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The Relationship of Gametes to Those Who Procreate and Its Impact on Artificially Generated Gamete Technologies

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Abstract

Current developments in reproductive technology forecast that in the foreseeable future artificially generated gametes might be presented as a possible fertility treatment for infertile couples and for homosexual couples desiring to have children genetically originating from both partners. It is important to evaluate the ethical issues connected to this technology before its emergence. This article first reviews the meaning that gametes (sperm and eggs) might have to those who procreate, as well as their ontology. From this, suggestions are made as to what qualities artificially generated gametes need to be truly called gametes. Finally, different proposed routes for artificial gamete generation are examined on the basis of these qualities, with their prospective problems and advantages highlighted. Autotransplanted gametes (or their progenitors) generated solely from patient-derived tissue are deemed to be the most ethically suitable route for the development of this technology.

Scope

A lot of attention in the bioethics debate concerning the issues of conception has been given to the embryo, its use to derive stem cells, and the possibilities raised by artificial gametes. However, very little attention has been given to the gametes themselves. The way people desiring to procreate view their gametes is important as it will affect their view on how they should be used, subjected to medical treatment or to technological manipulation. Only when there is a clear ontological view of gametes can methods for artificial gamete generation be discussed.

The article will first evaluate how people might perceive the stewardship of their gametes and the ontological meaning of sperm and eggs, and how this relates to their natural use and the persons who use them. Conclusions reached after exploring these topics will then serve as a basis for the evaluation of artificial gamete technologies.

This article will not discuss the details underlying gametogenesis, and the question of genetic parenthood will not be considered in depth. It is sufficient to say that a perceived desire to have genetically related children is a common phenomenon that impacts human decision making.[1,2,3] The article will only consider the topic from the point of view of heterosexual couples, as this is the natural context of procreation in which gametes exist.

Bringing Forth a Child

Reproduction is one of the fundamental characteristics of life.[4] Couples who have been affected by various forms of infertility often recognize this as an anomaly and may seek to alleviate it by means of assistive reproductive techniques. Even with declining family sizes among developed countries, children are still viewed as a blessing. Traditionally, children are viewed as a key good of marriage,[5,6,7,8] but even secular couples tend to look forward to having them. In some societies this importance of children is manifested by the size of the industry catering to infertile couples,[9] while in others by the restrictions guarding the process of begetting children and promoting virginity and chastity,[10,11] to ensure that children are not born outside of marriage. In Abrahamic religions, begetting children is in general reserved to the spouses. This is exemplified by the fact that, even though *in vitro* fertilization (IVF) is permitted in Islam and Judaism, the gametes must come from the spouses.[12,13,14] The Eastern Orthodox Church, though it permits IVF, restricts it to spousal gametes, and even then it recognizes this as an anomalous state,[15,16] while the Catholic Church opposes any forms of assisted reproduction that separate it from the marital act.[17] But why might having children be so important, and how does this relate to gametes?

A child might be seen as a seal between the two people, which helps to reaffirm the relationship between the spouses, a visible intermingling with their beloved and a means of preserving a part of them for the future. This tangibility of children and of bringing them to existence might be not only important for the relationship between the parents, but also to their relationship to the child. The parent-child relationship might have been completely different if the child originated through shared willpower or was brought by storks. The importance of children being "blood from my blood" is still seen in the fact that people want children of their own, to which biological relatedness contributes in some form.[18] Gametes are therefore something that has the potential to create a biological relatedness between parents and children and something that can continue their familial line.

The fact that reproduction occurs via sex and gametes deserves further attention. As noted before, there is both an act of will and a tangibility that are involved in it. Though children are sometimes welcomed as joyful "accidents," the importance of an act of will is highlighted by the fact that people argue about stolen ideas and how much the intellectual involvement of a person is important in patent applications,[19] even if their execution was sub-contracted. Equally, there is a satisfaction that something has been brought to being by someone's own effort. It might be possible that the rejection of surrogate children,[20] where the input of the intended parents was not as great as in normal sexual reproduction, is partly due to a weaker bond between the parents and children that is the result of the absence of this active involvement of the spouses.

Therefore it would be desirable if any artificially generated gametes (AGGs) were designed to work within the context of the marital act. This would reaffirm the parents as the ones who bring the child into existence with all their faculties. Further on, it would ensure that the child has a tangible reference to its moment of becoming and to its familial line; in this the gametes should only contain genetic material from both parents to reflect the unique relationship between one man and woman. A gameteless procreation or even one where the gametes did not fully originate from the persons intending to procreate would lack this linking potential that helps parties to realize

the relationship that they share. Children resulting from such cases would probably be partially puzzled by the same identity questions that adopted children experience—questions about their tangible origin.[21] Lastly, the use of AGG's functioning in such a way would be acceptable to people from a wide spectrum of belief backgrounds.

The Value of Gametes as a Means of Begetting Children

We intrinsically understand our authority over our gametes and wish to utilize their potential with those whom we choose. Therefore, pregnancies that result from random sexual encounters, and even more so from rape, are often viewed as problematic, as the persons did not intend to utilize the procreative potential of their gametes. Similarly, infertile couples are placed in a situation where they are unable to realize this potential and hence might wish to use an assistive reproductive technology to fulfill what they might perceive as their right to have a child. This shows that people recognize a natural capacity to procreate and want to control it to some extent. Therefore, part of the value attributed to gametes comes from their procreative potential that we want to fulfill only with those whom we choose.

The Stewardship of Gametes

As shown above, people assume that their gametes, with their potential, are indeed "theirs"; that they are the sole authority that can dispose of them in one way or another, and that this right is exclusive to them.[22] This further manifests itself when men talk about the condition of *their* "swimmers" or when people state that they have donated *their* eggs or sperm. The exact importance of gametes and how people will view their relationship to them varies greatly from culture to culture[23] and between various philosophical beliefs. For Libertarians this ownership might be total;[24] they can sell their bodies for sex,[25] or their parts for profit,[26] and no one can tell them how to exercise this ownership. From a Christian[27] or Muslim[28] perspective, ownership is more of a stewardship, as God is the ultimate Lord of the universe and all belongs to Him; they are given to man as a gift[29] that can only be used in a particular way. All would agree, though, that they have some sort of autonomy over their bodies, which also entails a responsibility for the way they act with their bodies. Individuals are responsible for their actions, whether by law, Social Darwinism, or at Judgement Day. This responsibility extends to how people use their gametes and treat the gametes of others. If we endanger the health of our gametes, we will impact the health of the child that is both ours and our spouse's. Though having an affair is bad, its effect is even more burdensome for the marriage if a child is born from that extramarital relationship, as it would remain a symbol (or even more: a reality[30]) of two people joined together who should not have joined in the first place. In hope of having healthy children, spouses might change their lifestyle to increase their reproductive health, i.e. the health of their gametes, hence acknowledging the responsibility they hold for the state of their gametes. Further, parents might blame themselves for any genetic mutations transmitted to their offspring. But people might also legally challenge those who have negatively affected their reproductive capacity,[31,32,33] and people who lost their fertility might look to AGGs as a means of restoring their fertility. This highlights the necessity of evaluating the legal status of gametes.

With the development of artificial reproductive technologies, conflicts started to arise as to who can decide in what way donated and stored gametes could be used. There is a long and noble legal tradition of not applying property rights to bodies;[34] this recognizes the intrinsic dignity of the human person and that we are not our ultimate masters. Nevertheless, a decision had to be made as to who has the authority over stored gametes. A large emphasis has been made on the fact that stored gametes gain property status due to the effort and fine skill put into their handling and not because they are body parts—interestingly, it was not the person exercising the skill that became the legal owner of the gametes, but the person for whom the skill was exercised.[35,36] This emphasizes that people value their gametes and that they do not want the procreative potential present in them to be used against their will, but also emphasizes the reluctance of attaching property rights to body parts which should not be treated as a commodity. Finally, it is important to note that people do feel wronged when a lover deceitfully uses their sperm for insemination without their acknowledgment,[37] with one case resulting in a man arguing that the woman had stolen his sperm, while she claimed that it was a gift.[38] Therefore, there seems to be a general appreciation that gametes have a purpose and that individuals should have some say in how their gametes are being used to fulfill this task.

The apogee of the responsibility for gamete use comes with the birth of children. This responsibility might be explicitly sought, for it is ultimately linked with many pleasures that arrive from having children, like their success.[39] When a parent is denied the opportunity to interact with his or her children due to the other parent's action, he or she might feel deprived of something, which other people could have perceived as a burden. In a loving relationship, care is not only a duty, but also a privilege and, in a specific way, a joy. This responsibility is again highlighted in law in cases where a biological father is made to pay child support if he separates from the rest of the family. Lastly, it is important to note that those who donate their gametes might want to avoid this relational responsibility (even if they have no legal responsibility) by remaining anonymous.[40] Yet in many cases it is deemed a child's right to know who his or her biological parents are—to know from whom they physically come,[41] and hence it might be unethical to bring children without such an identity into existence.[42] The issue of this relational identity has been already highlighted in the discourse on AGGs,[43] though not all agree that a lack of it would necessarily be a negative phenomenon.[44]

Finally, one might wish to compare this stewardship of gametes to that of other organs. But an important distinction exists here: organs sustain life, whereas gametes create life. Organs are meant to be working for the person to whom they are attached, whereas gametes do not directly do anything for the health of the person from whom they originate. Their value is only really meaningful when shared with another person, and in this they have status smaller than that of half an embryo, as only when a sperm and egg fuse is a person created.[45]

In summary, people mainly value gametes for the potential that they have in creating a child. The child can be seen as an extension of oneself and that of the spouse, a sign of the union of these people. Because of this, people appreciate not only the value of their gametes, but also their responsibility for their state and use. But is there an even deeper meaning of gametes that relates to the mode in which they work?

The Ontology of Gametes

Abrahamic religions recognize that God ordered the world in a particular way and that people should cooperate with it. This is apparent from the existence of Mosaic Law and the concept of Natural Law, as well as from the etymology of the word "Islam."[46] Further, science itself recognizes that there are fundamental rules governing the world and biological entities have particular functions to perform, which they do in a specific manner. It is therefore important to assess whether gametes are crucial for some actions, and if yes, then what makes them best suited for those actions.

It was already discussed that human gametes function within the context of the conjugal act that is both unitive[47] (bonding the man and the woman) and procreative (having the function of bringing a new life into existence), by its nature. In the context of the joining of woman and man it seems relevant to evaluate the joining of sperm and egg.

This joining is simultaneously unitive and procreative, as a new human is brought to life through the joining of two entities. Like a man and woman are complementary to each other,[48] so the gametes are to one another, each containing what the other is lacking for a new life to form. Further, there seems to be something female about the egg and something male about the sperm. As the man penetrates the woman during sex, so the sperm penetrates the ovum during fertilization, mimicking the respective duality of giving and receiving. Therefore, the association of eggs with women and sperm with men is possibly not only based on the fact that this is how they occur in nature, but also on their intrinsic properties. This implies that if sperm were made from cells originating from a woman or eggs made from cells originating from a man, these would be a lie. Lacking the intrinsic properties of the sex of the person from whom they originated, they would be implying that this person is someone else. This dissociation of the sex of the person from whom the gametes originate and what the gametes are would be so pronounced that it might create confusion as to which parent would be the mother and which the father.

Secondly, the sperm and egg DNA are epigenetically marked in different ways (different genes are switched "on" and "off"), corresponding to their origin, not dissimilar to how both parents might contribute to the child's upbringing in different ways even if both are equally present in the child's life. Further, the egg contributes the mitochondria, which nurture the cells, like the mother nurtures the child until the end of pregnancy and even beyond. Finally, in traditional settings where the husband is responsible for bringing income to the household that is managed by the woman, the act of the sperm coming to the ovum and the woman's body "managing" the pregnancy might also bear some resemblance to this.

The beauty of the conjugal act, in Christian understanding, lies partially in its totality[49] and exclusivity[50] to the spouses. Gametes might be seen as representing the people from whom they originate[51] in their totality, as well as by their nature in their exclusivity, as no other person participates in the reproductive act. They are the messengers of the people from whom they originate, symbolizing their femininity or masculinity, carrying their DNA, as well as various molecules made by them that will contribute to the new person that will be formed. Gametes are less than the person from whom they originate, but more than just any odd part of her or him; or, as previously suggested,[52] they are ambassadors of the person from whom they

come, and by extension a tangible genealogy[53] of his or her ancestors.[54] Possessing the aforementioned characteristics makes gametes entities that not only have a huge biological importance, but also a more subconscious importance to the person from whom they originate.[55] In this light, it is a curiosity that the word "gamete" derives from the Greek words meaning husband, wife, and marriage[56]—the two that they represent and the sphere in which they work.

Gametes represent the totality of their contributors, their full femininity and masculinity, not just their DNA. Similarly, the natural process of procreation excludes any third person's DNA. Adding third party mitochondrial DNA to the procreative process strips it of its meaning,[57] as procreation ceases to be a totally unique endeavor between the couple, of whose union the child is a visible sign. If a couple later splits, the child remains a physical reminder of the reality of that union. This sign is so strong that in case of embryos brought through IVF and being stored, the father or the mother might even desire their annihilation not to remind them of this union.[58]

Gametes and Future Reproductive Technologies

Gametes are God-given gifts and means of participating in His creative power.[59] They have the power to bring into existence something more than a gift, for a child cannot be disposed of as a commodity. The use of gametes is therefore a privilege that has a responsibility attached to it. They also truly represent the masculinity and femininity of the person from whom they originate and provide a tangible link between children and parents. Gametes not only pass on genetic information, but acting within the conjugal act facilitate the totality and exclusivity of that act. As medical intervention should aim as much as possible at restoring the proper functioning of the body, and not in giving it a new one or one removed from its proper environment,[60] emerging reproductive AGG technologies should mimic these properties to be truly therapeutic and deserve the label of gametes. In short, this would be achieved by fulfilling the following criteria:

1. The AGGs must originate fully from the patient. As gametes represent the whole person willing to procreate, AGGs have to originate from that person and not have anything subtracted from them, allowing for genealogical and identity continuity.
2. The AGGs must represent the patient exclusively. To achieve this no additional genetic or biological components (DNA, cellular organelles) can be added from other individuals or species.
3. The AGGs must correspond to the patient's sex. This will ensure that the gametes truly represent the masculinity or femininity of the patient.
4. The AGGs must be functional within the conjugal act. When procreation will happen within the context of sexual intercourse it will ensure that there is not only a will to become a parent, but also a tangible moment and experience to which the parent can refer back to appreciate his or her role in bringing the child into existence and fully embrace the responsibility that comes with this.

Overview of Reproductive Technologies

Many scientific breakthroughs have occurred that can aid the fulfillment of the desire to have a child, but they simultaneously possess a significant ethical burden. It was argued before that for most of those technologies there is no difference of the kind, but only of the degree to which these technologies assist reproduction.[61] Since the original technologies all separated procreation from copulation, this was largely true, but new interventions emerge that also change the nature of the gametes themselves. These technologies not only include artificially generated gametes, but also those procedures that were (quite inaccurately) collectively named by the media as mitochondrial transfer (they rely on the transfer of nuclear DNA).[62] Procedures that result in such a "three-parent-embryo" are of a new kind, as the gametes are no longer a representation of two individuals that participate in procreation.[63] Instead, they render procreation a process non-exclusive to the couple, as they involve third-party DNA. Further on, work has been undertaken to allow for targeted genetic manipulation of embryonic and germline DNA.[64,65] All these technologies include a novel element that is absent from previous methods, falling into a similar category as the "three-parent-embryo"—the gametes used or child that is born are altered by artificial biological manipulation, hence they become distanced from the persons procreated.

Basic Considerations of Artificial Gametes

Though still in its infancy, artificial formation of gametes is slowly gathering media attention.[66] About a dozen proposed routes exist for the formation of AGGs.[67] Each route raises its own ethical questions as well as the ethical questions associated with the research still needed for the technique to become functional. This second set of questions shall not be addressed in this article.[68] Further, if the ethical issues relating to the fundamental nature of these technologies prove to be unacceptable, then there will be no need to address the ethics of carrying out the research necessary for their development. The ethics of AGGs will be evaluated within the context of the previously established four properties of gametes.

The various methods of creating AGGs utilize different types of stem cells.[69] Some use embryonic stem cells (ESC), others generate induced pluripotent stem cells (iPSC) from somatic cells (cells other than gametes and stem cells) or reprogram adult stem cells (ASC) of various types, including ones obtained from bone marrow.[70] Certain techniques then proceed to generate the embryo via IVF, while in other cases auto-transplantation (the procedure of inserting the cells back into the patient from whom the original cells were taken) takes place and a child can be conceived through sexual intercourse.

Desired Qualities of Artificial Gametes

Considering the categories by which methods of generating AGGs can be grouped, it should be ensured that the technology uses only cells originating from the body of the person reproducing and that the technology does not separate procreation from the unitive act. This will allow the technology to emulate nature as much as possible, allowing the gametes to represent the procreating persons. Such technology would

eliminate some of the problems that are inherent to IVF in the eyes of those who value the natural order of the world—separating conception from sex, and "surplus" embryos. Hence it would be useful to people from the widest range of ideological backgrounds.

iPSC and ASC routes offer ethically licit routes of AGG generation, as opposed to the ESC route. Use of non-embryonic cells avoids the destruction of embryos, as well as some of the ethical problems associated with therapeutic and reproductive cloning, which the use of ESC causes;[71] it would also ensure that all of the generative material originates from the two persons wishing to procreate without third party DNA being involved. Using ASCs might involve less biological manipulation of the cells than the use of iPSCs and hence cause less DNA damage to the AGGs.[72] This is important as the extent and type of gamete damage caused by manipulating stem cells in order to obtain gametes might be too challenging for the DNA repair systems with which evolution has equipped us.[73] If the gametes (or their progenitors) were then auto-transplanted, it would allow for procreation to occur in its natural setting. This would simultaneously mean that the gametes would have to correspond to the sex of the person wishing to procreate. If gamete progenitors were auto-transplanted, this might offer an opportunity for natural means of epigenetic reprogramming (switching on and off of appropriate genes) to occur, which we are far from understanding,[74,75,76] but is vital for the healthy development of the child.

When using auto-transplanted gametes originating from the patient, one could actually start talking about truly restoring fertility in a way that cooperates with the nature of men and women. Auto-transplanted gametes would be superior to IVF as they would not require the separation of procreation from sexual union, making them accessible to people who object to this separation. When compared to IVF, such "naturalized" means of assisting reproduction might yield higher pregnancy success rates and lower risk of developmental disorders[77] in the children conceived this way, as well as eliminate the problem of "spare" embryos. Therefore, the route that will be further considered is the generation of gamete progenitors from ASCs originating from the patient for the purpose of auto-transplantation.

Therapeutic Applications of Artificially Generated Gametes

The first application for AGGs would be in treating infertility. Here AGGs could be implanted into the patient to allow them to procreate via sexual intercourse. AGGs could be thought of as bio-prosthetics or transplanted organs. These are not controversial ideas, as we are even happy for people who were born deaf to gain the sense of sound,[78] as we recognize that this is a natural faculty of human beings. When compared to organ donation, AGGs should cause less ethical issues as they originate from the recipients themselves, therefore avoiding many ethical problems related to organ donations.

Secondly, the technology could provide an opportunity for gene therapy for inherited disorders, be it Huntington's disease, which is hugely debilitating, manifests itself later in life, and has no cure, or diseases like Joubert Syndrome, which affect early development and for which parents might be known risk gene carriers. These are all conditions that have a huge impact on the life of the individual and their family. Therefore it is important to evaluate if AGGs would provide a licit intervention for

couples with a high risk of conceiving children with such disorders. The field of gene therapy is in itself an ethical minefield, especially that concerning the manipulation of germline cells.[79,80,81] Somatic gene therapy (not affecting cells involved in reproduction) has already gained overall approval. Opposition to germline cell therapy is in many cases due to safety issues[82] and the currently (if it were legally permitted) necessary separation of the procreative and unitive aspects of sex in cases where it would be implicated. There also remains the question of whether we have the authority to alter people in such a perpetual way without their consent, which will also affect their future descendants. Hence it is quite different from corrective surgery at birth. But even if research into this technology is undertaken in an ethically licit manner and the safety for the child-to-be is ensured, it remains doubtful whether the gamete would truly represent the parent, as foreign genetic material would sever the connection between the gametes and the person from whom they originate. Therefore, it is doubtful whether this would be an appropriate way to deal with such diseases, as the gametes would not fulfill their purpose. Further, if the patient was not sterile in the first place, it would require a pre-sterilization phase to ensure that only the modified gametes were produced inside his or her body. Some people could regard this as self-mutilation, and would not accept this procedure. Hence, germline cell therapy via AGGs fails to respect the nature of gametes themselves and might not provide a widely acceptable solution to heritable genetic disorders.

Another option that might be used when dealing with genetic disorders that would avoid the use of genetic manipulation is to concentrate on eliminating AGGs containing faulty gene copies. This would possess less ethical baggage than the screening of embryos that occurs as part of various assisted reproductive interventions, as it would not involve the destruction of human individuals, but of gametes or their progenitors, and even less baggage than the aforementioned germline DNA modification.[83] This would require the development of efficient flow cytometry screening technology and possess its own ethical problems as discussed below. One would need to be very cautious as this therapeutic intervention can provide precedence for future eugenic selection.[84] Any legislative body would need to balance the possibility of easing the disease burden for families with the risk of promoting a society that does not value life in any form except that of an imagined perfection. Screening gametes or their progenitors would likely not eliminate completely the chance of passing on genetic defects. If this were explained correctly to the couple wanting to procreate, it might make them realize that this process aims at risk reduction and not at creating "designer children." Such screening would probably become standard practice, even when no familial predisposition to genetic diseases was present, to counter the risk of abnormalities caused by artificial handling of the cells. If the technique was used with a risk-reduction mindset, rather than a risk-elimination one, it would not require sterilization of fertile individuals (as it would be based on increasing the number of non-risk-gene-bearing gametes and not the annihilation of the risk-bearing ones) to achieve its goal and hence could achieve wider acceptance.

Finally, some might argue that the technology could be used to generate sperm from women and eggs from men in an attempt to avoid mitochondrial disease, as an alternative to three-parent-embryos, as this would avoid introducing genes from a third person. Nevertheless this is still contrary to the nature of the persons,[85] as the gametes would not fully relate to the persons from whom they originate (neither in

their femininity or masculinity, nor in their historic heritage[86]) if they were to be transplanted into a different person. Additionally, unless the AGGs were transplanted successfully into the other partner (not rejected by their immune system), their use would involve IVF.

Risks of the Technology

We are only in the infancy of understanding the biology of gamete generation and maturation; hence we cannot manipulate them as precisely *in vitro* as our bodies can *in vivo*. If novel reproductive technologies are introduced rashly, it might lead to exacerbating the genetic problems that we wanted to avoid in the first place. The use of a screening process might mitigate some of those risks, but is it prudent to rely on just one safeguard? Despite our close evolutionary relationship, human beings are more complicated than mice, where most of the pioneering work in this field is being done. It is therefore wise to anticipate any risk that AGG technology might carry.

DNA quality of all cells (including germ cells) usually decreases with age,[87] and many individual cells also possess genetic variations that are absent from the rest of the body.[88,89] Such cells used to create artificial germ cells would increase the chances of children suffering from developmental disorders. Though older persons might have more somatic cell problems, they are also more likely to experience more problems with their natural gametes. Hence, it would seem fair to accept an increased risk in AGGs created from cells of older individuals that would be of a similar extent to that found in nature.[90] This would logically extend to an age limitation for the use of such technologies in women, where the organism can support childbearing only until a certain point.

There were some suggestions that AGG technology would offer an opportunity for social experimentation through multi-parent children and generation jumping, and that this might be desirable, as it would allow three or more people to share a child that would be related to all of them and hence accommodate newly emerging forms of romantic relationships.[91] Such applications would be opposed to the ontological properties of gametes, but could only be prevented on an administrative level.

Conclusion

Gametes function within the context of the conjugal act. They originate from the procreating persons and represent them (and by proxy their ancestors) through passing on their genetic material, but also by mimicking their masculinity and femininity. The process of bringing a child into existence is therefore an affair of two biologically complementary persons with their complementary gametes. This bringing forth of a child to life is a gift, not a right, yet it is recognized as a good proper to human existence. When, due to infertility, people are not able to conceive children, they might seek to use assisted reproductive techniques. Artificially generated gametes might be a set of techniques to which such people will have recourse in the future. This article has evaluated these techniques in light of the natural properties of gametes. Artificially generated gamete progenitors from non-embryonic cells that are re-introduced via homologous transplantation would both possess the characteristics of natural gametes and provide a truly therapeutic treatment for infertile people that would be seen as acceptable for people from a wide variety of backgrounds.

Nevertheless, such technology could only be welcomed if it could be developed via ethically acceptable research and provide a safety level for these gametes comparable to that in healthy age-matched individuals. Still, caution should be exercised not to abuse this technology, as it could contribute to a societal eugenic mindset. Finally, use of such assistive technology should be accompanied by helping the couple to understand the meaning of fertility and children in the wider context of their existence.

Note: The views expressed in this article are those of the author and do not necessarily reflect the positions of the professional organizations with which he is affiliated.

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