

Program for Evolutionary Dynamics, Harvard University

The Program for Evolutionary Dynamics (PED) is a multi-disciplinary research center which does cutting edge research at the interface of biology, mathematics, physics and computer science. The program consists of a team of visiting professors, research fellows and Ph-D students led by Martin Nowak, Professor of Mathematics and Biology at Harvard University.

The fundamental laws of nature are written in the language of mathematics. Our goal is to discover the mathematical principles of life. Living systems are those that have arisen by evolution and are capable of undergoing further evolution. The fundamental forces of evolutionary dynamics are mutation, selection and cooperation. Mutation generates diversity, selection drives adaptation, cooperation allows the construction of higher levels of organization. Cooperation is the architect of all major steps in evolution from the origin of life, to the emergence of the first cell, multi-cellular organisms, advanced social behavior and human language.

Our main discoveries over the last few years include:

1. Five mechanisms for the evolution of cooperation. (Natural selection is based on competition and therefore opposes cooperation; we have shown how cooperation can be victorious in a competitive world.)
2. A theory that explains the origin of evolution as a continuous transition from prelife to life.
3. The first quantitative model for the accumulation of driver and passenger mutations in cancer progression (in collaboration with Bert Vogelstein).
4. The fundamental laws that determine how population structure affect evolutionary dynamics.
5. A new theory for the emergence of advanced social behavior (in collaboration with E. O. Wilson).
6. Quantitative rules of language change.

Ever since its foundation in 2003, the Program for Evolutionary Dynamics has an impressive record of definitive scholarship. In 8 years the members of PED have produced more than 270 research papers, with 21 of those in Nature and Science (including several front covers). Three PhD students of PED were elected to the prestigious Harvard Society of Fellows. Corina Tarnita won the first prize for the best PhD thesis in mathematics. Erez Lieberman won the MIT Lemelson Prize for transformative work in linguistic and genomics. Martin Nowak won numerous awards and is one of the most highly cited scientists in theoretical biology (about 27000 citations for 310 papers; h-index 80).