GENETICS AND MITO

Genes control the way you look and the way your body functions.

Your physical features are the result of your genes. Genes also tell your body how to function. Irregularities in genes can lead to conditions such as mitochondrial disease (mito).

CELLS AND GENES

Your body is made up of about 40 trillion cells, and your genes are stored in these cells. We all have about 25,000 genes in every cell.

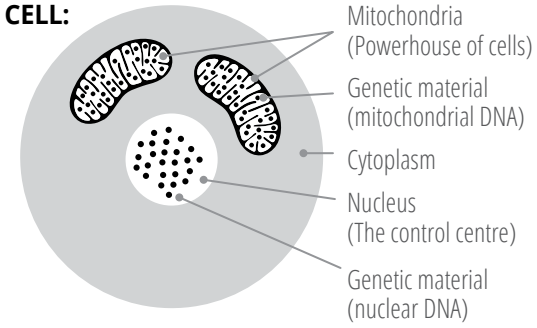
Each cell contains a complete blueprint of your genetic plan, packaged in the form of genes, that allows your body to function.

For example, neurons are the cells in nerves that transmit electrical signals that coordinate your movement. White blood cells fight disease and respond to infection.

All cells contain tiny organs, called organelles, which do things like transport nutrients and break down waste products. Only two of these organelles contain genes - the nucleus and the mitochondria.

Cells and genes

- ✓ **The nucleus:** The control centre of the cell where nearly all genes are stored. It contains about 25,000 genes.
- ✓ **The mitochondria:** The powerhouse of the cell that converts food into energy and contains a small number of genes. Each cell has many mitochondria and each mitochondria contains 37 genes.



Genes: the information that makes you unique

Genes pass physical features from parents to children. Genes are made up of DNA, which pass your physical features down to future generations.

Each of your cells contains two sets of genes: one from each parent. Each gene is therefore one of a pair. The combination of your mother's and father's genetic codes have resulted in an entirely new and unique individual: you.

Genes influence your outward appearance, such as eye colour, as well as how your body works from the inside.

Most of your genes are stored in the nucleus, these are known as 'nuclear DNA (nDNA)'. A small number are also stored in the mitochondria and these are called mitochondrial DNA (mtDNA).

MtDNA is different to nDNA as it doesn't influence your physical features.

Proteins: the building blocks of your body

Genes contain the information your body needs to make chemicals called proteins. Each gene corresponds with a protein.

Proteins are the building blocks of your body and make up your muscles, connective tissues, organs and skin. They build bones, control digestion, and keep your heart beating.

Proteins carry out all the chemical reactions around your body that keep you alive. The structure and function of the body is controlled by different types of proteins which are created within the cell. In that way, your body is regulated by your genes.

Mitochondria: the powerhouse of cells

Mitochondria contain proteins and enzymes that convert food and oxygen into energy for the body. These proteins work together like an assembly line, converting energy from food into a different kind of energy that cells can use.

If the supply of this specialised energy is low because of mito, some organs such as the heart, muscles and brain have trouble functioning normally.

Mitochondria have their own DNA and genes. Although most of a cell's DNA is in the nucleus, the mitochondria have a small but crucial piece of DNA that enables the mitochondria to convert food into energy.

How genetic variation causes mito

The genetic code in all of us is 99.9% identical but a relatively small number of differences makes everyone unique. If there are changes or variations in the genetic code, it can cause certain conditions, including mito.

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Mito occurs when genetic changes lead to incomplete or missing proteins in the mitochondria. These genetic variations stop the mitochondria from producing enough energy for your body. This causes the symptoms of mito.

WHAT INFLUENCES GENETIC INHERITANCE

Mito is usually inherited from your parents. Variations in genetic code are passed down from parents to children.

These are the some of the factors that influence genetic inheritance:

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Dominant or recessive

Mito nuclear genes can be either dominant or recessive. The dominant gene will always overrule the non-dominant, or recessive, gene.

For example, brown eyes are more common than blue eyes, because the gene for brown eyes is dominant over the gene for blue eyes. The same applies to dominant and recessive mito genes.

Even if you carry a recessive mito gene, you might not show any sign of mito. This happens if you carry only one recessive copy of the gene.

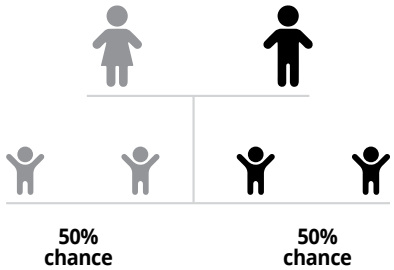
But if you have a child with someone with a recessive copy of the same mito gene, your child will have a higher chance of developing the disease.

Autosomal recessive inheritance when both parents are carriers

Autosomal recessive inheritance when one parent is a carrier

Autosomal recessive inheritance when one parent is affected and one parent is a carrier

Autosomal dominant inheritance when one parent is affected and one parent is unaffected



KEY

- Genetic carrier mother
- Non-carrier mother
- Affected or predisposed mother
- Genetic carrier father
- Non-carrier father
- Affected or predisposed father
- Genetic carrier child
- Non-carrier child
- Affected or predisposed child

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Gender

Mito genes can be linked to genes that decide gender. These mito genes affect one gender more often than another.

Females have two X chromosomes, while males have XY chromosomes. There is a type of X-linked mito that exists on the X chromosome, which usually only affects males.

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Maternal genes

Mitochondrial DNA is only passed down from the mother. Several genes that are important to mitochondrial function are passed down only from the mother as mitochondrial DNA (mtDNA). This type of genetic inheritance causes about half of all cases of mito.

If a mother's mtDNA has changes that cause mito, her children will inherit them as well. However, even if children inherit mutated mtDNA from their mother, not all will be affected or have symptoms.

Each of your cells can contain several thousand copies of mtDNA. If a child inherits mito from their mother, they usually have heteroplasmic cells. That means that some mtDNA do not contain the changes that cause mito, while others do.

That's why the symptoms and severity of mito can vary among family members.

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Spontaneous changes

Some genetic variations that cause mito can happen spontaneously when eggs and sperm are formed. In these cases, the parents don't carry the mito gene.

Why doctors need to know about your family history

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It's helpful for your doctor to understand your family history. This will help them work out your risk of passing mito onto your children, or whether other people in your family may carry the genes.

Before you see your doctor, gather as much information about your family history as you can.

For instance, if you have relatives with premature deafness, blindness, seizures or other signs of mito, this information will be helpful to your doctor. It can help them work out what type of mito may run in your family.

Doctors and genetic counsellors can also use this information to map out your family history, like a family tree. This can show who may carry certain genes and who may not.

How a genetic counsellor can help

Discussing your family history with a genetic counsellor can help you get more information about mito and how it may affect your family.

A genetic counsellor can give you more information about genetic testing and what the results mean.

You might also want to see a genetic counsellor if you're planning to have children, and you're concerned about passing on mito to your children.

Summary

- Your genes are stored in your cells
- There are about 25,000 genes in every cell
- Genes are passed from parents to children
- Genes make each of us unique
- Genes control the way you look and how your body functions
- Proteins are the building blocks of your body
- Mitochondria are the powerhouse of cells
- Each cell has lots of mitochondria
- Genetic changes can cause mito in different ways
- It's helpful for your doctor to know about your family history

Reference

- The Genetics of Mitochondrial Disease, Seminars in Neurology volume 31, number 5, 2011

mito FOUNDATION
Hope for mitochondrial disease