

Recombination in Biology and Computer Science

Proposal for an ALife XV workshop, Cancun, Mexico, 2016

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Sexual reproduction, and especially recombination, is one of the most central subjects in all of Biology. The evolution and maintenance of sex has been called the queen of problems, and is considered to be one of the only handful major evolutionary transitions. The literature on the subject is diverse, vast and often overwhelming, including domains such as Population genetic, Theoretical Biology, Microbiology, and Evolutionary Biology. In Computer Science, specifically in domains of Genetic Algorithms, Evolutionary Programming, and Artificial Life, recombination is equally central and important. For example, a recombination parameter is effectively mandatory in any genetic algorithm, as it has been repeatedly shown that recombination is essential for successful outcome of targeted/directed evolution.

Although the research questions concerning sex and recombination are diverse, both in Biology and Computer Science, they can be broadly grouped into three sub-categories: (1) how/why do sex & recombination evolve, (2) what are the mechanisms of sex & recombination, and (3) the effect of recombination on various properties, such as speed of evolution or genetic architecture. In some cases the goals of different fields may be divergent: while recombination in computer science may be inspired by biological mechanisms, it may be implemented and executed completely differently, without in any way decreasing the value of a particular study. In others, such as with testing hypothesis on evolution of sex, computer science can directly assist the research efforts of biologists. Finally, sometimes the two fields are directly aligned: understanding how directed evolution using a genetic algorithm with recombination explores the fitness landscape in a computer simulation may be crucial for designing an experimental protein evolution protocol that would be look for a new drug molecule. Overall, the two domains have much to learn from each other, but they common goals and interests can be easily lost in translation of concepts and terminology.

This review will serve multiple purposes. Firstly, it will be a (relatively) brief overview of relevant concepts and research finding from both Biology and Computer Science, enabling researchers to quickly access both the general background and the state of the art in the field. Secondly, it will clear up, or at least make connections terminological issues, since nearly all the important concepts, including recombination, reproduction, sex, are used and defined in different ways both within and between the fields. For example, recombination in biology typically implies homology, and may happen at different rates in different genomic locations, which is typically not taken into account in computer science. Sex in artificial life is often modeled on bacterial sex or plasmid conjugation, which can be confusing to biologists dealing with homologous recombination in higher organisms. Finally, the review has a potential to identify the areas of synergy, research direction where the two fields have the highest chance of benefiting from each other's expertise.