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# Mitochondrial Transfer Therapy as Enhancement Technology

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## Description

This case describes the February 2015 decision by the United Kingdom's Parliament to allow human trials of an *in vitro* fertility (IVF) treatment using mitochondrial transfer technologies. It provides an opportunity for discussion of the ethics of germline gene modification in humans as both therapy and enhancement.

## Body

In February 2015, the United Kingdom's Parliament voted to allow human trials of an *in vitro* fertility (IVF) treatment using mitochondrial transfer technologies. [\[1\]](#) These technologies are aimed at preventing the transmission of mitochondrial disease from pregnant women to their offspring.

Mitochondrial disease is an umbrella term that comprises a set of conditions with varying degrees of severity, including neurodegenerative disease, epilepsy, stroke-like episodes, blindness, diabetes, and deafness, among others. These conditions share a common origin of dysfunctional mitochondria, the energy-producing organelles found in cells. These organelles carry their own DNA, approximately 37 genes and less than 0.1% of the human genome. There is some disagreement about

the prevalence of mitochondrial disease. However, it is estimated that 1 in 400 people carry a mitochondrial mutation that may cause disease, and that 1 in 6500 babies are born with some kind of mitochondrial disorder (Dimond 2015; Sample 2013). More importantly, there is a wide spectrum of symptoms of the disease, and they can range from mild to severe.

The UK government considered and approved two different techniques of mitochondrial transfer in IVF procedures, pronuclear transfer and maternal spindle transfer. Pronuclear transfer occurs after fertilization and involves the transfer of the pronuclei from the zygote with the dysfunctional mitochondria into the enucleated donor zygote with functional mitochondria. Maternal spindle transfer involves a similar process of transfer, in which the spindle of the chromosomes from an unfertilized egg with dysfunctional mitochondria is transferred into an enucleated egg cell with functional mitochondria (Baylis 2013; Dimond 2015).

The UK government's decision was preceded by a report from the Nuffield Council on Bioethics, published in June 2012, and a review from the Human Fertilisation and Embryology Authority (HFEA). [\[2\]](#)

The Nuffield Council judged that the procedures were ethical and would allow women to have healthy, genetically-related children, who otherwise could not. Additionally, the Council described the IVF methods as germline genetic therapy, but claimed that any resulting children from these procedures should not be considered "three-parent babies" and the mitochondrial donors should not be identifiable. They did, however, recommend that adult children born from these procedures participate in long-term health check-ups to provide more information on the long-term consequences of these therapies.

The HFEA further assessed the safety and efficacy of the proposed techniques and judged that they were "not unsafe" and suggested that the public was generally supportive of the procedures. Before this decision, the HFEA did not allow any therapies or techniques that altered the DNA in human embryos.

The fact that this therapy has been described as germline gene modification with heritable consequences for future generations has led many critics to caution that such interventions may easily lead to non-therapeutic applications - in other words, *enhancement*. For example, some have already pointed out that the intervention could be desirable to lesbian couples who want to be both genetically related to

their child, or perhaps to older women to address age-related infertility. Given these prospective applications, legislative and regulatory bodies should be aware of the potential slippery slope towards the creation of designer babies.

### **Discussion Questions**

- What reasoning supports the Nuffield Council's dismissal of the idea that children born from these therapies are "three-parent babies"? What are some counter-arguments? What might be some of the social and ethical implications of identifying the prospective children born from these therapies as "three-parent babies"?
- Some proponents of these therapies, such as Julian Savulescu, chair of the Oxford Uehiro Centre for Practical Ethics at the University of Oxford, have compared mitochondrial transfer technology to organ transplantation or tissue donation, and argued that the minimal amount of DNA found in mitochondria is not important because it does not contribute to the "ethically important characteristics of the child." Is the exact nature of the genetic contribution of mitochondrial DNA to a child's characteristics morally relevant? Might there be other reasons why these techniques, described as germline gene therapies, might be ethically problematic?
- How might these therapies affect the reproductive choices of individuals? Should they be available to prospective parents who do not carry any disease-linked mitochondrial mutations, such as older women or lesbian couples who want to be both genetically related to their child? Why/why not?
- Are there morally salient differences between the two proposed IVF techniques for mitochondrial replacement?

### **Bibliography**

Amato, Paula, Masahito Tachibana, Michelle Sparman, and Shoukhrat Mitalipov. "Three-parent in vitro fertilization: gene replacement for the prevention of inherited mitochondrial diseases." *Fertility and sterility* 101, no. 1 (2014): 31-35.

Baltimore, David, Paul Berg, Michael Botchan, Dana Carroll, R. Alta Charo, George Church, Jacob E. Corn et al. "A prudent path forward for genomic engineering and germline gene modification." *Science* 348, no. 6230 (2015): 36-38.

Baylis, Françoise. "The ethics of creating children with three genetic parents." *Reproductive biomedicine online* 26, no. 6 (2013): 531-534.

Bredenoord, Annelien L., Wybo Dondorp, Guido Pennings, and Guido De Wert. "Ethics of modifying the mitochondrial genome." *Journal of medical ethics* 37, no. 2 (2011): 97-100.

Dimond, Rebecca. "Social and ethical issues in mitochondrial donation." *British medical bulletin* 115, no. 1 (2015): 173-182.

Mitalipov, Shoukhrat, and Don P. Wolf. "Clinical and ethical implications of mitochondrial gene transfer." *Trends in Endocrinology & Metabolism* 25, no. 1 (2014): 5-7.

Moraes, Carlos T., Sandra R. Bacman, and Sion L. Williams. "Manipulating mitochondrial genomes in the clinic: playing by different rules." *Trends in cell biology* 24, no. 4 (2014): 209-211.

Reznichenko, A. S., Carin Huyser, and Michael S. Pepper. "Mitochondrial transfer: Ethical, legal and social implications in assisted reproduction." *South African Journal of Bioethics and Law* 8, no. 2 (2015): 32-35.

Robertson, John A. "Oocyte Cytoplasm Transfers and the Ethics of Germ-Line Intervention." *The Journal of Law, Medicine & Ethics* 26, no. 3 (1998): 211-220.

Yabuuchi, Akiko, Zeki Beyhan, Noriko Kagawa, Chiemi Mori, Kenji Ezo, Keiichi Kato, Fumihito Aono, Yuji Takehara, and Osamu Kato. "Prevention of mitochondrial disease inheritance by assisted reproductive technologies: Prospects and challenges." *Biochimica et Biophysica Acta (BBA)-General Subjects* 1820, no. 5 (2012): 637-642.

### **Links:**

Baylis, Françoise. "Ethical Objections to Mitochondrial Replacement." *Impact Ethics*. July 2, 2013. Accessed March 21, 2016. <https://impactethics.ca/2013/07/02/ethical-objections-to-mitochondrial-replacement/>

Couzin-Frankel, Jennifer. "Controversial fertility treatments focus eggs' power plants." *Science*. March 30, 2015. Accessed March 24, 2016.

<http://www.sciencemag.org/news/2015/03/controversial-fertility-treatments-focus-eggs-power-plants>

Lucchese, Baldo. "Following science's lead to reflect on the ethics of mitochondrial transfer." *Nature Protocols*. November 12, 2012. Accessed March 21, 2016.

<http://blogs.nature.com.ezproxy1.lib.asu.edu/stepwise/2012/11/12/following-science-lead-to-reflect-on-the-ethics-of-mitochondrial-transfer>

Sample, Ian. "Three-person IVF: UK government backs mitochondrial transfer." June 28, 2013. Accessed March 24, 2016.

<https://www.theguardian.com/science/2013/jun/28/uk-government-ivf-dna-three-people>

Savulescu, Julian. "Mitochondrial disease kills 150 children a year. A micro-transplant can cure it." *The Guardian*. February 2, 2015. Accessed March 21, 2016.

<https://www.theguardian.com/science/2015/feb/02/mitochondrial-transfer-micro-transplant-parliamentary-debate>

Stein, Rob. "Combining the DNA of three people raises ethical questions." *NPR*. November 10, 2014. Accessed March 21, 2016.

<http://www.npr.org/sections/health-shots/2014/11/10/360342623/combining-the-dna-of-three-people-raises-ethical-questions>

Vogel, Gretchen. "Mitochondrial gene therapy passes final UK vote." *Science*. February 24, 2015. Accessed March 24, 2016.

<http://www.sciencemag.org/news/2015/02/mitochondrial-gene-therapy-passes-final-uk-vote>

<http://nuffieldbioethics.org/project/mitochondrial-dna-disorders/>

Jha, Alok. "Mitochondria donation wins ethical approval for fertility treatments." June 11, 2012. Accessed March 24, 2016.

<https://www.theguardian.com/science/2012/jun/12/fertility-treatments-mitochondria-donation-ethical-approval>

Vogel, Gretchen. "Therapy for Mitochondrial Disease is Ethical, Says Nuffield Council." June 11, 2012. Accessed March 24, 2016.

<http://www.sciencemag.org/news/2012/06/therapy-mitochondrial-disease-ethical-says-nuffield-council>

<http://www.geneticsandsociety.org/article.php?id=6527>

- [1] These technologies are also sometimes referred to as "mitochondrial replacement" and "mitochondrial manipulation."
- [2] The Nuffield Council on Bioethics is an independent body in the UK that addresses and reports on ethical issues in biology and medicine. "It was established by the Trustees of the Nuffield Foundation in 1991, and since 1994 it has been funded jointly by the Foundation, the Wellcome Trust and the Medical Research Council." See more at: <http://nuffieldbioethics.org/>. The HFEA is an executive body of the UK's Department of Health and oversees "the use of gametes and embryos in fertility treatment and research." See more at: <http://www.hfea.gov.uk/>

## Notes

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