage, challenges to the meaning of procreation and parentage, as well as worries about physical and psychosocial harms to the future child. Many of these concerns arise because IVG seems radically different from other means of procreation. In the context of prenatal screening, IVG raises concerns about its eugenic implications and potential to exacerbate social inequities.

Nevertheless, this piece does not conclude that IVG is inherently threatening and problematic either in its uniqueness or in its similarity to technologies that some find troubling. Instead, it draws from a relational account of autonomy to suggest that our assessment of IVG and its potential benefits or harms depends entirely on the social, scientific, and legal context in which it is situated and how it is used. The article begins with a brief discussion of the technology. Part II then describes the various ways in which the technology might be used for reproductive purposes—to create a child—and to 'perfect' reproduction, i.e., to refine prenatal testing. Part III turns to the issues surrounding the reproductive and 'improvement' aspects of IVG. It concludes that, under a relational account of autonomy, IVG is arguably preferable to some forms of ART

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https://www.newscientist.com/article/dn3688-embryonic-stem-cells-turned-into-eggs/ (last accessed Dec. 3, 2015); Sylvia P. Westphal, *Stem Cells Can Become 'Normal Sperm,'* New Scientist (May 7, 2003), https://www.newscientist.com/article/dn3700-stem-cells-can-become-normal-sperm/ (last accessed Dec. 3, 2015).

2 Cesar Palicios-Gonzales et al., *Multiplex Parenting: IVG and the Generations to Come*, 40 J. Med. Ethics 752 (2014).

3 Palacios-Gonzales, *supra* note 2, at 752.

4 Ainsley Newson & Anna Smajdor, *Artificial Gametes: New Paths to Parenthood?*, 31 J. Med. Ethics, 184, 186 (2005).

in certain instances and substantially more problematic in others.[5] Finally, it suggests that perfecting reproduction in many ways exacerbates the problematic aspects of increasingly expansive prenatal selection.

I. THE TECHNOLOGY OF IVG

The first attempts to derive gametes *in vitro* began, as much research does, with mice.[6] The initial work focused on deriving gametes directly from fetal gonads,[7] but ultimately researchers developed the ability to obtain gametes from mice embryonic stem cells (ESCs), derived from the inner cell mass of the blastocyst (the five-day-old fertilized egg).[8] ESCs are pluripotent cells that have the capacity, under the right conditions to differentiate, i.e., to develop into a range of specialized cell lines and tissues.[9] At first, scientists derived gametes from random differentiation of ESCs,[10] but more recently they developed methods to control the process of producing gametes.[11] Equally important were developments that allow for IVG via induced pluripotent stem cells, as opposed to ESCs, avoiding the need to use embryos.[12] Scientists have been refining the methodology to control differentiation with the possibility in the future of 'bypassing... the intermediate attainment of various pluripotent states'.[13]

One significant technical hurdle that researchers were able to overcome was the difficulty of obtaining both eggs and sperm from female and male mice.[14] Given that females lack a Y chromosome,[15] and that germ cells go down the route of producing ova unless signals from the testes direct the cells to become sperm,[16] the process of producing sperm from females is more complicated than deriving oocytes from males.[17]Yet scientists have been able to derive primitive sperm cells from female human ESCs.[18] Finally, scientists have been able to produce viable offspring using *in vitro* gametes from

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5 This article briefly addresses concerns that IVG, like many other forms of ART, privileges genetic connections and medicalizes reproduction. Nevertheless, it accepts as a given that ART is both widely used and offers reproductive options. Therefore, it evaluates IVG in that light. See *infra* text accompanying notes 110–13.

6 Westphal, *Stem Cells, supra* note 1.

7 Giuseppe Testa & John Harris, *Ethics and Synthetic Gametes*, 19 Bioethics, 146, 147 (2005). Researchers had been able to derive functional gametes from chimeras created by mouse stem cells mixed with embryo cells, but it took two decades to be able to achieve the same result *in vitro*. Anne McLaren, *Free Range Eggs?*, Science, April 20, 2007, at 339.

8 Newson & Smajdor, *supra* note 4, at 184.

9 Testa & Harris, *supra* note 7, at 147.

10 Westphal, *supra* note 1; Zubin Master, *Embryonic Stem-Cell Gametes: The New Frontier in Human Reproduction*, 21 Hum. Reprod. 857, 858 (2005).

11 Newson & Smajdor, *supra* note 4, at 184.

12 Palacios-Gonzales, *supra* note 2, at 752.

13 *Id.* at 753 (noting the possibility of attaining this differentiation with the use of mRNA, which would bystep the need to integrate DNA instructions into the genome and thereby avoid concerns about genetic manipulation). As some have described, we are in the 'current era of so-called "cell fate plug and play"', where scientists can reprogram 'somatic cells into a panoply of unrelated cell types'. *Id.*

14 Hannah Bourne et al., *Procreative Beneficence and In Vitro Gametogenesis*, 30 Monash Bioethics Rev. 29, 31 (2012).

15 Palacios-Gonzales, *supra* note 2, at 752.

16 Westphal, *Stem Cells, supra* note 1 .

17 Debra J.H. Matthews et al., *Pluripotent Stem-Cell Derived Gametes: Truth and (Potential) Consequences*, Cell Stem Cell, July 2, 2009, at 12.

18 Karim Nayernia et al., *In Vitro Derivation of Human Sperm from Embryonic Stem Cells*, Stem Cell Dev., July 8, 2009; Roger Highfield, *Sperm Cells Created from Female Embryo*, Telegraph, Jan. 31, 2008.

either female or male mice.[19] Thus far, however, this has not been achieved using only *in vitro* gametes, as opposed to one *in vitro* gamete fertilized with a 'naturally' produced gamete.[20] Moreover, we do not yet have information about the phenotype of mice created in this manner,[21] which is crucial to understanding the potential long-term effects of this method of procreation.

Not surprisingly, the work in humans has not progressed to the same extent. Researchers have derived the equivalent of primordial germ cells—cells with markers specific to mature germ cells —from human ESCs.[22] Advances in stem cell research suggest that IVG may be able to occur without using human embryos. Specifically, researchers have demonstrated the ability to create ESC-like cells—induced pluripotent cells—by dedifferentiating adult somatic cells and then differentiating them into 'haploid spermatogenic cells'.[23] So far scientists have not achieved similar success in creating human oocytes,[24] although they have derived egg-like cells.[25] Given that research on mice has yielded both sperm and oocytes, however, it is probably merely a matter of time before human oocytes can be derived *in vitro*. While mice are clearly not human, the research thus far suggests 'substantial' similarities between the two species and provides 'strong reasons to expect that human IVG would also prove equally functional in terms of live offspring generation'.[26] A great deal of research, of course, would be necessary to establish the reproductive capacity of human IVG and, even more important, to test its ability to produce healthy children.

Among the challenges of deriving *in vitro* gametes is the fact that gametes differ from other cell types in a few ways. First, they contain half of the genome (a haploid),[27] which, when the egg is fertilized by the sperm, leads to the creation of a full genome. Second, to become fully functional, they must be capable of undergoing meiosis, the process of cell division that divides the parent cell and diploid chromosomes to result in the final haploid cell or gamete. While researchers have been able to create germ cells *in vitro* that seem to be able to go through meiosis, they have not been able to make the meiotic process fully resemble normal meiosis *in vivo*.[28]

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19 Palacios-Gonzales, *supra* note 2, at 753; Tetsuya Ishii et al., *Ethical and Legal Issues Arising in Research on Inducing Human Germ Cells from Pluripotent Stem Cells*, Cell Stem Cell, Aug. 1, 2013, at 145. The initial efforts to produce live offspring resulted in pups dying shortly after birth, which was thought to be due to imprinting problems. Matthews et al., *supra* note 17, at 11.

20 Palacios-Gonzales, *supra* note 2, at 753.

21 *Id.*

22 Bourne et al., *supra* note 14, at 31 (citing to 2004 and 2007 articles about markers on germ like cells).

23 Charles A. Easley IV et al., *Direct Differentiation of Human Pluripotent Stem Cell into Haploid Spermatogenic Cells*, 2 Cell Rep. 440 (2012); Bourne et al., *supra* note 14, at 32.

24 Ishii et al., *supra* note 19, at 145.

25 Bourne et al., *supra* note 14, at 32.

26 Palacios-Gonzales, *supra* note 2, at 753. Palacios-Gonzales notes that the work on mice proves 'a clear framework for the assessment of human IVG, since their functional murine counterparts were subjected to extensive transcriptomic and epigenomic profiles. This means that in the critical issue of how to assess the first-in-human use …, we will not need to start from a blank slate and will be able instead to advocate a rigorous pipeline to test human IVG functionality to the best of our current knowledge, buttressed by the undeniable strength of the murine *in vivo* results'. *Id.*

27 Testa & Harris, *supra* note 7, at 150.

28 See Yuan-Chao Sun et al., *Reconstitution of Gametogenesis in vitro: Meiosis is the Biggest Obstacle*, 20 J. Genet. Genomics 87 (2014).

In addition, gametes have different imprinting patterns—the 'molecular tagging' of genes caused by the attachment of methyl groups to the genes (methylation), which affects gene expression.[29] Specifically, a small number of genes (about 50 out of the roughly 30,000 genes that make up the human genome) in oocytes and sperm have special imprinting patterns, which reflect whether the genes have a maternal or paternal origin, respectively.[30] The imprinting patterns, which remain in the fertilized egg, silence expression of the maternal or paternal version of these 50 genes, depending on parental origin, so that only one copy of the genes will be expressed in the zygote.[31] In contrast, for the rest (and vast majority) of the genome, both copies of genes (maternal and paternal) are expressed. Given these differences between somatic and germ cells, successful IVG must effectively erase the imprinting pattern of the somatic cells and 'reset' them so that the 'mature gametes… match the sex of that germline (paternal imprints in sperm and maternal imprints in oocytes)'.[32] Understanding these imprinting patterns *in vivo* and trying to replicate them *in vitro* will be among the greatest challenges in deriving *in vitro* gametes that will be functional for reproduction and normal development.[33] The ethical dilemmas about when and how such research should be done (although beyond the scope of this paper) will be enormously challenging.[34]

If IVG becomes a safe and effective method of human reproduction, the technique would involve taking a somatic cell from an individual, which could be used to produce a stem cell from which the gametes would be derived. One method would be via somatic cell transfer (SCNT), by which the nucleus of the individual's somatic cell would be transferred into an enucleated egg (an egg whose nucleus has been removed) to create an embryo. Once the embryo reached the blastocyst stage, immature gametes (developing germ cells) could be collected from the inner cell mass of the blastocyst and grown in culture to maturation.[35] Alternatively, somatic cells could be used to generate induced pluripotent stem cells from which gametes could be derived. As scientists better understand and refine the processes of dedifferentiation and differentiation, it seems plausible to imagine the ability to go directly from a somatic cell to an egg or sperm cell.[36] At that point, IVG would completely avoid concerns about research using embryos and would substantially streamline the process.

II. REASONS TO USE IVG

While there are numerous technical challenges that must be overcome before IVG becomes a viable option for human reproduction, commentators are already imagining the ways in which this technology might be used. IVG has multiple potential applications, including those that don't involve reproduction per se. For example, IVG can be used for research purposes, including analysis of 'ESC differentiation, gametogenesis, X-chromosome inactivation, fertilization, early embryonic development, germ-cell

29 See Derek H.K. Lim & Eamonn R. Maher, *DNA Methylation: A Form of Epigenetic Control of Gene Expression*, 12 Obstetrician & Gynecology 37 (2010).

30 Testa & Harris, *supra* note 7, at 150.

31 *Id.*

32 *Id.* at 151.

33 See M. Azim Surani, *How to Make Eggs and Sperm,* Nature, Jan. 8, 2004, at 106.

34 Ishii et al., *supra* note 19, at 145; Bourne et al., *supra* note 14, at 31.

35 Bourne et al., *supra* note 14, at 31, 32.

36 See *supra* text accompanying note 23.

tumors, and imprinting'.[37] By creating differentiated cells and tissue lines with different genetic mutations, researchers can better understand genetic disease and test potential drug therapies.[38] *In vitro* gametes also have potential application for therapeutic cloning by more easily allowing for the creation of autologous ESCs that could be differentiated into tissues needed for transplant.[39]

The focus of this piece, however, is on reproductive uses of IVG, whether to help individuals who cannot physically conceive a child or who, because of social or situational circumstances, 'desire to achieve pregnancy by means other than sexual intercourse'.[40] In addition, it explores IVG as a tool to try to have children who are as healthy, or even as 'fit', as possible by using new versions of prenatal selection. Before describing the different ethical and legal concerns that arise with respect to each of these uses of IVG, I explore below the various ways in which IVG might work in the different contexts.

A. IVG as Fertility Treatment

Perhaps the least controversial of the potential reproductive uses of IVG would be for those who, because of 'a disease of the reproductive system', are physically unable to conceive children.[41] Individuals may have damaged gonads or be unable to produce gametes due to injury, surgery, or cancer treatments.[42] Women who entered menopause prematurely would also fall within this category as would those who have been involuntarily sterilized.[43]

There are, however, additional groups who are also unable to conceive because of physical limitations, but their inability to conceive is not the result of a 'disease of the reproductive system'. This group includes postmenopausal women or premenarche girls. Assuming IVG has advanced sufficiently, these individuals could also reproduce by deriving gametes from stem cells (whether induced directly from their somatic cells or from embryos created from their somatic cells using SCNT).[44] As we shall see in Part III, however, the differences between the medically infertile and this group of individuals are significant and provide strong reasons to treat the latter differently from the former.[45]

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37 Master, *supra* note 10, at 859.

38 Robert Sparrow, *In Vitro Eugenics*, 40 J. Med. Ethics 725 (2014); Testa & Harris, *supra* note 7, at 152–53; Master, *supra* note 10, at 859.

39 Testa & Harris, *supra* note 7, at 154.

40 Reproductive Technologies and the Law 14 (Judith Daar ed., 2d ed. 2013) (quoting language from Assembly Member Felipe Fuentes of California bill to expand the definition of infertility to include 'social' infertility, as distinguished from 'medical' or 'physical' infertility). While some question the need to distinguish those who are 'medically' or 'physically' infertile from those who are 'socially' infertile, Julie Shapiro, *Do We Need to Talk about 'Social Infertility?'*, Related Topics (Nov. 4, 2013), https://julieshapiro.wordpress.com/2013/11/04/do-we-need-to-talk-about-social-infertility/ (last accessed Dec. 3, 2015), I distinguish these categories throughout the piece because, as I argue in Part III, the issues regarding IVG are not the same for the different groups. These distinctions are in no way intended to denigrate one group or privilege another.

41 American Society for Reproductive Medicine, *Frequently Asked Questions About Infertility*, https://www.asrm.org/awards/index.aspx?id=3012 (last accessed Dec. 3, 2015).

42 Testa & Harris, *supra* note 7, at 155; Palacios-Gonzales, *supra* note 2, at 755.

43 Palacios-Gonzales, *supra* note 2, at 755; Testa & Harris, *supra* note 7, at 155 (noting that while not a practice in the United States, this is occurring on an international level).

44 Palacios-Gonzales, *supra* note 2, at 756.

45 See *infra* text accompanying notes 80–92.

There is another category of infertile individuals who can reproduce biologically, but who are not in a social situation that easily allows them to reproduce. This category includes same-sex couples, who currently must rely on ART to have a child biologically. For example, lesbians can use artificial insemination and gay men can artificially inseminate a traditional surrogate or use *in vitro* fertilization (IVF) with an ovum donor and a gestational surrogate. Single individuals who do not wish to reproduce via a sexual relationship can rely on the same technologies to have genetically related children. Finally, while never before described as a form of infertility, one might include groups larger than two, who cannot, with current forms of ART, all reproduce together.

To address infertility in individuals whose social situations prevent conception, ART currently requires the use of genetic material from individuals—egg or sperm donors—who are not intended to parent the child. These donors are either completely outside the relationship and unconnected to the individual(s) seeking to procreate—in the case of unknown, anonymous donors—or they may be friends or acquaintances who have agreed to provide genetic material. What distinguishes IVG, in this context, from other ART techniques like IVF and gamete donation is that it allows these individuals (as well as dual-gendered couples with at least one individual who cannot produce gametes) to have biologically related children without relying on gamete donors. Thus, for example, IVG could be used to allow one member of a same-sex couple to derive a gamete of the opposite sex (eggs from men and sperm from women) from his or her cells,[46] which in combination with a 'naturally' derived gamete from the other member of the couple could be used to produce an embryo. The resulting child would share 50% of its genome with each member of the couple. For gay couples, a surrogate would still be necessary (unless artificial wombs become a viable option) to bring the embryo to term. For lesbian couples, one or the other would be able to have the embryo implanted in her uterus so she could carry the pregnancy to term, avoiding entirely the need to rely on individuals outside the relationship to assist in their reproduction. And for straight couples, where one or both cannot provide gametes, IVG would also allow them to reproduce without relying on gamete donation.

Single individuals might also theoretically use IVG to reproduce without depending on a partner or gamete donation—what I call 'solo IVG'. Just as with IVG in gay and lesbian couples, this technique would require the ability to create gametes of the opposite sex.[47] In short, the individual would derive the female or male counterpart of gametes via IVG to use with his or her naturally derived gamete to produce an embryo through IVF. The embryo could be implanted in the single female or, in the case of a single male, in a gestational surrogate. This use of IVG raises substantially greater scientific and safety challenges, as I discuss in Part III, because all of the genetic material would come from a single genome.[48]

Finally, individuals who want to reproduce as part of a group of more than two individuals could potentially use IVG to create children who are genetically related to all of them. Imagine, for example, that four different individuals (a quadruple) wanted to procreate together. Two different couples from the quadruple would each create embryos

[46] As noted earlier, it is technically more challenging, given biological differences, to produce sperm from women than to produce eggs from males. See *supra* text accompanying notes 15–17.

[47] Palacios-Gonzales, *supra* note 2, at 756.

[48] See *infra* text accompanying notes 128–29.

with their respective gametes. ESCs could then be extracted from the embryos from which gametes—sperm from one set of ESCs and ova from the other set —would be derived. Using IVF, the resulting sperm and oocytes (each representing genetic material from one of the two pairs of the quadruple) would be used to create embryos that would be genetically related to each of the four individuals.

IVG in this context would not be procreation in the traditional sense. First, each member of the quadruple would share only 25% of their genome with the child as compared with the 50% that a genetic parent shares with his or her child. In essence, the genetic relationship between each member of the quadruple and the child would be like that of grandparent and grandchild, rather than parent and child, and it would be a temporal compression of generations since the 'middle generation' would essentially exist only momentarily as an embryo and the source of the gametes used to create the resulting child.[49]

One could imagine combinations of different numbers and sexes for 'multiplex parenting', resulting in potentially different combinations of genetic relatedness.[50] A trio of individuals (a 'thruple'[51]) could create one embryo from two of the individuals, from which a gamete could be created. This gamete could then be combined with a 'naturally' derived gamete of the third individual, resulting in a 50% genetic connection between the third individual and the child and a 25% genetic connection between the first two and the child. If eight individuals were involved to create a child, the resulting child would be 12.5% related to each individual. The combinations are endless. Moreover, if we develop the ability to derive viable *in vitro* ova and sperm from both male and females, the combinations could include any possible arrangement of men and women, just men, or just women.

B. Perfecting Reproduction

While perhaps less obvious, IVG could also play a role in efforts to have healthy or enhanced children. Specifically, it could improve prenatal selection by making it much easier and more robust in several ways. It also could combine many of the advantages of the current methods of prenatal testing, while eliminating some of the less desirable features. The first approach, presuming *in vitro* gametes are as viable as natural gametes, would be to do PGD on embryos created from these gametes.[52] Couples would select the embryos that lacked whatever genetic mutations they wanted to avoid. As compared with other prenatal selection methods such as noninvasive prenatal testing (NIPT),[53] amniocentesis, and chorionic villus sampling (CVS), PGD offers the same (or greater, in the case of NIPT) diagnostic potential. Moreover, it avoids the risks

[49] Palacios-Gonzales, *supra* note 2, at 757.

[50] *Id*. at 756.

[51] See Jean H. Edelstein, *Why Shouldn't Three People Get Married?*, GUARDIAN, Aug. 30, 2012 (using the term in the context of marriage and describing a public notary in Brazil who conducted the marriage of three Brazilians).

[52] PGD is 'the genetic testing of embryos created through in vitro fertilization' and was first reported in medical journals in 1990. Susannah Baruch et al., *Genetic Testing of Embryos: Practices and Perspectives of U.S. IVF Clinics*, 89 FERTIL. & STERIL. 1053 (2008).

[53] NIPT involves the analysis of cell-free fetal DNA that can be found in the mother's bloodstream to determine whether the pregnancy is at heightened risk for chromosomal aneuploidies like trisomy 21. See Wybo Dondorp, *Non-Invasive Prenatal Testing for Aneuploidy and Beyond: Challenges for Responsible Innovation in Prenatal Screening*, 23 EUR. J. HUM. GENET. 1438 (2015).

associated with invasive procedures, such as amniocentesis and CVS, or the difficulties of terminating a pregnancy if the fetus were found to have an unwanted disease, which are negative aspects of NIPT, amniocentesis, or CVS.[54]

PGD, however, requires egg retrieval in order to create the embryo that will be analysed. Because IVG would allow for the creation of ova, it would eliminate the need for egg retrieval and its attendant physical burdens and even potential risks to women.[55] IVG would offer an additional benefit. While hormonal treatment can enhance ova retrieval, there are limits to how many ova can be retrieved from a woman at any time. IVG, in contrast, presents no such limits to the supply of ova.[56] As a result, IVG would make it possible to create far more embryos for PGD than is currently possible. For purposes of screening out a single disease gene, this may not be necessary. But if couples were interested in using PGD to select for or against several genes, the odds of finding an embryo with a desirable combination of genes would increase significantly.[57] Concerns about the creation and destruction of embryos would remain, and might even be enhanced, given the much larger number of embryos that would potentially be created and destroyed. In addition, one might imagine that the costs would remain high. Whether current uses of PGD would be more or less expensive than PGD in combination with IVG would depend on how the costs of ova retrieval compared with the costs of producing ova through IVG. While the price tag would be a barrier for some, the reduced burdens for women and the greater number of embryos one could test might make this version of PGD preferable to traditional PGD for many.

For those who are concerned about embryo destruction, IVG could potentially be used another way to improve fitness. Rather than use it to create multiple embryos, we could use IVG to create a large supply of gametes, which could be selected for the genetically optimal genotypes.[58] This would require the ability to test the genotypes of each gamete without destroying the gametes' viability.[59] Assuming that such technology eventually becomes available, IVG would offer the benefit, again, of allowing for the creation of far more ova than we can currently retrieve.[60] Even for those who are not per se morally opposed to embryo destruction, some may have qualms about creating vast numbers of embryos simply to find the optimal genotype.[61] As a result, testing gametes themselves may be morally preferable to many, if it becomes a viable option.

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54 Hannah R. Farrimond & Susan Kelly, *Public Viewpoints on New Non-Invasive Prenatal Genetic Tests*, 22 Public Underst. Sci. 730 (2013).

55 Society for Assisted Reproductive Technology, Risks of *In Vitro* Fertilization (IVF), http://www.sart.org/FACTSHEET_Risks_of_In_Vitro_Fertilization/ (describing the risks as including 'mild to moderate pelvic and abdominal pain, … injury to organs near the ovaries,…[and] pelvic infection').

56 Bourne et al., *supra* note 14, at 33; Wade, *supra* note 1; Surani, *supra* note 33, at 107.

57 See *infra* text accompanying notes 168–69.

58 Bourne et al., *supra* note 14, at 38. Of course, if IVG involved the creation of embryos for ESCs, then there would be some embryo destruction. But if induced pluripotent stem cells could be used, there would be no embryo destruction at all. *Id.*

59 This is different from preconception screening where the genotype of the source of the gamete is tested for various mutations. If an individual is a carrier for a particular recessive inherited disorder, he or she would be interested, if possible, in selecting which of his or her gametes carried the mutation and which did not.

60 Obviously, we would not need to rely on IVG to produce plentiful quantities of sperm.

61 Bourne et al., *supra* note 14, at 38.

III. EVALUATING IVG FOR REPRODUCTIVE PURPOSES

In many ways, the reproductive uses of IVG are similar to several forms of reproductive technologies we use today. As a result, it presents many of the same benefits and concerns. But as I discuss in detail below, in some respects, IVG is different in important ways from current reproductive technologies. Some of these differences argue in favor of IVG, and some of these differences argue against it. Ultimately, however, just as is true with respect to many of the concerns regarding current and future forms of ART, the degree to which these technologies are problematic is largely contextual, especially when assessed under a relational autonomy framework.

A. Relational Autonomy

Before I evaluate the potential uses of IVG, I briefly recount the relational autonomy framework, which I have used previously to assess advanced reproductive technologies.[62] One of the most common defenses of reproductive technologies is to argue that procreative autonomy, whether understood as a constitutional right or an ethical claim, justifies their use.[63] While the Supreme Court has recognized some kind of procreative autonomy—described more recently as liberty interests[64]—the scope of these interests remains highly uncertain.[65] Even the broadest conception of reproductive rights, however, is not absolute and would be limited when certain uses of the technologies are sufficiently harmful to the individual, the resulting children, and/or society.[66]

I have urged that we understand procreative autonomy, whether understood as an ethical or legal concept, in terms of relational autonomy, rather than the thin, individualistic notion of autonomy that underlies some of the Supreme Court jurisprudence in this area. The Court's discussion in *Casey*, for example, described decisions like marriage and procreation as 'matters involving the most intimate and personal choices a person may make in a lifetime, choices central to personal dignity and autonomy'.[67] In stating that 'at the heart of liberty is the right to define one's own concept of existence, of meaning, of the universe and of the mystery of human life',[68] the Court seemed to understand autonomy in terms of an 'atomistic conception of self-definition, in which the individual shapes herself without reference to others'.[69] I have argued that this

62 Sonia M. Suter, *The Repugnance Lens of* Gonzales v. Carhart *and Other Theories of Reproductive Rights: Evaluating Advanced Reproductive Technologies*, 76 GEO. WASH. L. REV. 1514 (2008).

63 Master, *supra* note 10, at 860.

64 Planned Parenthood of Se. Pa. v. Casey, 505 U.S. 833 (1992) (plurality opinion).

65 For example, debates focus on whether these procreative rights include affirmative efforts *to* procreate or simply negative rights to prevent procreation. See JOHN A. ROBERTSON, CHILDREN OF CHOICE: FREEDOM AND THE NEW REPRODUCTIVE TECHNOLOGIES 39 (1994) (suggesting Supreme Court jurisprudence includes a positive right to reproduce); Radhika Rao, *Constitutional Misconceptions*, 93 MICH. L. REV. 1473, 1475 (1995) (finding only 'sketchy support' for an affirmative right to reproduce); Glenn Cohen, *The Constitution and The Rights Not to Procreate*, 60 STAN. L. REV. 1135, 1141 (2008) (challenging the tendency in 'American constitutional jurisprudence … to treat the right to be and not to be a gestational parent … as conjoined'); Suter, *supra* note 62, at 1525.

66 *See, eg,* ROBERTSON, *supra* note 65, at 153 (1994) (Even a broadly construed conception of 'procreative liberty', which sets a presumption in favor of choice, could be overcome 'when harmful consequences justify overriding reproductive choice'.).

67 *Casey*, supra *note* 64, at 851.

68 *Id.*

69 Sonia M. Suter, *Disentangling Privacy from Property: Toward a Deeper Understanding of Genetic Privacy*, 72 GEO. WASH. L. REV. 737, 772.

approach suffers from a narrow conception of self-definition that does not consider the 'interests and attachments we may have at any moment', and is 'never identified by our aims'.[70] In contrast, a relational account of autonomy is grounded in a fuller conception of self-definition, which imagines the individual in terms of her relationship to others, where our 'moral identity' is shaped by our 'membership in communities such as those of the family, the neighborhood, the city and the tribe',[71] rather than 'unencumbered' and 'independent', without 'constitutive attachments'.[72]

A relational autonomy framework would not simply focus on whether various uses of IVG are an exercise of individual decision making related to procreation. Instead, it would consider whether 'our individual goals... dissolve[] community and divide[] us from each other'[73] and whether IVG reproductive technologies are central to the 'development and expression of the relational self', rather than merely the 'atomistic' self.[74] Such analysis requires evaluation of motivations, context, and results—which may be multivaried and complex—to determine whether particular reproductive uses of IVG are compatible with relational autonomy. As we shall see in the next section, this framework, which I employ primarily for ethical analysis, leads to very different conclusions as to the propriety of IVG for reproductive purposes in different contexts.

B. IVG to Assist Reproduction

Obviously one of the greatest concerns with respect to IVG is its safety for future children. Addressing this concern is challenging given the limits of our knowledge about the risks associated with IVG. For example, we have minimal knowledge about the implications of switching cell types from differentiated to undifferentiated states and the implications of erasing and resetting imprinting patterns to facilitate reproduction. Precisely because this technology is still evolving, many questions remain about the exact nature and degree of risk it could present to future children. Because IVG might potentially affect the resulting children's germlines, uncertainty also exists with respect to the potential risks to future generations.

Even before contemplating the use of IVG for reproduction, therefore, all would agree that we must have a clear understanding of the mechanics of IVG and its effects on mice and potentially other species when used to produce live offspring.[75] While such data would be helpful in understanding the potential risks of human reproduction via IVG, we cannot assume that what works without complications or heightened risks in one species will work similarly in humans. The only way ultimately to demonstrate the effectiveness and safety of these techniques in humans is to use *in vitro* gametes to try

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70 Michael H. Sandel, Liberalism and the Limits of Justice 175 (1987). One could argue that even the individualized notion of autonomy, in the context of reproduction, has a relational element given that reproduction necessarily includes some kind of relationship with others except, perhaps, with solo IVG. Even so, this notion of autonomy is not as richly focused on relational elements as the approach I describe below.

71 Alasdair MacIntyre, After Virtue: A Study in Moral Theory 205 (1981).

72 Sandel *supra* note 70, at 178, 179; cf. Robert W. Tuttle, *Reviving Privacy?*, 67 Geo. Wash. L. Rev. 1183, 1189–91 (1999).

73 Charles Taylor, Sources of the Self: The Making of Modern Identity 500, 501(1989).

74 Sonia M. Suter, *A Brave New World of Designer Babies?*, 22 Berk. Tech. L. J. 897, 954 (2007) [hereinafter Suter, *Brave New World*].

75 See eg, Ishii, *supra* note 19, at 145.

to produce viable offspring in controlled settings—when and if we deem it sufficiently safe to do so.

Whether and when such efforts would ever be ethical and legitimate under current laws and regulations is a paper unto itself and could potentially be one of the biggest obstacles to this technology's moving forward. On the other hand, for any new reproductive technology to move forward, at some point, researchers must explore its clinical uses. As some have pointed out, had we subjected IVF, before making it clinically available, to the kind of oversight and regulation some might urge for IVG, IVF might never have become a viable technology.[76] The safety concerns and the tensions between addressing those concerns and advancing new technologies are, therefore, enormously important matters.

The focus of this piece, however, is to explore the social and ethical issues of reproductive IVG, assuming it has reached the point where it is safe enough for clinical use. In other words, this paper goes beyond the question of safety to ask whether—if and when it is as safe as methods of reproduction we currently find acceptable[77]—relational autonomy justifies or condemns some or all reproductive uses of IVG. As before, I begin with the implications of IVG as a treatment for various forms of infertility, conceived broadly, and then as a vehicle to improve prenatal selection.

1. Infertility Based on Physical Limitations

Assuming relative safety of IVG, it is hard to argue that IVG is substantially different from other methods we currently use to treat physical infertility. There is, for example, nothing inherently different in using IVG to treat one form of physical infertility—the inability to produce gametes—from using IVF to treat other forms—such as blocked fallopian tubes. In both instances, the technologies overcome physical disabilities that prevent 'normal species functioning'.[78]

One might distinguish IVF from IVG by arguing that the former simply changes the location of fertilization, whereas the latter creates gametes and then uses additional kinds of ART (IVF or AI) to achieve fertilization. Assuming, however, that gametes generated through IVG lead to no greater health risks in reproduction, it is difficult to see how these differences are conceptually meaningful given that both aim to achieve the same outcome (procreation) in the face of physical limitations due to disease, injury, or other causes. IVG in this context, like IVF, is consistent with relational autonomy because the individuals would be using ART to achieve the kinds of relationships—familial—through which one defines oneself, which would be possible but for the physical limitations.[79]

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76 Palacios-Gonzales, *supra* note 2, at 754.

77 What the benchmark level of safety should be is open to question given that we are still learning about the risks associated with many forms of ART for children conceived through these technologies as well as for those involved in them, such as the source of the gametes.

78 Norman Daniels, *Justice in Health Care, in* Health Care Ethics: An Introduction 302 (Donald Van DeVeer & Tom Regan, eds. 1987).

79 This statement, of course, presumes that adoption is not an option or choice. It is also important to point out that not every instance of infertility treatment is consistent with relational autonomy. When the drive to produce children is distorted, as in the case of Nadya Suleman (the 'octomom'), by egotistical or confused motivations, instead of a sense of one's constitutive attachments to existing relationships, relational autonomy does not support IVF. Moreover, as I discuss below, one general concern with ART is its tendency to privilege

For individuals who cannot produce gametes at ages when we would not expect them to be able to do so, such as postmenopausal women or premenarche girls, however, the use of IVG and other methods of ART is no longer a treatment of infertility. While these individuals cannot reproduce due to physical limitations, as noted earlier, they are not technically infertile because their inability to reproduce is precisely what we would expect based on typical human development and aging. In other words, their physical limitations are within 'normal species functioning'.

This distinction has not, however, prevented the use of ovum donation to help postmenopausal women, even into their 60s and 70s, overcome their biological obstacles to bearing children.[80] The justifications for these uses of ART include a broad understanding of reproductive autonomy as well as equality arguments: if men can reproduce late into life, why should women be limited simply because biology precludes them from doing so at a younger age than men, particularly when men have a shorter life expectancy than women?[81] Of course, even with ovum donation, these postmenopausal women are not literally reproducing in the way that men do because it is not their genetic material that creates the child, but that of a donor. Even so, it brings them closer to the position of men. Further, advocates argue, given the number of children successfully reared by grandparents, we cannot assume that harms will necessarily come to children born to mothers in these age ranges.[82]

Critics of ART in this context argue that there is something fundamentally 'unnatural' about defying the limits that nature places on reproduction, an argument I challenge below with respect to general uses of ART.[83] Other concerns, however, should give us pause about using ART for these individuals. In particular, the best interests of the child and the mother argue for limits in this context. First, the advanced age of these women may make the already demanding job of parenting simply too demanding. Further, the resulting children would be far less likely to have long-lasting parental relationships with their mothers because of their advanced ages, even if in some instances, grandparents have successfully reared their grandchildren.[84] Moreover, elderly mothers face potentially significant health risks—such as hypertension, diabetes, preterm labor, and other complications—in carrying a child.[85] Finally, allowing women to have children in this manner does not fully achieve equality because current uses of ART do not allow them to become genetic parents in the way that older men can.[86] Because of these kinds of concerns, most fertility clinics impose age limits for patients, with 'a typical ceiling of 55 for women, and in some clinics 'a combined age limit of 110 for both partners'.[87]

Most of the arguments for and against current uses of ART for postmenopausal women apply to IVG in this context, with the exception of the equality argument.

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genetic over social connections, *infra* text accompanying notes 110–13, a large concern that goes beyond the scope of the piece.

80 See Judith Daar, *Death of Aging Mother Raises More Questions about IVF Babies*, L. A. Daily J., July 29, 2009.

81 Ethics Committee for the American Society for Reproductive Medicine, *Oocyte Donation to Postmenopausal Women*, 82 Fertil. & Steril., Supp. No.1, 254S (2004).

82 *Id.*

83 *Id.* See *infra* text accompanying note 100.

84 Ethics Committee, *supra* note 81.

85 *Id.*

86 *Id.*

87 Daar, *supra* note 80.

Whereas ovum donation only allows postmenopausal women to bear children, IVG would actually allow them to become genetic parents and to reproduce in the fullest sense of the word. Of course, some women might opt only to produce their own ova with IVG and have a surrogate carry the child. Even these women, however, would be literally reproducing post menopausally because they would be using their own genetic material. As a result, IVG places postmenopausal women (whether or not they gestate the child) in the same position as older men, thereby strengthening the equality argument. Even so, this argument doesn't overcome the legitimate and serious concerns about the health risks to such women, if they choose to gestate, as well as concerns about the extent of the parenting burden on older parents and the potentially shortened parent–child relationship.

While a fully individualistic conception of procreative autonomy might argue that individual choice is key here, the concerns noted above are precisely the kinds of concerns that make ART problematic under a relational autonomy framework, whether or not ART involves ovum donation or IVG (and whether or not a surrogate gestates). To suggest, however, that these uses of ART are per se unacceptable goes too far. Rather, the relational autonomy framework presumes that ART in this context is not ideal, while allowing that context and motivation may rebut the presumption against it. The key point for purposes of this paper is not what factors would overcome that rebuttal,[88] but instead to argue that, in the instances in which we are unwilling to countenance postmenopausal mothers using current forms of ART, we should be equally wary of IVG. Conversely, in the instances in which we would find ART appropriate for postmenopausal women, IVG should be equally acceptable because it achieves the same objectives as other kinds of ART.

With respect to premenarche girls,[89] we could theoretically use ovum donation just as we do with postmenopausal woman. Here again IVG could work as a parallel technology. But clinicians do not use ovum donation in this context because the arguments against it are even greater than for postmenopausal women.[90] First, helping young girls to bear children would raise similar concerns about the well-being of children born to parents at ages we don't typically expect people to parent. Premature loss of a mother, however, would not be a risk for children born to premenarche mothers. Instead, the concerns would go to the fact that these girls are far from ready, physically or emotionally, to bear children and to parent.

Here again, the interests of the mothers and their potential future progeny are intertwined, given that reproduction at that stage would not be in either's best interests. It would increase the young mother's risks of reduced life-time earnings, threatening both young girl and child with poverty.[91] Most important, and determinative, these young girls would not have the psychological or legal capacity to make such significant,

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88 Ethics Committee, *supra* note 81 (noting that the key concern is whether the circumstances would allow this technology to meet the interests of the mother and child, which are 'inextricably intertwined').

89 Given that children mature physically at increasingly younger ages, this would likely include girls under the ages of 10–13 years.

90 Ethics Committee, *supra* note 81 (noting that 'oocyte donation to prepubertal girls is unacceptable').

91 'Fully 30 percent of teen girls who have dropped out of high school cite pregnancy and parenthood as a key reason', resulting in 'devastating economic consequences'. Lisa Shuger, *Teen Pregnancy & High School Dropout: What Communities Can Do to Address These Issues*, Washington, DC: The National Campaign to Prevent Teen and Unplanned Pregnancy 2 (2012). 'Over the course of his or her lifetime, a single high school dropout costs

life-altering decisions.[92] This therefore violates not only relational autonomy but also the more individualistic conception of autonomy, which is rooted in competent decision making about such important matters. Thus, under relational autonomy, the irrebutable presumption is against using any ART to help premenarche girls reproduce. As with postmenopausal women, the very concerns that should prohibit ART would also limit IVG in this population.

2. Infertility Based on Social Barriers

As we have seen, the arguments for and against ART for those who face physical barriers to conception seem to apply equally to IVG. In the context of those who face social barriers, we might assume, therefore, that whatever concerns individuals have about using ART in this population should logically apply to IVG as well. While I conclude as a starting point that ART generally should be accessible to people whose fertility is impeded by social circumstances, I argue, however, that the factors that distinguish IVG from other kinds of ART are especially important in this context. In some instances, IVG offers marked advantages and therefore, in some ways, is preferable to other methods of ART, particularly for same-sex couples. On the other hand, some of the distinctions between IVG and other methods of ART create significant relational autonomy concerns, namely with respect to solo IVG and, to some extent, multiplex parenting.

a. Why ART Generally is Appropriate for Those Who Face Social Barriers to Fertility Before exploring the use of IVG by individuals who face social barriers to fertility, I start by addressing the concern that ART in general is problematic when used by same-sex couples or single individuals.[93] Because much has already been written on this topic, I only briefly counter this position. First, such attitudes are antiquated and contrary to social norms and laws as evidenced by the Supreme Court's recognition of the constitutional right of same-sex couples to marry,[94] the fact that the majority of states allow gay and

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the nation approximately $260,000 in lost earnings, taxes, and productivity', which negatively impacts their children. *Id.*

92 The law generally does not allow minors to consent to medical treatment, although there are sometimes exceptions for mature minors and/or for particular kinds of medical decisions, such as contraceptive use, abortions, and treatment for sexually transmitted diseases. See Dorraine L. Coleman & Philip M. Rosoff, *The Legal Authority of Mature Minors to Consent to General Medical Treatment,* 131 PEDIATRICS 786 (2013). While some of the areas where minors can make medical decisions concern reproduction (such as contraception and abortion), these are typically decisions that would affect much older girls. Moreover, premenarche girls, who would typically be under the ages of 10–13, would be too young to fall within the mature minor exception.

93 *See, eg,* North Coast Women's Care Medical Group, Inc. v. San Diego County Superior Court, 189 P.3d 959 (2008) (describing physicians' unwillingness to provide fertility treatment to a lesbian, who lived with her partner, because of religious objections); see also Judith F. Daar, *Accessing Reproductive Technologies: Invisible barriers, Indelible Harms*, 23 BERK. J. GENDER, L. & JUST. 18 (2008) (noting that roughly half and more than two thirds of the states, respectively, do not protect against discrimination on the basis of marital status and sexual orientation in public accommodations, including medical offices that provide fertility treatment). Because 'multiplex' parenting has not been an option, groups have not spoken out against it.

94 Obergefell v. Hodges, 576 U.S. ____, 135 S. Ct. 2584 (2015) (holding that the 14th Amendment requires states to license marriages between same-sex couples and to recognize such marriages lawfully licensed and performed in other states). Even before this ruling, more than 35 states and the District of Columbia allowed same-sex marriage. Richard Socarides, *The Coming Gay-Marriage Ruling*, NEW YORKER, April 8, 2015, http://www.newyorker.com/news/news-desk/the-coming-gay-marriage-ruling (last accessed on Dec. 3, 2015). These developments demonstrate how much social attitudes on this issue have changed. *Id.* (noting that over 60% of Americans support gay marriage).

lesbian couples to adopt,[95] and the fact that some jurisdictions affirmatively sanction the ability of single individuals to use ART and to be the sole legal parent of the resulting child.[96] Second, equality demands that singles and same-sex couples be able to access ART generally given that they, like fertile straight couples, face a barrier—albeit social versus physical—to something as important and personal as procreation.[97] Some dual-gendered couples, after all, also face social barriers to reproduction if their infertility is the result of the particular combination of individuals, i.e., the social circumstance of choosing a particular partner.[98] Third, concerns about the best interests of the child are simply unfounded.[99] Finally, the appeal to 'nature' argument is unpersuasive with respect to same-sex couples or single people using ART generally. If we allow noncoital reproduction for infertile dual-gendered couples, there is no principled reason not to allow it for gay, lesbian, or single individuals. And even though gay and lesbian couples cannot bring about children genetically related to both of them without IVG, infertile straight couples who cannot produce gametes face just the same challenge. Without some additional explanation about the significance of the difference, appeals to nature are generally problematic.[100] As we shall see below, however, the way that solo IVG differs from 'natural' reproduction does raise some legitimate concerns.

b. IVG in Couples Who Cannot Biologically Reproduce Together Having argued that the distinction between same-sex couples and straight people using ART does not seem relevant to the question of whether ART should be available to same-sex couples, I turn now to the advantages that IVG offers same-sex couples as well as straight couples who

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95 'All states allow gay individuals to serve as foster parents or legal guardians, and almost all permit them to adopt as well'. John Robertson, *Gay and Lesbian Access to Reproductive Technology*, 55 Case W. Res. L. Rev. 336 (2005). See also Ethics Committee for The American Society of Reproductive Medicine, *Access to Fertility Treatment by Gays, Lesbians, and Unmarried Persons: A Committee Opinion*, 100 Fertil. & Steril. 1524, 1525 (2013).

96 Some states, like Kansas and New Jersey have adopted modified versions of the Uniform Parentage Act that 'govern the relationship of a sperm donor to the child of an unmarried recipient as well as a married recipient'. In the Interest of KMH, 169 P.3d 1025, 1034 (Kan. 2007). These statutes were enacted in recognition of the interests of unmarried women in becoming parents via sperm donation without the donor having parentage rights as well. *Id.* Not all states are so enlightened, however. *Id.* (noting that state laws that follow the 1973 Uniform Parentage Act do "not address the determination of a sperm donor's paternity when an unmarried woman conceive[s] a child through artificial insemination" leaving the woman susceptible to efforts by the donor to seek parental rights).

97 Eisenstadt v. Baird, 405 U.S. 438, 453 (1972) (holding that if 'the right of privacy means anything, it is the right of the individual, married or single, to be free from unwarranted governmental intrusion into matters so fundamentally affecting a person as the decision whether to bear or beget a child'); North Coast Women's Care Medical Group, Inc. v. San Diego County Superior Court, 189 P.3d 959 (Cal. 2008) (holding that physicians are not exempt, even for religious reasons, from California's Unruh Civil Rights Act's prohibition against discrimination based on a person's sexual orientation); Daar, *supra* note 93 (noting statutes that prohibit discrimination in public accommodations on the basis of sexuality and marital status).

98 Shapiro, *supra* note 40.

99 See eg, Robertson, *supra* note 65, at 332. In writing the majority opinion that recognized a constitutional right for same-sex couples to marry, Justice Kennedy was impressed by data showing that 'same-sex couples provide loving and nurturing homes to their children, whether biological or adopted'. *Obergefell*, 135 S.Ct. at 2600. In fact, he stated that a 'basis for protecting the right to marry is that it safeguards children and families'. *Id.*

100 See eg, John Corvino, *Why Shouldn't Tommy and Jim Have Sex? A Defense of Homosexuality, in* Contemporary Moral Problems 268, 270 (James White ed., 2006). If carried to its logical extreme, an appeal to nature would argue against many medical advances that virtually everyone values, such as antibiotic treatment, setting broken bones, eye glasses, anethesia, to name just a few. Conversely, it would justify abhorrent actions, such as rape or leaving the weak unaided simply because these behaviors occur in "nature" among many species.

cannot reproduce together because one or both of the partners lacks the ability to produce gametes. Currently, it is biologically impossible for any gay or lesbian couple to have a child who is biologically related to both of them. It is similarly impossible for a straight couple if one or both cannot provide gametes. In both instances, the couples currently have only the option of using gamete donors or adopting. By allowing each member of the couple to contribute genetic material, IVG would allow these couples to reproduce in a manner similar to fertile straight couples—although, until artificial wombs become available, gay couples would still require a surrogate. In terms of equality, therefore, IVG offers significant advantages over other ARTs.

Given that some members of society strongly value genetic connections between parent and child, as evidenced by the demand for ART, it is easy to imagine how significant this genetic connection might be to some same-sex couples or straight couples who cannot produce gametes. One can also understand why some of them might also want to avoid using donors, especially given the difficulty of assigning parentage when conflicts arise between gamete donors, surrogates, and intended parents. Courts and legislative bodies have struggled to set rules and default principles to address the competing interests of all involved.[101] Although the consensus seems to be moving toward giving intended parents parentage rights over gamete donors or surrogates,[102] gay and lesbian couples (as well as straight couples or singles who use gamete donors) may rightly worry whether the donors will ultimately be given parental rights, whether or not they ask for them, as has happened in some instances.[103]

Even when parentage determinations are clearly established, complexities can arise when 'outsiders' provide genetic material to bring about a child. Among these complexities is the issue of donor anonymity. As many have noted, the interests regarding donor anonymity of the donor-conceived child, intended parents, and donor may not be fully aligned.[104] Given that the child is not able to advocate for his or her relational interests in having knowledge of the donor, and that anonymity threatens to 'erase' the donor's contribution, a relational autonomy framework argues for banning donor anonymity, even if this conflicts with the interests of donors and intended parents.[105] On the other

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[101] See eg, Uniform Parentage Act (2000/2002). See Naomi Cahn, *The New Kinship*, 100 Geo. L. J. 367, 390 (2012).

[102] Cahn, *supra* note 101, at 391 (noting that the 'parentage statutes that are on the books generally attempt to erase donors by identifying the legal parents').

[103] *Id*. at 390, 391. For example, a sperm donor who had been found by a lesbian couple on Craigslist was required by a Kansas Court to pay child support because a physician was not involved in the artificial insemination. Chandrika Nayaran, *Kansas Court Says Sperm Donor Must Pay Child Support*, CNN, Jan. 24, 2014. The case is still being challenged. Steve Fry, *Attorney: Marotta Not the Father in the 'Unusual' Circumstances of Sperm Donor Case*, Cjonline.com, Jan. 4, 2015. In another case, a lesbian couple had written agreements from two separate sperm donors that they would not pursue any parenting roles. Both donors, however, changed their minds and sought visitation rights. So far, the courts have sided with the donors, again, because the insemination occurred without the supervision of a physician. John Culhane, *Sperm Donors Are Winning Visitation Rights: Marriage Equality Isn't Enough to Protect Gay Families*, Slate, Feb. 20, 2015.

[104] See Naomi Cahn, *Children's Interests and Information Disclosure: Who Provided the Egg and Sperm? Or Mommy, Where (and Whom) Do I Come From?*, 2 Geo. J. Gender & L. 1 (2000); Cahn, *supra* note 101, at 367; Sonia Suter, *Giving In to Baby Markets: Regulation Without Prohibition*, 16 Mich. J. Gender & L. 217, 260–77; but see I. Glenn Cohen, *Rethinking Sperm-Donor Anonymity: Of Changed Selves, Non-Identity, and One Night Stands*, 100 Geo. L. J. 431 (2012); Gaia Bernstein, *Regulating Reproductive Technologies: Timing, Uncertainty, and Donor Anonymity*, 90 B. U. L. Rev. 1189 (2010).

[105] Cahn, *Children's Interests*, *supra* note 104; Cahn, *supra* note 101; Suter, *Giving In, supra* note 104.

hand, as other countries[106] and even one state in the United States[107] move toward removing donor anonymity, intended parents may worry even more about someone outside the intended family insinuating him or herself into the lives of the child and/or family, even after the child reaches the age of majority.[108] Further, even if anonymity remains the preference in this country, it may ultimately become elusive as advances in genetic sequencing make it ever easier to pierce the shield of family (and donor) privacy that anonymity was intended to provide.[109]

Whether or not one believes that donor anonymity is appropriate for gamete donors, the issue highlights the complexities of including others in reproduction. IVG therefore offers the decided advantage of avoiding gamete donations and their attendant complications. By more clearly aligning the interests of the intended/genetic parents with the child produced through ART, and by making it easier for the intended parents to preserve the integrity and privacy of the family unit, IVG in this context is consistent with the goals of relational autonomy. Thus, the balance of interests seems to argue strongly in favor of IVG use by same-sex couples and straight couples, when at least one lacks the ability to produce gametes.

Defending IVG on these grounds, however, raises legitimate concerns. Many same-sex couples have created families with an explicit emphasis on the importance of social rather than biological bonds. These families can include multiple kinds of biological connections; some children may be biologically related to one social parent, other children to the other, and some to none of the social parents. The meaning of kinship in these families is based not on biology, but on intent and social parenting.[110] As the number of such families grows, they challenge social norms about the value of genetic connection between child and parent and diminish the importance of biological links even for families parented by dual-gendered couples.[111] Arguing for IVG on equality grounds therefore potentially suggests that the families created by same sex (or, for that matter, dual-gendered infertile couples who rely on donor gametes) are inferior to families that straight (fertile) couples can create. Rather than allow broader notions of kinship to shape social norms, IVG may privilege a biological connection between parent and child and become one more technological fix in the endless pursuit to create genetic links within families.

How important it is for functional parents to be genetically related to their children, of course, goes to the heart of questions about the value of IVG. From a relational autonomy perspective, the key issue is the parental connection with the child, whether

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106 Sweden, Austria, Germany, Switzerland, the Australian states of Victoria and Western Australia, the Netherlands, Norway, the United Kingdom, and New Zealand have all banned donor anonymity. Cohen, *supra* note 104.

107 Washington state does not have a complete ban on donor anonymity, but instead a presumption in favor of banning anonymity. Donors can opt out from having their identity revealed. WASH. REV. CODE ANN. § 26.26.750 (Lexis Nexis 2012).

108 In spite of these concerns, I have argued that the child's relational autonomy interests should prevail, particularly because the child did not have a chance to negotiate on her behalf. Suter, *Giving In, supra* note 104, at 260–77.

109 See eg, Melissa Gymrek et al., *Identifying Personal Genomes by Surname Inference*, 339 SCIENCE 321, 321 (2013).

110 Kimberly Mutcherson, *The New Kinship is the Old Kinship: Assisted Reproduction and the Resurgence of Biology as Destiny* (unpublished manuscript) (on file with author); Douglas NeJaime, *Marriage Equality and the New Parenthood*, HARV. L. REV. (forthcoming 2016).

111 See NeJaime, *supra* note 110.

the child is connected to the parent(s) only socially or both genetically and socially. The fact that IVG makes it possible to create genetic links in certain families—like same-sex families—where it may not have been possible before does not ensure greater connection between parent(s) and child. Indeed, we should worry about functional parents whose only sense of connection with their children is based on genetic links, rather than the social bonds that develop over time. It seems difficult to imagine, however, that the latter does not play an enormous, if not primary, role for virtually all parents. Genetic connections are special and unique connections. Ultimately, however, they do not bind parent and child the way that being fully responsible for a child and spending hours caring for her through sleepless nights, major milestones, and the quotidian events of childhood do.

To the extent that IVG privileges genetically related families over other families, it raises relational autonomy concerns by potentially undervaluing socially constructed relationships. This outcome would be potentially insidious if such attitudes seeped into the family psyche of the nonbiological families, thereby potentially weakening the connections in those families. I have faith, however, that the formation of deep familial relationships has far more to do with sharing lives with and assuming responsibility for someone else than sharing genes. Therefore I am skeptical that the value of these relationships within the nonbiological families would diminish. Even so, in light of the potential of IVG (and ART generally) to reinforce societal attitudes regarding the primacy of genetic links, we must ensure that the law enforces the stability, legitimacy, and viability of socially constructed families. In addition, we should think hard about how we approach and think about ART generally in our society.

I am also attentive to the reality that, for many people, the importance of genetic connections is strong enough to lead them to pursue expensive and sometimes uncomfortable reproductive interventions. Under the 'selfish gene' theory that we are simply vessels through which our genes attempt to propagate,[112] one could argue that there is something biological and evolutionary in this drive. While arguments from nature only go so far given that nature is not always worthy of emulation,[113] we should take these desires seriously given that they are not necessarily problematic under, and can even be consistent with, relational autonomy. If individuals seeking genetic connections with their children fully value the social connections they will form with their child and their desire is not rooted in contempt or dismissiveness toward other kinds of families, their desire to use IVG (or other forms of ART) to form genetic connections would align with relational autonomy.

Thus, in spite of my concerns about the potential of ART generally and IVG specifically to privilege genetic connection, the concept of IVG as a tool to create genetic connections between parent and child can be supported under relational autonomy with the caveats noted above. As long as we countenance other methods of ART that allow parents to form genetic links with their future child, as we have done with dual-gendered couples, equality argues for similar options for same-sex couples or dual-gendered families who cannot benefit from current methods of ART. The focus of this piece therefore is to address the issues surrounding IVG in light of the role that ART has in our society, while acknowledging the overarching concern about the value of ever pushing toward

[112] Richard Dawkins, The Selfish Gene (2006).

[113] See *supra* note 100 and accompanying text.

genetic connections in families and recognizing that IVG is just one more step in the relentless medicalization of reproduction and the valorization of genetic links.

c. 'Solo IVG' I turn now to single individuals who might choose 'solo IVG'. Their obstacle to reproduction is not physical, but the lack of a partner. While single individuals can currently reproduce with gamete donors, in the future some may choose solo IVG to avoid relying on gamete donation. Specifically, they would use IVG to create gametes that would complement their naturally produced gametes. That is, a single woman or man would use IVG to derive, respectively, the male or female gamete. Using IVF, the single female's ova would then be fertilized with IVG-derived sperm or the single male's sperm would fertilize IVG-derived ova.[114] The single male, however, would require the assistance of a surrogate to carry and bear the child, whereas the single woman would, barring physical obstacles, be able to carry the child herself.

One might argue, for the reasons discussed above, that, because solo IVG allows the single person to reproduce without relying on gamete donors, we should advocate its use. There is, however, something palpably different about solo IVG. Not only does it avoid gamete donations, it eliminates entirely the need for a second individual with whom to procreate genetically. It would, however, require a surrogate for single men and for single women who were not able to or who chose not to gestate. Whether or not single IVG involved a surrogate for the pregnancy, this ability to procreate without the use of anyone else's genetic material resembles cloning, which arouses worries about the underlying motivations that would compel such uses of ART.[115] It also raises concerns about its 'unnaturalness' in that it may not, according to some definitions, even constitute reproduction.

I begin with the worries about motivation, which are not nearly as troubling as some of the concerns about the ways in which solo IVG differs from 'natural' reproduction. An interest in solo IVG would seem to be less about trying to procreate genetically and more about avoiding the involvement of others in the reproductive process.[116] We might worry, just as some do with reproductive cloning, that only egoism and selfishness[117] would motivate a single person to reproduce with just his or her gametes. If the motivation to avoid genetic contributions from others is grounded in a belief that no one else could contribute anything of value to one's future child, it is inconsistent with a relational conception of autonomy. This concern is greatest with the single female who plans to carry the child because she would rely on no one but herself for reproduction. But even the single male's decision to use solo IVG, which would require the use of a surrogate, could still be rooted in an egotistical belief that only his genetic contributions have value.

If, however, the goal is to preserve the integrity and privacy of the family unit, as would be likely in many or most instances, then the motivations are more consistent with relational autonomy. While the single male (or female who uses a gestational surrogate) cannot completely ensure that the integrity of the family unit will be preserved,

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[114] As noted earlier, deriving sperm from females is more technically challenging than obtaining ova from males. See *supra* text accompanying notes 15–17.

[115] See Christof Tannert, *Thou Shalt not Clone*, 7 EMBO REP. 238 (2006).

[116] See *supra* text accompanying notes 101–09.

[117] Tannert, *supra* note 115.

given the reliance on a surrogate,[118] IVG still offers a better chance of minimizing the threats to the family unit than relying on both gamete donors and surrogates. Thus, even in these cases, the motivations may be rooted in relational autonomy goals.

Nevertheless, solo IVG is unique. While the use of IVG by same-sex or infertile straight couples might also be motivated by a desire to avoid using gamete donors, solo IVG (whether or not surrogates are involved) literally deprives the resulting child of a second genetic parent. Even though many children are born to and raised by single parents, another person contributed genetically to their existence. With solo IVG, however, the resulting child is deprived of the heritage of two parents. Of course, the child born of two genetic parents, who only knows the single parent, has also lost her heritage in one sense. She knows another genetic parent exists (or existed), but may have limited or no knowledge of that person. It is not clear which is more painful, the absence of a relationship with someone who shares 50% of one's genes or the nonexistence of a second genetic parental relationship.

The concerns about possible psychological harm in these scenarios are, however, speculative, much like concerns about the possible psychological effects of being cloned.[119] Moreover, the degree of psychological harm would likely vary considerably, depending to a large extent on how, and the circumstances in which, the single parent raises the child. Further, many children are born into less than ideal circumstances for various reasons. The mere fact that a child's circumstances may be challenging is not in and of itself a reason to prevent bringing children into the world by these methods. Thus, it is difficult, on these grounds alone to argue fully against solo IVG, despite some of the possible negative psychological harms it may present.

The more substantial objection, however, is based on the notable difference between solo IVG and other methods of ART. Solo IVG not only differs from 'natural' reproduction, but it challenges (much like cloning does) how we understand reproduction. Current forms of ART mimic reproduction by joining gametes (and two haploids) from two different individuals (and two completely different genomes) to create a child.[120] The location and manner of fertilization may differ—in a petri dish with IVF and noncoitally with AI and IVF, for example—but the process is essentially the same. In contrast, solo IVG (like cloning) is procreation from a single genome.

Procreation in this manner troubles many people because of its significant divergence from our understanding of reproduction as something that occurs between two

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[118] This is not a hypothetical concern. Conflicts over parentage have arisen between gestational surrogates and genetic parents. In jurisdictions that do not recognize or ban gestational surrogacy, the surrogate may have parental rights, even if she was not the intended mother. See eg, Uniform Parentage Act § 809(b) (approved 2000, amended 2003) (noting that 'if birth results under a gestational agreement that is not … validated' the mother-child relationship can be established by giving birth). Some courts have ruled that the gestational surrogate has parental rights, even when the surrogate does not desire such rights. See *In re* T.J.S., 54 A.3d 263 (N.J. 2012).

[119] Sparrow, *supra* note 38, at 6.

[120] Mitochondrial transfer is an exception because it involves three individuals. But the third only contributes mitochondrial DNA, which, while important for some diseases, 'represents less than 0.054 per cent of the total DNA, and is not part of the nuclear DNA, which determines our personal characteristics and traits such as personality, hair and eye colour'. Sarah Knapton, *Three-Parent Babies: The Arguments for and Against*, Telegraph, Feb. 3, 2015, http://www.telegraph.co.uk/news/science/science-news/11386151/Three-parent-babies-the-arguments-for-and-against.html (quoting Professor Dame Sally Davies) (last accessed Dec. 3, 2015).

individuals.[121] Even if a gestational surrogate is used, the reproduction—that is the bringing together of genetic material to create a child—only involves one person: the single individual. This raises difficult parentage questions and forces us to struggle to find language to describe the resulting relationships. While a same-sex couple procreating with IVG would not result in a mother and father, both individuals would be genetic (and social) parents of the child. In this way, reproduction remains consistent with the idea of two individuals bringing together half of each of their genomes to create a third person.[122] The inability to name them 'mom and dad' is less important than the idea that we would understand, conceptually, who the genetic parents were. We might struggle with nomenclature, wondering perhaps whether gay men would be 'papa and daddy' and lesbians 'mama and mom'. But we would know what we meant by calling each of them a genetic parent; we would understand that each provided half of a genome to the child.

In contrast, with solo IVG and cloning, the child does not inherit 50% of their parents' genomes.[123] The cloned child, for example, would share virtually 100% of its genome with the donor.[124] Would the donor be a genetic parent and the clone, son or daughter because the former begat the latter? Or would they be more like (delayed) twins because of the shared genome? Or would they be something altogether different?

Solo IVG provides an even more complicated genetic relationship. Here the resulting child would not be genetically identical to the single person. Instead, virtually every allele the child inherited would be an allele that the single person had,[125] but the child's composition of alleles would be different. For some loci, the child would have double copies of the single person's maternally inherited version of the gene (and none of the paternally inherited genes); for other loci, the child would have double copies of the paternally inherited version of the genes (and none of the maternally inherited genes); and for the remaining loci, the child would have the same combination of the single individual's maternally and paternally inherited genes. This is a genetic relationship we have never encountered before. According to our understanding of genetic parentage, where the child inherits 50% of the parent's genome,[126] the single parent would not be the genetic parent. And unlike the cloned child, for whom the parents of the donor are genetic parents (because the child shares 50% of her genome with them),[127] the child born of solo IVG would have no genetic parent. This potentially threatens the child's relational autonomy interests by severing an important kind of relational connection

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121 Robertson, *supra* note 65, at 166, 167 (arguing that reproductive efforts that 'deviate too far from the experiences that make reproduction a valued experience', like cloning or enhancement, fall outside of procreative liberty); Tannert, *supra* note 115 (noting that cloning is problematic because it doesn't involve the 'recombination of genetic material during gamete development' and the 'combination of parental genomes' to 'ensure[] that the embryo and the resulting fully developed human are still the product of random processes').

122 Again, mitochondrial transfer is an exception. See *supra* note 120.

123 Tannert, *supra* note 115.

124 They would not be truly genetically identical because the mitochondrial DNA in the clone would be different from that of the genetic source since it would have come from the donor ovum.

125 The process of recombination or *de novo* mutation would alter this for some genes, but overall this statement would be true.

126 Robert Sparrow, *Cloning, Parenthood, and Genetic Relatedness*, 20 Bioethics 308 (2006).

127 Robert Sparrow, *Orphaned at Conception: The Uncanny Offspring of Embryos*, 26 Bioethics 173, 175 (2012) [hereinafter Sparrow, *Orphaned*].

that defines many of us. Social parenting relationships, however, which are also central to one's relational self-definition would still be possible.

One might argue that in the instances in which a gestational surrogate is involved—for the single man or for the single woman who can't, or chooses not to, carry the pregnancy—the relational autonomy concerns would be lessened. After all, the child would have a biological parent of sorts via the gestational surrogate. While there is some distinction between this instance and the instance in which the single woman is the sole participant in procreation, the relational connection is still quite thin, especially if the surrogate is not intended to and does not play any role in the rearing of the child. While she may provide some environmental influences in utero, she offers neither genetic material nor rearing, just a few months of biological connection, which does not overcome what is lost to the child through this manner of procreation.

An additional concern about the 'unnaturalness' of solo IVG has to do with the fact that the process eliminates the evolutionary and health benefits of 'natural' reproduction, which reshuffles and divides two different genomes during meiosis, bringing the haploids together to form new genomes. Such reshuffling promotes genetic diversity, which, evolutionarily speaking, is advantageous; it creates various genetic combinations, some of which might be optimal to address potential environmental challenges. It is unlikely, however, that the interest in solo IVG would be sufficiently widespread to affect human evolution. As a result, the potential effect on human diversity is only a limited concern.

More significant, however, is that solo IVG—unlike 'natural' reproduction—increases the possibility of homozygosity for recessive genes, contributing to a greater risk of disease and disability. Because each of us carries around 400 mutations, at least a couple of which are associated with disease,[128] procreating from just one genome substantially increases the risk of passing on two copies of recessive mutations. The risk with solo IVG would be even greater than with cloning because it would involve a reshuffling of the genetic combinations of just one individual's genome through meiosis, thereby increasing the possibility of turning heterozygous mutations in the individual into homozygous mutations in the resulting embryo.[129] This risk is an extreme version of the risks associated with consanguinity, when reproduction among individuals who share a percentage of their genomes—such as siblings or cousins—increases the possibility of homozygosity for recessive mutations.

While IVG could be used in combination with PGD to test for such homozygosity, this would not fully reduce the risks. Often the recessive mutations would not be known in advance, limiting the value of PGD. As we gain more knowledge about various genetic mutations, our ability to detect previously unidentified recessive mutations might be more fruitful. But even then, we may not fully understand which recessive mutations are problematic in which ways. In other words, PGD currently and even in the future can only reduce this risk to some extent.

As we have seen, the novelty of solo IVG and the difficulties it presents in conceptualizing the resulting relationships are not reasons alone to condemn solo IVG. But, in combination with the health risks noted above and concerns about depriving children

[128] Yali Xue, *Deleterious- and Disease-Allele Prevalence in Healthy Individuals: Insights from Current Predictions, Mutation Databases, and Population-Scale Resequencing*, 91 Am. J. Hum. Genet. 1022 (2012).

[129] Palacios-Gonzales, *supra* note 2, at 756.

of a genetic parent, they raise serious red flags. For these reasons, solo IVG is the least justifiable and the most problematic reproductive use of IVG, particularly as compared with same-sex couples and, even to some extent, as compared with multiplex parents.

d. 'Multiplex' Parenting 'Multiplex' parenting also potentially raises concerns about its novelty and 'unnaturalness', given that we have never been able to reproduce in this manner before. It does not, however, increase the risk of homozygosity for recessive genes like solo IVG. Moreover, unlike solo IVG, 'multiplex' parenting combines haploid genomes of unique entities, which makes it more like 'natural' reproduction.

Nevertheless, multiplex parenting raises concerns about the nature of the relationships between the individuals and the resulting child. Again, the intended parents would not have the type of genetic relationship we associate with parent and child in 'normal' reproduction. With a quadruple, for example, reproduction would combine haploid genomes, but the haploids would come from embryos, which would never have existed as a living person, even if genetically speaking the embryo constituted a unique single genome. The resulting children would therefore be 'orphaned', since their genetic 'parents', the embryos, would have died before the child was even born.[130] These children would never have the possibility of learning about the person that the embryos might have become and therefore they would lose the kind of information about genetic parentage that children may find meaningful. As Robert Sparrow argues, they would not be able to 'interpret their lives and experiences in light of "biographies" of embryos'.[131] As the number of individuals involved increases, the genetic distance from the child to any one intended parent would become increasingly sparse: from 25% genetic connection with quadruples to 12.5% with octuples, 6.25% with 16 intended parents, 3.125% with 32 intended parents, and so on.

Multiplex parenting would also test our methods for determining parentage. No one would be a genetic parent of the child. We could, however, use the intent test to assign legal parentage. Even under this test, however, multiplex parenting would differ from the typical use of intent, which assigns parentage to only one or two legal parents, whereas with multiplex parenting intent applies to more than two individuals. Until recently, all jurisdictions and courts have limited parentage to two individuals.[132] Just over a year ago, however, California made the novel decision to allow for the possibility of more than two legal parents.[133] Even in this exceptional case, however, the decision was based on the best interest of the child,[134] rather than intent.

Multiplex parenting, therefore, forces us to grapple with questions about whether to continue to limit the number of legal parents a child may have and, if so, on what basis.

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130 Sparrow, *Orphaned, supra* note, at 177.

131 *Id.*

132 See eg, Johnson v. Calvert, 851 P.2d 776 (Cal. 1993).

133 West's Ann. Cal. Fam. Code § 7601 (2014). The legislation was enacted in response to a 2011 case, *In re M.C.* This was a case in which the lesbian spouse, biological father, and woman who gave birth all met the criteria to be a legal parent of the same child. Given that none of them was well equipped to raise the child, the state appellate court was sympathetic to the child's argument to have all three recognized as parents. Nevertheless, it held that, 'given many prior pronouncements from the state's highest court on the subject, it could not award that status to all three'. Joanna Grossman, *California Allows Children to Have More Than Two Legal Parents*, Verdict.justicia.com, https://verdict.justia.com/2013/10/15/california-allows-children-two-legal-parents (last accessed Dec. 3, 2015).

134 While it would be rare for children to have more than two legal parents, the law creates the possibility of allowing for more parents if the limit of two 'would be detrimental to the child'. *Id.*

Until, and unless, we allow all intended multiplex parents to be legal parents, there is likely to be conflict over which of the equally genetically connected individuals involved in the multiplex arrangement should be entitled to legal parentage. This could lead to protracted litigation and difficulties for the child during the period of uncertainty about who the legal parents are. On the other hand, we have faced similar struggles about legal parentage with other forms of ART and that alone has generally not been a reason to prohibit those reproductive arrangements.[135]

Obergefell v. Hodges,[136] in which the Supreme Court held that same-sex couples have a constitutional right to marry under the Fourteenth Amendment, has some bearing on the question of whether parentage would be recognized among multiplex parents. As Chief Justice Roberts notes, 'much of the majority's reasoning would apply with equal force to the claim of a fundamental right to plural marriage'.[137] If polyamorous marriage were found to be constitutionally based, the law would likely conclude that polyamorous partners were the legal parents of children that issued from those marriages, including children born of multiplex reproduction.

While some have argued that *Obergefell* opened the door to a constitutionally recognized right to plural marriage, there is a reason to be circumspect about jumping to that conclusion. It is true that Justice Kennedy's statement in the majority opinion declaring that the 'the right to personal choice regarding marriage is inherent in the concept of individual autonomy'[138] could support a claim that the individual's 'autonomy to make such profound choices' should extend to choosing not just one, but multiple, life partners.[139] Similarly, if one of the rationales to find a constitutional right to gay marriage is the concern that laws banning same-sex marriage 'demean' gays and lesbians, 'disparage their choices and diminish their personhood',[140] and 'humiliate the children of same-sex couples'[141] by imposing on them 'the stigma of knowing their families are somehow lesser',[142] it could be equally true that laws prohibiting plural marriage would have the same harmful effects on polygamous partners and their children. And, if, '[i]n forming a marital union, two people become something greater than once they were',[143] 'why isn't four better than two?'[144]

As some have argued, however, Justice Kennedy's majority opinion also offers rationales that distinguish same-sex marriage from polyamorous marriage. William Saletan notes that Kennedy discusses the 'immutability' of homosexuality, which doesn't exist for polygamy.[145] Justice Kennedy also describes marriage as saving gay and lesbians from a fate of loneliness, which polyamorists are not condemned to since they

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135 Surrogacy may be an exception to this statement, where some states have prohibited or criminalized this form of surrogacy.

136 576 U.S. –, 135 S. Ct. 2584(2015).

137 *Obergefell*, 135 S. Ct. at 2621 (Roberts, C.J., dissenting).

138 *Id.* at 2589.

139 *Id.* at 2622 (Roberts, C.J. dissenting).

140 *Id.*at 2602.

141 *Id.*at 2590.

142 *Id.* at 2600.

143 *Id.* at 2608.

144 William Saletan, *The Case Against Polygamy*, SLATE, June 29, 2015 http://www.slate.com/articles/news_and_politics/politics/2015/06/is_polygamy_next_after_gay_marriage_chief_justice_roberts_obergefell_dissent.html (last accessed Dec. 3, 2015).

145 Saletan, *supra* note 144.

can marry a man or woman.[146] While bans of same-sex marriage deny gays and lesbians and their children many state benefits that straight couples and their children can enjoy through marriage, polyamorists and their children can also enjoy these benefits if the parents of the children pair up in marriage.[147] Saletan also notes that the 'highest ideals of love, fidelity, devotion, sacrifice and family "that Kennedy asserts are embodied in marriage"[148] distinguish homosexuality from polygamy'. As the number of partners to whom you are devoted and faithful increases, 'the value of your fidelity and devotion are diminished, just as surely as inflation shrinks the value of a dollar'.[149] Similarly, as Mary Bonauto, the attorney representing the gay couples in *Obergefell* observed, there is a greater risk of conflict and 'disrupting family relationships' if the number of marital partners increases beyond two.[150]

Ultimately, it seems possible, but unlikely for the reasons given above, that the Court would recognize a constitutional right to polyamorous marriage. Nevertheless, this conclusion does not resolve the question as to whether and why multiplex parenting is legitimate or desirable. As I suggest below, the answer to that question is complex.

One can imagine some very positive outcomes if multiple individuals intentionally create a child together. If several individuals use IVG to have a child whom they intend to raise, this may accrue to the child's benefits. As they say, it takes a village to raise a child. The more adults who feel responsible for the child's well-being, the better off the child is likely to be. This motivation for using IVG seems consistent with relational autonomy given that it is aimed at providing a community to offer the child support and care. Whether two or four people procreate with this goal in mind does not seem to detract from the way in which these motivations for procreation can be defended under a relational autonomy framework.

Of course, these arrangements may not always be idyllic. Confusion about the roles of the parents and conflicts about how to parent might arise. Given that two parents sometimes (often?) are confused about their respective roles or disagree about parenting philosophies, adding more parents to the mix might lead to even more such conflict.[151] On the other hand, we might expect that most people would probably not choose to parent with more than one person. As a result, the rare few who share the desire to engage in such parenting arrangements might be more aligned and communicative in their views about parenting and parental roles than many couples who parent.[152] One simply cannot assume that multiplex parenting arrangements will be more or less optimal than typical parenting relationships, which vary tremendously in their quality. Thus, these concerns do not seem certain or severe enough to reject multiplex

146 *Id.*
147 *Id.*
148 *135 S. Ct.* at 2608.
149 Saletan, *supra* note 144.
150 *Id.*
151 See *supra* text accompanying note 150.
152 'The nascent research … suggests [that] modern polyamorous relationships can be just as functional – and sometimes even more so – than traditional monogamous pairings'. Olga Khazan, *Multiple Lovers, Without Jealousy,* ATLANTIC, July 21, 2014, http://www.theatlantic.com/health/archive/2014/07/multiple-lovers-no-jealousy/374697/ (last accessed Dec. 3, 2015). While polyamorous relationships may not be precisely the same as multiplex parenting, one might imagine that multiplex parents would most often be romantically involved, in spite of their use of 'high-tech' procreation.

parenting. Further, to the extent that the goal is to create a robust, supportive community for the child, multiplex parenting is consistent with relational autonomy.

As the number of individuals contemplating multiplex parenting increases, however, the relational autonomy justifications diminish because the nature of the relationships necessarily thins. Going from two parents to four parents, for example, may not seem so dissimilar from many parenting arrangements today, such as divorced parents and stepparents co-parenting together. But imagine multiplex parenting involving a much larger group. In those instances, the genetic connections between every adult and the child would be minimal. With 32 individuals, for example, the genetic connection would be only 3.125%. Even though this minimal genetic contribution is greater than what is likely with mitochondrial transfer,[153] as the genetic contribution declines its resemblance to our conception of reproduction lessens. Far more significant, however, is that interpersonal connections and interactions that constitute an intimate, parent–child relationship would be next to impossible with increasing numbers. Thirty-two adults simply cannot all have the kind of intimate relationship that is central to social parenting. At some point, as the number of intended 'parents' increases, the social connections inevitably thin and intimacy diminishes, making multiplex reproduction more like the creation of 'clans' and less like the creation of parent–child relationships.[154] This is inconsistent with relational autonomy for the child, who would lose the benefits of the close relationship of a true social parent.

One could imagine multiplex reproduction involving many genetic 'parents', but only a few (say four) of the group who would act as the social, intended parents. From a relational autonomy perspective, this arrangement would be preferable to having 32 thinly invested parents because it would be far more likely to create the intimacy and closeness that are essential to the parent–child relationship and the development of the child. But, one wonders, what would be the point of multiplex parenting with so many, if only a few intend to be social parents? Would it be to create genetically connected groups of children?

This notion brings the clan image to mind again and raises other relational autonomy concerns. The worry is that the desire to use technology like IVG to create groups of genetically related 'clans' would be rooted in divisive attitudes and a desire to segregate genetically. Such motivations are entirely inconsistent with relational autonomy because they potentially promote discriminatory attitudes and push against membership within the larger community. While there is no precedent for multiplex parenting, there have been a few instances in American history where commune-like groups have practiced 'complex marriage'. One such instance involved 300 members who had consensual relations with whomever they wanted to in the group. More pertinent to multiplex reproduction, people who wanted children were 'matched in arranged marriages and prevented from bonding with their children, all as part of [the leader's] plan to create a 'superior uber-race'.[155] It is not, therefore, out of the realm of possibility that some groups might use multiplex procreation to similar ends.

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153 See *supra* note 120.

154 This is similar to Saletan's point about 'the value … fidelity and devotion' diminishing as the number of partners increases. See *supra* text accompanying note 148.

155 Khazan, *supra* note 152.

From time immemorial, for social or religious reasons, however, we have witnessed genetic segregation among groups who intermarry. Even so, these effects are far less deliberate and occur more slowly than the multiplex 'clan' approach to parenting I describe above. While the fact that something happens by chance isn't necessarily better than its occurring deliberately,[156] the establishment of genetically related 'clans' through multiplex parenting would create in the span of only one generation the equivalent of what would happen over several generations of intermarriage. For example, if 32 individuals engaged in multiplex parenting, in genetic and generational terms, they would be like great-great-great-grandparents to the child because the child would be five 'generations' away. If many children were born to these groups, multiplex parenting could, through generational compression, create genetically segregated groups far more quickly than intermarrying within ethnic groups.

Multiplex parenting also raises evolutionary concerns that are potentially greater than with solo IVG. By integrating genomes into several children in only one generation, multiplex parenting would prevent the intermediary genetic combinations from being tested over time by environmental insults thereby eliminating the evolutionary benefits of gradually testing different combinations of genomes over time.

Ultimately, however, the likelihood of these problematic scenarios is largely speculative and dependent to some extent on the numbers of groups who would choose to engage in multiplex parenting for these reasons. Planning a 'superior uber race' would clearly be problematic under a relational autonomy perspective. But unless many groups procreated in this manner and did so prolifically, the societal impact of genetic segregation and evolutionary distortions would be quite minimal. One might imagine that such desires are not rampant in modern society. Indeed, the limited research on polyamorous relationships, which most groups interested in multiplex reproduction would be, suggests that 'polyamorous configurations with more than three people tend to be rarer and have more turnover'.[157]

As a result, we see that multiplex reproduction can sometimes offer potential benefits, but can also raises relational autonomy concerns. One important factor is how many individuals are involved. The greater the number, the fewer the benefits and the more threats to relational autonomy, suggesting that there should be a presumption against multiplex parenting when the numbers grow too large. What that precise number should be would depend on the degree of connectedness that is possible as well as the circumstances and rationales for the large group. The burden, however, should be on those seeking large multiplex parenting arrangements to show why this approach is consistent with relational autonomy as opposed to being driven by socially threatening, clan-like motivations.

C. IVG to Perfect Reproduction

We shift gears now to using IVG to 'improve' or 'perfect' reproduction. Specifically, IVG might be used in combination with PGD or gamete selection to eradicate disease—serious or mild, childhood- or adult-onset—or to select for or against, respectively, desirable and undesirable traits. For many, this possibility raises the specter of 'eugenics'. Drawing on my earlier work that used a relational autonomy framework to

[156] Suter, *Brave New World, supra* note 74.

[157] Khazan, *supra* note 152.

evaluate genetic selection and other technologies that might 'improve' reproduction, I briefly revisit the argument that these technologies are not per se problematic. Instead, their moral worth depends on the motivations and circumstances in which they are used.[158] While the combination of IVG with these technologies should not automatically lead us to condemn its use, it may nevertheless subtly shift attitudes about prenatal selection and intensify some of the relational autonomy concerns surrounding prenatal selection.

Whether or not IVG is involved, efforts to select embryos or gametes can be justified under relational autonomy if the underlying motivation is rooted in concerns about the best interests of the child and family. This may be most persuasive with respect to the prevention of serious genetic diseases that manifest in childhood, though one might be able to make similar claims for less severe conditions or even, potentially some traits. Resolving what is actually in the best interests of all is complicated, and some families may not get it right, but such concerns are consistent with relational autonomy because they consider 'whether the choices enrich the self as understood in relation to family and larger community'.[159]

If, however, selection of embryos or gametes is based on prejudice or conceptions of the future child only in terms of the presence or absence of disease or traits, it 'promotes a fragmented conception of individuals with those traits or disease and limits us from seeing them in their wholeness as humans'.[160] Moreover, it can reinforce prejudice by reducing the incidence of children born with disabilities or less desired traits.[161]

If individuals with the most resources have greatest access to these technologies and use them to select against traits and diseases that are devalued by society or accord fewer societal advantages, prenatal selection would reinforce existing inequalities and challenge relational autonomy. If these conditions or traits become proportionately less prevalent among the most advantaged and relatively more prevalent among the least advantaged, it would exacerbate negative associations with the traits or conditions, and intensify existing inequalities, particularly if society shares strongly held norms about which traits or conditions are desirable and undesirable.[162]

Some also worry that such technologies commodify reproduction by seeing the future child as a product we can design, rather than a 'gift' to accept as is,[163] which would threaten relational autonomy by treating the child 'as something separate from us and our deep relationships'.[164] It is not obvious, however, that a desire to 'improve' reproduction necessarily means parents fully or even partially commodify reproduction or the resulting child.[165]

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158 See Suter, *Brave New World, supra* note 74.

159 *Id.* at 967.

160 *Id.* at 956, 957.

161 *Id.* at 955, 958.

162 *Id.* at 959

163 See eg, Michael J. Sandel, *The Case Against Perfection*, Atlantic Monthly, Apr. 2004, at 55.

164 Suter, *Brave New World, supra* note 74, at 961, 963 (noting that such an attitude is not only intrinsically problematic, but also potentially consequentially problematic if the parents treat the resulting child as a product whose quality needs to be controlled and whose imperfections or deviations from the norm will not be tolerated).

165 *Id.* at 960, 962.

Finally, some worry that overuse of prenatal selection may reduce genetic diversity and inadvertently reduce or eliminate genes with potentially selective advantages in certain environments.[166] To the extent we identify ourselves as part of our larger community, this scenario would threaten relational autonomy. In fact, however, it is exceedingly unlikely, without a vast shift in reproductive norms, which at this point seems largely speculative.[167]

While all of the relational autonomy concerns regarding current efforts to improve reproduction through genetic selection are not equally persuasive or certain, introducing IVG into the mix potentially intensifies some of them. For example, by significantly improving the selective potential of prenatal diagnosis (PGD),[168] IVG may shift attitudes about the purpose of PGD. By eliminating the need for egg retrieval, which is currently essential to PGD, IVG would prevent the physical burdens of egg retrieval. In addition, the number of eggs that could be created would be limited only by cost, as opposed to the physical limitations of egg production during stimulated ovulation, thereby offering the possibility of creating a significantly larger supply of embryos to evaluate as compared with current PGD. As scholars have noted, this increased availability of embryos would allow for far more nuanced and comprehensive selection. If for example, IVG was used to create 10,000 embryos, a couple seeking to have a child with a particular genotype at 15 loci would have a 99.99% chance of success as compared with a 1% chance with traditional PGD.[169]

This distinction could change how PGD is used and viewed. Today, most people use PGD to avoid a single genetic disease, particularly those that will have livelong effects for a child, although a 2006 study showed that 42% use it for sex selection.[170] Many factors, however, may lead to the ability to choose embryos not just based on disease propensity, but also based on other traits besides sex. The much more comprehensive selection possible with IVG might reframe people's thinking about PGD and prenatal selection as not just a means to select against serious disease, but also a means to select the most ideal embryo. In other words, IVG has the potential to change norms about what parents 'should' do, shifting expectations from disease prevention toward 'perfection' of reproduction. While not everyone will want to choose the qualities of their future child so precisely, it is hard to imagine that it would not push some, perhaps many, to think that prenatal selection is a valuable method of 'quality control'. These attitudes may not only make such fine-tuned testing become more mainstream, but may also make it easier for many to commodify reproduction and even possibly the resulting child.

One feature of IVG/PGD that might limit its widespread use, at least to some extent, is the fact that it would involve the creation and destruction of not just a handful of embryos, but literally thousands. For anyone who takes the position that the embryo is a person, any form of PGD would be problematic with or without IVG. But even for those who do not find the creation and destruction of embryos troubling under current

166 *Id.* at 959, 960.

167 Robert Wachbroit, *What is Wrong with Eugenics?, in* Ethical Issues in Scientific Research: An Anthology 335 (Edward Erwin et al. eds., 1994).

168 See *infra* text accompanying note 169.

169 Bourne et al., *supra* note 14, at 34, 36.

170 See Baruch, *supra* note 52, at 4, 5.

uses of PGD, the exponential increase in embryo creation and destruction, as noted above, might be problematic.[171]

Given that, for many, embryos hold an important moral status greater than that of any other biological tissue,[172] the ability to engage in prenatal selection without embryo destruction might make IVG with gamete selection especially appealing for those who can afford it.[173] At present, we do not have mechanisms for genetic selection of the optimal egg or sperm.[174] Should that become possible, however, it would eliminate any moral qualms people may have about the creation and destruction of embryos.[175] This feature, however, raises even greater concerns about the potential routinization of efforts to 'perfect' or just 'improve' reproduction, at least for those with adequate resources.

For some period of time, cost might cut against the routinization of IVG/PGD or IVG/gamete selection. Even if the price of genetically analysing thousands of embryos decreased from current levels, creating gametes for either PGD or gamete analysis and performing genetic analysis on thousands of embryos or gametes will not likely be cheap for a long time, if ever. As long as such procedures remain relatively costly, insurers are not likely to cover their use, especially to cull out minor conditions or undesired traits. The cost–benefit analysis would undoubtedly cut against such reimbursement in a way it would not with more serious and costly medical conditions.

If, however, technology advances to the stage where such analysis becomes substantially cheaper, insurers might approach the reimbursement question differently. At that point, genetic analysis would have moved well beyond the evaluation of single genes or even arrays of genes toward whole genome or exome sequencing.[176] While our current ability to analyse such enormous amounts of data is currently quite limited and

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171 See *supra* text accompanying notes 57–58, 169.

172 See eg, Rafael Pardo & Felix Calvo, *Attitudes Toward Embryos Research, Worldviews, and the Moral Status of the Embryo Frame,* 30 Sci. Comm. 8 (2008).

173 As with IVG/PGD the limits of this technology would not be physical, but economic—based on how many eggs one could afford to create and to have analysed.

174 The challenges in doing this are not small. With PGD, the embryo is biopsied to allow for analysis of one cell from the embryo. Baruch, *supra* note 52, at 4. An egg or sperm could not be biopsied in this manner, presenting issues about how to gather DNA from the gametes for analysis without destroying the egg or sperm.

175 It does have the downside, however, that it would require analysis of both egg and sperm and assessment of which combinations would be most compatible with one another. To some extent, we are already on the path toward something like that with emergent efforts to determine which genetic combinations of individuals are preferable. A new company, GenePeeks, has partnered with a fertility clinic to create digital models of the genetic makeup of 10,000 children that would result from the pairing of the gametes of potential donors and fertility patients. See Paul Rincon, *GenePeeks Firm to Offer 'Digital Baby' Screen for Sperm Donors,* BBC, Oct. 2013, http://www.bbc.com/news/science-environment-24398312 (last accessed Dec. 3, 2015); Azeen Ghorayshi, *This Company is Trying to Make More Perfect Babies,* Buzzfeed, July 12, 2015, http://www.buzzfeed.com/azeenghorayshi/more-perfect-babies (last accessed Dec. 3, 2015). For less than $2,000, the company can determine the risk of roughly 450 genetic conditions in the 'virtual' babies created by these digital models. It ultimately plans to expand its analysis to include about 1000 diseases, including more complex conditions like diabetes and schizophrenia. And it will eventually offer its services to fertile couples. *Id.*

176 Pressures are growing in several areas to move toward whole genome and exome sequencing. See Sonia M. Suter, *Genomic Medicine–New Norms Regarding Genetic Information,* 15 Hous. J. Health L. & Pol'y 83 (2015).

rudimentary,[177] by the time viable gamete selection is possible, genetic analysis will be far more comprehensive than it is today. At that point, insurers might find economic value in covering IVG coupled with PGD or gamete selection to choose embryos or gametes with the lowest probability of disease. Although the predictive value of genetic information will likely always be limited given that other factors play a role in disease risk, the cost–benefit analysis for insurers might cut in favor of selection of the 'fittest' embryos or gametes.

Given the breadth of genetic information that would potentially be available with such technological advances, future parents would have the potential to select embryos or gametes not only based on genetic factors associated with illness, but also based on certain traits. This development might motivate ever more fine-tuning of the 'quality' of future offspring and potentially normalize the kinds of commodification attitudes that are troublesome under relational autonomy. While not everyone would proceed down this path, we could imagine a gradual, but potentially notable, cultural shift in attitudes, which would probably involve a complicated mix of concerns about the best interest of the child (procreative beneficence) and a growing desire for perfection that goes beyond best interest concerns. The more societal norms shift in the latter direction, the more the relational autonomy concerns grow.

An additional problem with the potential routinization of efforts to 'perfect' reproduction is that it can, ironically, limit choice. Specifically, it can diminish how fully individuals consider what they are choosing to do, why, and whether it fits into their values. It can also impoverish the informed consent process as providers and patients view a procedure or attitude as routine, rather than a deeply personal choice that is not necessarily for everyone.[178] The less the options are fully considered and discussed as choices, rather than presumed actions, the more the norms solidify, creating a vicious cycle.

If societal norms shift toward viewing IVG/PGD and IVG/gamete selection as mechanisms to fine-tune reproduction, rather than just to prevent suffering, the concerns about potential discrimination—including discrimination against the disabled and discrimination based on disfavored traits—also grow. Whatever risks exist today regarding the reduced number of children born with disabilities would be magnified. If the use of these technologies to select against more minor conditions and certain undesired traits truly becomes routinized, we might reinforce prejudice by reducing the incidence of children with these features and by valuing people in terms of the absence or presence of certain traits or disease.[179]

Finally, the concerns about negative effects on genetic diversity, while still speculative in this context, may carry a bit more force, especially if social attitudes about the value of certain traits began to coalesce. To the extent that preferences for certain traits remain individualized, the nature of embryo or gamete selection would vary among individuals. Certain traits that confer an advantage (real or perceived) in our culture, however, would frequently be the basis for prenatal selection. Genes associated with the absence of those traits might therefore become less prevalent. While the effects on

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177 Eline M. Bunnik, *A Tiered-Layered-Staged Model for Informed Consent in Personal Genome Testing*, 21 Eur. J. Hum. Genet. 596, 598 (2013) (noting that because of our still limited understanding of the genome, there are various regions where the significance of variations is uncertain).

178 Sonia M. Suter, *The Routinization of Prenatal Testing: Cause and Effect*, 28 Am. J. L.. & Med. 233 (2002).

179 *Id.* at 955, 958.

gene frequency would be greater than with current uses of prenatal selection, it would still take many generations and widespread selection on the same basis before we could see any measurable effects on genetic diversity. Therefore, even in this context, such concerns are theoretically possible, but not highly likely.

As we have seen, IVG in combination with PGD or gamete selection does not change the nature of the relational autonomy concerns regarding the efforts to improve reproduction. Instead, it affects the degree and extent of these concerns. Specifically, it is the ability of IVG to intensify the comprehensiveness of prenatal selection and the potential for it to become routine, which may subtly shift attitudes and expectations about reproduction and our resulting children. As choice about the nature of our progeny becomes more expansive based on a smorgasbord of information about disease risks and traits, and as our methods of making such choices do not involve egg retrievals, pregnancy terminations, or potentially even embryo destruction, the efforts to select in these manners may become ever more compelling. And as the costs—physical, emotional, and economic—decrease, the desire to use technology in these ways will only grow, intensifying the relational autonomy concerns that already exist, to some extent, with current prenatal selection.

CONCLUSION

IVG challenges us to revisit many of the issues surrounding various advanced reproductive technologies, but it also pushes us to grapple with new issues concerning the meaning of reproduction and whether there can be too many or too few parents. Its use to assist in the reproduction of certain groups such as premenarche girls, postmenopausal women, and individuals choosing to procreate without the genetic contribution of anyone else is presumptively problematic under a relational autonomy framework. Multiplex parenting, in contrast, provides arguments for and against the use of IVG, although it becomes increasingly problematic as the number of individuals involved increases. IVG's potential role in prenatal selection may refine the ability to reduce suffering, but it may also greatly intensify some relational autonomy concerns. Finally, assuming that we can eliminate worries about its safety, IVG may offer benefits over existing methods of ART, in some contexts, especially for same-sex couples.

While I have argued that IVG is valuable for some groups precisely because it can help individuals form genetic connections with their children, I end by highlighting an underlying concern regarding ART generally and efforts to expand its potential, which I discussed briefly earlier. Specifically, ART privileges genetic connections in parenting. While the drive for such connections is clearly powerful for many, we should be circumspect about technologies that further promote genetic connections rather than encourage other forms of kinship. IVG not only raises many challenges to relational autonomy in some contexts, but, like many forms of ART, it distracts from the richness of many forms of families that are not connected by genes and from the problem of the many children who need, but are left without, a home and parents. Noting that caveat, however, and given the context in which we support ART as a society, in many contexts, IVG can be seen as just another way to make a baby.