

# The Universal Replication Principle and the Emergence of Life

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## Abstract

This work explores the relationship between the Universal Replication Principle (URP) and the emergence of life in the universe. According to this principle, stable physical configurations tend to persist and reproduce over time, allowing the emergence of replicative systems to be interpreted as a natural consequence of cosmic dynamics.

From this perspective, life does not constitute an anomaly within physical laws, but rather a continuation of the processes of organization and replication present since the origin of the universe. The article examines the transition from physical and chemical replication to biological replication, as well as the role of information in this process, and discusses its ontological implications.

This approach is situated at the intersection of fundamental physics, prebiotic chemistry, and origin-of-life studies, proposing a unified conceptual framework based on the URP.

## 1. Introduction

The emergence of life remains one of the most profound problems in contemporary science. Despite advances in biology, chemistry, and cosmology, the transition from inert matter to living systems continues to be debated, particularly regarding whether it should be understood as a contingent or a natural outcome of the universe's evolution.

Within the standard scientific framework, the origin of life is typically approached as an emergent process arising from specific physico-chemical conditions, in which complexity progressively increases until systems capable of replication and metabolism appear. However, this perspective leaves open a fundamental question: is life an exceptional phenomenon resulting from contingent circumstances, or is it a natural consequence of the deeper properties of the universe?

This work addresses this question through the Universal Replication Principle (URP), according to which stable physical configurations tend to persist and reproduce over time. This principle can be understood as a conceptual foundation underlying the coherence observed in physical systems.

In simple terms, the URP describes the tendency of stable structures to recur over time, either by maintaining their form or by generating new similar configurations. It does not introduce a new physical interaction, but rather expresses a general property of dynamical systems: the persistence and reiteration of coherent configurations.

From this perspective, the transition from matter to life does not represent a rupture in natural laws, but a shift between different levels of organization of coherence: from physical stability, through chemical replication, to systems capable of structured information replication.

The aim of this article is to analyze this continuity, showing how the emergence of life can be understood as a coherent consequence of the URP rather than as an isolated event in the history of the universe.

## **2. From Physical Coherence to Chemical Replication**

The transition from inert matter to the first replicative systems should not be understood as an abrupt event, but as a gradual process involving increasing structural coherence in open physical systems.

In the early stages of the universe, the formation of particles, atoms, and molecules already reflects a general tendency toward stable configurations. These structures are not static; they maintain their identity through dynamic interactions that preserve coherence against entropic dispersion, consistent with frameworks of non-equilibrium thermodynamics.

As chemical complexity increases, certain molecular configurations acquire the capacity to participate in cyclic processes in which their own structure contributes to the formation of similar configurations. This phenomenon can be interpreted as a primitive form of replication and represents a key transition in the dynamics of matter.

In this context, replication does not emerge as an external or exceptional process. Rather, it appears as a natural extension of the general tendency of coherent configurations to persist. Molecular structures that facilitate their own reproduction tend to remain and proliferate, leading to progressively more complex systems.

Importantly, not all replicative configurations persist. Only those compatible with their dynamic environment and capable of maintaining stability over time are selectively reinforced.

From the perspective of the URP, this process is not anomalous but instead constitutes a local manifestation of a more general principle governing stability across all scales. The transition toward replicative systems does not introduce a fundamentally new dynamic but intensifies an already present property of physical systems.

Thus, prebiotic chemistry can be understood as the domain in which replication becomes explicit, setting the stage for the emergence of biological systems capable of structured information storage and transmission.

Schematically, this process may be represented as a progression of increasing coherence:

Physical coherence

→ Formation of stable structures (particles, atoms, molecules)

→ Increasing chemical complexity

→ Emergence of molecular replication cycles

→ Information replication

→ Living systems

This sequence should not be interpreted as strictly linear, but as a general trend toward increasing complexity in the replication of coherence.

### **3. From Chemical Replication to Life**

The emergence of life represents a qualitative shift in how coherence is organized and maintained over time. While chemical replication relies on physico-chemical properties of structures, living systems introduce a new level of organization: the replication of information.

This transition does not require the introduction of entirely new dynamics, but rather the consolidation of processes already present in earlier stages. Molecular systems capable of more efficient replication tend to stabilize and integrate into increasingly complex structures, in which structure and function begin to differentiate.

In this context, the emergence of information-based systems—such as early analogues of RNA or DNA—marks a critical turning point. Replication becomes mediated not only by immediate structure but by sequences capable of encoding and transmitting stable configurations across time.

In other words, information becomes central: not only the structure itself, but the pattern that enables its reproduction.

This new level introduces a key property: heredity—the ability to preserve and transmit specific configurations over time. Structures do not merely reproduce; they do so while maintaining patterns that can vary and adapt.

Replication thus becomes an accumulative process, in which coherence is not only preserved but progressively transformed and refined.

From the perspective of the URP, life does not represent a break from physical dynamics, but its most elaborate known expression. The replication of information constitutes the highest level of the universal tendency toward the persistence and reproduction of coherence.

Living organisms can therefore be understood as systems in which matter has acquired the capacity to sustain, transmit, and develop highly organized coherent structures, extending into the biological domain the same principle that governs physical stability.

### **4. Life as a Consequence of the URP**

In light of the previous sections, the emergence of life can be interpreted not as a purely contingent phenomenon, but as a coherent consequence of the fundamental dynamics of the universe as described by the Universal Replication Principle.

From the earliest physical structures to complex chemical systems, the evolution of the cosmos exhibits a persistent tendency toward the preservation and replication of stable configurations. This process is neither uniform nor strictly linear, but it shows a clear direction: structures capable of reproducing their coherence tend to persist and amplify over time.

In this context, life emerges when replication reaches a level at which not only structures are reproduced, but also the information that defines them. That is, not only form is repeated, but the pattern that enables its reproduction.

This transition does not introduce an exception into the dynamics of the universe, but represents its continuation under conditions of greater complexity.

Systems capable of storing, transmitting, and modifying information should not be understood as isolated phenomena, but as the most developed known expression of the universal tendency toward the replication of coherence.

Life thus represents a point of convergence between structural stability, energetic dynamics, and informational capacity.

From the perspective of the URP, the question of whether life is accidental or necessary acquires a new meaning. If the replication of coherence is a fundamental property of the universe, then the emergence of advanced replicative systems—such as living organisms—is not arbitrary, but consistent with the general logic of cosmic evolution.

This does not imply that life must arise under all conditions. However, wherever suitable conditions exist for the stabilization of complex replicative processes, its emergence becomes a natural possibility within the framework of the universe.

Thus, life may be understood as a structural consequence of the URP: not an exceptional event, but one of the ways in which the universe extends and develops its coherence through time.

## **5. Implications and Conclusion**

The analysis presented in this work allows the emergence of life to be reinterpreted within a framework of continuity with the fundamental dynamics of the universe. From the perspective of the Universal Replication Principle, life does not constitute an exception or a rupture in physical laws, but an advanced manifestation of the general tendency of reality to preserve and reproduce coherent configurations.

This approach provides a unified perspective in which cosmic evolution, the organization of matter, and the emergence of living systems are understood as aspects of a single continuous process. The distinction between the physical, chemical, and biological domains is not eliminated, but can be interpreted as different levels of organization within a common underlying dynamic.

Replication, in its various forms—structural, chemical, and informational—thus appears as a unifying axis across all scales of reality. From the stability of physical configurations to the transmission of information in living systems, the universe exhibits internal consistency grounded in the persistence and reiteration of coherence.

This framework allows the origin of life to be approached from a non-reductionist perspective. Physico-chemical processes are not considered sufficient in isolation, but are integrated within a broader principle that gives coherence to their continuity.

Life does not arise independently of the universe, but as one of the ways in which it develops its capacity for organization.

In this sense, the question of whether life is accidental or necessary can be reformulated. Life is not inevitable under all conditions, but neither is it arbitrary. Its emergence belongs to the range of possibilities that the universe both permits and, under appropriate conditions, favors.

The Universal Replication Principle thus provides a conceptual framework in which life is understood as a coherent consequence of cosmic dynamics—not as an isolated occurrence, but

as the continuation of a fundamental tendency present throughout reality: the preservation and replication of coherence over time.