Dynamic notions of emergence: interplay of entropic driving principle and environmental/genetic constraints over the hierarchy of life

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Abstract

Emergence and Downward Determination in Biological Systems? (Naoki Sato, Toshiyuki Nakajima, Shunkichi Matsumoto)
Life and mind are considered as good examples of emergence. As Malaterre (2010) discussed in his book, there are different notions of emergence, synchronic/diachronic or epistemic/ontological. Recent developments in biophysics revealed a new type of synchronic ontological emergence in complex systems. Synchronic emergence, in general, involves phenomena at two different levels. A structural organization at a higher level appears to result spontaneously from complex dynamics at a lower level. Bénard convection is a classical example, in which a simple mechanical causality between heat flow and convective structure is not apparent. The convection is instead a result of a conflict between thermal non-equilibrium and gravitational constraint. This, in turn, may suggest that the notion of levels is relative to conflicting forces, and that emergence should be considered in a dynamic context.
This physical model can be extended to biological models, in which internal entropic force and environmental constraints conflict with each other. I suppose a universal entropic driving force ("inhomogeneity" or Brillouin's "order") in the forms of free energy, spatial disequilibrium, or genetic information, which ultimately originates from the sunlight and drives all biological phenomena throughout various levels (*Entropy* **14**, 233-251, 2012). We can discriminate biological systems from non-biological ones by genetic information, a form of inhomogeneity, which provides an additional constraint over the metabolic free energy to produce reproducible "self-organized" structures. Such dynamic interplay between internal motive force and the environmental/genetic constraints is a general feature of biological systems, which will overcome classical controversy on emergence.

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