What biological clocks and geological rocks tell us about life in space

July 13 2017, by Sarah R.n. Mcintyre And Charley Lineweaver

Credit: AI-generated image (disclaimer)

One of the first geological lessons we learn is that continents are constantly moving. The evidence of these plate tectonic movements is written in the rocks. But the rocks only tell us half of the story. The other half is contained in the evolutionary history of animals.

In our recent paper we have made the most comprehensive comparison yet between tectonic plate movements and the evolution of the genes of animals. We found they are in agreement for dating million year old breakup of continents and the divergence of different animal groups.

This result on its own provides further validation regarding the accuracy of both dating methods and is of interest to biologists and geologists.

But the reason two astronomers have undertaken this study has more to do with life in space than life on Earth.

Are we alone?

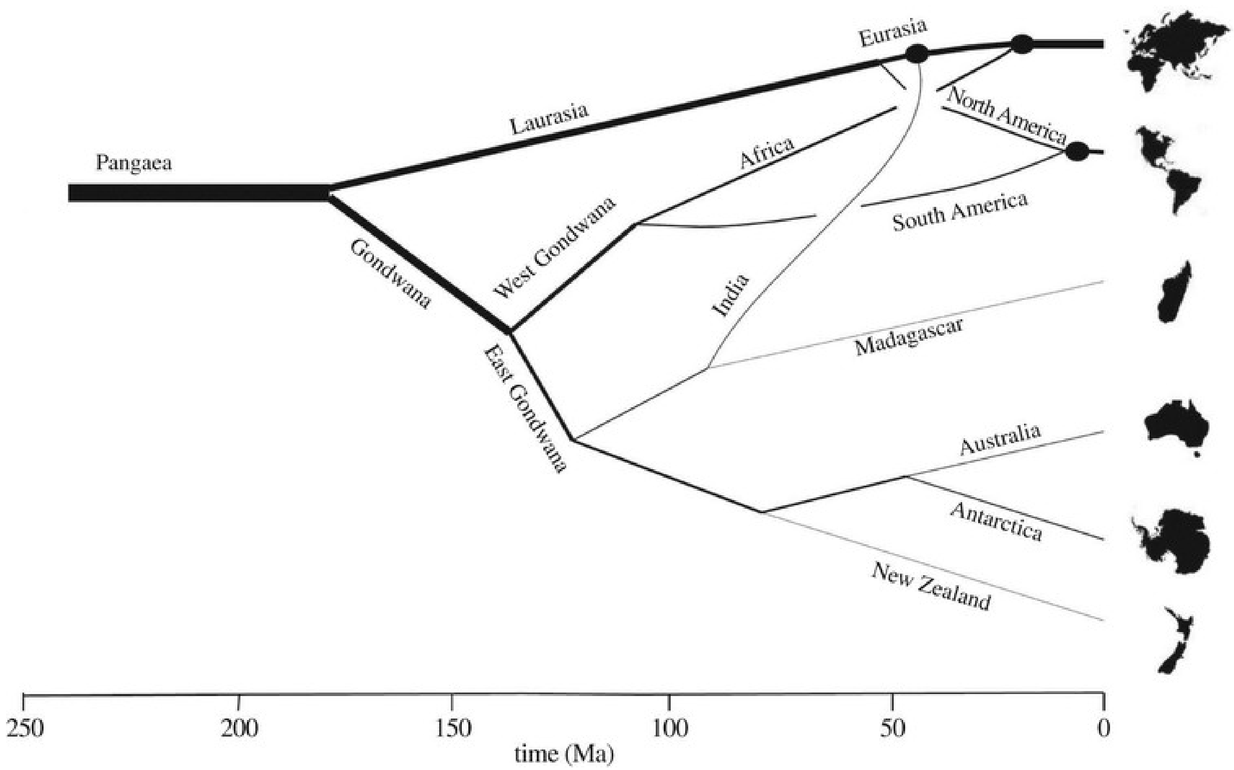
Our investigations initially began with the question: are there any other intelligent beings in the Universe? Without evidence of life elsewhere in space, we adjusted our course to explore how we could answer this question by observing life on Earth.

Most of us think that there is a selection pressure on animals to become smarter, because it is more useful, from a survival point of view, to be "smart" than "stupid".

The assumption here is that a highly successful species will occupy the most advanced position from an evolutionary point of view, a so-called "intelligence niche". If this is true, the niche must have been present even before we humans came onto the scene less than a million years ago. Also, there should be evidence of evolution towards smarter organisms in Earth's long palaeontological (fossil) records.

As far as the evolution of land-locked vertebrates is concerned, Earth is not just one biological experiment – it is many. Each isolated continent has hosted a multi-million-year independent experiment in vertebrate evolution.

To determine how likely it was that species evolved into the "intelligence niche", we needed to first measure the length of these large-scale experiments.



The break-up of the supercontinent Pangaea over the past 180 million years (Ma). Circles indicate continental collisions. Line thickness is a rough proxy for landmass area. Credit: McIntyre et al 2017

Continental break up

About 180 million years ago, the supercontinent Pangaea began to break up.

Geologists have well established dates for this breakup, based on the alignment of magnetic minerals in rocks and sediments; this method for geological dating is referred to as palaeomagnetic. Furthermore, a wealth of new biological data is now becoming available and can provide additional information about the continental breakup.

Full genome sequences from thousands of different species are now known. Historical maps of how life evolved – called phylogenetic trees – are being constructed from the comparison of these genomes. They tell us how different species are related to each other, when they had common ancestors and when those common ancestors diverged and evolved into separate lineages.

This is interesting because when Pangaea broke up, continents separated and from the same original species, new species evolved on both sides of the breakup. The dates of the divergences of these new species can now be timed with molecular clocks based on the evolution of DNA. The more different the DNA, the longer the species had been separated.

However, molecular clocks do not tick uniformly. A lot of effort has gone into debugging them, and calibrating them with fossils and cross-calibrating them with each other.

Even then, scepticism remains about how well the divergence dates from phylogenetic trees can be trusted. No such scepticism haunts the much more well-established palaeomagnetic dates used in geology.

Phylogenetic dates provide a chronology of evolution, while palaeomagnetic dating provides a chronology of tectonic events. Our analysis compared the new and independent species divergence dates from phylogeny with the more established continental divergence dates from palaeomagnetism. If continental breakups cause species to diverge, the phylogenetic dates should agree with the palaeomagnetic dates.

Biology and geology agree

After taking statistical steps to eliminate the more mobile species (that could most easily migrate across oceans) we found that biology and geology do agree. We were even able to phylogenetically date when continents collided with each other, and found that these also agree with the geology-based chronology. We conclude that with proper caveats, phylogenetic dates have come of age.

Comparing and combining these two independent techniques, and finding that they agree with each other lends more credence to the divergence dates from phylogenetics. It also gives us more precise and accurate estimates of the continental breakups responsible for the distribution of animals around the world.

Now that the duration of the isolation of continents and islands has been confirmed, we can move forward and continue with our research estimating the rate at which different species on different continents have evolved towards the "intelligence niche".

These investigations will take us a step closer to determining whether or not there is an intelligence niche that has existed on Earth, and ultimately, whether the evolution of human-like intelligence is inevitable, or exceptional.

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