Fossils versus molecular clocks: which performs best in establishing a timescale for recent and ancient episodes in our evolutionary history?

Supervisors

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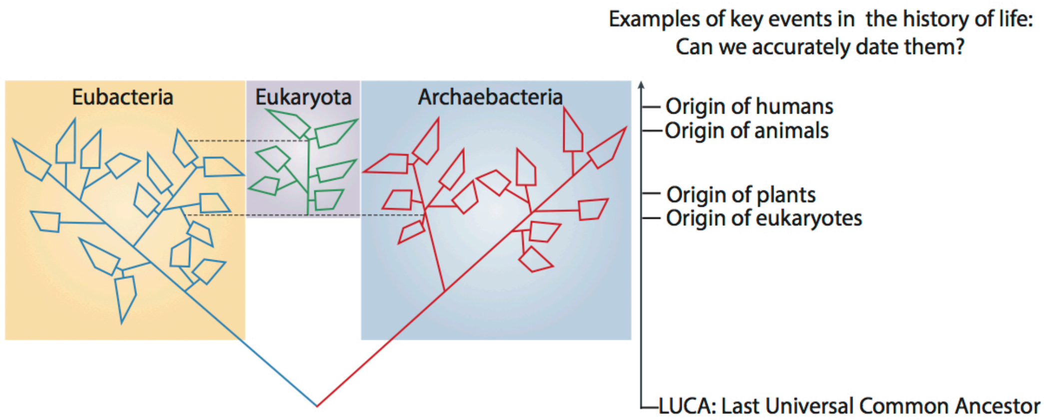
Project description

Establishing a reliable and precise evolutionary timescale (e.g. the origins of animals and humans) is an essential prerequisite to understand the processes underpinning biological evolution[1]. This is because only the knowledge of the correct divergence times between organisms can inform us on the rates of evolutionary processes or dates of concordance between the evolution of Earth and Life. There are two sources of information to date evolutionary events: the fossil and the genomic record. Genomic data are used to establish genealogical relations among living lineages and the distance, in terms of molecular evolution between them, while fossils that constrain the age of evolutionary lineages are used to calibrate those relationships to time. While the fossil record extends back to a time that is likely to be very close to that at which life itself originated (~3.4 Billions of years ago), its quality deteriorates as we move deeper in time[2]. Hence it is impossible, from the fossil record alone, to obtain precise information about the deepest history of life on Earth. Recently, the coupling of genomic and fossil information (through the use of molecular clocks) has improved our ability to reconstruct an accurate timescale of for the evolution of life. However, the temporal limits of current molecular clock methods are unclear, and while there is evidence that they work well when dealing with relatively recent divergence events it is not that clear how accurate they are in dating really ancient divergences, such as that of animals, eukaryotes, and of Life itself. In such instances, it might be possible that the fossil constraints on the timing of evolutionary events are much more influential that are the genomic data.

To determine the efficacy of the molecular clock, you will establish an evolutionary timescale for the formative evolutionary events in our evolutionary history, from the ancestral hominin through to the Last Universal Common Ancestor (LUCA) of all of Life, effectively establishing a timescale for Dawkins Ancestors Tale[3]. In so doing, you will compare different divergence time methods (node versus tip calibration versus coalescence) and establish the relative informativeness of the fossil calibrations and molecular data in establishing the age of the chain of ancestors that lie intermediate of humans and LUCA.

Objectives: This project has two aims. The first is testing the applicability of molecular clock methods as we go back in time, and the second is deriving an accurate timescale for the evolution of life on Earth. The student will learn (1) how to integrate genomic and fossil data to derive timescales, (2) investigate how to test the accuracy of estimated divergence times and (3) use molecular timescales to test hypotheses about the origin of life particularly to test alternative hypotheses for the origin of the eukaryotes. Note that there is scope for the development of the project to suit the interests of the applicant for instance, to include elements of de novo sequencing of living species to obtain a greater diversity of molecular sequence data, or by focusing on specific lineages that particularly interest the student.

1) Erwin, Laflamme, Tweedt, Sperling, Pisani, & Peterson (2011). The Cambrian conundrum: Early divergence and later ecological success in the early history of animals. Science 334:1091-1097.
2) McInerney, OConnel, and Pisani (2014) The hybrid nature of the Eukaryota and a consilient view of life on Earth. Nature Reviews Microbiology 12: 449455.
3) Dawkins R. (2004) The Ancestors tale. Weidenfeld & Nicolson, London, UK.



Tree from Reference N.2