Eukaryote lateral gene transfer is Lamarckian

To the Editor — Darwin saw natural variation as operating at random and internally within the organism, with natural selection sculpting species adapted to their environment. Lamarck's theory involved the inheritance of acquired traits. Although it was not Lamarck's main contribution[1], it is the one that stuck; in Lamarckian inheritance, the environment impresses variation upon individuals, providing them heritable access to new niches. The theories of both Darwin and Lamarck only concerned organisms that we today call eukaryotes. This Correspondence, too, is only about eukaryotes. Evolution in eukaryotes differs from that in prokaryotes, as was always clear to microbiologists, because lateral gene transfer (LGT) was always part of the paradigm for prokaryotic natural variation[2]. The recognition that genetics and mutations supply eukaryotes with the endogenous, non-directed mechanism of variation that Darwin sought was the triumph of the Modern Synthesis[3]. Yet genome sequences have spawned many reports proposing LGT as a mechanism of adaptation in eukaryote evolution[4]. Recent interpretations suggest that eukaryotes acquire genes for adaptively useful traits to gain access to new environments, including anaerobic[5], acidic[6] and parasitic niches[7]. Eukaryotic gene acquisition for niche adaptation? Adaptationist claims for eukaryote LGT are Lamarckian in tooth and claw.

The core of eukaryote LGT adaptation claims is that eukaryotes lack the genetic material required to survive in particular environments and acquire the genes needed in order to access those environments from organisms that already live there. Lamarckian? Yes. In eukaryote LGT adaptationism, the environment is the source of natural variation, not the evolving organism itself[8]. Claims for eukaryote adaptation to anaerobic niches via LGT are perhaps the most common recent theme[5]. Such claims are founded in single gene phylogenies and overlook the bigger picture that those genes common to eukaryotes and prokaryotes, including genes required for anaerobic metabolism[9], trace to the eukaryote common ancestor[10], not to LGTs. Moreover, eukaryotes arose and diversified a billion years before atmospheric and marine O_2 reached its present levels[9,11]; the vector of physiological adaptation in eukaryote evolution was from low O_2 to high O_2 environments, not vice versa.

Will Lamarckian lateralism displace Darwinian lineage inheritance for eukaryotes? If eukaryotes are evolving by Lamarckian means, with LGT being a real rather than artefactual force underlying adaptation, genomes need to show us evidence for cumulative effects. What are cumulative effects? Small morphological changes that accrue over time to generate new species and lineages are cumulative effects. Single nucleotide changes that accumulate over time to generate sequence divergence within and between lineages are cumulative effects. Among prokaryotes, where LGT indisputably occurs[2,12], gene acquisitions accumulate over time, creating pangenomes[12]. In eukaryotes, cumulative effects of LGT are not observed[8]. Why not?

Sceptics such as myself contend that most claims for eukaryote LGT are more easily explained as bacterial contaminations, misinterpretations, data analysis artefacts, differential loss[10], or combinations thereof. The most serious cause for scepticism about eukaryote LGT is that it produces no detectable cumulative effects[8]. Even if LGT to eukaryotes was occurring in such a way as to be neutral rather than adaptive, LGT would still produce a pangenome structure to eukaryote species and populations[12].

The Modern Synthesis was brought to us by genetics[3]. Eukaryote LGT was brought to us by genomics, a field still striving to produce contamination-free data[8]. Before genomics there were no traits in eukaryotes that required LGT in order to account for their evolutionary distribution, endosymbiosis and transposons excepted[8]. If Darwin and the Modern Synthesis were right, claims for adaptive eukaryote LGT will fail the test of time. If Darwin was wrong, mechanisms of adaptive acquisition in eukaryotes and cumulative effects will someday surface, and grandeur in Darwin's view may succumb to Lamarckian genetics. ❐

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Competing interests

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