BigPicture

# It takes three, baby

## *What is mitochondrial donation – a process sometimes said to create 'three-parent babies' – and what does it involve?*

The first time you heard the phrase 'three-parent babies', what did you think it meant? The phrase – which is most commonly used by the media – actually describes the scientific technique of mitochondrial donation, which involves creating human embryos with three biological 'parents' to treat devastating mitochondrial diseases.

The technique transfers DNA from one egg into a new denucleated egg (an egg with the nucleus removed) from a third person. The nucleus of the biological mother is then placed inside the donor egg, where it can be fertilised from sperm of the biological father. The UK government announced a public consultation on this process in early 2012, and in 2015 the UK became the first country to allow the process to prevent life-threatening conditions. In late 2016, clinics in the UK were allowed to start applying for licences to carry out the process.

### The basics of mitochondrial DNA disease

People with mitochondrial diseases have problems producing enough energy to power their cells properly. Mitochondria are like tiny generators keeping all of our cells going: they carry out the reactions that extract the energy from our food through a process called aerobic respiration. Each cell contains many mitochondria, and those cells that need to produce a lot of energy contain the most. A single heart cell, for example, can contain 1,000–2,000 mitochondria.

It has been estimated that at least one in 200 children are affected by mitochondrial disease in some form. Around one in 6,500 babies develop severe forms of mitochondrial disease, and many of these children will die soon after birth. Others will grow up with a variety of difficulties, such as blindness or liver failure, and will need treatment to help their cells function more normally.

### ABOUT THIS RESOURCE

This resource was first published in 'Sex and Gender' in October 2014, reviewed in December 2016. Published by the Wellcome Trust, a charity registered in England and Wales, no. 210183.
**bigpictureeducation.com**

### Sourcing a solution

Repairing mitochondrial faults would not involve making modifications to DNA sequences. Instead, the DNA from the nucleus of the mother's egg cell would be transplanted into a different egg provided by a donor – a third 'parent' – with healthy mitochondria, before being fertilised via *in vitro* fertilisation (IVF).

You might think the donor would be providing little more than a home for the DNA of the two 'real' parents, but in fact mitochondria have their own DNA. In babies without a donor, this DNA is simply passed down from the mother (although it isn't technically 'her' DNA, as it's shared down the maternal line). In mitochondrial donation IVF, the baby would have nuclear DNA from its two parents, plus mitochondrial DNA from the third parent.

Mitochondrial DNA encodes proteins involved in the energy-generating process. Whereas the DNA in the nucleus of a human cell encodes more than 20,000 genes, which control everything from the colour of your hair to aspects of your personality, mitochondrial DNA encodes just 37 genes.

Although these 37 genes have an important job to do, they're limited to producing machinery for the mitochondria themselves. So replacing faulty mitochondria with properly functioning ones should mean they can do the job they're supposed to do without any effect on the vast majority of the cell's DNA.

### Is there a downside?

One concern is that mitochondrial and nuclear DNA may interact in ways that depend on some level of shared inheritance. However, studies in non-human primates have shown no adverse effects so far.

In a 2009 study, a rhesus monkey gave birth to the first healthy baby monkeys (named Mito and Tracker) created using the DNA transfer technique. When the researchers checked the DNA of the babies, they found that – as expected – the nuclear DNA was inherited from the two 'traditional' parents while the mitochondrial DNA was inherited from the egg donor.

## ABOUT THIS RESOURCE

This resource was first published in 'Sex and Gender' in October 2014, reviewed in December 2016. Published by the Wellcome Trust, a charity registered in England and Wales, no. 210183.
**bigpictureeducation.com**

However, some people have warned that legalising this procedure may lead the way to other 'human genetic modifications', as female babies born as a result of this method will carry the donor mitochondrial DNA for life and pass it on to their own children unchanged. Because egg cells act as carriers for mitochondrial DNA, it is always inherited from the mother without mixing with the father's DNA (see our articles Male and female genomes and You, me and mitochondrial 'Eve' for more).

**Ethical considerations**

As with many scientific procedures, there are ethical considerations to take into account.

There are some religious and ethical objections to IVF: not all the embryos created are used, so some people see terminating those that aren't used as immoral. Others disagree, suggesting a merciful and loving God would want humans to use their knowledge and ability to alleviate the suffering of others.

Others have warned about the status of the donor – in terms of both the medical procedure she will undergo and her rights. Although egg removal is minimally invasive, no surgery is without risk, and some individuals worry about women being exploited for their eggs if institutions are willing to pay women to donate them.

As for the donors' legal status: under UK law they are not regarded as having the same status as the parents; rather, they are regarded similarly to organ or tissue donors. Any children conceived using this technique would be allowed to access 'non-identifying' information, such as medical information, about the donor.

While the Nuffield Council on Bioethics has said that "if these novel techniques are adequately proven to be acceptably safe and effective as treatments, it would be ethical for families to use them", the Human Genetics Alert group has warned that "the techniques are unethical according to basic medical ethics, since their only advantage over standard and safe egg donation is that the mother is genetically related to her child."

## ABOUT THIS RESOURCE

This resource was first published in 'Sex and Gender' in October 2014, reviewed in December 2016. Published by the Wellcome Trust, a charity registered in England and Wales, no. 210183.
**bigpictureeducation.com**

**Questions to consider:**

Do you think the creation of a child with DNA from three people is ethical? Consider and discuss reasons why some people may think it is ethical and others disagree.

Do you agree that the donor should not receive the same legal status as the parents and instead have a status more like that of organ donors?

It would be possible to use sex selection to allow only male embryos to be conceived, to prevent the donated mitochondria being passed down to future generations. Discuss the advantages and disadvantages of **not** incorporating this into the law.

## REFERENCES

Animation: What is mitochondrial disease?
Mitochondrion – much more than an energy converter
Mitochondrial donation – a quick summary [PDF]
Human Fertilisation and Embryology Authority: Mitochondria replacement consultation – advice to government
Mitochondrial gene replacement in primate offspring and embryonic stem cells (2009)

## ABOUT THIS RESOURCE

This resource was first published in 'Sex and Gender' in October 2014, reviewed in December 2016. Published by the Wellcome Trust, a charity registered in England and Wales, no. 210183.
**bigpictureeducation.com**