

Hypothesis

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Hypothesis

DNA as Crystallized Knowledge: A Process-Ontological Reinterpretation

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Abstract

Contemporary biology remains deeply shaped by an implicit atomistic ontology in which DNA is treated as the primary source of biological causation, organization, and meaning. Although empirically productive, this framework rests on metaphysical assumptions that are rarely made explicit or critically examined. Drawing on Alfred North Whitehead's process philosophy, this paper proposes an ontological redefinition of DNA. I argue that DNA is neither primary information nor an instructive code, but the material sedimentation of historically successful processes of biological becoming. When similar concrescent pathways are repeatedly realized across time, they stabilize and precipitate into matter as DNA. In this sense, DNA functions as crystallized knowledge—habitus rather than instruction. Reframing DNA in this way does not constitute an incremental theoretical adjustment but calls for a paradigmatic reorientation in biological ontology, shifting explanation from static entities to historically conditioned processes. This perspective aligns with developmental systems theory and challenges reductionist gene-centered views, offering a processual foundation for understanding biological stability, plasticity, and innovation.

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1. Introduction

Few assumptions in modern biology are as deeply entrenched—and as rarely questioned—as the ontological centrality of DNA. Common metaphors such as blueprint, program, genetic code, or book of life implicitly position DNA as the origin of biological order, assigning it a privileged explanatory status. While these metaphors have proven heuristically useful, they also import a substance-based, atomistic ontology in which causation flows unidirectionally from molecular structures to biological outcomes.

This paper does not seek to replace one explanatory model with another, nor to propose an alternative genetic theory. Rather, it addresses a prior and more fundamental question: what kind of entity is DNA, ontologically speaking? I argue that prevailing accounts tacitly conflate DNA's material persistence with causal primacy. By contrast, a process-ontological perspective reveals DNA as a stabilized outcome of biological history rather than its initiating source.

Adopting this perspective entails not an evolutionary refinement of existing theory, but a conceptual reorientation at the level of first principles. Such reorientations are rare precisely because they challenge assumptions that have become effectively invisible through long success.

2. The Ontological Commitments of DNA-Centered Biology

Treating DNA as information immediately raises an ontological difficulty: information for whom, and in what sense? Information, to be causally efficacious, must be enacted within a process. Outside such processes, DNA is chemically inert. Its apparent causal power derives not from intrinsic

instructional content, but from its participation in complex, historically conditioned biological activities.

The dominance of DNA-centered explanation reflects an atomistic bias inherited from classical physics, in which stable entities are treated as ontologically primary and processes as secondary. In biology, this bias manifests as the assumption that molecular structures precede and determine higher-level organization. Yet this assumption is philosophical rather than empirical, and it merits critical scrutiny.

Current biological discourse often treats DNA as what Whitehead would call a "simple location"—an entity with fixed properties independent of its relations. This view ignores the fundamental insight that biological significance emerges only within specific relational contexts, including epigenetic frameworks, cellular environments, and organismal histories (Tez 2024a).

3. A Whiteheadian Process Ontology

Whitehead's process philosophy offers a radically different ontological framework. Reality, on this view, is composed not of enduring substances but of events of becoming—actual occasions. Each actual occasion prehends aspects of the past and integrates them into a novel unity through concrescence. Once completed, the occasion perishes, contributing itself as datum to future becomings.

Stability, within this framework, is not primitive but emergent. Relatively enduring structures arise from the repetition of similar patterns of becoming, forming what Whitehead calls *nexūs*. Matter itself is understood as a comparatively stable outcome of process. This reversal—from substance to process—provides the conceptual resources needed to reconsider the ontological status of DNA.

4. DNA as the Sediment of Biological Becoming

4.1. From Concrescence to Stability: The Processual Origin of Genetic Constraints

From a process-ontological standpoint, DNA should not be located at the origin of biological activity, but at its outcome. Biological systems continually integrate multiple contextual conditions into situated responses. Each such integration constitutes a concrescent event: a momentary unification of many influences into a single act of becoming.

When similar concrescent pathways are realized repeatedly across evolutionary time, they acquire stability through what might be termed "processual reinforcement." This stability emerges not from external imposition but from the sustained viability of certain ways of integrating past conditions into present action. Over extended temporal scales, these stable patterns precipitate into material constraints—a phenomenon I call "processual sedimentation."

DNA represents the ultimate expression of this sedimentation. Rather than being a prescriptive code, it embodies the durable trace of historically successful biological activity. Its molecular structure reflects not a predetermined plan but a crystallization of processes that have consistently led to viable outcomes across generations.

This perspective finds resonance in developmental systems theory and niche construction theory, both of which emphasize the reciprocal construction of organisms and their environments (Oyama 2000; Lewontin 2000). DNA, in this light, is not the sole repository of biological information but one component in a larger system of inheritance that includes epigenetic marks, cytoplasmic factors, and environmental regularities.

4.2. Crystallized Knowledge Rather Than Instruction: An Information-Theoretic Reframing

If knowledge is understood as the stabilization of relational patterns produced through repeated activity, then DNA can be coherently described as crystallized knowledge. Crystallization here denotes relative persistence, not immutability or determinism. DNA embodies the memory of what has been biologically possible, not a set of instructions dictating what must occur.

This perspective inverts conventional causal narratives. DNA does not command biological processes; it constrains and channels them by shaping a historically conditioned space of possibilities. Its causal role is permissive and selective rather than prescriptive, functioning more as a set of boundary conditions than as a detailed script.

This reframing aligns with recent work on biological information that emphasizes its contextual and processual nature (Tez 2024a). Information in biological systems is not primarily semantic but operational—it exists in the doing, not in the static structure. DNA's significance emerges through its participation in cellular processes of transcription, translation, and regulation, all of which are themselves dynamic and context-dependent.

4.3. Matter as Stabilized Process: Dissolving the Genotype-Phenotype Dichotomy

Within a process ontology, matter itself is understood as slowed or stabilized process. DNA exemplifies this principle. Its molecular persistence reflects not ontological priority but historical success: certain patterns of becoming have proven sufficiently reliable to be carried forward as material constraints. This view dissolves sharp dichotomies between genotype and phenotype, recasting both as moments within an ongoing processual continuum.

The traditional separation between genetic information (as cause) and phenotypic expression (as effect) gives way to a more integrated view in which both are seen as interdependent aspects of biological becoming. Phenotype is not the readout of genetic information but the contemporary expression of historical processes that have sedimented into genetic constraints.

This dissolution of boundaries has practical implications for how we understand phenomena such as phenotypic plasticity, developmental constraints, and evolutionary innovation. Rather than viewing these as exceptions to genetic determinism, they become expected features of a processual system in which DNA serves as one (albeit crucial) stabilizing element among many.

5. DNA as Biological Habitus

5.1. Extending the Concept of Habitus to Molecular Biology

Pierre Bourdieu's concept of habitus refers to historically formed, embodied dispositions that guide action without explicit awareness or deterministic control. Although developed within sociology, habitus captures a structural logic applicable beyond the social domain.

Interpreted ontologically, DNA functions as biological habitus. It is unconscious, historically constituted, and action-guiding without being action-determining. DNA shapes tendencies and probabilities rather than issuing commands. Like social habitus, genetic habitus operates below the level of conscious deliberation, structuring possible responses without fully determining them.

This conception helps explain phenomena that trouble deterministic accounts of genetics, such as context-dependent gene expression, developmental plasticity, and the remarkable robustness of biological systems in the face of genetic variation. DNA-as-habitus provides constraints that make certain outcomes more likely without rendering them inevitable.

5.2. Constraint Without Determinism: The Logic of Biological Improvisation

As habitus, DNA narrows the space of viable biological responses while preserving openness to novelty and contextual variation. Biological organization thus emerges as structured improvisation rather than scripted execution. This framework accounts for both stability and change without invoking rigid genetic determinism.

The improvisational quality of biological systems becomes particularly evident in processes such as cellular differentiation, immune response, and neural development, where predetermined genetic instructions would be insufficient to account for the observed outcomes. In each case, genetic constraints interact dynamically with environmental inputs to produce contextually appropriate responses.

This view of DNA as enabling rather than determining biological outcomes finds support in research on gene regulatory networks, which increasingly reveals the context-dependent nature of gene expression (Davidson 2006). What matters is not the presence of specific genes but the dynamic interactions among genetic elements, epigenetic marks, and environmental signals.

6. Philosophical Implications for Biology

6.1. Challenging Reductionism and Embracing Complexity

Reconceptualizing DNA as crystallized knowledge has profound implications for biological explanation. It challenges reductionist strategies that seek to explain higher-level phenomena solely through reference to molecular components. Instead, it invites explanations that acknowledge the multiple scales and temporalities involved in biological processes.

This approach aligns with recent developments in systems biology and complex systems theory, which emphasize emergent properties and network dynamics. However, it goes further by providing an ontological foundation for these approaches, grounding them in a coherent metaphysical framework that takes process as fundamental.

6.2. Reframing Causation and Explanation in Biology

The processual view of DNA reframes debates over causation and explanation in biology. Rather than searching for linear causal chains from genes to traits, biologists might instead investigate how genetic constraints emerge from and subsequently shape biological processes. This shifts attention from static entities to dynamic patterns, from substances to relations, from being to becoming.

This reorientation has practical consequences for research methodology. It suggests greater emphasis on longitudinal studies, processual models, and interdisciplinary approaches that can capture the temporal and contextual dimensions of biological phenomena. It also encourages integration of historical perspectives, recognizing that current biological forms carry the traces of their evolutionary past.

6.3. Opening New Questions and Research Directions

By reframing DNA's ontological status, this approach opens new lines of inquiry. Rather than asking "what do genes do?" we might ask "how do genetic constraints emerge from and shape biological processes?" This shift invites investigation of the feedback loops between process and constraint, between becoming and being, between activity and structure.

Specific research questions might include: How do developmental processes become genetically encoded over evolutionary time? How do genetic constraints themselves evolve as processes of biological becoming change? How do different levels of biological organization (molecular, cellular, organismal) participate in the sedimentation of process into constraint?

7. Conclusion: Toward a Processual Biology

DNA is not the book of life; it is the frozen residue of sentences life has written again and again. Ontologically, DNA is the sediment of successful biological becoming—the crystallized habitus of living systems. Recognizing this does not resolve empirical questions, but it fundamentally alters how such questions are framed.

This reorientation from substance to process has implications beyond genetics. It suggests a more comprehensive shift in biological ontology, one that takes time, history, and relationality as fundamental rather than derivative. In such a biology, entities would be understood as stabilized processes, causes as emergent from complex interactions, and explanations as necessarily historical and contextual.

The Whiteheadian perspective offers not just a critique of existing paradigms but a positive alternative—a vision of biology as the study of dynamic, historically conditioned processes of

becoming. This vision aligns with emerging approaches in systems biology, developmental systems theory, and evolutionary developmental biology, providing them with a coherent philosophical foundation.

In opening this new conceptual page for biology—one grounded not in atomistic substances but in historically conditioned processes—we may find fresh insights into life's enduring mysteries: its stability amid change, its creativity within constraints, and its remarkable capacity to generate novelty while preserving identity across generations.

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