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Comment

# Ontologies of life: From thermodynamics to teleonomics Comment on "Answering Schrödinger's question: A free-energy formulation" by Maxwell James Désormeau Ramstead et al.

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In a far-reaching essay, Ramstead and colleagues [1] offer an answer to Schrodinger's question "What is life?" [2] framed in terms of a thermodynamic/information-theoretic free energy principle. In short, "all biological systems instantiate a hierarchical generative model of the world that implicitly minimizes its internal entropy by minimizing free energy" [1]. This model generates dynamic stability—that is, a recurrent set of states that constitute a dynamic attractor. This aspect of their answer has much in common with earlier thermodynamic approaches, like that of Prigogine [3], and with the metabolic self-organization central to Maturana and Varela's notion of autopoiesis [4]. It contrasts with explanations of life that emphasize the mechanics of self-replication [5] or autocatalysis [6,7]. In this approach, there is something gained and something lost. Gained is an explanation and corresponding formalism of great generality. Lost (or at least obscured) is a way to understand the "teleonomics" [8], goal-directedness, purposiveness, or agency of living systems—arguably, precisely what makes us ascribe the quality of "being alive" to an organism. Free energy minimization may be a necessary condition for life, but it is not sufficient to characterize its goals, which vary widely and, at least at the level of individual organisms or populations, clearly can run counter to this principle for long stretches of time.

In place of an account of teleological organization, Ramstead and colleagues argue that "organisms can be described in terms of a (high dimensional) phase space induced by hierarchically nested Markov blankets." They substitute the variational principle of Lagrangian mechanics for the explicitly teleological organization of cybernetics [9]. Of course, insofar as each level of the hierarchy is driven by the same process of minimization, it may replicate the hierarchical structure of goals, plans and feedback loops that characterize teleological control systems [10]. Moreover, the model has the potential to make specific predictions, at least when presented with alternate trajectories or models for which entropy and free energy can be measured. But determining the correct measure of entropy in complex systems can be difficult. Indeed, this relates to basic questions about dimensionality that are unresolved by their generic account. What is the right dimensionality to characterize the state space of a specific kind of living organism?

In the case of human life, this question is particularly challenging because, in the course of constructing our own ecological niche, we can change the dimensionality of the organism-environment system. Moreover, we can choose not to minimize our own free energy (and entropy) but to minimize that of a shared niche, group, or cooperative

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system, even at our own expense. In so doing, we enlarge the Markov blanket that bounds the states that determine our own behavior. This is the notion captured in arguments for extended mind [11]. In effect, humans can work collaboratively to extend their Markov blankets beyond their individual boundaries to include new aspects of the environment, including groups of other humans. They can pack up and move this enlarged boundary and re-erect it like a tent on new ground, creating a designer niche that allows them to occupy previously inhospitable terrain, remaking into a habitable environment.

More than this, the humanly co-constructed social world can function less like a blanket or moveable tent, than as a flag—that is to say, a marker planted somewhere in a heretofore unbounded domain that creates a new gradient, causing self and others to orient themselves toward the symbol as center, and work cooperatively to create new boundaries. In the process, individuals expend energy, at times increasing their own entropy, in the service of the collective. In rudimentary form, this function of orientation is shared with other forms of life, but human symbolic cognition and communication allow such actions enormous reach. Engaging with others, moving the tent or planting a flag, all invite exploration of parts of the adaptive "fitness landscape" we would not otherwise discover as individuals bound to our own cognitive frames and behavioral repertoires [12].

The upshot is that we need not just one answer to Schrodinger's question but several—reflecting the different forms of life of different species, cultures and communities. Life as we know it, depends not only on a self-propagating and evolving autocatalytic biology [7], but equally on modes of collaboration that result in generative hierarchies that can find new sources of free energy and sinks for entropy. When organisms like humans create new fitness landscapes, we end up with historically contingent trajectories that may be exquisitely sensitive to initial conditions [13].

In such circumstances, as Prigogine [3] suggested, scale matters because it determines the extent to which spatially or temporally distant factors can influence the process of 'self'-organization. Changes in temporal and spatial scale thus, may result in dimensional differences. Indeed, to the extent that these distal processes are humanly constructed, it is fair to ask how far we need to extend the Markov blanket in space (to include others and the environment) and time (to include historical contingencies and consequences). Characterizing these timescales has implications for the size of the niche needed to give an account of human activity and the sorts of processes that are relevant.

For a start, we can distinguish evolutionary, co-evolutionary, historical, biographical, and quotidian timescales [14,15]. If the minimization of free energy occurs not only within the skin of the individual but across larger boundaries that reflect socially cooperative activity, then human forms of life are deeply embedded in contingent histories of relationships and institutions. Information from a socially and culturally constructed world, populated by other minds and agents can provide knowledge, signals, and affordances that reach up the hierarchy to install higher order priors that shift the goals and metrics of fit that govern behavior [16,17].

The metaphor of the Markov tent is meant to draw attention to two features of human life: (1) its dependence on the social group or community brought together to cooperate under the tent; and (2) the portability of the group—the sense in which it is possible for any group of individuals to pull up stakes and move to new terrain to establish a new way of life. The metaphor of the flag stands for the process of bringing people together around an external symbol that reorganizes priorities by mobilizing affective meaning (allegiance to the flag) that may transcend more immediate goals of free energy minimization. The metaphor of the flag reminds us that symbols orient human activity, leading people to organize themselves in ways that draw new boundaries. While the metaphors of tents and flags are not systematic or easily formalized, they draw attention to the distinctive dynamics of human life, which are irreducibly social and symbolic.

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