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The Chemistry of Social Life

Michael Macy

How did life emerge from lifeless chemicals? A possible answer is a chemical reaction that catalyzes its own reproduction (*1*). In their edited volume, *The Emergence of Organizations and Markets*, John Padgett and Walter Powell explore the possibility that autocatalysis may also explain the genesis of social life and the emergence of novel forms of social organization. "Chemistry, especially regarding the origins of life, does not provide all of the answers, but it at least asks the right questions—for social science as well as for biology."

The Emergence of Organizations and Markets

John F. Padgett and Walter W. Powell, Eds.

Princeton University Press, Princeton, NJ, 2012. 607 pp. $120. ISBN 9780691148670. Paper, $45. ISBN 9780691148878.

The book's relational paradigm will feel familiar to readers of Harrison White [e.g., (*2*)], to whom Padgett and Powell dedicated this edited collection of theoretically integrated historical case studies. The book carries White's imprint analytically, methodologically, and stylistically, but the method the editors employ, derived from models of autocatalytic chemical reactions, is not your father's social network analysis. The book's intellectual genesis is traceable to the interdisciplinary ferment at the Sante Fe Institute, with which both editors are affiliated.

Following the editors' introductory overview, three chapters explain biochemical autocatalysis in language intended to engage social scientists. Chemical reactions can be thought of as interactions embedded in networks, with paths not only between reactants but also between reactants and the paths between reactants—an arrow that targets an arrow. A special case is an arrow from a chemical that targets another arrow that targets the chemical—an interaction that catalyzes its own reproduction. Things get even more complicated when the catalytic agent is not a single node in a single network but an autocatalytic set that overlaps multiple networks, in which no single element of the set is sufficient to catalyze itself but the sum total of the interactions becomes self-sustaining.

The remainder of the book comprises a series of detailed historical case studies (the majority authored or coauthored by one of the editors) in network autocatalysis. Although the book's analytical framework is inspired by biopoietic models of prebiotic chemical autocatalysis, the historical applications more closely resemble speciation rather than abiogenesis. The universality of DNA suggests that biotic life may have evolved from a single common ancestor, with subsequent evolutionary branching. The book's historical cases involve the emergence of new organizational forms from Renaissance Florence to the present, a process that has more in common with the subsequent branching of cellular life rather than its Eoarchean genesis. Perhaps a closer life-science parallel is not the emergence of a nucleotide chain out of prebiotic chemistry, but repeated episodes of massive evolutionary jumps in response to global environmental changes, such as the oxygen content of the atmosphere.

Early evidence of organization. Stromatolites formed by cyanobacteria biofilms.

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The editors use the case studies to illustrate "network-folding mechanisms of organizational genesis," in which parts of multiple social networks (e.g., economic, political, and kinship) are folded together in novel ways, analogous to Mendel's mechanisms that govern genetic recombination. In a quartet of chapters, Padgett considers "early capitalism and state formation." The second of these, "Transposition and refunctionality," traces the diffusion of the master-apprentice relationship from local guilds to merchant finance in Renaissance Florence, leading to a new organizational form, the business partnership. Another depicts "migration and homology" in Spanish Netherlands, where the joint-stock company can be traced to the massive influx of Protestant merchants and artisans from Antwerp. In the fourth, Jonathan Obert and Padgett explore the organizational genesis of 19th-century Germany as geographically disparate principalities under a novel constitutional troika that welded together democratic and autocratic political currents.

The next section examines "processes of organizational innovation and invention in the communist bloc through the end of the 1990s." Its opening chapter, comparing economic reform in the Soviet Union and China, discusses "robust action," which refers to efforts to keep strategic options open in the face of constraints imposed by political and organizational adversaries. Padgett shows how Deng Xiaoping initiated economic development (including market expansion and liberalization) in response to initiatives by his political opponents, through strategic applications of political patronage that encouraged entrepreneurship at the local administrative level. The chapter also describes "purge and mass mobilization," in which organizational elites are displaced by a rising core of younger officials, as in Stalin's Great Terror and Mao's Cultural Revolution.

The last and longest section takes up the development of today's science- and technology-based sectors. In "Chance, nécessité, et naïveté," Walter Powell and Kurt Sandholtz document the transposition of the life-sciences lab from the university to the business world, leading to the creation of the biotechnology firm. Turning to information technology, Lee Fleming, Lyra Colfer, Alexandra Marin, and Jonathan McPhie consider the roles of social

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networks and "regional agglomeration" in the emergence of industrial districts in Silicon Valley and Boston.

In their concluding chapter, Padgett and Powell acknowledge the absence of attention to perturbation as a source of novelty, which is an essential but empirically challenging piece of their theoretical framework. They see the "percolation of perturbations" through complex networks as the next research frontier in the program of study that they propose, and they hope their initial forays in *The Emergence of Organizations and Markets* will inspire readers across the sciences to pick up the torch. If that happens, this theoretically innovative contribution to social science will have catalyzed the regeneration of historical applications of complexity science.

References

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2. H. C. White, *Identity and Control: A Structural Theory of Social Action* (Princeton Univ. Press, Princeton, NJ, 1992).

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Business as Usual —or Not?

Robert E. Horn

Four decades ago, the furiously debated *The Limits to Growth* presented a set of computer model–based visions of the future (*1*). Its authors' views were widely dismissed until recently, when the accuracy of a great many of the findings of their standard reference scenario was recognized (*2*). The authors were also extensively but incorrectly criticized for forecasting a single future. Now one of them, Jorgen Randers, does just that in *2052: A Global Forecast for the Next Forty Years.*

To prevent being blindsided, businesses and governments ordinarily desire a group of scenarios that covers a diverse range of plausible futures. Nonetheless, the single, highly detailed depiction of our future Randers provides this time is welcome and helpful in the midst of the proliferation of climate, energy, and sustainability models, the totality of which often feels more like noise than signal. Anyone interested in the profound social, economic, political, and climate challenges confronting us will want to consider his predictions—either to agree with him or to show convincingly how their future world will differ from the one he presents.

2052
A Global Forecast for the Next Forty Years
by Jorgen Randers
Chelsea Green, White River Junction, VT, 2012.
414 pp. $34.95.
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Randers (BI Norwegian Business School) argues strongly for the impact of business as usual on our future. He believes our course over the next 40 years will be strongly shaped by five big issues: capitalism (surviving but modified); economic growth (continuing but affected by decreasing resources); democracy (holding on but with changes, some toward authoritarianism, forced by ecosystem decline); intergenerational harmony (ending as the young seek to change their lot); and climate stability (ending, but mostly after 2052).

Helpfully, Randers documents and extensively discusses the assumptions that underlie his forecast, which allows other scenario-makers to check their assumptions against his. He is extremely gifted at explicating the consequences of his assumptions, models, educated guesses, and results. And while he relies on a "backbone" of a couple of systems dynamics models (*3*), as did *Limits*, Randers uses his experience and judgment to carefully qualify and sometimes amend outcomes of the quantitative results. In this way, he allows his personality and vast experience with quantitative models to come through.

Some of Randers's predictions differ from those of most standard or reference models of the future. He expects lower per capita consumption in rich countries. For 2052, he foresees 8 billion people (a billion below the United Nations Population Bureau's median estimate). His forecast has no apocalyptic overshoot and collapse due to climate change before 2052 but posits a rapid downturn beginning very soon afterward.

In keeping with the business-as-usual perspective, we find no major discontinuities or wild cards. Rather, Randers depicts the huge momentum of industrial society and the inertia of modern thought (growth, progress, democracy, capitalism, free trade, etc.); modern life (keeping on doing what we have been doing because it is very difficult to change our personal ways); and structural aspects of society and, especially, governance. Randers's picture includes technological improvement and innovation at about the same rate as for the past 40 years. Thus, forecasters favoring more breakthrough technology and exponential growth scenarios face considerable challenges in the book's rigorous assumptions and theories of change.

After reflecting on his global forecast, Randers offers a closer view of the futures of five "regions": the United States; the remaining Organization for Economic Cooperation and Development countries; China; Brazil, Russia, India, South Africa, and 10 big emerging economies; and the rest of the world. He then compares his predictions with results from simulations using two earlier dynamic world models. His closing chapter ("What should you do?") offers 20 "pieces of personal advice" for individuals (e.g., know the problems your location is going to face), in business (e.g., distinguish between growth in volume and in profits), and in politics (e.g., seek benefits that can be gained in the short term).

One successful ingredient in the book is the inclusion of two- to four-page "Glimpses" of trends and consequences, written by 34 invited experts from around the world (e.g., Chandran Nair, Mathis Wackernagel, Herman Daly, and Catherine Cameron). Randers agrees with many of the points they raise and uses some for qualified distinction, amplification, and disagreement. This rhetorical move works well, and rather than making the book choppy, it adds liveliness and specificity.

I was surprised that Randers omitted mention of his "one degree war plan"—an investigation that described the emergency changes needed to keep civilization on a sustainable path of no more than 1ºC increase in average global temperature over preindustrial levels (*4*).

In the final chapter of *2052*, Randers advises us to "Learn to live with impending disaster without losing hope." He reminds readers, "Anyone who is the least interested knows well what must be done.… Global society needs to (a) increase energy efficiency; (b) shift to renewable energy; (c) stop destroying the forests; and (d) build carbon capture and storage." And he points out that "[a]ll of these actions are technically feasible and not particularly expensive." But in his forecast, the inertia and momentum of business as usual rule.

References

1. D. H. Meadows *et al.*, *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (Universe, New York, 1972).
2. G. M. Turner, *Glob. Environ. Change* **18**, 397 (2008).
3. The models and data are available at www.2052.info.
4. J. Randers, P. Gilding, *J. Global Responsibility* **1**, 170 (2010).

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