

How to Evolve Cooperation

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Abstract Cooperation is needed for evolution to construct new levels of organization. The emergence of genomes, cells, multi-cellular organisms, social insects, and human society are all based on cooperation. Cooperation means that selfish replicators forgo some of their reproductive potential to help one another. But natural selection implies competition between individuals and therefore opposes cooperation unless a specific mechanism is at work. Five mechanisms for the evolution of cooperation are discussed: kin selection, direct reciprocity, indirect reciprocity, network reciprocity, and group selection. I will argue that cooperation is essential for evolvability.

1 Introduction

Evolution occurs in populations of reproducing individuals. Mutation, selection, and cooperation can be seen as the three fundamental principles of evolution. Cooperation is needed for evolution to construct new levels of organization. The origin of life, the emergence of the first cell, the arrival of eucarya, the rise of multi-cellular organisms, and the advent of human language are all based on cooperation. A higher level of organization emerges, whenever the competing units on the lower level begin to cooperate. Cooperation is always vulnerable to exploitation by defectors. Hence, the evolution of cooperation requires specific mechanisms, which allow natural selection to favor cooperation over defection. In this paper, we discuss five such mechanisms, and for each mechanism we derive the fundamental condition for the evolution of cooperation.

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