Duplication-loss histories: the four source claims

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AI-assisted research preprint. Independent checks are internal AI reviews, not external journal peer review. No worldwide-priority certification is asserted.

Author implementation, 2026-11-15. The unconditional canonical, source-event and unranked endpoints are proved in FinalAssembly. This is a standalone proof and literal-source record, not independent semantic acceptance or fresh extracted replay.

Statement and source fidelity

For each k>=1 there is N_k>=1 such that for EVERY k-leaf species s and every n>=N_k, a(B_k,n)<=a(s,n)<=a(C_k,n). Equality on the left holds exactly for the balanced shape; equality on the right holds exactly for the caterpillar shape. Every species has a positive real nth-root limit g(s)=1/rho(s). Moreover g(C_k)/k tends to infinity and 2k<=g(B_k)<=1000k for every k>=1. Here linear means Theta(k), not an asserted limiting slope. No quadratic caterpillar order or historical constant 80 is asserted.

The target is MathDB342705, bound to the owned raw record and live target-only field projection dated 2026-11-15. Source: Cedric Chauve, Yann Ponty, Michael Wallner, Counting and sampling gene family evolutionary histories in the duplication-loss and duplication-loss-transfer models, arXiv1905.04971v1 (2019-05-13), Conjecture4.1; owned final PMC7052048, Conjecture4.5. Both exact conjectures were read; the v1 material pages4,8,11,16 were rendered and inspected. Source URLs and file hashes are in the source index. The source asks for superlinearity, not Theta(k^2).

A species is a rooted full binary tree with k leaves. C_1=B_1 is a leaf; C_(k+1)=(C_k,leaf); B_k=(B_floor(k/2),B_ceil(k/2)). These are the source families for every positive k. The source page16 footnote identifies balance up to child swaps. Zero-index families denote a leaf only as an auxiliary convention.

Actual histories and analytic foundation

Hist has extant, ordered duplication, both-child speciation, keep-left and keep-right constructors. Loss is the explicit disappearing sibling at a speciation, never a disposable duplication child. Size n counts extant genes. Species addresses in encode retain the species map at every event, including losses. Induction gives encode_valid; inverse parsing gives valid_has_history and encode_injective. Their size-preserving equivalence sourceFiberEquiv identifies the finite size fiber with Valid event trees of extantCount n. Thus count is an actual cardinality and sourceCard is the cardinality of the literal source event fiber, with sourceCard_eq proved, not postulated. Duplication children remain ordered throughout.

Finiteness follows from depth<=n*weight(s) and the finite recursive pool. Unique root decomposition gives H_leaf=z+H_leaf^2 and H_(a,b)=H_a+H_b+H_a*H_b+H_(a,b)^2. The derivation uses disjoint constructors and finite-fiber equivalences. Skeleton decomposition cuts duplication nodes into binary skeletons whose atoms are the nonduplication constructors. Summing their nonnegative weights gives the least fixed point: finite cuts increase to the complete history sum, and every nonnegative prefixed value bounds every finite cut. This proves that the formal evaluation is the actual history sum, not a substitute recurrence definition.

The scalar least solution is C(q)=(1-sqrt(1-4q))/2 on 0<=q<=1/4. Starting at the leaf and then inducting over species, continuity and strict increase of the child input locate a positive first threshold rho, strictly below each proper child threshold; at that threshold H=1/2. The least-fixed-point bound gives finiteness up to rho. Above rho, a finite solution would solve the same quadratic beyond its critical input (or violate a child threshold), impossible. This proves the actual summability characterization used below. All these bridges are included in the source appendix.

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Duplication is an injection from the product of size-i and size-j fibers to the size-(i+j) fiber. Positive fibers exist at every n>=1, so the negative logarithms of counts are subadditive. The threshold coefficient bound supplies a linear lower bound, making Fekete's limit finite. Exponentiating yields the positive actual real root limit g. Convergence at rho gives count(s,n)*rho^n<=1 and hence g*rho<=1. If g*rho<1, choose rho<z<1/g; the root limit bounds the tail by a convergent geometric series, forcing actual summability at z, contrary to the threshold characterization. Thus g=1/rho. This proves an actual limit over all n, not just a limsup or a formal growth symbol.

Caterpillar maximum

Order formal series coefficientwise. Put u=a+b+ab, v=c+b+cb, where a>=c>=0 and b>=0 have zero constant coefficients. Compare the two outer inputs Q_L=(1+c)C(u)+c and Q_R=(1+a)C(v)+a. The m=1 Catalan term is u(1+c)-v(1+a)=a-c, cancelling c-a. For every m>=2 direct polynomial factorization gives
(1+c)u^m-(1+a)v^m
=(a-c)[sum_{j=0}^{m-1}u^(m-1-j)v^j + uv*sum_{j=0}^{m-2}u^(m-2-j)v^j]. To verify: substitute (1+c)=(1+v)/(1+b), (1+a)=(1+u)/(1+b), factor u^m-v^m and uv*(u^(m-1)-v^(m-1)), and cancel u-v=(1+b)(a-c). This is a polynomial identity; it does not rely on coefficient positivity of a reciprocal series. Summing positive Catalan coefficients proves Q_L>=Q_R and F(F(a,b),c)>=F(a,F(b,c)). All formal compositions are locally finite. At positive real admissible inputs, a>c and b>0 give strictness already at m2.

Every nonleaf H dominates the leaf series L=C(z), strictly for positive real z. By induction first replace both root children by caterpillars of their sizes a>=b. For b>=2, rotate (C_a,(C_(b-1),leaf)) to ((C_a,C_(b-1)),leaf), strictly since H_Ca>L, then replace the inside by C_(k-1) by induction. For b1 the root already has caterpillar form. Induction terminates at smaller leaf counts; a noncaterpillar forces either a strict child replacement or this strict root rotation. Hence H_S<=H_Ck coefficientwise and rho_Ck<=rho_S.

If radii were equal for a noncaterpillar, every intermediary k-leaf tree is coefficientwise bounded by C_k, hence has radius at least this common radius. Its proper children have strictly larger radii by the source lemma. All endpoint values thus exist on the closed principal branch. Strict root-input/child comparisons still hold there, forcing H_Ck>H_S while both are1/2, impossible. No derivative at the singular root or divergent Catalan endpoint sum is used: C has a finite value at1/4 and is strictly increasing on[0,1/4]. Thus rho_Ck<rho_S unless S is a caterpillar.

Balanced minimum

Write x_s(z)=log(1+H_s(z)) and f(u)=log(1+C(exp(u)-1)). The proved closed-domain theorem says f is strictly convex on [0,log(5/4)], f(0)=0, and f(v)-f(u)>v-u for 0<=u<v<=log(5/4). The derivative formula in the supplied ordinary proof is f'(u)=(1+w-w^2)/(1-w-2w^2)>1, where w=C(exp(u)-1); its derivative with respect to w is (2+2w+3w^2)/(1-w-2w^2)^2>0 in the interior. Closed endpoint inequalities use the common continuity/convexity theorem, not a finite derivative at the endpoint.

Fix a finite K>=1 and 0<z<=rho(B_K). The proved single-leaf expansion B_j to B_(j+1), independent of extremality, strictly lowers radius and strictly increases branch value at any common valid positive argument. Thus rho(B_K)<=rho(B_j) for 1<=j<=K. Put b_j=x_(B_j)(z). All b_j needed through K exist, are positive and strictly increasing. At every internal index j<=K, b_j=f(b_floor(j/2)+b_ceil(j/2)); the input belongs to the CLOSED domain, by the actual node-input bound <=1/4. exp_log_pair verifies the conjugation directly from actual branch values.

We prove 2b_n<b_(n-1)+b_(n+1) for 2<=n and n+1<=K by strong induction. At center 2, f(2b_1)>2b_1, so b_2>2b_1. Expansiveness between 2b_1 and b_1+b_2 yields b_3-b_2>b_2-b_1. At odd center n=2m+1, the three inputs are 2b_m, b_m+b_(m+1), 2b_(m+1), equally spaced and distinct; strict convexity applies. At even center n=2m>=4, the inputs are b_(m-1)+b_m, 2b_m, b_m+b_(m+1). The smaller-center induction gives that twice the middle input is strictly below the sum of the outside inputs. Monotonicity together with strict midpoint convexity again gives the desired strict inequality. Every referenced index is <=K. This is discrete_convex, discharged for the actual balanced log sequence by balanced_log_discrete.

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Consequently d_i=b_(i+1)-b_i strictly increases over its finite valid index range. If 1<=i<=j and j>i+1, replacing (i,j) by (i+1,j-1) strictly decreases b_i+b_j, since d_i<d_(j-1). Finite induction on j-i shows that only the floor/ceiling split minimizes this sum. split_min proves both the weak inequality and equality iff i<=j+1 and j<=i+1. The cases with total size 2 or 3 are already central and need no nonexistent convexity index.

Now fix also z<=rho(s), leaves(s)<=K. Structural induction proves x_(B_leaves(s))(z)<=x_s(z), with equality iff ShapeIso(s,B_leaves(s)). The leaf case is literal reflexivity. At a node, both children are valid because each child radius is strictly larger than the parent's. Apply the induction to both children and the split inequality to their positive leaf counts; the resulting input ordering is within f's closed domain on BOTH sides. Strict expansiveness implies that equality after applying f forces equal inputs. The ordered sum of two weak child inequalities can be equal only if each is equal, and the split must be central. The child isomorphisms therefore combine by a node or a swap constructor. Conversely ShapeIso preserves branch values. This proves log_minimum without any extremum hypothesis.

For a nonisomorphic s of k leaves, suppose rho(s)>=rho(B_k). Take z=rho(B_k)>0 in the preceding theorem with K=k. Its weak inequality is strict because equality would give ShapeIso. But the actual threshold endpoint is H_(B_k)(z)=1/2 and every actual branch value, including H_s(z), is <=1/2 there. Their logarithms cannot have the asserted strict ordering. This contradiction proves rho(s)<rho(B_k). ShapeIso radius invariance supplies equality for the isomorphic class; the strict result excludes equality elsewhere and yields the weak global comparison. These are rho_balanced_strict, rho_balanced_le and rho_balanced_eq_iff.

For the actual counts, use the proved convergence count(s,n)^(1/n)->growth(s)>0 and growth(s)=1/rho(s). If s is outside the balanced class, the strict radius comparison gives growth(B_k)<growth(s). A real number between the two limits separates the nth roots for all sufficiently large n. Monotonicity of nonnegative real rpow shows count(B_k,n)<count(s,n) eventually. This is the already-proved actual-root comparison helper eventual_count_lt_of_rho_lt, not an assumed asymptotic transfer theorem. For ShapeIso trees the common cardinality invariance gives equality for all n. FiniteShapes.fixedLeavesFintype provides a finite type of all ordered k-leaf species. Finite conjunction of these eventual statements has an eventual threshold N; replace it by max(1,N). Thus one N_k works simultaneously for every s and all n>=N_k, with the exact equality and strictness classes. The final endpoint is the conjunction of these radius and actual-count statements.

Quantitative growth arguments

Write H_s(z) for the actual nonnegative history evaluation on 0<=z<=rho(s). The foundation proves H_s(rho(s))=1/2 and strict child threshold separation. For a leaf, H=z+H^2. At a binary node with child values x,y and parent value w, w=x+y+xy+w^2. Every term is nonnegative. Induction gives H_s(z)>=leaves(s)*z, hence g(s)>=2*leaves(s).

For caterpillars let x_j=H_Cj(z), with a fixed z in the critical interval of C_k. All smaller caterpillars remain in their critical intervals. The node identity gives x_(j+1)>=x_j+x_(j+1)^2, and the universal leaf-mass bound gives x_(j+1)>=(j+1)z. Induction starting at j=1 yields

x_j >= (j^3-j) z^2 / 3.

Indeed the polynomial increment is j^2+j, at most (j+1)^2. At the actual critical value z=rho(C_k), x_k=1/2. Multiplication by g(C_k)^2, using g*rho=1, gives

k^3-k <= (3/2) g(C_k)^2.

For k>=2, k^3>=2k, so g(C_k)^2>=k^3/3. For any M>0, choose an integer N>3M^2+2. If k>=N and g(C_k)/k<M, positivity implies g(C_k)^2<M^2 k^2<k^3/3, a contradiction. M<=0 follows from positivity. This proves the full filter limit, not merely a subsequence. The k^(3/2) lower bound suffices; no quadratic upper bound or two-sided quadratic order is claimed.

For balanced trees we prove the following quantitative bound throughout the actual critical interval:

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H_Bk(z) <= k*z + 20*(k*z)^2, provided k*z <= 1/1000.

The leaf case follows from H<=1/2 and H=z+H^2: H<=2z, then H<=z+4z^2. For a split k=a+b, a=floor(k/2), b=ceil(k/2), we have a,b>=1 and k^2<=5ab. Put x=H_Ba(z), y=H_Bb(z), w=H_Bk(z), and q=x+y+xy. The inductive bounds and az,bz<=1/1000 give x<=1.02az, y<=1.02bz, xy<=2abz^2, and q<=1.1kz. The exact node equation and w<=1/2 imply w<=2q and w^2<=4q^2<=5(kz)^2. Thus

w <= kz + [20(a^2+b^2)+2ab+5k^2]z^2
<= kz + 20k^2 z^2,

because 5k^2<=25ab<=38ab. The children are inside their proved critical intervals by strict child threshold separation. Strong induction covers every positive integer k, including odd splits.

If g(B_k)>1000k then krho(B_k)<1/1000. Apply this bound at the actual root threshold: 1/2<=1/1000+20/1000^2, impossible. Hence g(B_k)<=1000k. The universal lower bound supplies 2k. This proof uses neither the parallel strict balanced extremum theorem nor dyadic comparisons, generic singularity transfer, numerical samples, or an assumed semantic bridge.

The formal endpoint also states the positive actual count root limit and inverse-threshold identity for every species tree. ShapeIso preserves count, radius, growth and leaf number. Additional exported theorems transport the balanced inequalities and caterpillar family limit across arbitrary child swaps.

One cutoff and genuine unranked transport

For each k take A_k from eventual_balanced_minimum and B_k from eventual_caterpillar_maximum. Set N_k=max(A_k,B_k). It is at least one. Each n>=N_k satisfies both comparisons and both equality equivalences simultaneously for every species with k leaves. The finite family here is all ordered full binary k-leaf trees, so it covers every unranked class; it is not a selected sample. At k=1,2,3 the shared shape cases obey the same proofs. No k-independent cutoff is asserted.

ShapeIso is exactly the inductive independent-child-swap relation. Its refl/symm/trans proofs make a setoid. FinalSourceTransport constructs the actual quotient Unranked and uses proved invariance to descend leaves, count, rho and growth via Quotient.lift. Quotient equality is proved equivalent to ShapeIso. Quotient induction transports the uniform inequalities and positive root limits to every unranked species; canonical family growth is definitionally the descended growth. This is the expanded unranked_four_claims_expanded theorem. Arbitrary representatives of the balanced family satisfy the same uniform bounds, and arbitrary caterpillar representatives satisfy the same superlinear limit. The source_event_four_claims_expanded theorem separately replaces every count by sourceCard using the proved event-fiber equivalence. These transports assume no source-count, extremum or convergence bridge.

Reproduction contract

The source appendix is UTF-8 literal text, with byte length and SHA256 in each SOURCE marker. Copy the extractor below verbatim and run taskset -c 4,5 python3 -I -B extract_final_paper.py FINAL-PAPER-v1.md cache/paper-extracted. It does not consult the project layout, JSON index or provider cache. Compare its manifest to the embedded source map and both prefix maps.

The pinned external boundary is Lean4.34.1 plus mathlib revision d13f23b723b8a846827a245b89c10fc7d3f11612 and the exact upstream package paths/imports in PINS. Binary hashes are enforced by formal_command.py. Upstream oleans are trusted pinned inputs; no complete upstream source rebuild/origin attestation is claimed. Each custom import must resolve only to the listed production module of that name.

Author commands, from this lane, were taskset -c 4,5 bash ./check32.sh MODULE UNIQUE_LABEL and separately taskset -c 4,5 bash ./checker32.sh MODULE UNIQUE_LABEL. The embedded receipt/resource map gives every exact invocation and low-level argv, source/olean hashes, limits, stdout references and outcomes, including the failed

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initial transport elaboration. A fresh paper-only replay must use a separately authorized empty build directory, extracted src, literal harness and pins, and execute those two commands once for each module in the embedded dependency_order. No cached project olean is a replacement for that replay. The author32-call allocation does not authorize spending126 replay calls here.

Author extraction verifies all63 literal sources without invoking Lean on the60cached providers. For independent replay, archive the full output of each wrapper invocation and reparse all axiom outputs, rather than trusting this paper's stored success labels. Olean hashes can depend on file metadata/build context; source equality is mandatory and fresh separate kernel checking is mandatory.

Exact expanded endpoint types

LiteralDL.FinalStage.source_target

lean
theorem source_target : SourceTarget

LiteralDL.FinalStage.source_four_claims_expanded

lean
theorem source_four_claims_expanded :
(∀ k : Nat, 0 < k → ∃ N : Nat, 1 ≤ N ∧
∀ s : Species, leaves s = k → ∀ n : Nat, N ≤ n →
count (balanced k) n ≤ count s n ∧ count s n ≤ count (caterpillar k) n ∧
(count (balanced k) n = count s n ↔ ShapeIso s (balanced k)) ∧
(count s n = count (caterpillar k) n ↔ ShapeIso s (caterpillar k))) ∧
(∀ s : Species, 0 < growth s ∧
Tendsto (fun n : Nat => (count s n : ℝ) ^ (1/(n:ℝ))) atTop (nhds (growth s)) ∧
growth s = (rho s)$^{-1}$) ∧
Tendsto (fun k : Nat => growth (caterpillar k)/(k:ℝ)) atTop atTop ∧
(∀ k : Nat, 0 < k → 2*(k:ℝ) ≤ growth (balanced k) ∧
growth (balanced k) ≤ 1000*(k:ℝ))

LiteralDL.FinalStage.source_event_four_claims_expanded

lean
theorem source_event_four_claims_expanded :
(∀ k : Nat, 0 < k → ∃ N : Nat, 1 ≤ N ∧
∀ s : Species, leaves s = k → ∀ n : Nat, N ≤ n →
sourceCard (balanced k) n ≤ sourceCard s n ∧ sourceCard s n ≤ sourceCard (caterpillar k) n ∧
(sourceCard (balanced k) n = sourceCard s n ↔ ShapeIso s (balanced k)) ∧
(sourceCard s n = sourceCard (caterpillar k) n ↔ ShapeIso s (caterpillar k))) ∧
(∀ s : Species, 0 < growth s ∧
Tendsto (fun n : Nat => (sourceCard s n : ℝ) ^ (1/(n:ℝ))) atTop (nhds (growth s)) ∧
growth s = (rho s)$^{-1}$) ∧
Tendsto (fun k : Nat => growth (caterpillar k)/(k:ℝ)) atTop atTop ∧
(∀ k : Nat, 0 < k → 2*(k:ℝ) ≤ growth (balanced k) ∧
growth (balanced k) ≤ 1000*(k:ℝ))

LiteralDL.FinalStage.unranked_four_claims_expanded

lean
theorem unranked_four_claims_expanded :

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(∀ k : Nat, 0 < k → ∃ N : Nat, 1 ≤ N ∧
∀ q : Unranked, unrankedLeaves q = k → ∀ n : Nat, N ≤ n →
unrankedCount (shape (balanced k)) n ≤ unrankedCount q n ∧
unrankedCount q n ≤ unrankedCount (shape (caterpillar k)) n ∧
(unrankedCount (shape (balanced k)) n = unrankedCount q n ↔
q = shape (balanced k)) ∧
(unrankedCount q n = unrankedCount (shape (caterpillar k)) n ↔
q = shape (caterpillar k))) ∧
(∀ q : Unranked, 0 < unrankedGrowth q ∧
Tendsto (fun n : Nat => (unrankedCount q n : ℝ) ^ (1/(n:ℝ)))
atTop (nhds (unrankedGrowth q)) ∧ unrankedGrowth q = (unrankedRho q)$^{-1}$) ∧
Tendsto (fun k : Nat => unrankedGrowth (shape (caterpillar k))/(k:ℝ))
atTop atTop ∧
(∀ k : Nat, 0 < k → 2*(k:ℝ) ≤ unrankedGrowth (shape (balanced k)) ∧
unrankedGrowth (shape (balanced k)) ≤ 1000*(k:ℝ))

Author SELF, read/unread and process record
Final four-claim assembly handoff v1

AUTHOR IMPLEMENTATION COMPLETE; acceptance pending independent review/replay. No credit claimed or administered. Current campaign72/80 NEW,111 total unchanged.

Mathematical deliverable

FinalAssembly.source_target (namespace LiteralDL.FinalStage) proves SourceTarget without source, extremum, root-limit or family-bound assumptions. source_four_claims_expanded exposes the canonical actual-cardinality statement; source_event_four_claims_expanded exposes the same statement for literal species-addressed Valid event-tree cardinalities. unranked_four_claims_expanded is the fully expanded quotient statement. uniform_extrema uses max of the two independently proved cutoffs and covers all k-leaf species and all n beyond one N_k>=1, with equality iff the corresponding ShapeIso. Positive real root limits and growth=1/rho are included. Caterpillar growth/k tends to infinity; balanced growth lies between2k and1000k for every positive k. No stronger historical quadratic or80 claim is made.

Three new production modules: FinalSourceTransport, FinalAssembly, FinalExpandedAudit. The 60 cached providers were neither overwritten nor recompiled. Exact own-paper prefix comparison matches all52 balanced sources and all54 growth sources, with common46 identical; SOURCE-APPENDIX-v1.json verifies cached source and olean hashes against the supplied provider map. PREFIX-HASH-MATCH-v1.json is byte custody, not an assertion about the separate Claude reader. No other lane was read or polled.

Verification and remaining acceptance gates

11/32 formal invocations used, including one failed elaboration and all intermediate compiles/checkers. Every call used frozen check32/checker32, CPU4,5,32GiB AS,6GiB RSS,CPU115/wall130,j1/M3500,warnings-as-errors. FORMAL-RESOURCES-v1.json records commands, hashes, full outputs and telemetry. All three FINAL modules compiled and separately kernel checked. FinalExpandedAudit prints272 named transitive axiom closures, all within propext/Classical.choice/Quot.sound. Runtime reports4.34.1; wrappers enforce pinned executable hashes.

The complete paper appendix mechanically extracts all63 production source files with exact bytes/hashes and verified dependency order. No redundant whole-closure author compilation was performed. Independent semantic review of the new growth8, transport/assembly and full expanded endpoint remains required, as does one fresh paper-only extraction, full closure compile and separate kernel audit under a separately authorized replay allocation. The independent52-prefix review result is not assumed. Root must compare exact source hashes before reusing any

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reading coverage. These are external acceptance gates, not unproved hypotheses in our theorem.

Hostile SELF review

Checked: one cutoff shared by both inequalities; finite conjunction over EVERY fixed-k species, not a selected family; all positive k and all n beyond the cutoff; both equality directions; genuine unranked quotient with equality equivalent to ShapeIso; histories retain ordered duplication children and explicit loss/species maps; root limits are real positive actual-count limits; cubic certificate suffices for superlinearity; balanced bound covers odd splits; no asymptotic-equivalent slope or quadratic estimate is smuggled into the result. Quotient descent uses already proved count/rho/growth invariance. Source-event cardinality is tied by an actual equivalence. Expanded endpoints have no residual bridge premise.

Author checks do not certify source fidelity independently, significance, novelty, or literature clearance. Parker's Conditions for Optimality of the Huffman Algorithm remains unread/closed after SIAM robots denial; its precise subsumption risk remains unresolved. Gromada, DMGT companion, homomesy/toggleability, legacy github.com/openai/math and all other named stops remain in force; no body recovery, origin traversal, network/search, prototypes, children, ledger, accounts or credit actions occurred. The common provider producer was UNSEALED; root byte custody does not repair that historical defect or replace independent review.

Honest reading and process inventory

Personally read full TASK/current model/additional restrictions (initial overlarge output), full three applicable AGENTS across bounded slices, prospective clarification, budgets/reservation/grants/PINS and wrappers/runner/writer; Parker/Gromada named controls and matched legacy/homomesy stops. All own JSON keys/scalars were machine screened recursively; CONTROL-SCREEN-v1 and CONTROL-RESCREEN-v2 preserve exact scope/patterns/matches. Machine screening is not personal reading. Broad host matches do not close unrelated works. The later authenticated-author rescreen does not retroactively repair chronology.

Scientific reading: complete raw342705 record and live target statement projection; title/authors/date metadata; v1 text0:1900,17478:21278,36232:40032,51000:54800,75393:77293; final text60437:62337. Rendered v1 pages4,8,11,16 inspected. A prior source-locate display exceeded the cap and was truncated; exact conjecture passages were subsequently reread in bounded slices. Other source bodies, unrelated control narratives and historical proofs/receipts were not personally read end to end.

Provider/interface reading: SpeciesShapes complete; ShapeTransport complete; ActualRootLimit complete; ThresholdIdentity except final namespace tail; GrowthFinalEndpoint complete; BalancedFinalExtremum through character3800 (exports and proof complete, final print tail unread); SourceHistory0:1900,SourceFiber0:1900,CaterpillarCounts0:1200; EndpointAudit complete. The ordinary caterpillar section of PAPER-v3, balanced ordinary proof in BALANCED-PAPER-v1 and growth ordinary proof in GROWTH-PAPER-v1 were read and integrated. Other provider bodies are copied and hashed, not thereby personally read. Newly authored source/proofs were personally constructed and reviewed.

UNWAIVED current defects: directory inventory preceded the prescribed initial sequence; initial combined controls response exceeded6000 and logical/payload limits; full run.py and combined PINS read exceeded logical slices; source-locate output was oversized/truncated; some payloads exceeded2400; comprehensive normalized author/host/control screening and title metadata authentication occurred after some technical reading; runtime version attestation followed early compiles (binary hashes were enforced from the first wrapper call). One wrong ancestor-path read failed without reading an outside source. Historical defects remain UNWAIVED. No clean-process PASS is asserted.

Files and closure

FINAL-PAPER-v1.md contains the full ordinary proof, exact expanded endpoint types, literal63-module source appendix in dependency order, pins, imports, provider/source/olean/declaration/axiom maps, prefix byte

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comparisons, actual formal receipt/resource map and literal build/extraction harness. SOURCE-APPENDIX-v1.json is its structured index. extract_final_paper.py performs independent-of-layout byte extraction into cache/paper-extracted; extraction verification is recorded in paper-extraction and paper-byte-verification receipts. The full formal closure is intentionally not recompiled in this author lane.

After all writes and documentary checks, standalone verify_frozen.py after produces frozen-after.json. Terminal physical sealing enumerates every own-lane physical directory/file, rejects symlinks/special files, hashes every regular file, and excludes exactly FINAL-SHA256-v1.json, final-seal.receipt.json, final-seal.output.txt. The terminal seal invocation produces those three files and is followed by no commands or writes. Its actual outcome, not this prospective description, is authoritative. No resource/mathematical blocker remains for the assigned author assembly; remaining independent acceptance work is explicitly external.

Literal source appendix

The complete literal source appendix is supplied byte-exact in publication/complete-literal-source-appendix.md in supporting.zip and proof-sources.json. Extract using extract_sources.py. No ordinary proof above this appendix has been removed.

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