

Moving Forward: Putting Genetic Testing to Use

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THE RISE OF GENETIC TESTING has revolutionized individuals' awareness of what genetic conditions they may face in the future and what they might pass on to their children. This revolution has led to the development of 37,103 genetic tests for rare and common conditions and the birth of 644 genetic testing laboratories in the United States (Gene Tests 2014). From prenatal to diagnostic to carrier tests, these tests may enable individuals to plan various aspects of their life, albeit with the limitation that the results and their interpretation are not always certain. Genetic tests with "positive" results can cause emotional strife, anxiety, and depression, in addition to social or genetic discrimination (Genetics Home Reference). Knowing near-term or future challenges often does little to mitigate the condition but may provide a basis for planning.

Such is the case with mitochondrial disease, a condition that affects a person's mitochondria (the small organelles that supply cells with power). Defective mitochondria affect organs differently and may damage the cells of the brain, heart, liver, skeletal muscles, kidney, and respiratory and endocrine systems. Such cell abnormalities may contribute to various conditions, including heart disease, respiratory disease, hearing and visual problems, and gastrointestinal disease, and more (United Mitochondrial Disease Foundation). Genetic tests use blood or muscle samples to screen for known mutations that cause mitochondrial disease (MDA). Although these tests inform patients as to whether they have the disease or carry the gene responsible, there is no effective treatment—the only therapy entails techniques that may alleviate symptoms on a case-by-case basis (United Mitochondrial Disease Foundation).

Each individual has two types of DNA: nuclear DNA and mitochondrial DNA (mtDNA). Mitochondrial disease stems from a defect in the mtDNA and can be passed from mother to child. When passed, defective mtDNA can produce defects ranging from mild, with few or no symptoms, to debilitating and potentially fatal (United Mitochondrial Disease Foundation). Before genetic testing, having a child with mitochondrial disease was almost unavoidable if the mother herself did not show symptoms or know she had mitochondrial disease. With genetic testing, a conundrum is set forth before potential parents: risk having a child with potentially severe disability, or refrain from having biological children?

Recently, an innovative procedure has changed the question that mothers with mitochondrial disease face. Elim-

inating mitochondrial disease may be possible in the near future by the use of three-person in vitro fertilization (IVF) through mitochondrial-replacement therapy (Tingley 2014). There are two methods for three-person IVF; pronuclear transfer and spindle transfer. Both techniques involve combining the nuclear DNA of a potential mother, whose mtDNA is damaged, with the mtDNA of a healthy woman. The two DNA sets are combined in the egg of the woman with healthy mtDNA, and this donor egg—which is fertilized either before or after combination, depending on the technique—is then implanted into the potential mother (NHS 2014). Mitochondrial DNA dictates basic cell functions, while nuclear DNA encodes the majority of a person's genome. With three-person IVF, a child will have the nuclear DNA, and thus all of the traits of, the parents—except with effective mitochondria. If female, the child will also avoid the risk of passing defective mtDNA on to her own children (Tingley 2014). The question is not "Should I have children?" but rather "Should I take the steps necessary to ensure my children are born healthy?"

The decision should be simple; all parents want their children to be born healthy. But it is not so simple. The Food and Drug Administration met earlier in 2014 to discuss the legality of three-person IVF and altering the germ line but has not yet released a decision (Smith 2014). While clinical trials have not been conducted at length, research is being done at Newcastle University in the United Kingdom, and the British Parliament has backed the three-person IVF procedure (Gallagher 2013). Comparable cases of in vitro fertilization with cytoplasmic material have been reported. In these cases, cytoplasmic material were injected into a potential mother's eggs to cure infertility, and children who were born as a result have not shown any abnormalities (Tingley 2014). Such results are promising for the similar three-person IVF.

If effective, three-person IVF may be the beginning of a new age of preventive medicine, as well as the transition from simply knowing about the potential for genetic disease to knowing and being able to use this information to make decisions. We may be entering an age where genetic testing can be used to empower individuals to make reproductive decisions with more information, and where genetic testing provides critical information that will affect the health of one's children.

Some believe that three-person IVF is the beginning of a shift toward "designer babies" (Lupkin 2013). Others

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contend that this technique represents important options for parents who desire a child free of mitochondrial disease and that genetic testing leads to options that parents want to hear.

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