

# LIFE FROM CHEMISTRY: A CRITICAL COMMENTARY ON THE STATE OF ABIOGENESIS RESEARCH

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Lane and Xavier (1) should be commended for publishing their “Comment: To unravel the origin of life, treat findings as pieces of a bigger puzzle” in *Nature*. The authors provide a valuable assessment of the abiogenesis field, correctly identifying the origin of life as probably the most difficult challenge in biology, if not in all science. While the authors make several pertinent observations, their analysis warrants further critique and discussion.

I appreciate Lane and Xavier’s recognition that the key question for abiogenesis is the origin of evolution rather than the notoriously ambiguous origin of life. However, as Koonin highlighted two decades ago, evolution requires an extremely complex and finely tuned protein replication system that could not have developed through the evolutionary process itself. Wolf and Koonin (2) considered the universal ribosomal translation system a good example of irreducible complexity. Lane and Xavier (1) rightly caution against “cherry-picking ... the most beautiful bits of data”, yet their discussion of the genetic code’s origin appears to do just that. They highlight “suggestive evidence” of direct physical interactions between amino acids and nucleotides, but these interactions lack the specificity required for a high-fidelity information encoding system. The central question of how such low-specificity interactions could evolve into a highly accurate information system – a prerequisite for Darwinian evolution (3) – remains unaddressed. This aligns with Koonin’s argument and directs the attention of the abiogenesis field to this central question.

Furthermore, the authors reflect the general bias in the field toward the abiotic synthesis of biochemicals. Notably absent is a discussion of Assembly Theory, recently published by

by Cronin and his colleagues (Marshall et al, ref, 4). Their work suggests a quantifiable complexity threshold that distinguishes biologically produced molecules from those formed abiotically, implying that compounds like adenosine triphosphate (ATP) or a simple tripeptide are never produced in the abiotic world.

This omission highlights a more profound issue: even complete success in abiotic synthesis of all of life’s biochemicals would not solve the abiogenesis problem. The principles governing the assembly of these component molecules into functional, life-sustaining machinery such as DNA/RNA synthesizing molecular machines, ribosomes, and metabolic networks remain entirely unknown. Life is fundamentally more than the sum of its chemical parts.

I endorse Lane and Xavier’s concluding recommendations, particularly the call to embrace open science and publish negative results. As the authors point out, negative results are critically important in this field, where eliminating hypotheses, ideas, and possible mechanisms is probably more important (and much more possible) than finding the final true answer. The paper ends with a phrase that sums up the state of abiogenesis research quite well “... the field might one day get close to an answer.” I fully agree. However, this conclusion invites a most fundamental question: Why has the origin of life proven to be such an intractable problem? After more than 70 years of research, the lack of substantial progress suggests a potential paradigm failure. Lane and Xavier (1), and the field as a whole labour under the implicit assumption that the answer will be found through application of the known laws of chemistry and physics. My own view is that this assumption is the primary obstacle.

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The persistent mystery of life's origin signals the need for a conceptual revolution, akin to those that redefined physics in the 20th century. A complete understanding may require the formulation of new scientific laws and theories that account for how chemistry can transition into biology. One such scientific principle is the phenomenon of teleonomy, which according to recent research is displayed in all of life (see a recent book edited by Corning et al. (5) titled *Evolution "On Purpose": Teleonomy in Living Systems*).

I will end this commentary by suggesting that the stubborn mystery of the origin of life, like the mysteries of the constant speed of light, the nature of quantum mechanics, and the relationship of matter and energy will only be solved by entirely new ways of addressing the problem. Progress in abiogenesis research will depend not on refining existing chemical pathways, but on discovering new, radical, and perhaps even formerly discarded concepts and ideas outside of known chemistry and physics that are applicable to biology.

## References

1. Lane N, Xavier JC. To unravel the origin of life, treat findings as pieces of a bigger puzzle. *Nature*. 2024;626(8001): 948–951. doi: 10.1038/d41586-024-00544-4
2. Wolf YI, Koonin EV. On the origin of the translation system and the genetic code in the RNA world by means of natural selection, exaptation, and subfunctionalization. *Biology Direct*. 2007;2: 14. doi: 10.1186/1745-6150-2-14
3. Garte S. Accurate phenotypic self-replication as a necessary cause for biological evolution. *Bio Systems*. 2024;237: 105154. doi: 10.1016/j.biosystems.2024.105154
4. Marshall SM, Mathis C, Carrick E, Keenan G, Cooper GJ, Graham H, et al. Identifying molecules as biosignatures with assembly theory and mass spectrometry. *Nature Communications*. 2021;12(1): 3033. doi: 10.1038/s41467-021-23258-x
5. Corning PA, Kauffman SA, Noble D, Shapiro JA, Vane-Wright RI. (eds.) *Evolution "on purpose": Teleonomy in living systems*. The MIT Press, Cambridge (MA); 2023.