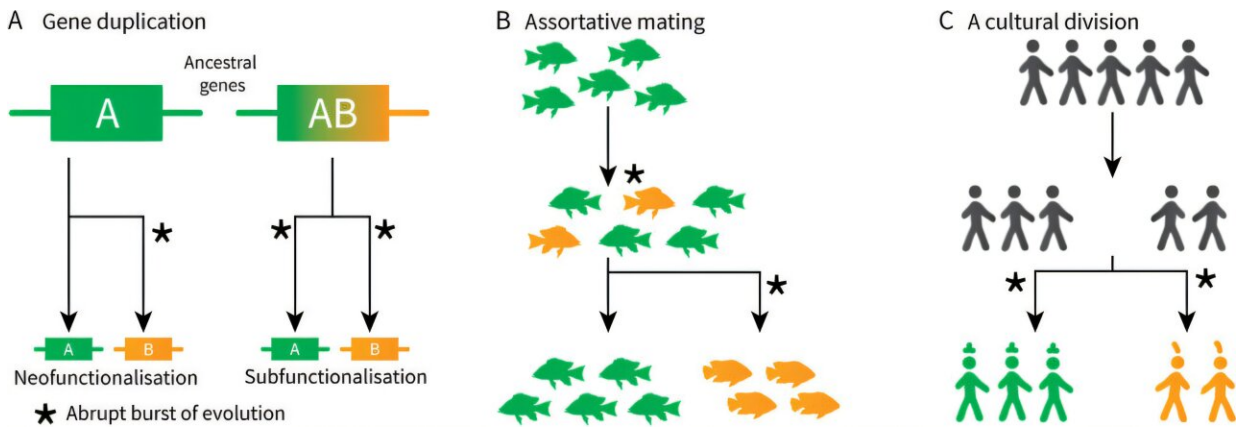
Punctuated equilibrium: Analysis shows rapid evolutionary leaps in cephalopods, languages and ancient enzymes

June 5 2025



Evolutionary changes are often the driving force behind branching, or are accelerated by branching. The scenarios above depict examples of this process at molecular (A), morphological (B), and human cultural (C) scales. The coupling between evolutionary change and lineage splitting cannot be explained by clock-like evolution alone. Credit: *Proceedings of the Royal Society B: Biological Sciences* (2025). DOI: 10.1098/rspb.2025.0182

Over the past 500 million years, nearly all evolutionary changes in octopuses and squids occurred in rapid bursts during the emergence of new species, according to research from the University of Auckland.

The paper is published in the journal *Proceedings of the Royal Society B:*

Biological Sciences.

The findings support the theory of "punctuated equilibrium," first proposed in the 1970s by paleontologists Stephen Jay Gould and Niles Eldredge. This controversial theory suggests that evolution is mainly not a slow, continuous process but instead happens in short, intense periods of change, followed by long stretches of stability.

The study was led by evolutionary biologist Dr. Jordan Douglas from the University of Auckland's Department of Physics. Douglas refined a probabilistic model for use with BEAST 2, a software tool for constructing evolutionary trees to test how species evolve over time.

Douglas and senior scientist Peter Wills applied the model to cephalopods (including octopuses, squids, cuttlefish, and vampire squids), as well as to the evolution of Indo-European languages, and ancient enzymes required for genetic coding. Their analysis of cephalopod traits—such as shell shapes, tentacle numbers, and fin structures—suggested that gradual evolution played only a "trivial role."

The Indo-European languages and aminoacyl-tRNA synthetases—enzymes dating back to the dawn of life—also evolved in sudden leaps, said the scientists and co-authors Dr. Remco Bouckaert, Associate Professor Simon Harris, and Professor Charlie Carter, an origin-of-life scientist from the University of North Carolina-Chapel Hill.

For the Indo-European languages, the research supported the so-called "hybrid theory," which posits that they originated south of the Caucasus Mountains before spreading northward.

Eldredge, 81, is a curator emeritus at the American Museum of Natural History in New York. In an email to the authors of the paper, he said the

new research may serve as a "tipping point" for acceptance of the theory, which has remained controversial for decades.

Over the past 50 years, the concept has been applied to everything from bacteria to dinosaurs, cancer, and even human culture, but doubts have remained about its general applicability, he said.

The new paper, using advanced mathematical techniques, confirms that rapid evolutionary change almost always coincides with the branching of new species. The paper "removes all doubt," he said.

"Saltative branching" is the term that the University of Auckland scientists prefer to "punctuated equilibrium," highlighting that the rapid evolutionary bursts take place when a new species emerges, branching off from the family tree.

More information: Jordan Douglas et al, Evolution is coupled with branching across many granularities of life, *Proceedings of the Royal Society B: Biological Sciences* (2025). DOI: 10.1098/rspb.2025.0182

Provided by University of Auckland