

## Life in time: the missing temporal dimension in autopoiesis

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There is a widespread view in the artificial life community that life is not so much about materiality but about organization. However, one of the favourite candidate theories that explain what this organization should be like has an ambivalent position with respect to materiality. This is the theory of autopoiesis (Maturana and Varela, 1980, *Autopoiesis and cognition*, D. Reidel). Accordingly, autopoiesis is the self-production of a unity in the domain of processes of material construction, transformation and destruction. The identity of the living system, in this view, is sustained in its form in spite (or rather because) of its material flux.

This notion seems to imply an inherent temporal dimension to autopoiesis. It is, intuitively, a dynamical concept. However, because of its insistence on a set-theoretic focus on conservation of autopoiesis, the theory says little about the temporality of life (leaving relevant phenomena such as stress, fatigue, pathologies and development untouched).

Efforts have been made to bring thermodynamic material constraints into the theory of autopoiesis (Ruiz-Mirazo and Moreno, 2004, *Artificial Life*, 10, p. 235). The implications are not trivial, nor are they foreseen in the theory as postulated in the original literature and interpreted purely in formal terms. One immediate consequence of realising autopoietic organizations in dissipative physical structures far from equilibrium is that there is an obvious time arrow introduced into the process of life: the arrow of thermodynamics. Bare autopoiesis, paradoxically, does not present us with a similar time arrow (a time-reversal thought experiment leads to this conclusion).

But this temporality belongs to the nature of dissipative processes and is in some sense only inherited by life because such material processes constitute it.

I shall argue that living systems enjoy a different kind of temporality, given by their own interactive and teleological organization. This temporality is richer and different from that of the background time's arrow — it is a consequence of expanding the theory of bare autopoiesis with the notion of adaptivity, (Di Paolo, 2005, *Phenomenology and the Cognitive Sciences*, 4, p. 429). This temporality is characterized by intentional direction, minimal granularity, rhythmicity, and the presence of historical transitions (in behaviour and development). It belongs to the organization of an adaptive autopoietic system under precarious circumstances.

It is conceivable that this temporality could emerge even if the system were not subject to thermodynamical constraints since it is a consequence of the higher order relations between interactive and constitutive aspects of self-maintenance. It is also conceivable for aspects of the temporality of life to contradict the temporality of the thermodynamics time's arrow, since the temporality of life is inherently related to its intentionality. Even at a minimal level, a living system may retroactively alter the virtual possibilities of the past through its sense-making activity in the present.