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A New Criterion for Demarcating Life from Non-Life

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Abstract Criteria for demarcating life from non-life are important for deciding whether new candidate systems, either discovered extraterrestrially or constructed in the laboratory, are genuinely alive or not. They are also important for understanding the origin of life and its evolution. Current criteria are either too restrictive or too extensive. The new criterion proposed here poses that a system is living when it is capable of utilizing active causation, at evolutionary or behavioural timescales. Active causation is produced when the organism uses an estimate of its own Darwinian fitness to modulate the variance of stochasticity that drives hereditary or behavioural changes. The changes are subsequently fed back to the fitness estimate and used in the next cycle of a feedback loop. The ability to use a self-estimated fitness in this way is an evolved property of the organism, and the way in which fitness is estimated is therefore controlled and stabilized by Darwinian evolution. The hereditary and behavioural trajectories resulting from this mechanism combine predictability with unpredictability, and the mechanism produces a form of self-directed agency in living organisms that is absent from non-living systems.

Keywords Active causation · Agency · Darwinian evolution · Definition of life · Spontaneity

Introduction

General criteria for demarcating life from non-life are important for several reasons (Cleland and Chyba 2002). First, they may help to recognize life if it is discovered on other planets than Earth and if its composition and function differ strongly from those of life on Earth. Second, they may help efforts to produce artificial life in the laboratory (Stano and Luisi 2010), and may be used to evaluate to what extent those efforts are successful. And third, they may assist studies that aim to understand the origin and evolution of life on Earth.

There is currently no consensus on what would constitute sufficient and necessary criteria for establishing that a system lives (Bedau 2007; Tsokolov 2009; Benner 2010). It is clear that various properties are important, specifically material and physical requirements, requirements with respect to heredity and information, and requirements with respect to system integrity and autonomy. An example of a physical requirement is that some form of metabolism is needed

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