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A biophysical perspective on molecular evolution

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The field of molecular evolution investigates how genes and genomes evolve over time. It has its origin in the late 1960s, when the first DNA and protein sequences were becoming available. With rapid progress in sequencing technologies came ever increasing demand for computational tools to study molecular evolution. Today, molecular evolution is among the largest subfields of evolutionary biology, and arguably one of the most computationally advanced. A side effect of the strong emphasis on developing sophisticated methods for sequence analysis has been that the underlying biophysical objects represented by the sequences, DNA molecules, RNA molecules, and proteins, have taken a back-seat in much computational molecular-evolution work. The vast majority of algorithms for sequence analysis, for example, operate purely on strings of letters, and don't incorporate any information of the biophysical reality that these letters represent. However, DNA, RNA, and proteins are three-dimensional physical objects composed of many interacting particles. We thus expect that their genetic evolution over time is shaped to some extent by these physical properties. Here, I will discuss the extent to which biophysical properties of proteins shape genetic evolution, and how we can use these properties to improve evolutionary analyses.