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How things get complicated

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Pre-biotic evolution created something almost infinitely unlikely to have arisen by chance: reproducing entities whose many parts interact in a way that is vastly more complex and interdependent than the disorganized interactions of the inanimate objects in the surrounding environment. And yet this creation of primitive organisms was all achieved in perhaps a few hundred million years. In the January 16 Proceedings of the National Academy of Sciences, Jain and Krishna use mathematical modeling to propose that this creation event was no freak occurrence, as complexity and stability evolve rapidly and inevitably from interacting systems (*Proc Natl Acad Sci USA* 2001, **98:**543-547). Their model involves a matrix of nodes, where each node could represent a chemical, species or element of human society. The nodes are given arbitrary starting populations, and random connections, with some connections positive (node A causes an increase in the population of node B) and others negative. A link from a node to itself can only be inhibitory. After multiple iterations the nodes with the lowest populations are removed and replaced with new nodes that have new (and random) sets of connections.

The resulting networks are invariably unstable for a time, with equal numbers of cooperative and destructive links, but then suddenly the ratio of cooperative to destructive links soars ten-fold in a rapid increase in both cooperation and interdependence. This change is caused by the emergence of autocatalytic sets (ACSs), such as a loop where A increases B and B increases A. ACSs rapidly grow to encompass the entire matrix, because nodes outside the ACS are inherently unstable and so preferentially lost, whereas some of the replacement nodes are by chance connected to the ACS and thus contribute to its enlargement. A complete ACS is, however, subject to catastrophic events after elimination of an ACS node that has a low population but critical connections. Similar effects may cause catastrophic events in fields as diverse as ecology and economics.

References

1. *Proceedings of the National Academy of Sciences*, [http://www.pnas.org/]

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