

Peer Review

Review of: "Aging as Cybernetic Attractor Decay: Beyond the Stochastic-Programmed Dichotomy"

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Summary and overall assessment

This manuscript presents a conceptual and theoretical commentary arguing that aging should be understood neither as purely stochastic damage accumulation nor as genetically programmed senescence, but rather as cybernetic attractor decay within hierarchical information-processing networks established during development. The author reframes molecular aging clocks, rejuvenation, and developmental gene enrichment through a computational and cybernetic lens, emphasizing attractor drift, loss of regulatory fidelity, and entropy increase in biological networks.

The paper is ambitious and intellectually stimulating, drawing on ideas from aging biology, developmental biology, cybernetics, information theory, and evolutionary theory. It offers a unifying narrative that may appeal to readers interested in systems-level interpretations of aging.

However, while the manuscript is thought-provoking, it currently falls short of the standards required for publication as a commentary without substantial revision. Its primary weaknesses are insufficient operational definitions, rhetorical overreach, and limited engagement with existing quasi-programmed and systems-aging literature.

Recommendation: Minor and major revision required

Major strengths

1. Conceptual originality and synthesis

The manuscript attempts a genuine synthesis between stochastic and programmatic aging frameworks by reframing both within a systems-level computational architecture. The notion that aging clocks

reflect drift from developmentally established attractors is conceptually appealing and aligns with emerging systems biology perspectives.

2. Timely engagement with aging clocks and rejuvenation

The discussion of epigenetic clocks, partial reprogramming, and rejuvenation is relevant and well-motivated. The manuscript correctly highlights that simple damage-accumulation models struggle to explain clock precision and reversibility.

3. Clear narrative thread

Despite its density, the paper maintains a coherent argumentative structure, progressing from critique of dichotomous frameworks to presentation of an alternative explanatory model.

Major concerns

1. Lack of formal definition and testable structure

Although the author repeatedly invokes terms such as cybernetic computation, computational fidelity, attractor landscapes, and regulatory entropy, these concepts remain largely metaphorical rather than operational. Several practical editorial revisions are needed:

- Clarify scope early: Explicitly state that the article offers an interpretive framework for existing aging data rather than proposing a new aging mechanism or theory.
- Simplify and anchor terminology: Tie abstract terms (e.g., computational drift, attractors, regulatory entropy) directly to familiar biological processes such as loss of gene-regulatory precision and epigenetic instability.
- Focus on relevance to aging research: Emphasize how this framework helps interpret epigenetic clocks, rejuvenation, and developmental gene enrichment, rather than broader philosophical claims about life as computation.

2. Overstatement of novelty relative to existing literature

The manuscript presents the proposed framework as a decisive transcendence of prior models, but some ideas in the manuscript closely overlap with the 'quasi-programmed aging' model. These connections are insufficiently acknowledged or critically compared. As written, the paper risks reinventing or renaming existing concepts rather than clearly distinguishing its contribution.

3. Rhetorical tone and pole-framing

The critique of Meyer et al. is rhetorically strong but at times overly adversarial and philosophically charged. Phrases suggesting “false dichotomy” may be appropriate for a commentary, but they sometimes substitute assertion for demonstration.

Minor concerns

1. The introduction is conceptually strong and well grounded in both historical and contemporary aging theory, but it opens too reactively by foregrounding critique of Meyer et al. before clearly stating the paper’s own unifying insight. Beginning with the empirical paradox of predictable yet reversible aging would better orient a broad readership and make the proposed cybernetic attractor framework feel generative rather than primarily corrective. I would suggest an opening that foregrounds the central empirical paradox rather than beginning with a critique of Meyer et al. For example:

“Aging follows remarkably predictable molecular trajectories across individuals and species, despite arising from inherently stochastic biological processes, and these trajectories can be partially reversed by developmental reprogramming, challenging both pure stochastic damage models and strong notions of programmed senescence.”

2. Redundancy and length

Several arguments (especially regarding Weismann and programmatic vs stochastic aging) are repeated with minor variation. The manuscript could be shortened without loss of content.

3. Citation balance

The reference list is weighted toward classical theory and a small number of modern studies. Engagement with recent systems-aging and epigenetic instability literature would strengthen credibility.

4. The citation of Claude Shannon (1948) is problematic, as *A Mathematical Theory of Communication* is a purely mathematical framework for signal transmission and entropy and does not address biological computation, teleology, or purposive information processing. Its use here therefore exceeds the original scope of the work. To strengthen the argument, the authors should either (i) restrict the claim to Shannon’s formal definition of information and clearly state its limitations in biological contexts, or (ii) replace this citation with literature that explicitly bridges information theory and living systems (e.g. work on cybernetics, biological control, or information processing in biology).

Declarations

Potential competing interests: No potential competing interests to declare.