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BOOK REVIEW

Pierre M. Durand, *The Evolutionary Origins of Life and Death*, Chicago & London: The University of Chicago Press, 2021

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Ursula K. Le Guin famously wrote that 'only in dying life'. This sentence could be considered a perfect summary of the core idea of Pierre Durand's new book, *The Evolutionary Origins of Life and Death* (*EOLD*, hereafter). *EOLD* constitutes an impressive effort to integrate into a unified and coherent framework different and dispersed pieces of empirical work about how life and death emerged on Earth, and about how these two phenomena coevolved to become deeply entangled. As Durand acknowledges, investigating these two phenomena requires a perspective that combines data from bioinformatics, computational simulations, genetics, experimental biology, and philosophy. The real challenge of formulating a unified framework like the one that Durand aims to offer lies in making coherent the different pieces of evidence and the relatively local pieces of knowledge that each of the aforementioned disciplines provide. What is the conceptual nexus connecting Gánti's chemoton, the theory of evolutionary transitions in individuality, and the organisational conception of life? *EOLD* takes on this challenge as its point of departure, and in doing so it takes the reader on an interesting and philosophically rigorous exploration in which molecular details are entangled with a deep knowledge of evolutionary models. At its core, the book underlies the importance of distinguishing the traits the biological world has produced as real adaptations (be it a consequence of kin or group selection) from the traits that constitute a by-product of the way in which certain lineages evolved (be it cases of pleiotropy, genetic drift, etc.). This last point is especially relevant for Durand's discussion of the evolution of death.

EOLD is divided in three parts, introduced by a short Foreword by Eugene V. Koonin, and concluded with a short, but stimulating Postface. Part One (pp. 7–70), which comprises chapters 1 to 7, investigates the origin of life from an evolutionary,

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and not merely a mechanistic, point of view. As Durand declares in a paragraph that could have perfectly been written by anyone working in the tradition of process philosophy: "From a mechanistic point of view, all the component parts that are mentioned as being a part of living systems, are essential. […] The quintessential feature, however, is the *process* that gave rise to life (the emergent property) rather than discrete events or whether one type of substance was more important than another" (p. 15). This emphasis on the *process* that originated life, and the step(s) in it, rather than on the set of discrete entities that originally appeared, percolates this part of *EOLD* to the point that the origin of life is equated to the origin of the properties of heritability and variance in fitness, which allow evolution by natural selection to take place. This way of addressing the origins of life impregnates Durand's thesis with the necessity of adopting an integrated plurality of perspectives. In the end of this part, Durand suggests that the origin of life should be thought of as an evolutionary transition in individuality, where group selection played a major role.

Part Two (pp. 71–146) investigates the origins of death. It comprises chapters 8 to 14, and it is in my view the most stimulating part of the book. It is important to note the key paradox that Durand is addressing here: we can understand how life appeared, and we can understand that life may cease to exist when certain extrinsic or environmental conditions are not favourable (e.g. predation). However, living creatures also contain genes that can trigger their own self-destruction in a phenomenon called *programmed cell death* (PCD, hereafter). The question addressed in Part Two is why PCD evolved. Why did living beings evolve mechanisms that lead to their self-destruction, and why were these not eliminated by natural selection? Durand formulates the necessity of addressing PCD as an *evolutionary* problem (the interested reader should also consult P. M. Durand & G. Ramsey (2019) The Nature of Programmed Cell Death. *Biological Theory* 14: 30–41). Durand contends that many researchers explore PCD mechanistically, but he convincingly argues that a purely mechanistic approach to PCD leaves the fundamental question unanswered: when is a case of PCD an adaptation and when is it a by-product of evolution? In most cases, PCD will be realized by *the same mechanisms*, but knowledge of these mechanisms will reveal very little about whether they had *the same history* across different lineages; i.e. about *why* these very mechanisms are there. Durand stresses the importance of distinguishing between adaptive (or *real*) PCD and ersatz (or non-adaptive) PCD. Moreover, he discusses several cases where PCD has evolved as an adaptation that benefits kin (kin selection), as well as cases where it is an adaptation that evolved to benefit the group (group selection). Cases of the latter have major evolutionary significance, since group selection has been severely contested as biologically unfeasible. Yet Durand persuasively shows that some examples of PCD are in fact group adaptations. Again, as in the origins of life, group selection has played a fundamental evolutionary role in the origins of death.

Part Three (pp. 147–168) comprises the last two chapters, where the author connects the topics raised in the previous parts by postulating that life and death may have coevolved. This part, although not as elaborated as the rest of the book, is very stimulating, for it suggests the possibility that some of the biomolecules and mechanisms that are involved in PCD were also involved in the origins of life, or at least, in some key transitions in life. This is because PCD may be a mechanism to enhance group-level viability by mediating the conflicts between levels and reinforcing the division of labour that favours group-viability. Durand illustrates this with the endosymbiotic origin hypothesis

of eukaryotic cells, the evolution of multicellularity, and the evolution of social organisms. In these three cases, he shows that PCD may be a good mediator between different evolutionary interests of the partners involved, especially since PCD can sometimes be triggered by other organisms. This possibility may have been fundamental in the origins of multicellularity, as it prevents the spread of cheaters. This line of research would appear to have deep implications for some conceptions of the evolution of multicellularity. Multicellularity may have evolved not primarily as a result of kin selection, but rather as a result of the possibility that a group of cells is tied together because any effort to cheat would be contested by triggering their PCD. This, in turn, may have generated the tendency to homogenise the group of cells, and subsequently kin selection may have become a dominant force. Yet, before that, the possibility that PCD created for group selection may have been key in certain lineages; hence 'Only in dying life'.

Before concluding I want to briefly comment on the Postface, as it mentions one of the topics that I have worked on more deeply. In it, Durand states: "the levels-of-selection debate in PCD will likely enter a new phase, where holobionts are considered a bona fide unit of selection […] and that the PCD trait can be maintained when the holobiont is an inherited condition as opposed to an acquired one" (p. 170). When I read Part Two, and especially when I read that PCD can sometimes be triggered by other cells, I wondered whether the holobiont may not be a case in which cohesiveness is maintained in part because the host has the capacity to trigger PCD in the microorganisms that compose it. Research shows that the microbiome is ecologically stable during a holobiont's lifetime, and it is only altered in cases of severe infection. Additionally, it has been shown that ecological competition among members somehow helps maintain this stability, with the host acting as a leash that keeps the game going. The question is how this competition is exactly exercised. An intuitive response based on our current knowledge suggests that this is due to resource allocation. Still, if Durand is right about PCD, one wonders whether PCD may be a mediating trait between the members of the holobiont. Whether this is true or false is, however, open to empirical research.

Overall, *EOLD* is a thought-provoking book that will be read profitably not only by those interested in the origins of life and death, but more generally by anyone interested in the relationship between kin and multilevel selection, the differences between processual (or historical) and mechanistic thinking in the life sciences, and the major transitions in evolution. The evidence presented in *EOLD* is amenable to careful philosophical scrutiny and—adequately analysed in terms of contemporary debates in philosophy—it could potentially be used to inform and advance new arguments in favour of certain views, such as why historical reasoning matters and is not reducible to mere biochemical analysis, or why looking at processes instead of the entities carrying out these processes allows us to expand our views of the natural world. In conclusion, *EOLD* is a must-read for biologists, philosophers of biology, and other philosophers of science aiming to analyse how disciplinary integration works, how different types of explanations are built, and why the metaphysical views of the world scientists hold condition the type of research they carry out.