Scientists report the oldest known case of conserved gene order

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Dr Nick Matzke. Credit: University of Auckland

Genes are encoded in DNA, and closely related species will often have the same genes in the same order in the genome. However, over millions of years of evolution, this shared gene order gets lost as the DNA gets broken, repaired and reshuffled.

More rarely, the gene order is "conserved" ¬- retained even between distant evolutionary relatives—if the genes encode for proteins that cooperate closely.

Previously, the oldest known cases of conserved gene order traced back to the Last Universal Common Ancestor of life, known as LUCA. LUCA was a population of cells billions of years ago that was ancestral to all cellular life. Its existence is inferred from genes that are shared across all major branches of the tree of life.

A new study in the journal *BioEssays*, authored by scientists at the University of Auckland and the University of New South Wales pushes the existence of conserved gene order back even further, to a time before LUCA.

The scientists made the discovery by closely examining data in "plain sight," that is, in publicly available genome databases of bacteria.

The scientists looked at the order of genes coding for two famous rotating nanomachines: the bacterial flagellar motor, and the ATP synthetase. Both protein complexes are so tiny that they can only be visualised with electron microscopes.

The flagellar motor is a rotating "tail" that many bacteria, including pathogens like cholera, use to swim. The ATP synthetase is found in the mitochondria of the cells of all animals and plants, and it generates ATP, the energy currency of life and a key chemical used by most cells. Remarkably, although the ATP synthetase is much smaller than the flagellum, both motors rotate tiny wheels to do their job.

Scientists have studied both nanomachines for decades, fascinated by the example offered by nature producing nanotechnology far more impressive than that produced by humans. For the same reason, they often feature in creationist arguments against evolution, as something too complex to evolve gradually.

However, evidence gradually accumulated that the two systems were evolutionarily related.

Two student researchers, Micaella Stone from University of Auckland and Angela Lin from UNSW, were recruited to search through genome databases and record the gene order in the two systems across hundreds of species of bacteria.

Dr. Matzke said that it has been known for a while that the bacterial flagellum and the ATP synthetase have several proteins that are probably evolutionarily related, but showing that these two very different systems have several related genes in identical gene order, across essentially all of life, clinches the case that the systems are related.

"Finding conserved gene order dating back not just to LUCA, but to before LUCA, makes this the most ancient case of conserved gene order known to science," said the lead author, Nick Matzke. "Such an extreme example of gene order conservation also suggests that there is a gene expression pattern shared between the two systems that also goes all the way back to that ancestral system," he added.

"The fact that we can say anything at all about the genome structure of a pre-LUCA ancestor is amazing," says corresponding author Matt Baker, who runs a lab devoted to experimentally evolving bacterial flagellar motors at UNSW.

"Our study adds to the evidence that suggests that deep in the core of the bacterial flagellum, there is a 'molecular fossil' that looks like a very primitive version of the ATP synthetase."

The discovery is reported in the journal *BioEssays*.

More information: Nicholas J. Matzke et al. Flagellar export apparatus and ATP synthetase: Homology evidenced by synteny predating the Last Universal Common Ancestor, *BioEssays* (2021). DOI: 10.1002/bies.202100004

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