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How does genetics explain non-identical identical twins?

March 17, 2016 1.03pm GMT

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Newspapers recently went wild with a story about identical twin sisters with a difference: they weren't identical. Like all identical twins, Amelia and Jasmine arose from a single fertilised egg so have identical DNA, but somehow look different from each other.

One child has dark skin, black hair and brown eyes while the other has fair skin, light-brown hair and blue eyes. How is this possible? Have the doctors or scientists got it wrong?

No one has got it wrong. They really are identical twins. While this is a rare event – the doctors were as surprised as anyone – genetic and epigenetic research tells us that it is possible. In fact, it is likely to be the result of common biological processes that are going on inside all of us all of the time – although, typically, with less visually striking effects.

Author

Colin Moran
Senior Lecturer in Health and Exercise Sciences, University of Stirling

Types of twin

Twins fall into two broad categories: identical and non-identical. Non-identical twins are the result of a mother releasing two eggs at once, both of which become fertilised by different sperm resulting in two separate zygotes which develop into two children.

Like most full siblings, non-identical twins share 50% of their DNA. Identical twins, however, result from a single fertilised egg (one zygote) separating into two parts during early cell division. It's normal for a zygote to divide and it does this repeatedly during development to grow the many cells needed to make a full-term baby, whether that baby is a twin or not. But for singletons and non-identical twins these cells remain tightly packed together. If the cells separate early on in the process they can develop as two independent but twinned zygotes that share 100% of their DNA. Since DNA and the genes within it contain all the biological instructions for making us, this should result in two identical looking babies: identical twins.

Imperfectly perfect

We are taught in high school biology that when cells replicate their DNA and divide as we grow, they replicate our DNA perfectly. Actually, they do it almost, but not quite, perfectly. With each round of DNA replication and cell division our cells are accumulating a small number of changes in their DNA sequences. So even within our own bodies, our cells do not contain identical DNA. This is known as somatic variation.

Some of these changes give rise to common familiar features such as moles, some have been linked to diseases such as cancer, but the majority have no obvious effect. The same process occurs as identical zygotes grow and divide and will result in numerous subtle genetic differences between identical twins most of which we barely notice.

Consequently, identical twins do not actually share 100% of their DNA although they share very close to 100%. And when the differences are in the genes responsible for features such as hair colour, eye colour or skin colour, twins will have obvious and dramatically different looks.

The role of epigenetics

In addition to this, genes can be switched on and off in different cells. In fact, they have to be. If all of our genes were switched on all of the time in all of our cells then we would not be able to grow different tissue types and organs from a single set of biological instructions.

One of the main processes switching genes on and off is an epigenetic process known as DNA methylation. By controlling which genes are on or off in any given cell, we are able to grow kidneys, heart, skin, etc and control how these cells behave and what they look like.

DNA methylation marks can be inherited across generations, but, equally, they can be altered by relatively short-term stimuli such as exercise or nutrition. More importantly, there is evidence that the genes involved in controlling eye, skin and hair colour are subject to this epigenetic control.

So whether they had a different experience in the womb – such as one twin receiving more nutrients due to a better connection to the placenta – or whether there was some chance epigenetic reprogramming, it seems likely that epigenetics will have a role in explaining the difference in the appearances of Amelia and Jasmine.

Although a few eyebrows may be raised when Amelia and Jasmine are described as identical twins, biologically they are as identical as any other pair of identical twins. The differences between them are just more visually striking.

Genetics Epigenetics Twins

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