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Peer Review

Review of: "Fractal Biology — Evolution from Molecular to Cognitive, and Psychological Dimensions"

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This review presents an ambitious and interdisciplinary synthesis attempting to unify fractal symmetry across physical, molecular, neural, cognitive, and psychological domains under a space–time symmetry and relativity (STSR) framework. The manuscript's strength lies in its breadth: it integrates literature from fractal physics, molecular assembly, cytoskeletal organization, neuronal morphology, physiological dynamics, immune systems, perception, cognition, and environmental psychology. The attempt to trace fractal determinants across hierarchical biological levels—from protein aggregation and actin cytoskeleton organization to pyramidal neuron morphology and cognitive laterality—is conceptually intriguing and intellectually bold. The extensive referencing demonstrates deep engagement with both classical fractal theory (e.g., Mandelbrot) and contemporary biological literature.

However, the manuscript currently reads more as a speculative philosophical synthesis than as a structured scientific review. Several major issues should be addressed:

Conceptual Overextension and Causality Claims

The manuscript frequently implies mechanistic continuity (e.g., transfer of chirality/fractality from elementary particles to cognition) without providing direct empirical evidence linking these levels. Assertions of hierarchical "transfer" of fractality require either mechanistic models or clearly stated hypotheses rather than declarative conclusions.

Lack of Operational Definitions

"Fractality," "space-time symmetry," and "transfer" are used across scales without consistent quantitative definitions. The review would benefit from specifying measurable fractal metrics (e.g., box-counting dimension, power-law scaling, Hurst exponent) and distinguishing geometric fractals from statistical self-similarity in temporal signals.

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Insufficient Critical Evaluation

The review largely compiles supporting evidence but rarely discusses contradictory findings, methodological pitfalls in fractal analysis (e.g., scaling window selection, false power-law detection), or debates regarding the biological meaning of fractal dimensions.

Imbalance Between Physics and Neuroscience

Extended discussion of string theory, gauge theory, and cosmology may distract from the neuroscience focus unless clearly tied to empirical biological findings. The physics sections should either be condensed or explicitly connected to testable biological predictions.

Disease Implications Need Evidence

Statements linking fractal disruption to psychiatric, neurodegenerative, or immune disorders require clearer citation of quantitative studies demonstrating altered fractal metrics in disease states.

Structure and Clarity

The manuscript would benefit from clearer sectional organization (e.g., Molecular Fractality, Cellular Fractality, Neural Networks, Cognitive/Perceptual Fractality, Clinical Implications). Some paragraphs are dense and philosophically framed rather than analytically structured.

Distinction Between Hypothesis and Evidence

Where experimental support is lacking (e.g., fractal actin contributions to pyramidal soma morphology), this should be explicitly framed as a hypothesis or research agenda.

Overall, this is a visionary and wide-ranging conceptual review with interdisciplinary appeal. To increase its scientific rigor and impact within cognitive neuroscience, the author should (i) tighten the theoretical framework, (ii) clarify operational definitions and quantitative metrics, (iii) reduce speculative extrapolations across scales, and (iv) strengthen evidence-based links between fractal biology and cognition/disease. With these refinements, the manuscript could become a valuable integrative contribution rather than a predominantly philosophical synthesis.

Declarations

Potential competing interests: No potential competing interests to declare.