Chapter 4
Dynamical Disequilibrium, Transformation, and the Evolution and Development of Sustainable Worldviews

Liane Gabora
University of British Columbia, Canada

Maegan Merrifield
University of British Columbia, Canada

ABSTRACT

This chapter begins by outlining a promising, new theoretical framework for the process by which human culture evolves inspired by the views of complexity theorists on the problem of how life began. Elements of culture, like species, evolve over time; that is, they exhibit cumulative change that is adaptive in nature. By studying how biological evolution got started, it is possible to gain insight into not just the specifics of biological evolution, but also general insights into the initiation of any evolutionary process that may be applicable to culture. The authors, thus, explore the implications of this new framework for culture on the transformative processes of individuals. Specifically, they address what this emerging perspective on cultural evolution implies for to go about attaining a sustainable worldview; that is, a web of habits, understandings, and ways of approaching situations that is conducive to the development of a sustainable world.

HOW DOES AN EVOLUTIONARY PROCESS GET STARTED?

In attempting to gain insight into the origins of transformative processes in individuals, it is instructive to look at the transformative processes by which the earliest forms of life evolved. Research into how life began is stymied by the improbability of a spontaneously generated structure that replicates itself using a self-assembly code such as the genetic code. Something so complex as this is unlikely to emerge out of the blue! Hoyle (1981) infamously compared it to the probability that a tornado blowing through a junkyard would assemble a Boeing 747.

DOI: 10.4018/978-1-4666-2077-3.ch004

This has led to widespread support for different versions of the proposal that the earliest self-replicating structures were autocatalytic sets of molecules (Bollobas, 2001; Bollobas & Rasmussen, 1989; Dyson, 1982, 1985; Gabora, 2006; Kauffman, 1986, 1993; Morowitz, 1992; Segré, Ben-Eli, & Lancet, 2000; Segré, et al, 2001a, b; Wäechtershäeuser, 1992; Weber, 1998, 2000; Williams & Frausto da Silva, 1999, 2002; Vetsigian *et al*., 2006). A set of molecules is *autocatalytic* if every molecule in the set can be regenerated through chemical reactions occurring amongst *other* molecules in the set. (The term 'autocatalytic' comes from the fact that the molecules speed up or *catalyze* the reactions by which other molecules are formed.) Reactions between molecules generate new, different molecules. As the number of different molecules increases, the number of reactions by which they can interconvert increases even faster (Cohen, 1988; Erdös & Rényi, 1960). Thus some subset of them reaches a critical threshold where there is a reaction pathway to the formation of every molecule in the set.

At this point, the parts can reconstitute the whole in a piecemeal manner, through bottom-up interactions rather than top-down interpreting of a genetic code (Kauffman, 1993; for summary see Gabora, 2008). The hydrophilic (water-loving) molecules orient toward the periphery, forming a spherical vesicle that encloses the more hydrophobic (water-avoiding) molecules. This kind of spherical vesicle made up of collectively self-replicating parts is sometimes referred to as a *protocell*. It is prone to fission or budding, wherein part of it pinches off, and it divides in two. So long as there is at least one copy of each polymer in each of the two resulting vesicles, they can self-replicate, and continue to do so indefinitely, or until their structure changes drastically enough that self-replication capacity breaks down, and by that point there will exist other self-replicating sister-lineages. The process is sloppier and more haphazard than the self-replication that occurs in modern day organisms. Some raise the concern that, at least with respect to some versions of this theory, replication occurs with such low fidelity that evolvability breaks down (Vasas, Szathmary, & Santos, 2009). Nevertheless, there is broad consensus that such a structure remains sufficiently intact over generations for stable evolution (Schuster, 2010). A key thing to note here is that with this kind of self-replication there is nothing to prohibit the inheritance of acquired characteristics. A change to any one part of the structure persists after fission occurs, and this may cause other changes that have a significant effect further downstream.

Evolution of these early life forms occurs through horizontal exchange (i.e. not restricted to vertical transmission from parent to offspring) of "innovation-sharing protocols" (Vetsigian *et al.,* 2006). It was not until the genetic code came into existence—and the process in which self-assembly instructions are copied (meiosis) became distinct from developmental processes—that acquired characteristics could no longer be passed on to the next generation (Gabora, 2006). The work of Woese and his colleagues indicates that early life underwent a transition from this fundamentally cooperative process horizontal evolution through communal exchange, to a fundamentally competitive process of vertical evolution by way of the genetic code. This transition is referred to as the *Darwinian threshold* (Woese, 2002) or *Darwinian transition* (Vetsigian et al., 2006) because it marks the onset of what we think of as conventional Darwinian evolution through natural selection. Kalin Vetsigian (pers. comm.) estimates that the period between when life first arose and the time of the Darwinian threshold spanned several hundred million years.

Thus we have two kinds of self-replication (Gabora, 2004). *Coded self-replication,* such as is seen in present-day organisms, uses self-assembly instructions as proposed by von Neumann. This ensures they replicate with high fidelity, and acquired characteristics are not inherited. *Uncoded self-replication,* such as is seen in protocells, involves autocatalysis. This is a low fidelity means of replication, and there is nothing to prohibit

Related Content

Networks: A Sketchy Portrait of an Emergent Paradigm
Alessandro Giuliani (2013). *Complexity Science, Living Systems, and Reflexing Interfaces: New Models and Perspectives (pp. 184-195).*
www.irma-international.org/chapter/networks-sketchy-portrait-emergent-paradigm/69461

Artificial Mind
Rita M.R. Pizzi (2008). *Reflexing Interfaces: The Complex Coevolution of Information Technology Ecosystems (pp. 83-93).*
www.irma-international.org/chapter/artificial-mind/28373

Riddle of the Sphinx: Paradox Revealed and Reveiled
Terry Marks-Tarlow (2008). *Reflexing Interfaces: The Complex Coevolution of Information Technology Ecosystems (pp. 21-32).*
www.irma-international.org/chapter/riddle-sphinx-paradox-revealed-reveiled/28369

Antimonotonicity, Crisis, and Route to Chaos in a Tumor Growth Model
Dionysios Sourailidis, Christos Volos, Lazaros Moysisand Ioannis Stouboulos (2021). *Handbook of Research on Modeling, Analysis, and Control of Complex Systems (pp. 583-596).*
www.irma-international.org/chapter/antimonotonicity-crisis-and-route-to-chaos-in-a-tumor-growth-model/271055

Social Responsibility: A Crucial Knowledge and Ethics
Matjaz Mulej, Vojko Potocan, Zdenka Zenko, Anita Hrastand Tjasa Strukelj (2011). *International Journal of Knowledge and Systems Science (pp. 21-38).*
www.irma-international.org/article/social-responsibility-crucial-knowledge-ethics/61132