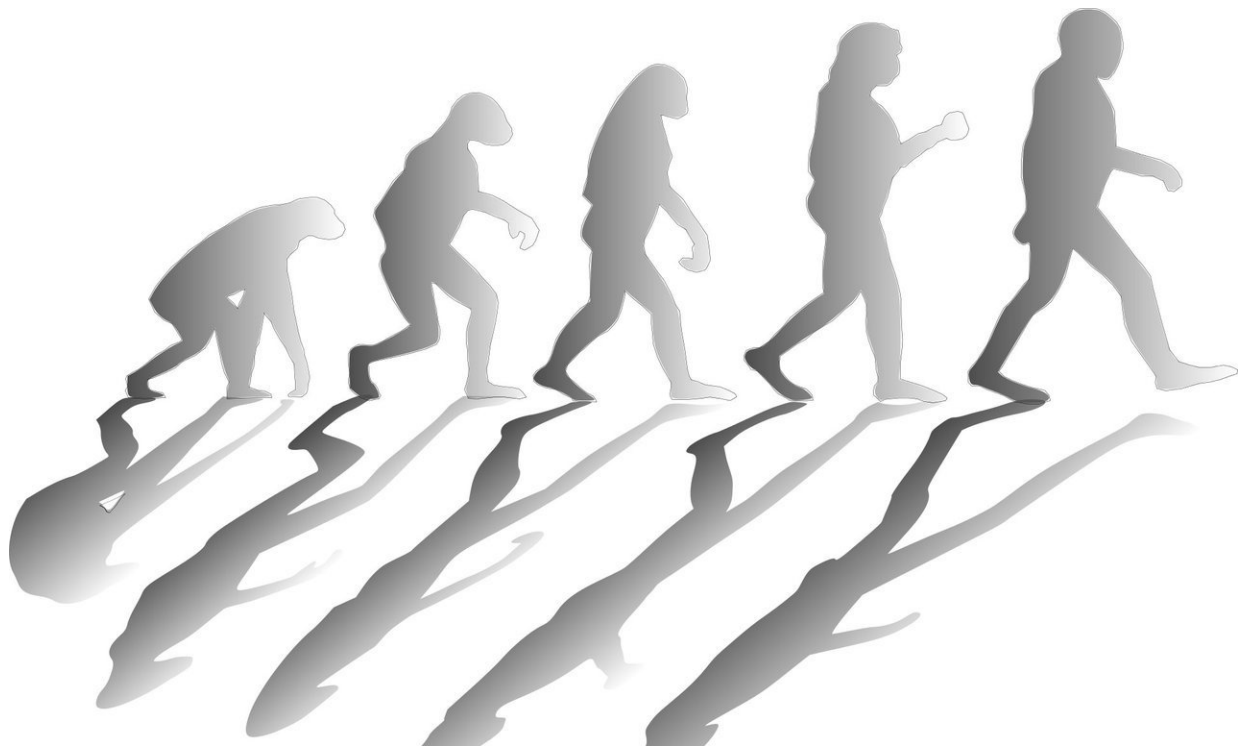


Well established theories on patterns in evolution might be wrong

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How do the large-scale patterns observed in evolution arise? A new paper in the journal *Evolution* by researchers at Uppsala University and University of Leeds argues that many of them are a type of statistical artefact caused by our unavoidably recent viewpoint looking back into the past. As a result, it might not be possible to draw any conclusions

about what caused the enormous changes in diversity observed over time.

The [diversity](#) of life over time shows some striking patterns. For example, the animals appear in the [fossil record](#) about 550 million years ago, in an enormous burst of diversification called the Cambrian Explosion. Many groups of organisms appear to originate like this, but later on in their evolutionary history, their rates of diversification and morphological change seem to slow down. These sorts of patterns can be seen both in the fossil record, and also in reconstructions of past diversity based on the relationships between living organisms, and they have given rise to a great deal of debate.

Do organisms have more evolutionary flexibility when they first evolve? Or do ecosystems get "filled up" as more species evolve, giving fewer opportunities for further diversification later on? In their new paper, Graham Budd and Richard Mann make the provocative argument that these patterns may be largely illusory, and that we would still expect to see them even if rates of evolutionary change stay the same on average through time.

Biologists and palaeontologists use statistical models called "birth-death models" to study how random events of speciation and extinction give rise to patterns of diversity. Just as a dice rolled five times can produce five sixes or none, the outcomes of these random models are variable. These statistical fluctuations are particularly important at the origin of a [group](#), when there are only a few species. It turns out that the only groups that survive this early period are those that happen to diversify quickly—all the others go extinct. As is it exactly those groups that become the large, successful groups living today, and that fill most of the fossil record, it follows that they are likely to show this rapid [pattern](#) of diversification at their origin—but only because they are a biased subset of all groups. Later in their history, when such groups are diverse,

statistical fluctuations have much less effect, and therefore their rate of evolution appears to slow down to the background average.

As a result, the patterns revealed by analyzing such groups are not general features of evolution as a whole, but rather represent a remarkable bias that emerges by studying only groups already known to be successful. This bias, called "the push of the past," has been known theoretically for about 25 years, but it has been almost completely ignored, probably because it was assumed to be negligible in size. However, Budd and Mann show that the effect is very large, and can, in fact, account for much of the variation observed in past diversity, especially when combined with the effects of the great "mass extinctions" such as the one that killed off the dinosaurs some 66 million years ago. Because the resulting patterns are an inevitable feature of the sorts of groups available for study, Budd and Mann argue, it follows that we cannot perceive any particular cause of them—they simply arise from statistical fluctuation.

The push of the past is an example of a much more general type of pattern called "survivorship bias," which can be seen in many other areas of life, for example, in business start-ups, finance and the study of history. In all these cases, failure to recognize the bias can lead to highly misleading conclusions. Budd and Mann argue that the history of life itself is not immune to such effects, and that many traditional explanations for why diversity changes through [time](#) may need to be reconsidered—a viewpoint that is bound to prove controversial.

More information: Graham E. Budd et al, History is written by the victors: The effect of the push of the past on the fossil record, *Evolution* (2018). [DOI: 10.1111/evo.13593](https://doi.org/10.1111/evo.13593)

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