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Axelrod R & Hamilton W D. The evolution of cooperation. *Science* 211:1390-6, 1981; and,
Axelrod R. *The evolution of cooperation*. New York: Basic Books, 1984. 256 p.
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How can cooperation emerge in a world of egoists without central authority? Computer tournaments and mathematical analysis demonstrate that cooperation based upon reciprocity can emerge and prove stable provided the shadow of the future is long enough. Applications include politics, economics, and evolutionary biology. [The *SSCI*® and the *SCI*® indicate that this paper and book have been cited more than 320 and 695 times, respectively.]

How to Promote Cooperation

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My original interest in game theory arose from a concern with international politics—especially the risk of nuclear war. The iterated Prisoner's Dilemma game seemed to me to capture the essence of the tension between doing what is good for the individual (a selfish defection) and what is good for everyone (a cooperative choice). Therefore, I was intrigued by the many strategies proposed to play this game effectively.

An interest in artificial intelligence led me to read about computer chess tournaments. This, in turn, led to the idea that a good way to evaluate alternative strategies for the iterated Prisoner's Dilemma would be to invite experts to submit their strategies in the form of computer programs; then I could run a computer tournament to see which one would do best.

The result was that the simplest of all submitted entries won the tournament. This was "Tit For Tat": cooperate on the first move, and then cooperate or defect exactly as the other player did on the preceding move. I next organized a larger tournament with both experts and computer hobbyists, with a total of 62 entries. The result was again a victory for Tit For Tat.

Seeing that Tit For Tat was quite robust, I developed a mathematical analysis to show how cooperation based upon reciprocity can emerge in a population of egoists (with only a small cluster of reciprocators), and then resist invasion by mutant strategies.

Suspecting that these results would have implications for evolutionary biology as well as the social sciences, I invited William D. Hamilton, a renowned evolutionary biologist, to collaborate with me on developing the biological implications of my work. This led to the article in *Science*. This article on the evolutionary biology of cooperation received the Newcomb Cleveland Prize of the American Association for the Advancement of Science.

This gratifying response encouraged me to present these ideas in a form that would make them accessible not only to biologists and mathematically oriented social scientists, but also to a broader audience interested in the conditions that can foster cooperation among individuals, organizations, and nations.

The resulting book (including the coauthored article as one chapter) has been published in eight languages. It has been used by others (1) as a basis for further theoretical work in game theory (especially by economists and evolutionary biologists), (2) as a set of hypotheses for empirical testing (in fish, birds, bats, monkeys, and nations), (3) as a source of advice on promoting cooperation, and (4) as a reading in courses on theory building in the social sciences.

I believe the work has been well cited because it fits a widespread desire to provide a "hardheaded" rationale for cooperation, because it is easy to understand, and because it is general enough to be applicable to a wide range of disciplines. My work on cooperation (along with more recent work on norms) was awarded the first National Academy of Sciences Award for Behavioral Research Relevant to the Prevention of Nuclear War.[1] Since my original aspiration was to contribute to the prevention of war, it was especially nice to be appreciated for this reason as well as for a contribution to evolutionary biology. No doubt the same work has also been instrumental in my receiving a MacArthur Prize Fellowship and in my election to the National Academy of Sciences.

For a review of work on the evolution of cooperation, see Axelrod and Dion.[2]

1. **Axelrod R.** An evolutionary approach to norms. *Amer. Polit. Sci. Rev.* 80:1095-111, 1986. (Cited 45 times.)
2. **Axelrod R & Dion D.** The further evolution of cooperation. *Science* 242:1385-90, 1988.

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