Geneticists solve 40-year-old dilemma to explain why duplicate genes remain in the genome

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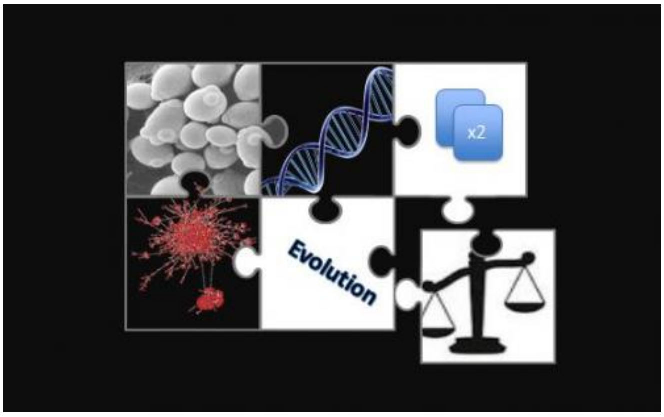

An informational graphic of the process of gene duplication, showing how sister genes can confer mutational robustness by allowing organisms to adapt to novel environments. Credit: Mario Fares, 2014.

Geneticists at Trinity College Dublin have made a major breakthrough with important implications for understanding the evolution of genomes in a variety of organisms.

They found a mechanism sought for more than four decades that explains how gene duplication leads to novel functions in individuals.

Gene duplication is a biological phenomenon that leads to the sudden emergence of new genetic material. 'Sister' genes – the products of gene duplication – can survive across long evolutionary timescales, and allow organisms to tolerate otherwise lethal mutations.

The Trinity geneticists have now identified and described the mechanism underlying this increased tolerance, which is known as 'mutational robustness'.

By experimentally demonstrating that this robustness is important for yeast cells to adapt to novel conditions, including those that are stressful to the cells, they have underlined the likely reason for the existence of gene duplication.

"Natural selection - a process that keeps essential things in the cell - also removes genes that are redundant from the genome," said Dr Mario A Fares, Assistant Professor in Genetics at Trinity, and leading author of the study.

"The mechanism resolving the conflict between sister genes and their apparent evolutionary instability had remained a mystery for decades, but we have now cracked this latest part of the genetic code."

Gene duplication is a frequent phenomenon in eukaryotic organisms (which safeguard their genetic material within cell membranes), including yeast, plants, and animals. But understanding how duplication leads to biological innovation is difficult because evolution cannot be easily traced seeing as it occurs on timescales in the order of millions of years.

Despite their apparently redundant nature, duplicate genes that originated 100 million years ago can still be found in today's organisms. This phenomenon has always suggested the existence of a mechanism maintaining them in the genomes. The researchers in this study chose to work with yeast – an organism whose entire genome has been duplicated over time – to join up the dots.

They 'evolved' yeast cells in the laboratory under conditions that allowed the spread of mutations rejected by natural selection, by simply reducing the effect that natural selection had on these 'maladapted' cells. They found that duplicate genes tolerated the maladaptive mutations to a greater degree than non-duplicate genes.

The geneticists' simple experimental approach revealed that these genes, duplicated 100 million years ago, were still able to respond to different environments as they changed, as well as highlighting their potential to generate new adaptations that might give them an advantage in new environments.

"Discovering the mechanism of innovation through gene duplication marks an exciting beginning for a new era of research in which evolution can be conducted in the laboratory and theories hitherto speculative tested," added Dr Fares.

"Our discovery also has implications for explaining the importance of redundancy in the human society as well. The role of increased redundancies in a fashioned job market in lenient economical conditions could lead, in crisis times, to the emergence of new companies, specialized workforces, and the optimization of individual capabilities, for example, although this requires a profound investigation."

The research, recently published online in the high-profile international journal, *Genome Research*, was supported by Science Foundation Ireland (SFI).

Provided by Trinity College Dublin