Cybernetics And Human Knowing, Vol.7, no.1, 2000, pp. 21–43

Thermodynamic Cycles, Developmental Systems, and Emergence

Bruce Weber[1] and Terrence Deacon[2]

Abstract: The problem of evolutionary emergence is particularly well exemplified in the theories of the origins of life and of language. To adequately address these evolutionary problems requires not only deploying the full resources of biological science but also developing a general theory of emergent phenomena that treats biological information and natural selection as derived, not primitive, features. Currently popular approaches that give genetic reductionism and computational analogies primary roles in their description of the essential organization that constitutes life or mind, ignore the role of self-organization and self-reconstitution in epigenetic systems except as mere expressions of adaptive genetic information. The present approach partially inverts this perspective. We show how use of complex systems dynamics, in the context of developmental systems theory, can provide a general account of evolutionary emergence, in which distributed systemic features can serve as the precursor to localized information replication mechanisms and the natural selection processes these can be come enmeshed in. Following ideas explored by Weber and Depew (1996; and Weber 1999), we first apply this approach to the problem of the origin of life. In this hypothesis genetic information emerges as an artifactual molecular re-presentation of the distributed process regularities and self-organization of a dissipative thermodynamic system. The evolution of the dependence of the thermodynamic self-organization of cells on the genetic re-presentation of aspects of these processes, and vice versa, arises spontaneously as this informational redundancy masks selection and causes a partial degradation of the autonomy of component processes. These same fundamental principles are also seen in some ways of construing the Baldwin effect and its role in mental evolution. Understood more generally as a between-levels evolutionary dynamic in which higher order regularities influence lower-order component dynamics, this effect can be seen as a critical contributor to emergent transitions in many aspects of evolution. Following Deacon's (1997) argument that the co-evolutionary emergence of brain and language was driven by Baldwinian processes, the present analysis suggests that the emergence of symbolic communication in human evolution greatly amplified this top-down influence so that it became the dominant factor driving the evolution of human cognition. In summary, the Baldwin effect might not be an anomalous variant of natural selection but rather one example of a class of general mechanisms for evolutionary emergence that can be applied across levels from the origins of life to the origins of the human mind.

[1] Department of Chemistry and Biochemistry, California State University, Fullerton

[2] Department of Biological Anthropology, Boston University