Review of: "Micro- and Macroevolution: A Continuum or Two Distinct Types of Change?"

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This article is better understood and analysed if seen as a virtual (digital) experiment. Its workbench will become clear soon. The phenomenon addressed in the experiment, however, is not simple nor monolithically understood by researchers. Nevertheless, evolutionary theories seek to explain important natural processes which can be rephrased as follows. (Citations in numbers refer to references in the article. My own comments are supported by the references listed at the end of these comments and are not explicitly cited. Improvements introduced by the authors in the 25/04/2024 version are commented in parenthesised notes.)

As the number of atoms on Earth of each kind is essentially fixed, though abundant, the unbounded diversity of living components and organisms (together with their enormous potential for unrestricted growth) can only result either from assembling and disassembling aggregates of more basic elements, like atoms, molecules, and molecular complexes, or from recycling molecular organisations through re-organisation processes. This building-and-destroying game, or Life, is a collective phenomenon performed by Nature with the aid of organisms, which are themselves organisations with many parts. Events (changes) in this picture result from re-arranging and exchanging parts of organisations and are driven by interactions between its elements or between its elements and stimuli either internal or external to them. Organisms and viruses are also the utmost guardians and reservoirs of living organisations. Certainly, it is utterly important for biologists to understand how constellations of organisations entail each other; how they change along time; how entailments lead to novel organisations; and how organisations enter stasis, become resilient, and develop spacio-temporal traits.

The *phenomenon* called evolution occurs over this ever-changing landscape. It requires, though, an element strange to this backcloth — the concept of *evolving,* which is a human idea(l). It further requires the ability to*compare* biological entities, stating that ‘A’ is more (or less) evolved than ‘B’, or that ‘B’ evolved from ‘A’. This can only be done by observers outside this backcloth, with a global and integrative perception of it. Evolution is an evaluation and *interpretation* of patterns of traits, facts, or processes, and is also anthropocentric. Can automata (or non-human living entities, by the way), as intelligent and rational as feasible, declare that ‘A’ is more evolved than ‘B’? In the case that a complexity measure for organisations exists, automata could possibly compare them, stating that one is more or less complex than another, even when the organisations are not easily comparable, like cells and birds, for instance. But, is there any manner of comparing ‘evolved’? Birds are made of cells, certainly, but which one is more evolved, and in which sense? Theories are grounded on observations, and observing presupposes choices and limitations. Observations for macro-evolutionary theories are grounded on perception and judgement rather than on immediately observable natural traits, adding a new layer to scientific explanations. Many of the controversies discussed in *section 5* come from a fuzzy perception of this distinction by the scientific community, intermixed with inexplicit feelings about the Aristotelian fourth clause. Nonetheless, evolutionary theories search to disentangle and explain what we may consider Nature's experimentation with organisations, and should be highly valued for that.

The previous paragraphs account for my reading of *section 1*, being also an overview of its underpinnings as I see them. Tools for studying evolutionary phenomena, particularly if devoid of subtle connotations associated with the term 'evolution', are consequently of great relevance to understand life and support a deeper treatment of our perceptions about biological evolution. The authors suggest improving neutrality while inspecting micro- and macro-evolution through virtual experiments, and I completely endorse their initiative, motivations, and investigations. The virtual workbench chosen by them includes the theory of generic systems, systems of variable structure (that are effectively collections of systems), and simulations of virtual (digital) amoebae populations varying through replication and random variation. The chosen workbench and tools are described in *section 2* of the article, the experiment itself of comparing evolutionary theories in *section 3*, while *section 4* enrolls the procedures used to exemplify, validate, justify, and interpret the (theoretical) moves in the previous sections. *Section 5* conspicuously contains an evaluation of the gain in knowledge provided by the experiment and plans for further experimentations, but includes also justifications of several options made in *sections 2, 3*, and *4*. This somewhat buries part of their reasoning and makes the lights of their message blurry. I wish the authors could reorganise the text to lay this more clear. (The modifications introduced by the authors in consequence of other reviews greatly improved the readability of *sections 3* and *4*, particularly *3.1*. However, long clarifying examples could be moved into notes or appendices.)

My main criticism (not an objection) of the authors is that, by binding knowledge about systems exclusively to references [3, 4], they failed to profit from the vast wealth of concepts, tools, and understanding that current systems science provides to support and improve essays like theirs. The above references are paramount and seminal, having given birth to systems science. However, their contents were written before 1962 (see the foreword of [4]). During the three subsequent decades, their authors, Ashby at least, and other brilliant researchers sharpened, widened, and enlarged our knowledge about systems and the state of systems in important ways. For instance, vectors have components that may be variables or parameters, while dimension is something else; variables reflect the system's behaviour (evolution) while parameters are attributed by the experimenter to control the experiment and are not supposed to vary during observation; the system's state is a collection of information that allows foreseeing the system's propensities and behaviour in the near future — writing it as a vector being but a convenience. Moreover, other concepts have been developed that can be of enormous help in understanding and handling systems of variable structure, which indeed include the authors' second-order change as a special case, as well as the important broken bridges [1,2] alluded to in the Introduction. Some of these concepts are: interaction graphs, of which trophic webs and biochemical networks are particular cases, observability, controllability, critical behaviour, objectives, and attraction basins.

Adding this basic understanding to their background amounts to grasping concepts, requires no mathematical skill or manipulation, and could greatly simplify and enhance the expression of their ideas throughout the paper, illuminating their goals, widening the reach of their effort, and clarifying the switching from first- to second-order change. For instance, why second-order evolution arises exclusively from the addition of new genes and cannot result from swapping a gene/allele for a new one, or even losing a collection of inefficient genes, analogously to our rear molars? The present evolutionary landscape has more shades of grey than the macro- and micro-evolution black-and-white picture described suggests. The concepts they missed could allow for a more encompassing treatment of the many evolutionary procedures identified today. They *shouldn't, though, become mathematicians or mathematically oriented* but find a willing collaborator skilled in system science instead, which transcends mathematics a little. Also, for the readers' benefit and the impact of their work, they could be more clear about the moves, decisions, and justifications in *sections 3* and *4*, as well as portions of *section 5*. (And more clear about what *evolution* means to them.)

Bibliography: The above comments are grounded in the publications below and references contained in them:

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