Factoring for cosmic radiation could help set a more accurate 'molecular clock'

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A depiction of the double helical structure of DNA. Its four coding units (A, T, C, G) are color-coded in pink, orange, purple and yellow. Credit: NHGRI

Scientists long have used the "molecular clock" to establish when species may have branched from each other on the Tree of Life.

Since the 1960s, scientists have theorized the number of molecular differences in DNA, RNA and proteins from related species could pinpoint the time of their genetic divergence. Accordingly, a higher number of molecular differences indicates a greater number of years since any two species' split from a common ancestor.

"It's an attempt to time events in the evolutionary past by looking at the DNA of various species which are related," said Adrian Melott, professor of physics and astronomy at the University of Kansas. "Assuming that changes in DNA happen at some modeled rate, one could figure out how long ago the species diverged by counting the differences in the DNA."

A paper by Melott to be published in the forthcoming book "Earth and Life II" will examine a major hiccup in the molecular clock theory. The problem is that fossil evidence doesn't always sync with molecular dating for a variety of species.

"In general, molecular clock estimates are far older than the fossil record indicates that the species diverged," Melott said. "There have been many attempts at an explanation. One of them is to say that the fossil record is just missing the important early part of the record."

The KU researcher looked closely at a 2014 study of these discrepancies within bird species, concluding that patterns are "inconsistent with attributing all of the age disparity to gaps in the fossil record."

Instead, Melott believes there may be an astrophysical explanation for conflict between the molecular clock and the fossil record.

"Increased radiation reaching the Earth would increase the mutation rate, temporarily speeding up the molecular clock," he said.

Sources of such cosmic radiation would include our sun and distant exploding stars, or supernovae, that throw off gamma-ray bursts.

Melott urges further study of the time period between 2 and 2.5 million years ago that would have accelerated molecular clocks if his idea were right.

"There is strong evidence, in the form of Iron-60 found in multiple ocean sediments, as well as in the spectrum of cosmic rays reaching the Earth, that one or more supernovae about 300 light years away dumped these isotopes on the Earth," he said. "We would have had an uptick in radiation then which might have accelerated the molecular clock."

In other words, the accumulation of mutations from such radiation would seem to make the molecular clock move faster, measured against the fossil record.

"Going back toward this increase of radiation, the molecular clock would speed up," Melott said. "Going back before the event, say 10 million years, the rate of the clock would slow down again toward a more long-term average."

Similarly, deep-sea creatures should have molecular clocks that line up more precisely with the fossil record, because large volumes of water act as a shield from astrophysical radiation.

"Very little radiation can penetrate more than a few hundred meters into the ocean," Melott said. "So a key prediction of the hypothesis is that organisms deeper in the ocean will show less disparity between the two methods."

Melott concludes that his is one of many possible explanations for gaps between the molecular clock and the fossil record.

"But it's a possibility that should be considered," he said.

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Provided by University of Kansas

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