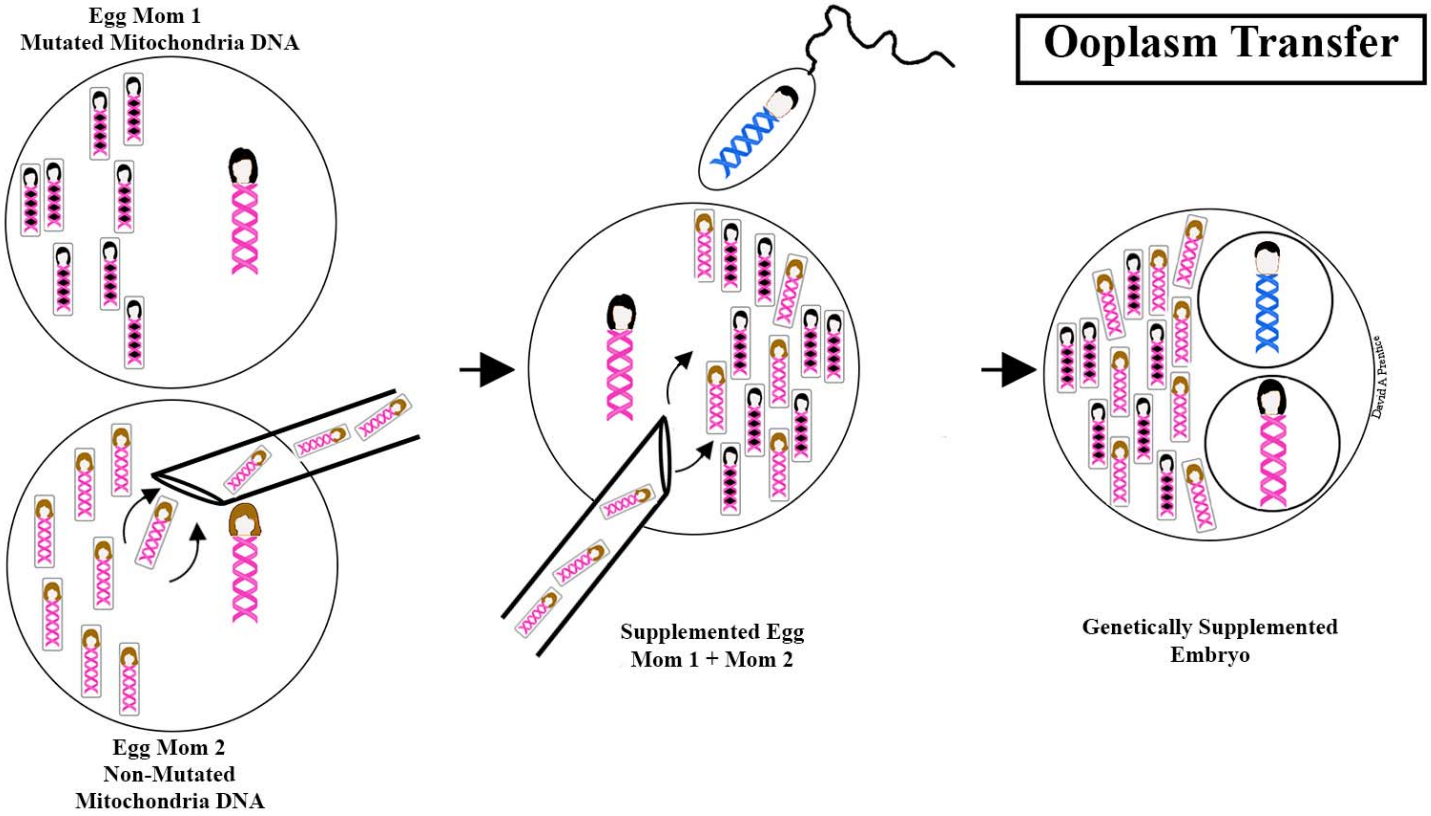
Genetically Modified Human Embryos and GM Children

Proposals of various types have been made that involve genetic modification of human embryos.
While proponents all claim that these genetic modifications are for treating disease, in fact they are all aimed at creating new, genetically-modified children whom they hope will not have disease.
All of the proposals involve "germline" or "inheritable" genetic modification, *i.e.*, the genetic changes affect not only the individual, but can be passed down to future generations.

Ooplasm Transfer

Injection of ooplasm from a donor egg (Mom 2) into Mom 1's unfertilized egg prior to fertilization *in vitro*. Mitochondria are transferred as part of the donor ooplasm, resulting in offspring who carry genetic material from three separate individuals—nuclear genetic Mom 1 and father, and the mitochondria/ooplasm genetic donor (Mom 2). **The newly-created embryo is a "3-parent embryo".**
As of June 2015, this technique had been used in the creation of human embryos.

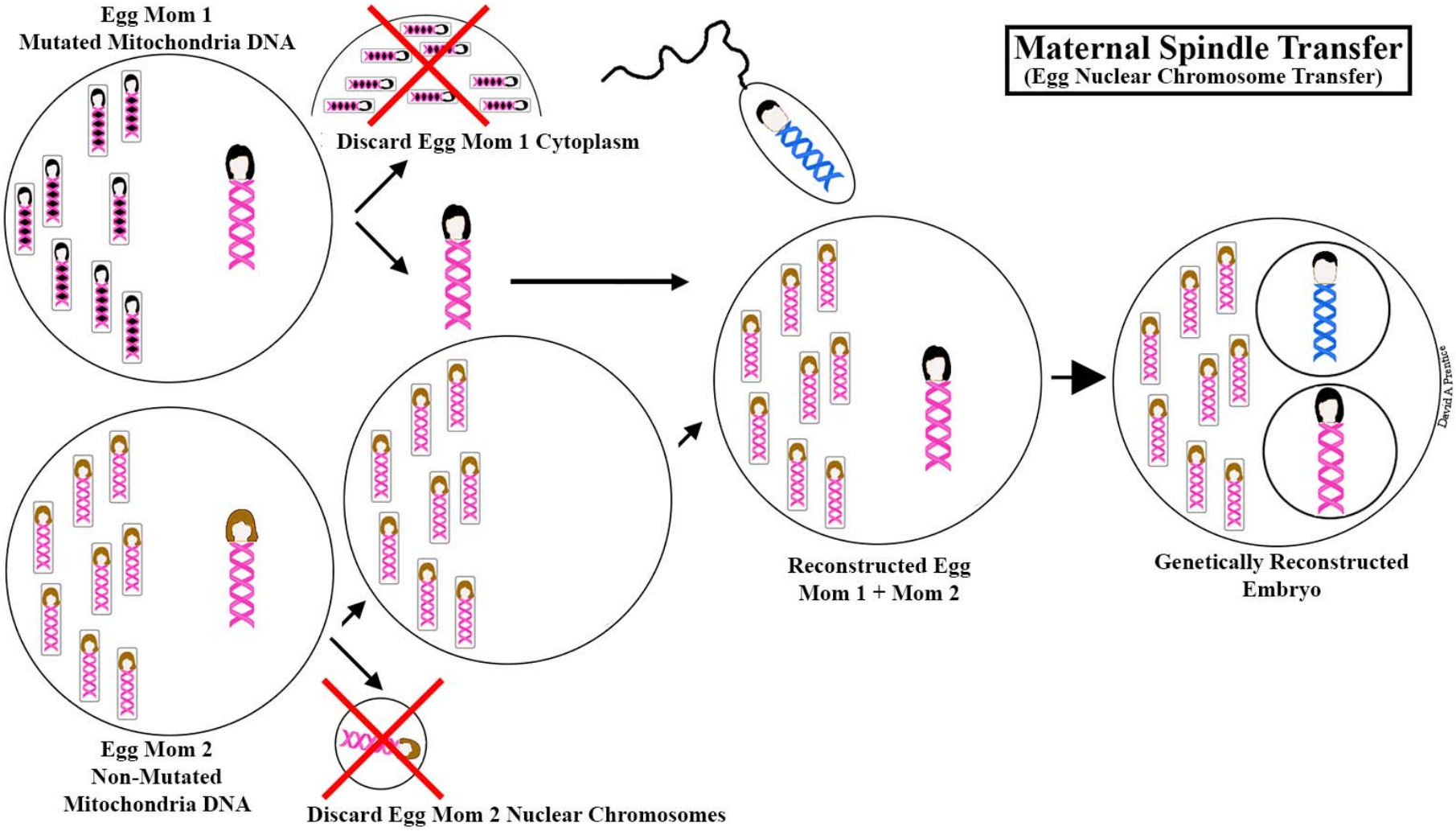


Maternal Spindle Transfer

Eggs from the intended mother (with mutated mitochondria, Mom 1) and eggs from a donor (with non-mutated mitochondria, Mom 2) are harvested. The nucleus from Mom 1, which at this stage is arranged as chromosomes on a mitotic spindle, is removed from egg of Mom 1 and from the donor egg (Mom 2).

The nucleus from genetic Mom 1 is placed into the ooplasm containing non-mutated mitochondria of the donor egg (Mom 2), and the genetically reconstructed egg is fertilized with genetic father's sperm. **The newly-created embryo is a "3-parent embryo".**

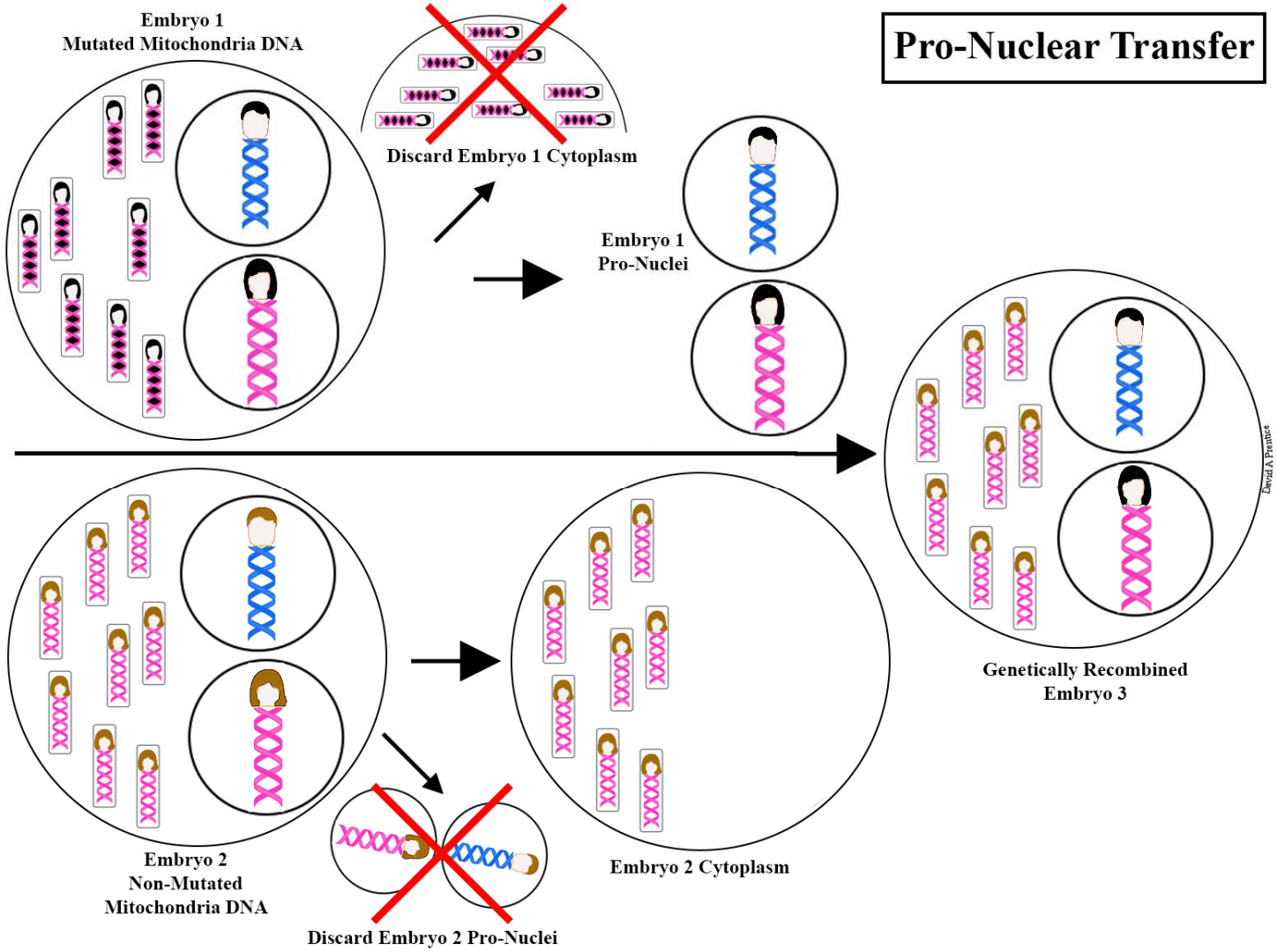
As of June 2015, this technique had been attempted to create human embryos as well as animal embryos.



Pro-Nuclear Transfer

Two single-cell embryos are created using IVF. Embryo 1 uses Mom 1's egg (which contains mutated mitochondria DNA) and intended father's sperm. Embryo 2 uses a donor egg from Mom 2 (that contains non-mutated mitochondria) and donor sperm (or sperm from the intended father). The pro-nuclei (egg and sperm nucleus, prior to their fusion into a zygote nucleus) are removed from both embryos.

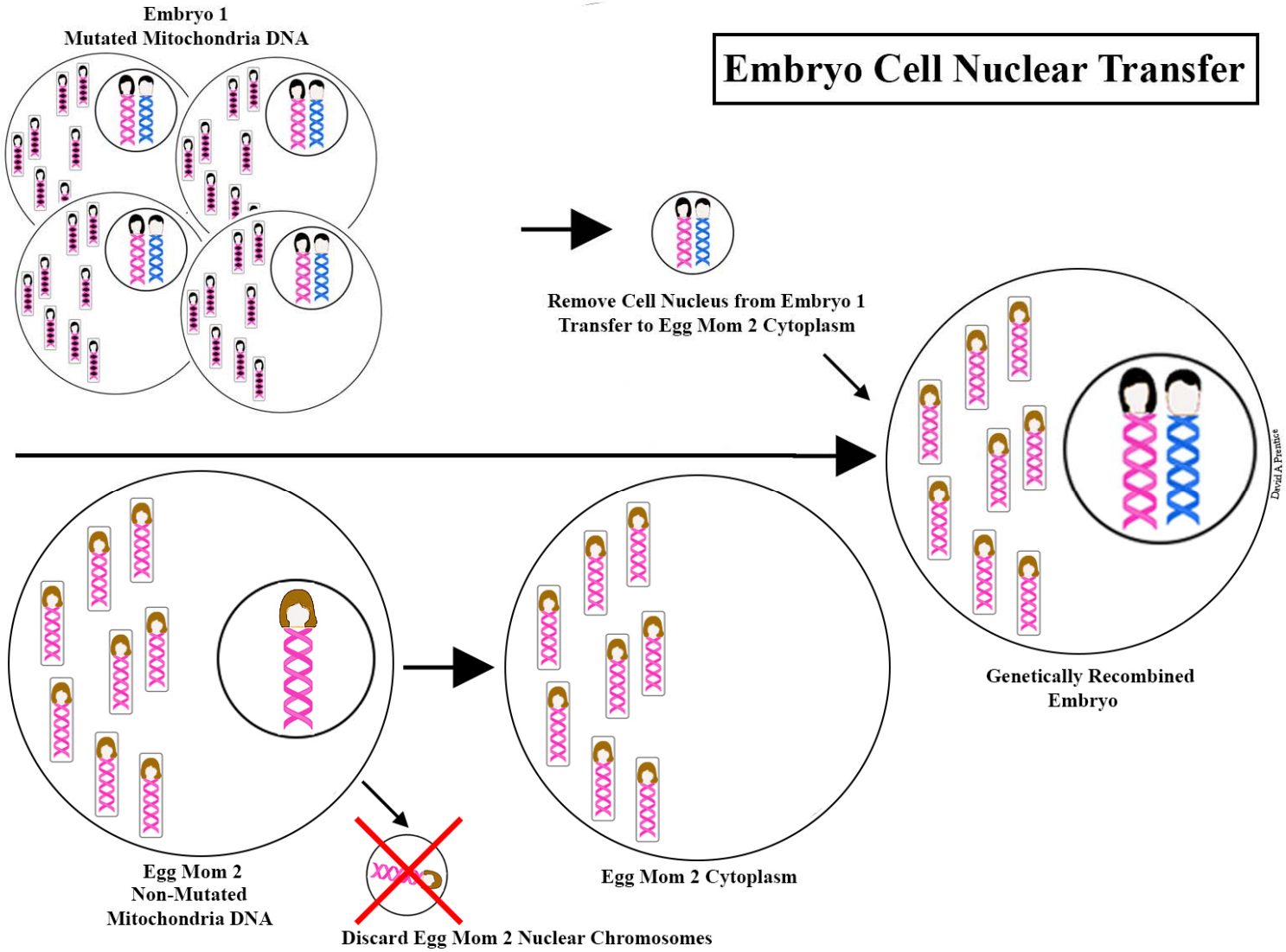
The pro-nuclei from Embryo 1 (from the intended parents) are placed into the cytoplasm of the donor embryo. The genetically recombined embryo now has the intended mother's (Mom 1) and father's nuclear genetics and non-mutated mitochondria from the embryo donor (Mom 2). **The newly-created embryo is a "3-parent embryo".** As of June 2015, this technique had been attempted with human embryos as well as animal embryos.



Embryo Cell Nuclear Transfer

This technique transfers the nucleus of an early embryo cell (genetics of Mom 1 and father) into an enucleated egg (Mom 2). The donor egg (Mom 2) contains non-mutated mitochondria.

This nuclear transfer is the cloning of an embryo; same technique as somatic cell nuclear transfer, *i.e.*, cloning of an adult). Human somatic cell nuclear transfer (cloning of an adult) has been successfully accomplished by the same lab that developed Maternal Spindle Transfer. **The newly-created embryo is a "3-parent embryo".** As of June 2015, there are no reports yet of this technique being attempted with human embryos.



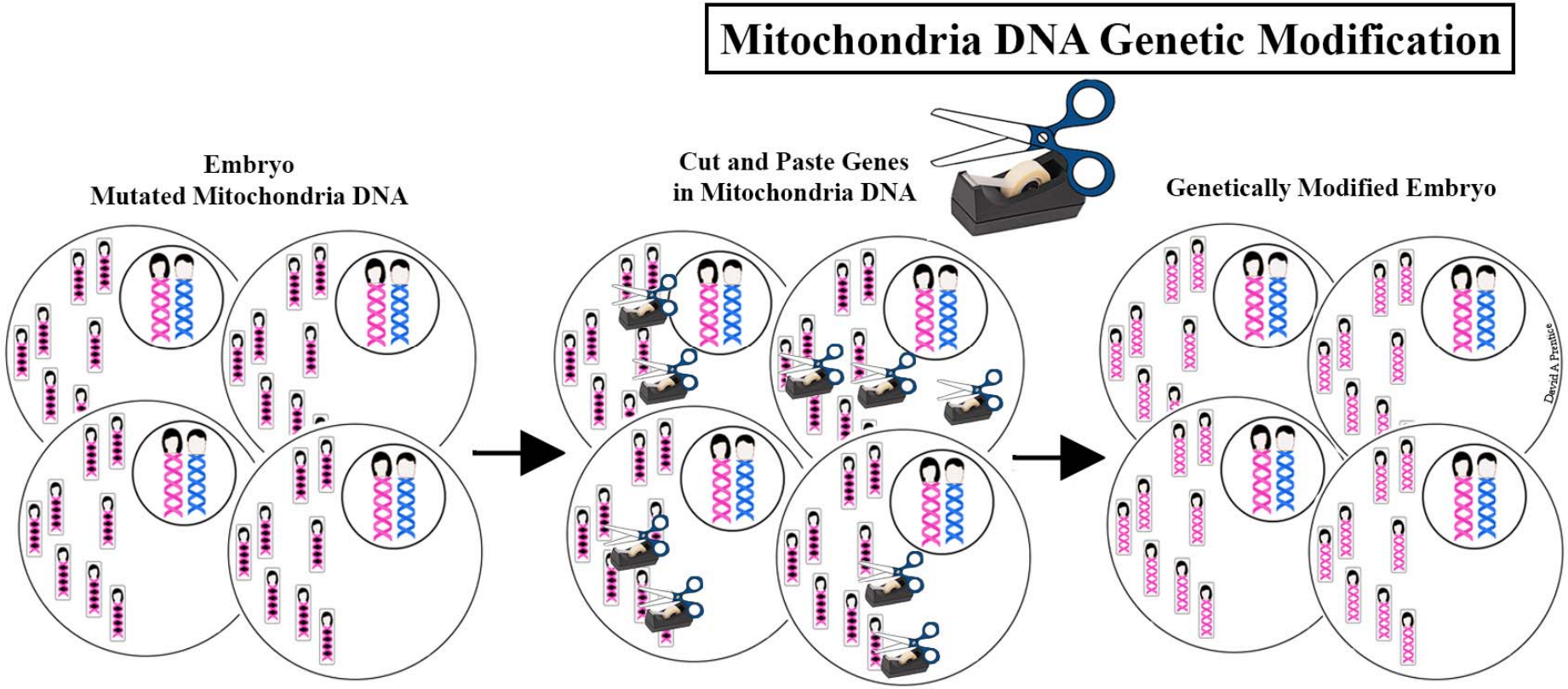
Mitochondria DNA Genetic Modification

This technique uses a molecular "cut and paste" process to replace mutated mitochondria DNA in an embryo. Various enzyme complexes can be used (*e.g.*, ZFN, TALEN, CRISPR-Cas9) to find specific mutated DNA sequences, cut out the mutated sequences, and replace with non-mutated DNA sequences. **This creates a genetically modified human embryo.**

This technique could also be used to alter or enhance normal, non-mutated DNA.

Note that the technique need not be used with embryos, but could instead be used with born individuals.

As of June 2015, this technique had only been used in mouse embryos.



Nuclear DNA Genetic Modification

This technique uses a molecular "cut and paste" process to modify mutated nuclear DNA in an embryo. Various enzyme complexes can be used (*e.g.*, ZFN, TALEN, CRISPR-Cas9) to find specific mutated DNA sequences, cut out the mutated sequences, and replace with non-mutated DNA sequences. **This creates a genetically modified human embryo.**

This technique could also be used to alter or enhance normal, non-mutated DNA.

Note that the technique need not be used with embryos, but could instead be used with born individuals.

As of June 2015, this technique had been used to genetically modify human embryos by Chinese scientists.