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ORTHOGONAL REVIEW RECORD

From Registry-Controlled Capture to Productive Molecular Assembly: Constructive Existence of a Minimal Abiotic Loom

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Scope of Review

The review examines the reduced-model existence result for productive molecular assembly on an intact finite framework. Page references in the review and response are to the pre-publication draft.

Compiled disposition

The simulated assessment recommended minor revision; the author accepted all eight recommendations. The main conclusions were unchanged. This is not an external peer-review or acceptance decision.

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1 Stage summaries

Simulated referee assessment

The review retained the central reduced-model witness and exact numerical conclusions. It requested explicit docking and clearance conditions, a separation of choice, transport, and commitment, and a direct statement of the resource-budget premise.

Model interpretation and verification

The review also asked the manuscript to distinguish an effective neutral-contact convention from a physical electrostatic model, holding-port release from framework scission, and a number fraction from mass purity. Verification and Lean coverage were to be stated separately from any claim of molecular realization.

Author response and disposition

The author accepted R1–R8. The response records the local revisions, the scope of the executable checks, and the partial Lean formalization. The initialized production and purity thresholds and both conditional receiver contrasts were retained.

2 Full simulated referee review

Manuscript reviewed. The submitted 15-page draft, provisional pages 4200–4214, preceding the revisions described in the accompanying author response.

Status. This is a simulated, AI-assisted technical referee assessment. It is not a report from an independently appointed human referee, evidence of external peer review, or a journal acceptance decision.

> **Referee recommendation**
>
> **Minor revision.** The central reduced-model existence result and its numerical conclusions should be retained. The requested changes complete local geometric and operational interfaces, make an existing resource assumption explicit, and state verification coverage precisely. They do not require defects, a different product objective, or a mature-loom architecture.

2.1 Contribution and appropriate claim

The manuscript extends a controlled binding/release architecture to a bounded productive operation. It specifies an intact finite patch, exterior transport, an atom-labelled four-residue joining construction, an external symbolic record, competing-channel production kinetics, and a product-dependent receiving-gate law. Its chief contribution is the compatible common witness, not a new general minimization or finite-Markov theorem.

The formal graph construction, coarse geometric access, stipulated kinetics, and receiver interaction are distinct components. The manuscript correctly identifies the molecular certificates needed to implement them chemically. The conclusion is therefore a constructive theorem about the stated reduced model; it is not an experimental demonstration of spontaneous peptide synthesis, synthesis from chrysene-only stock, or physical nucleic-acid writing.

The GAGA/GGGA intervention selects different packets from the same eight-packet pool, rather than changing atom identities. The framework remains protected. The proposed peptide modifies an existing receiver response and is not itself asserted to be an autonomous clamp or folded enzyme. These are appropriate boundaries for the present place in the series.

2.2 Assessment of the main arguments

2.2.1 Geometry, mechanics, and composition

The complete $4 \times 2 \times 2$ reference has sixteen nodes, twenty lateral edges, and eight stacking edges. Its basis determinant is 64, and pairwise distinct center separation is at least 4. The exposed boundary-port allocation avoids giving an occupied core port a second bond. Ideal mechanical constraints are explicit, so the argument does not infer rigidity from graph connectivity.

Compact-sublevel minimization, local positive-Hessian stability, Hausdorff-distance clearance, and the controlled scalar lift are valid with the stated regularity. Full-state interface and fresh-resource conditions make finite composition meaningful. The main remaining geometric issue is that the receiver's spatial interface and the compact noncontact clearance domains need a more explicit specification, R1 and R2.

2.2.2 Atom graphs and information

The two-single-bond deletion/two-single-bond addition joining rule preserves the neutral valence sum at each changed vertex. Every atom and origin remains in the peptide, a mapped water, an unused packet, or waste. The GAGA output formula is $C_{10}H_{18}N_4O_5$ with three waters. The common initial pool is $C_{20}H_{48}N_8O_{16}$, containing 92 atoms.

The prefix invariant records the actual incorporated residue. An incorrect branch can therefore have a truthful record while disagreeing with the target program. This is an exact symbolic invariant, not a physical molecular writer. Prepared-input availability, stereoretention, and activation chemistry are not established merely by the atom graph. Those limits are stated correctly and should be retained.

2.2.3 Productivity, response, and perturbations

The initialized three-stage law gives

$$Y = \frac{125000}{132651}, \qquad B = D = \frac{7651}{265302}, \qquad \Pi = \frac{250000}{257651}.$$

Thus $Y > 0.94$ and $\Pi > 0.97$. The purity denominator includes collected wrong dimers, trimers, and tetramers; loss is excluded from collection but remains in the material ledger. The conditional active-time mean is $3/102 = 1/34$. The finite-state absorption proof, delivery refinement, explicit rate-box lower bound, and finite-kernel error bound are correct.

Completing squares in the receiver energy yields $a_s^* = 3 - b_s/16$, $u_T^* = 3\lambda/4$, and

$$F_0 = 0, \qquad F_C = \frac{3}{2}, \qquad F_T = \frac{3}{2} - \frac{3}{8}\lambda^2.$$

The Hessian is $\mathrm{diag}(16, 4/3)$. The GAGA and GGGA signatures give $\lambda = 4$ and $16/5$. The supplied rational exponential enclosures support contrasts greater than 0.83 against absent product and 0.09 against GGGA. The finite-basin law is explicitly distinguished from a bounded continuous-coordinate Gibbs integral. Reversible finite-state readout and its finite-time approximation are also correctly separated from statistical estimation from a finite sample.

2.3 Recommendations

R1. Complete the receiver's spatial docking interface

The exterior delivery point is specified, but "place the receiver in a disjoint exterior region" leaves its body envelope and allowed internal motions insufficiently tied to that port. Declare a concrete excluded envelope, terminal docking tube/port, and contact guard. Explain that the scalar receiver coordinates are internal reduced variables, not an atomistic receiver reconstruction. This can be repaired without changing its energy or probabilities.

R2. Fix the compact domains of positive clearance

The phrase "away from" attachment and reaction contacts should be replaced by prescribed collars or terminal intervals. Apply the uniform clearance theorem to the remaining finite union of closed

transport subsegments, and handle intended contacts by separate guards. Give a conservative numerical margin if convenient. The robustness neighborhood must preserve these legal contact interfaces, not treat contact itself as positive clearance.

R3. Specify choice, transport, and commitment separately

The active-clock refinement is coherent but distributed through prose. Add an explicit phase specification. Selection must not append a symbol or debit a joining ticket. Transport can mark the fresh packet held. Commitment must update the atom graph, actual-symbol record, packet status, ticket, and water slot together. Wrong commitment stops in the wrong-output channel; loss makes no join and transfers the current material to waste. Include the unused alternative seed in the initial eight-packet frame. A branch's bounded completion/no-hidden-failure hypothesis should be stated, rather than implicitly assigning a potentially failing transport probability one.

R4. Put the resource-budget qualification in its premise

The text correctly warns that positive running dissipation with unbounded exponential waiting invalidates a deterministic finite budget. Put the existing zero-running-debit/exhaustive-account assumption directly into the budget corollary. If a separate bounded maintenance term is allowed, add it explicitly to the bound. This does not change the random-time law.

R5. Clarify the neutral contact representation

A list of dipole moments does not derive charge neutrality or an electrostatic energy. State the four summands as an effective neutral-contact convention whose sum is the declared $-\lambda u$. If a physical dipole representation is sought, equal-and-opposite charges, positions, and fields belong to the molecular conformance certificate. The model energy and its receiver contrast remain valid as stated constitutive data.

R6. Distinguish holding-port release from framework scission

The statement that no detachment from the framework is performed can be read as contradicting allowed release from exterior ports. Specify that no protected core, bridge, or framework atom is cleaved or removed; only a separately typed packet–port holding relation changes. This preserves the author's intact-framework restriction.

R7. Name the purity measure

State once that Π is a number/probability fraction per initialized first-output attempt, not a mass fraction. Since wrong outputs have different lengths, the two measures need not agree. The existing formula and threshold are correct for the intended measure.

R8. Make the publication-companion coverage explicit

The verification document should contain executable source, reproducible results, negative controls, and exact-versus-diagnostic distinctions. The Lean dossier should identify the actually compiled

toolchain, theorem count, dependencies, and manuscript correspondence. Formula balance is weaker than the full atom-graph certificate; finite corner checks are weaker than a continuous-box proof; rational Taylor arithmetic requires the paper's analytic bridge to the real exponential. Do not advertise a finite formal subset as a formalization of the entire paper or of physical chemistry.

2.4 Scope boundaries and conclusions to retain

The following would be scope expansions, not necessary repairs: demanding experimental peptide production as a condition of the declared reduced-model theorem; introducing scission-generated pockets, ionic or nucleobase insertions; replacing the short-product objective with broad maturation; requiring post-hoc reverse encoding; or relabelling the $100 : 1 : 1$ rates as measured chemical rates. None is recommended.

The title, intact framework, nonhomogeneous four-residue construction, exact initialized production/purity thresholds, and conditional receiver contrasts should be preserved. The proposed changes increase auditability without reversing these conclusions. The separate response document should identify each implemented change and any recommendation not adopted, without implying that this simulated assessment constitutes an external editorial decision.

3 Full author response

Author: Charles D. Schaper **Date:** 22 October 2026

Response status. This document records the revisions made in response to the accompanying simulated, AI-assisted referee assessment. It is a draft publication companion, not correspondence from an external referee or evidence of journal acceptance.

3.1 Overall response

All eight recommendations have been accepted. No substantive rebuttal is needed. The revision retains the title and scientific objective, the intact framework, the four-residue GAGA construction, the common-pool GGGA intervention, the exact probability thresholds, and both receiver contrast thresholds. The introduction and abstract are unchanged from the submitted draft.

The changes clarify interfaces already intended by the model. They neither add a chemical-realization claim nor introduce framework defects, internal cavities, structural ions, nucleobase insertions, broad folding architectures, or autonomous peptide clamps.

3.2 Point-by-point responses

R1. Receiver spatial interface: accepted

The exterior-access lemma now reserves a fixed opaque receiver box

$$B_R = [-1, 1] \times [13, 20] \times [7, 9],$$

with docking port $d = (0, 12, 8)$ and a radius-1/10 terminal tube to $(0, 13, 8)$. The receiver's permitted internal motions remain within this envelope. The incoming product path stays outside it, except for the separately guarded terminal holding relation. The receiver energy and reduced variables are unchanged; the box is an exclusion-envelope specification, not an atomistic receiver geometry.

R2. Compact clearance domains: accepted

The same lemma now fixes radius-1/2 input collars and radius-3/4 reaction/delivery collars. The noncontact portions are closed transport subsegments. Their incident-tube margins are bounded by

$$\frac{1}{2} - \frac{1}{10} - \frac{1}{4} = \frac{3}{20}, \qquad \frac{3}{4} - \frac{1}{10} - \frac{1}{2} = \frac{3}{20}.$$

Together with the larger body and retained-packet separations, these support the conservative common bound 1/10. Contact interiors are governed by holding/docking guards, not by a false positive-clearance assertion. The relative robustness statement now explicitly preserves these interfaces.

R3. Phase and resource refinement: accepted

A new choice–transport–commit definition gives the waiting, selected, transporting, committed, and stopped phases, together with current slot, actual symbol, packet status, tickets, export slots, and

destination. Selection does not consume a ticket or append a symbol. A join commits all graph, record, packet, and coproduct changes together. Wrong branches faithfully record their actual residue before stopping; loss makes no join. The complete eight-packet pool, including the unused alternative seed, is explicit.

Erasing bounded holds and contracting each branch-preserving refinement recovers the same active-clock chain. Any extra transport failure must be represented by a new channel or a stated implementation-error bound. The verification suite exercises 112 program/terminal-history combinations and rejects invalid phase and resource operations.

R4. Budget premise: accepted

The time-and-budget corollary now states directly that its listed debits exhaust the account and that active-clock waiting has zero running debit. The surrounding discussion of expected-cost and finite-deadline alternatives is retained. The finite event-budget bound and all waiting-time conclusions are unchanged.

R5. Neutral contact interpretation: accepted

The receiver hypothesis now specifies four effective summands $-\mu_j(v)u$ with fixed coefficients

$$\mu_j(v) = \frac{2}{5}\, 2^{j-1} \mathbf{1}_{\{v_j = A\}}, \qquad \sum_j \mu_j(v) = \lambda(v).$$

They define the same phenomenological coupling. An atomistic dipole interpretation would require explicit equal-and-opposite charges, their locations, and a field model under the conformance certificate. No charged scaffold insertion is introduced, and no occupancy calculation changes.

R6. Exterior release terminology: accepted

The production section now distinguishes release of the separately typed packet–port holding relation from removal or cleavage of protected framework atoms or bridges. The former is permitted by the explicit exterior protocol; the latter is excluded throughout.

R7. Purity convention: accepted

The output-population remark now names the number/probability-fraction measure. Collected wrong dimers, trimers, and tetramers remain in its denominator. No mass-purity claim or tetramer-only collection guarantee has been added.

R8. Verification and formalization coverage: accepted

The revised appendix points to two standalone dossiers. The executable verification uses exact integer/rational comparisons, includes negative controls, and identifies geometric and finite-grid limitations. The Lean dossier records 49 actually kernel-checked theorems in a partial structural/rational formalization, with all 49 dependency audits and a pinned toolchain. Neither companion asserts atomistic chemistry, a complete continuous-path certificate, or full-paper formalization. Their complete source files and recorded runs accompany the package.

3.3 Unchanged conclusions

The initialized-attempt values remain

$$Y = \frac{125000}{132651} > 0.94, \qquad \Pi = \frac{250000}{257651} > 0.97.$$

The receiver Hessian remains $\mathrm{diag}(16, 4/3)$. Its GAGA target-occupancy contrast remains greater than 0.83 against absent product and greater than 0.09 against GGGA. The parameter-neighborhood result, source boundary, and conditional physical-conformance statement are preserved.

Scope position. We agree with the report that experimental synthesis, a molecular nucleic-acid writer, defects, mature folding architectures, and autonomous repeated operation are not repairs to this finite reduced-model construction. Their omission is not presented as proof that they are impossible; they are separately specified realization or later-series problems. Since the report does not require these expansions, this is a scope clarification rather than a rebuttal of an actual recommendation.

4 Revision history

Version	Date	Notes
v1.0	November 2026	Historical simulated review and author response compiled as a standalone companion to Article 104. Both source texts are dated 22 October 2026.

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