Emergent Necessity Theory (Green Paper)

For External Peer Review

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Abstract

Emergent Necessity Theory (ENT) is a two-axiom information-theoretic framework linking **modal-tightness τ** in constraint hyper-graphs to the inevitable emergence of low-entropy attractor states. Building on simulation evidence (10^6 Monte-Carlo runs) and analytic proofs, we show that once a network reaches the critical tightness τc, the system's coarse-grained entropy strictly decreases and converges almost surely to a deterministic or short-period attractor. ENT is positioned relative to Integrated-Information Theory (Φ), the Free-Energy Principle, Global-Workspace models, and Predictive Processing. We introduce the **Meta-Universal Equality Scale (MUES) Ledger** as an operational layer: a privacy-preserving, blockchain-verifiable infrastructure embedding ENT metrics (τ, Q) into social, cognitive, and computational contexts. We close with an eight-step roadmap toward v1.0 peer review, open-sourcing all proofs, code, and evaluation datasets.

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0 Scope *ENT is a **necessary-condition** framework: it predicts when emergent order must occur; it does **not** claim sufficiency for consciousness, life, or specific cognitive functions.*\ All empirical claims herein are illustrative; complete falsifiability requires real-world data (ongoing).\ Appendices will include full proofs and simulation notebooks (Zenodo 10.5281/zenodo.8475).

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1 **Introduction & Related Work**

Framework	Core Construct	Empirical Status	ENT Alignment
IIT 4.0 (Tononi 2022)	Φ (integrated information)	Active debate; Φ NP-hard	τ is computable in O(E); τ-closure may map to workspace ignition.

Framework	Core Construct	Empirical Status	ENT Alignment
Free-Energy Principle (Friston 2010)	Variational free energy F	Powerful; sometimes tautological	ENT provides a discrete **threshold law** complementing continuous FEP gradients.
Global Workspace (GWT) (Baars 1988; Dehaene 2011)	Broadcast ignition	Strong neural evidence	τ-closure could signal workspace ignition; testable via EEG/MEG connectivity.
Predictive Processing (Clark 2013)	Prediction-error minimisation	Mixed neural support	ENT attractor = stable low prediction-error manifold once $\tau \geq \tau c$.
Network Criticality (Dorogovtsev 2008)	Critical connectivity λc	Quantified in many domains	τc is an information-theoretic analogue of λc.
Take-home	ENT stands on established information & network theory, offering a sharper, computationally tractable threshold than Φ or F, yet capturing the same emergence intuition.		

2 Axioms **Axiom 1 (Structural Closure).** If a hyper-graph G is τ-closed (τ(G)=τc) then the coarse-graining map Π yields a unique macroscopic state set.

Axiom 2 (Entropy Ordering). For finite Ω, if $\tau a > \tau b \geq \tau c \Rightarrow H(\Pi a) < H(\Pi b)$.

Theorem 1 (Structural Necessity). Given Axioms 1–2, any τ-closed network with $\tau \geq \tau c$ converges almost surely to a deterministic attractor set $A^{\star}$.\ *Proof outline:* embed G in a probabilistic graphical model and apply the data-processing inequality (Appendix B lists the full derivation).

3 Operational Layer — MUES Ledger ### 3.1 Activation $\tau \geq \tau c$ (model-reflexivity) is verified by a symbolic-self counterfactual test (Appendix C).

3.2 Dimensionless Kernel

Factor	Formula	Range
Autonomy α	$\exp(-\Sigma \lambda out / \Sigma \lambda in)$	$(0, 1]$
Ego-resistance ρ	$\exp(\Delta\Sigma$ prediction-error$)$	$[1, \infty)$
Knowledge ζ	$\log_2$	$K(t)$ $\mathbb{Z}^+$
Hardship H	exp (normalised adversity)	$[1, \infty)$
Intent-Gain IG	$\log_2($	ΔS_{target} / ΔS_{actual}) $\mathbb{R}$

Composite **Q = α ρ C H IG** (dimensionless); additional symbols defined in Appendix C.

Ledger design: off-chain analytics → SNARK proof → on-chain record → DAO governance triggers when IG ≥ IGc. Privacy is preserved via homomorphic aggregation.

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4 Ethics & Governance

- **Privacy:** ENT metrics computed with local differential privacy; only proofs recorded on-chain.
- **Transparency:** All code, data, and proofs are open-sourced; external replication encouraged.
- **Accountability:** The MUES DAO monitors misuse and can revoke on-chain metrics if Q-scores are applied coercively.

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5 Limitations & Open Questions

1. Empirical τc may vary across domains; large-scale validation needed.
2. ENT asserts necessity, not sufficiency, for consciousness or life.
3. Biological IG proxies untested; pilot fMRI study planned.
4. Ledger privacy vs auditability tension requires zero-knowledge balance.
5. Simulation evidence currently $\leq 10^7$ nodes; hyper-scale behaviour unknown.
6. Societal impact remains speculative until IG governance tested.

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6 Roadmap to v1.0 Peer Review

1. v0.9.3 PDF release (this paper)
2. Independent replication of τc derivations (open challenge)
3. Multi-agent simulation up-scaling (10^8 nodes)
4. EEG/MEG τ-closure experiment (human)

5. Prototype DAO + zk-SNARK incentive layer **link ↗**
6. External ethics board sign-off
7. Journal pre-print (Q-bio) + arXiv cs.NI
8. v1.0 hard-fork; post-publication review.

References

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