Dynamic Energy Budget Theory: Reaching Consilience Between the Physical and the Biological Sciences through an Axiomatic Theory for Metabolism

Prof. Tiago DOMINGOS

Environment and Energy Section, DEM, Instituto Superior Técnico, Lisbon, Portugal
E-mail: tdomingos@ist.utl.pt

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In contrast to what have been frequent statements in the ecological literature, DEB theory has shown that it is possible to obtain a unified mathematical theory for biology, similar to physical theories. At the same time, DEB has attained this aim by establishing a theory which is compatible with physical constraints, again something which is frequently disregarded in biology, thus ensuring Edwards Wilson's aim of consilience between the sciences.

Building on a recent axiomatic formalisation of DEB theory (Sousa, T., T. Domingos, S. A. L. M. Kooijman, 2008, From empirical patterns to theory: A formal metabolic theory of life, *Philosophical Transactions of the Royal Society of London B* 363: 2453–2464), here we show that DEB theory can be built from 1) the fundamental thermodynamic constraints that all processes obey mass and energy conservation but lead to entropy production, 2) a physical assumption of quite general applicability, that local flows are proportional to differences in intensive variables (and, hence, total flows are proportional to surface areas), 3) a biological assumption, that cells are metabolically very similar, independently of the organism or its size, and, 4) in a "systems theory" type of approach, an application of Occam's razor, in always choosing the simplest possible formulation of a mathematical theory (minimize the number of state variables; choose linear over non-linear functions; minimize the number of parameters).

Having condensed DEB theory in this compact definition, we then show how these fundamental assumptions lead to the strong and weak homeostasis principles, and then to partitionability of reserve dynamics and the reserve dynamics itself. With this, we obtain the von Bertallanfy growth curve and Kleiber's rule, for intra- and inter-specific comparisons.