What (molecular) time is it?

Using ancient DNA to date evolutionary events

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Abstract

This work aims to explore the use of genetic sequences sampled serially through time (heterochronous data), to infer the timescale of past evolutionary events. Such data can be generated from preserved sub-fossil or fossil organismal remains (like mummified tissues, fossilized bones or coprolites), and then used to observe genetic modifications in real-time. Most importantly, the dates of the samples provide firm temporal tie points for their genetic sequences, and can be used to calibrate phylogenetic reconstructions.

This thesis presents several case studies where ancient DNA was used to re-calibrate evolutionary timescales. In every situation, the use of heterochronous data led to elevated molecular rate estimates, resulting in the reconstruction of younger timescales, as compared to estimates based on fossil calibrations. These observations are in agreement with the recent demonstration that molecular rates vary according to the time period over which they are calculated.

This work shows that, ancient DNA offers crucial temporal information to reliably estimate the timescale of recent population evolution, and is generally the only source of direct calibration available for this specific timeframe.

Along with the results specific to each organism studied (hyena, bison and human), an emphasis was placed on the methodological aspects of the use of ancient DNA to generate timed phylogenetic inferences. Additionally, simulated data and mathematical modelling were used to extend the understanding of specific aspects of the temporal dependence of molecular rates.

The results discussed in the present study help to further elucidate the evolutionary mechanisms behind the molecular clock concept, and have implications for the development and application of statistical models to obtain accurate time estimates from genetic data.

Thesis declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Julien Soubrier and, to the best of my knowledge and belief, contains no material previously published or written by any other person, except where due reference has been made in the text.

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The published works of my thesis include:

Ho, SYW, R Lanfear, L Bromham, MJ Phillips, J Soubrier, AG Rodrigo, A Cooper. 2011. Time-dependent rates of molecular evolution. Molecular ecology 20:3087 3101.

Soubrier, J, M Steel, MSY Lee, C Der Sarkissian, S Guindon, SYW Ho, A Cooper. 2012. The influence of rate heterogeneity among sites on the time dependence of molecular rates. Molecular Biology and Evolution 10.1093

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