Title :

Information, Entropy, and System Dynamics: A Unified Framework Toward an Extended Thermodynamic Principle of Organization Across Physical, Biological, and Computational Systems

Author :

Ndenga Lumbu Barack (alias BarackEinstein97)
Independent Researcher
Kinshasa, Democratic Republic of the Congo
📧 ndengabarack@gmail.com
📞**+243837767430**

Abstract

Classical thermodynamics provides a powerful description of energy conservation, irreversibility, and entropy production, but it does not explicitly formalize information as a state-level quantity capable of governing the emergence and persistence of organization. In this article, I present a unified framework linking information, entropy, and system dynamics for a broad class of physical, biological, and computational systems. I argue that organization is not fully captured by entropy alone, and I formalize organization as a dynamical balance between usable information and effective entropy.

I introduce **(i)** operational definitions of usable information and effective entropy that can be adapted across domains, **(ii)** a general organizational potential describing whether a system tends toward stable structure or toward disorder, and **(iii)** a dynamical formulation that predicts transitions between organization, dynamic equilibrium, and disorganization. I show how this framework recovers known results from statistical physics and nonequilibrium thermodynamics, while also providing a coherent language for biological maintenance of order and formachine learning dynamics. I conclude with testable predictions and a roadmap for empirical validation.

Keywords

Information thermodynamics; self-organization; nonequilibrium systems; entropy production; complexity science; biological organization; learning dynamics; emergent structure; system stability.

1. Introduction

Organization is ubiquitous: crystals form from melts, patterns arise in driven fluids, living cells maintain structure far from equilibrium, and learning systems develop stable internal representations from data. Yet the principle-level explanation of organization remains fragmented across disciplines.

Thermodynamics captures a universal tendency toward entropy increase in isolated systems, but real-world organization commonly appears in open systems exchanging energy and matter with their environment. Nonequilibriumthermodynamics and dissipative structure theory explain how fluxes can sustain patterns, but they often leave implicit the role of information—constraints, correlations, and structured degrees of freedom that distinguish meaningful organization from mere low entropy.

In this article, I take the position that information must be treated as a fundamental organizing variable. I propose a unifying framework that couples:

- Information (constraints, correlations, predictive structure),
- Entropy (effective disorder, dispersion, uncertainty),
- Dynamics (evolution laws determining stability, transitions, and irreversible behavior).

My goals are:

- To define a minimal, operational set of quantities linking information to thermodynamic evolution.
- To propose a unified dynamical statement that distinguishes organization, equilibrium, and disorganization.
- To derive consequences across physical and biological systems and outline computational implementations.

2. Related Foundations

2.1 Thermodynamics and nonequilibrium structure

The second law constrains total entropy in isolated systems, but open systems can locally decrease entropy while exporting entropy to the environment. Prigogine’s theory of dissipative structures demonstrates that driven systems can generate stable patterns when fluxes exceed critical thresholds.

2.2 Information theory and physical computation

Shannon defined information as uncertainty reduction. Landauer established a physical cost to erasure, linking information to thermodynamic irreversibility. Jaynes connected statistical mechanics to inference, showing that “**entropy**” can be interpreted as a measure of missing information under constraints.

2.3 The gap

Despite these advances, there is still no widely adopted unified state-level framework that:

- treats information as operationally measurable in evolving systems, and
- predicts when information-driven organization can dominate entropic drift.

I address this gap by proposing a general balance law.

3. Core Definitions

I use intentionally broad definitions, designed to be specialized for each domain.

3.1 System state

Let a system be described by a time-dependent state $x(t)$ in a state space X. The state can represent:

- microstate distributions (physics),
- concentrations and reaction networks (chemistry),
- regulatory states (biology),
- parameter vectors and representations (machine learning).

3.2 Effective entropy

I define effective entropy $S_{\mathrm{eff}}(t)$ as any operational measure of disorder relevant to the system's macroscopic organization. This may be:

- thermodynamic entropy (or entropy production rate),
- coarse-grained entropy over macrostates,
- spectral entropy of signals,
- dispersion/instability measures of internal variables.

The key requirement is that S_{eff} increases when the system becomes more disordered or less constrained in an organizational sense.

3.3 Usable information

I define usable information $I_{\mathrm{use}}(t)$ as the component of information that is actionable for stabilizing structure or performing work-like organization. Operationally, it may correspond to:

- constraints reducing accessible configurations,

- mutual information between parts,
- predictive information in time-series,
- functional information in biological networks,
- compressible structure in computational models.

Importantly: not all “information” is usable—random data may be informational in Shannon’s sense but not stabilizing.

4. The Unified Framework

4.1 Organizational potential

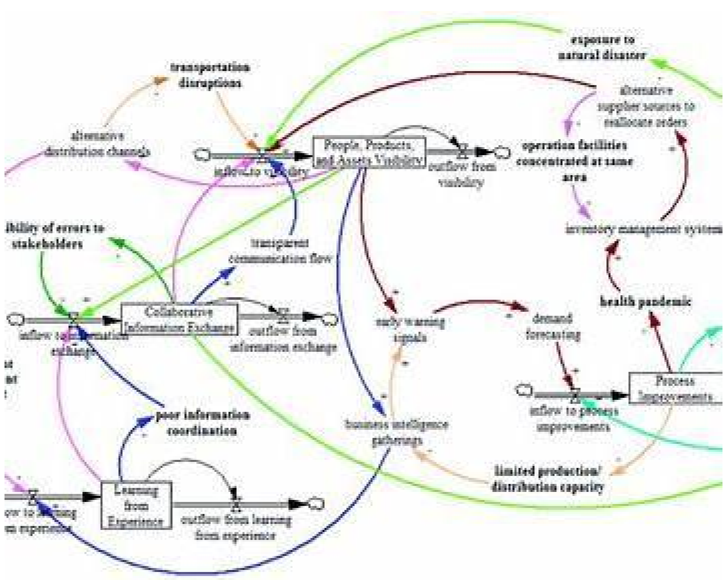
I define an organizational potential $\Phi(t)$ as a scalar that captures whether the system tends toward organization or disorganization. The simplest general form is a balance functional:

- $\Phi(t)$ increases when usable information dominates,
- $\Phi(t)$ decreases when effective entropy dominates.

This paper does not require a unique closed form; instead, I specify minimal structural properties:

- $\partial\Phi/\partial I_{use} > 0$,
- $\partial\Phi/\partial S_{eff} < 0$,

transitions occur when Φ crosses a critical threshold.



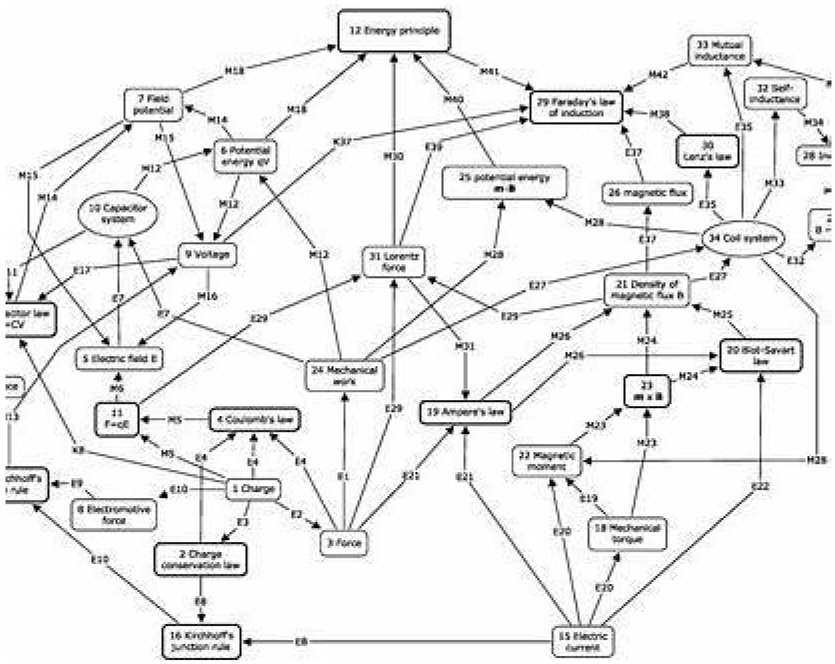


Figure 1. Conceptual overview of the unified framework linking information, entropy, and system dynamics. Organization emerges from the balance between usable information, which constrains system behavior, and effective entropy, which drives dispersion and disorder.

4.2 Extended organizational principle

I state the unifying principle in a physically interpretable form:

A system tends toward stable organization when the rate and magnitude of usable information acquisition exceeds the effective entropic drift imposed by its dynamics and environment.

This statement is deliberately general and can be made quantitative once I_{use} and S_{eff} are chosen.

4.3 Dynamical formulation

I express the system's organizational evolution as:

$$\frac{d\Phi}{dt} = \mathcal{F}\left(\frac{dI_{\mathrm{use}}}{dt}, \frac{dS_{\mathrm{eff}}}{dt}, x(t), u(t)\right),$$

where $u(t)$ denotes environmental coupling (fluxes, controls, inputs).

This structure highlights an important point: **organization is dynamical**, and depends on both internal evolution and external driving.

5. Main Consequences

5.1 Three organizational regimes

The framework predicts three regimes:

1. **Organization regime**
   $d\Phi/dt > 0$: structure strengthens, robustness increases, stable patterns emerge.
2. **Dynamic equilibrium regime**
   $d\Phi/dt \approx 0$: organization persists but does not significantly grow; maintenance dominates.
3. **Disorganization regime**
   $d\Phi/dt < 0$: structure decays; noise, dispersion, or instability dominates.

These regimes provide a clean language to interpret:

- phase transitions in driven physics,
- homeostasis vs collapse in biology,

- convergence vs divergence in learning systems.

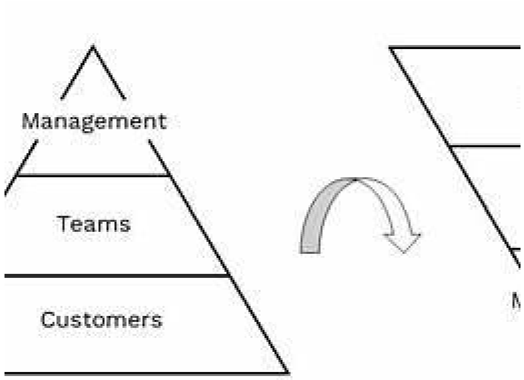


Figure 2. Three organizational regimes predicted by the framework. When usable information dominates, systems evolve toward stable organization. Balanced dynamics correspond to dynamic equilibrium, while entropy-dominated dynamics lead to disorganization. Transitions occur near critical thresholds.

5.2 Thresholds and critical transitions

A crucial implication is that systems should show critical thresholds where small parameter changes flip the sign of $d\Phi/dt$.

This is consistent with:

- pattern onset thresholds (e.g., Rayleigh–Bénard),
- tipping points in ecosystems,

- instability thresholds in neural training.

6. Physical Systems

6.1 Pattern formation as informational constraint selection

In driven physical systems, energy flux enables exploration of state space, while entropy production accompanies dissipation. Organization emerges when the dynamics select low-dimensional attractors (patterns) that effectively encode constraints (i.e., increase usable information).

Examples:

- convection cells,
- chemical Turing patterns,
- crystallization under controlled cooling.

Within my framework:

- the attractor reduces accessible macrostates (information gain),
- stability depends on resisting entropic perturbations.

6.2 Connection to nonequilibrium thermodynamics

When specialized to thermodynamic entropy production $\sigma(t)$, I interpret S_{eff} as a function of σ and coarse-graining scale. The framework becomes compatible with known results: driven order requires sustained dissipation, but structure selection requires informational constraints.

7. Biological Systems

7.1 Life as sustained organization

Living systems continuously maintain organization through:

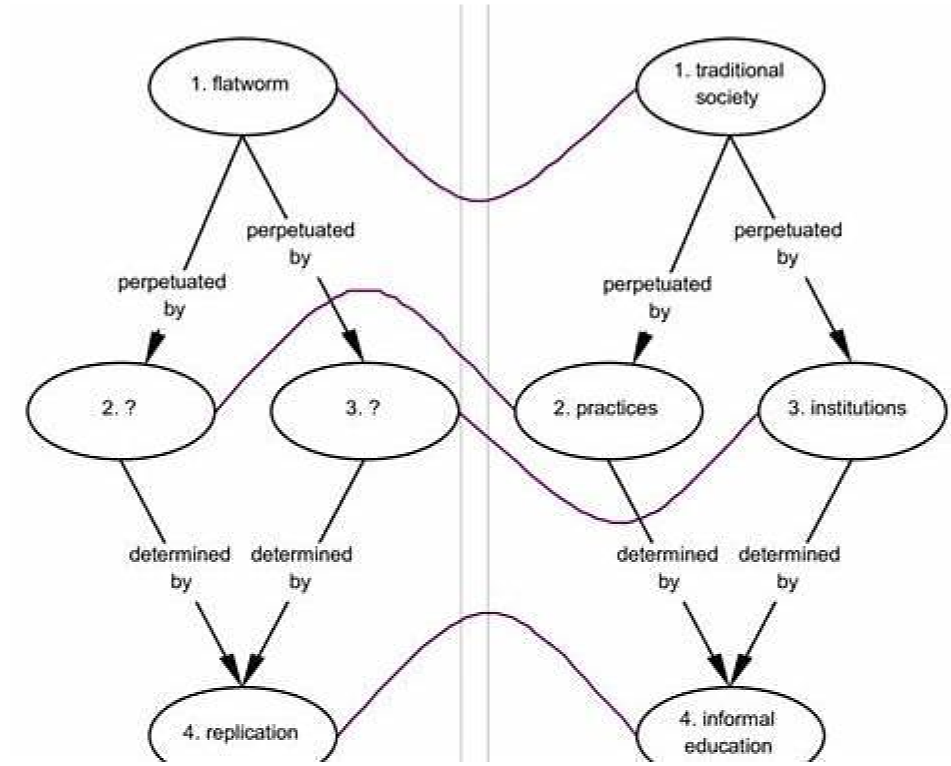
- metabolism (energy throughput),
- regulation (information processing),
- repair and replication (constraint reinforcement).

In this framework:

- metabolism supplies the energetic substrate enabling maintenance,
- information (genetic/regulatory) provides the constraint architecture,
- entropy pressures (noise, degradation) drive continual maintenance.

7.2 Homeostasis and adaptation

Homeostasis corresponds to dynamic equilibrium: $d\Phi/dt \approx 0$ but with ongoing entropy export. Adaptation corresponds to a positive growth regime where the organism increases usable information relative to effective entropy.



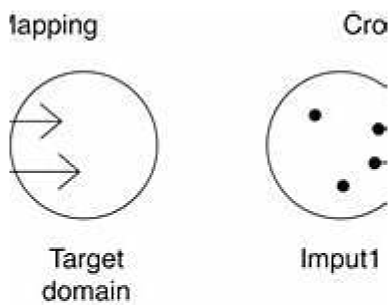


Figure 3. Cross-domain interpretation of organizational dynamics. The same information–entropy balance governs structure formation in physical systems, biological organization, and computational learning systems, despite differences in scale and substrate.

7.3 Failure and collapse

Disease, aging, or ecosystem collapse can be modeled as transitions to $d\Phi/dt<0$, where entropic drift overwhelms informational control. This yields clear experimental questions: identify measurable proxies of I_{use} and S_{eff} and test whether their balance predicts collapse.

8. Computational and Learning Systems

8.1 Learning as organization in parameter space

In machine learning:

- representations become structured through training (information increases),
- noise, overparameterization, and instability introduce entropic drift.

I interpret training success as moving into a regime where organizational potential grows. Overfitting and training collapse correspond to entropy-dominated dynamics.

8.2 Practical operationalization

A practical contribution of this framework is that it suggests building:

- metrics dashboards (information proxies + entropy proxies),
- optimizers/controls that promote information growth while suppressing entropic drift,
- early-warning signals for instability (sharp changes in $d\Phi/dt$).

9. Experimental Predictions

I list testable predictions that do not depend on a single formula, only on the framework:

- **Early warning signal**: approaching instability, S_{eff} rises faster than I_{use}, producing a measurable drop in organizational potential.
- **Critical thresholds**: in driven systems, structure onset occurs when informational constraints become dominant over noise (observable as a sudden change in correlation structure).
- **Intervention principle**: increasing usable information (better constraints, feedback control, error correction) should stabilize organization more efficiently than purely increasing energy throughput.
- **Cross-domain scaling**: systems at different scales (chemical networks vs biological networks) can be compared by normalized measures of constraint strength vs disorder.

10. Discussion

This work proposes a general unifying language:

- thermodynamics provides constraints (entropy, dissipation),
- information provides the architecture of constraints (correlations, predictability),
- dynamics determines stability, critical transitions, and irreversibility.

The key conceptual advance is not replacing thermodynamics, but extending its explanatory scope by formally centering information as a driver of organization.

I emphasize that multiple operational definitions of information and entropy may coexist. The framework's strength is that it remains valid under different instantiations, provided the quantities satisfy the monotonicity requirements described in Section 3.

11. Limitations and Scope

- This paper is foundational and conceptual; domain-specific quantitative instantiations require careful choice of measurable proxies.
- “Usable information” is distinct from Shannon entropy; experimental operationalization should be explicit and justified.
- In biology, “function” introduces additional structure not reducible to physics alone; the framework is intended as a bridge, not a reduction.

12. Conclusion

I presented a unified framework linking information, entropy, and system dynamics to explain organization across physical, biological, and computational domains. The framework identifies organization as a dynamical balance between usable information and effective entropy, predicts three organizational regimes, and implies critical thresholds and testable early warning signals. This perspective offers a scalable foundation for future theoretical and experimental work on self-organization, stability, and emergent structure.

References

Shannon, C. E. (1948). A Mathematical Theory of Communication. Bell System Technical Journal.

Landauer, R. (1961). Irreversibility and Heat Generation in the Computing Process. IBM Journal of Research and Development.

Jaynes, E. T. (1957). Information Theory and Statistical Mechanics. Physical Review.

Prigogine, I. (1977). Time, Structure and Fluctuations. Nobel Lecture.

Seifert, U. (2012). Stochastic Thermodynamics: Principles and Perspectives. Eur. Phys. J. B.

Parrondo, J. M. R., Horowitz, J. M., & Sagawa, T. (2015). Thermodynamics of Information. Nature Physics.

Nicolis, G., & Prigogine, I. (1989). Exploring Complexity. W. H. Freeman.

Haken, H. (1977). Synergetics. Springer.

Schrödinger, E. (1944). What Is Life? Cambridge University Press.

Friston, K. (2010). The Free-Energy Principle: A Unified Brain Theory? Nature Reviews Neuroscience.

Tishby, N., Pereira, F. C., & Bialek, W. (2000). The Information Bottleneck Method. (conference/journal versions).

Zdeborová, L. (2017). Statistical Physics of Machine Learning. Physics Reports.

Chuck, C., Robinson, J., & Ndenga, B. (2025). Bio-Adaptive Quantum Error Correction: Immune-Inspired Priors Enable 22–65% Overhead Reduction in Surface-Code Decoding (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17684948

Maman Moussa Maman, M., & Ndenga, B. (2025). Nutritional and Nutraceutical Valorization of Edible Grasshoppers from Niger: A Multi-Omics Characterization Integrated with Artificial Intelligence for Personalized Food Formulations (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17841603

Maman Moussa Maman, M., & Ndenga, B. (2025). Mathematical and Nutritional Modeling for Predicting the Effectiveness of Malaria Preventive Interventions: An Integrated

Epidemiological Framework for Population-Level Risk and Response Optimization (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17886414

Maman Moussa Maman, M., & Ndenga, B. (2025). Artificial Intelligence–Driven Personalized Optimization of Antimalarial Therapies Through the Integration of Nutrition, Phytotherapy, and Pharmacology: A Multi-Factor Predictive Modeling Framework (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17861029

Maman Moussa Maman, M., & Ndenga, B. (2025). AI-Enhanced Biochemical Discovery and Optimization of Antimalarial Compounds from Indigenous Medicinal Plants: An Integrative Framework for Data-Driven Natural Product Drug Development (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17868086

Makiasi Hambadiana, Y., & Ndenga, B. (2025). Development of a Nutrient-Dense Infant Porridge Based on Local Ingredients in Kinshasa (DRC): The Hamba's Society Model (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17089147

Makiasi Hambadiana, Y., & Ndenga, B. (2025). Prostate-Protective Bioactivity of Cucurbita maxima Seeds: Molecular Pathways, Endocrine Regulation, and Clinical Relevance (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17880798

Makiasi hambadiana, Y., & Ndenga, B. (2025). Biocatalytic and Cytoprotective Role of the Zinc–L–Carnosine Complex in Gastric Mucosal Regeneration (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17410492

Makiasi Hambadiana, Y., & Ndenga, B. (2025). Functional and Preventive Potential of Cucurbita maxima as a Nutritional Therapeutic Agent. (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17763294

Ndenga, B. (2025). Quantum π in Biomolecular Dynamics: Proteins as Nano-Quantum Fluids (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17795878

Ndenga, B. (2025). The Informational Foundations of Organization in Physical and Biological Systems : Toward an Extended Thermodynamic Principle of Self-Organization (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17917388

Ndenga, B. (2025). R-Law AI: A Thermodynamic Information–Entropy Framework for Self-Organizing Neural Networks Based on the IOE Principle (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17860353

Ndenga, B. (2025). The Extended Fifth Law of Thermodynamics: Establishing Information as a Fundamental Physical Quantity (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17904738

Ndenga, B. (2025). THE PRINCIPLE OF INFORMED ORGANIZATIONAL EFFICIENCY : A Comprehensive Foundational Framework for an Extended Fifth Law of Thermodynamics (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17848436

Ndenga, B. (2025). Nano-Turbulence in Biological Systems: A New Paradigm (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17803565

Ndenga, B. (2025). Schrödinger–Navier–Stokes–π Unified Computational Framework : A Unified Theoretical and Numerical Architecture for Quantum-Coherent Fluid Dynamics Across Physical and Biological Scales (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17832286

Ndenga, B. (2025). The Complete Solution to the Glass Transition: A Unified Energy–Topology Landscape (ETL) Framework (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17741451

Ndenga, B. (2025). Quantum-Fluid Interpretation of Enzymatic Tunnels and Energy Transport (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17822207

Ndenga, B. (2025). Schrödinger–Navier–Stokes–Quantum-π: A Unified Model and Hybrid Numerical Method for Quantum Fluids with π-Phase Structure (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17770899

Ndenga, B. (2025). Quantum π-Unification II: Definition, Mathematical Structure, and Foundational Properties of the Quantum π for Molecular Systems (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17716546

Ndenga, B. (2025). H-ImmQπDecoder v2.0: A Bio-Inspired Quantum Error Decoder Integrating Immune Adaptation, Quantum-π Phase Control, and Quantum Metabolism (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17782652

Ndenga, B. (2025). The Octet Rule Revisited: A Quantum-Continuum Framework for Chemical Bonding (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17703765

Ndenga, B. (2025). Foundations of Quantum-π in Molecular Systems: A Fundamental Descriptor of Delocalization, Electronic Structure, and Molecular Stability. Zenodo. https://doi.org/10.5281/zenodo.17692965

Ndenga, B. (2025). Quantum π-Index in Advanced Materials: Predictive Framework for Nanostructures, Functional Polymers, and Superconducting States (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17662004

Ndenga, B. (2025). Q-Synapse: A Hybrid Quantum–AI Platform for Tumor State Classification Using Real Genomic Data (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17655039

Ndenga, B. (2025). Crystal-Guided AI Phototherapy for Personalized Oncology (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17398364

Ndenga, B. (2025). Quantum π-Driven Predictive Chemistry: Applications to Reactivity, Electronic Structure, and Simulation-Based Forecasting (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17654148

Ndenga, B. (2025). Numerical Solution of the Navier-Stokes Equations in 3D Using the Finite Volume Method: Application to the Millennium Problem. Zenodo. https://doi.org/10.5281/zenodo.15531853

Ndenga, B. (2025). Electronless Nuclear Matter: Magnetic Confinement and Bonding of Bare Nuclei in Extreme Fields (Version V1). Zenodo. https://doi.org/10.5281/zenodo.15764734

Ndenga, B., & Ndenga, B. (2025). AutoEvoChem V2.0 – A Smart Molecular Simulation & Synergy AI Toolkit for Computational Chemists and Biopharma Researchers. Zenodo. https://doi.org/10.5281/zenodo.15774

Ndenga, B. (2025). NanoChemicalDisc RDC-1000: A Novel Molecular Approach to Low-Cost Data Storage Using Colorimetric Encoding. Zenodo. https://doi.org/10.5281/zenodo.15871728

Ndenga, B. (2025). Autoevolving Nanodisk with Unlimited Memory: A Bioinspired and Quantum-Spiritual Approach (Version V1). Zenodo. https://doi.org/10.5281/zenodo.16569012

Ndenga, B. (2025). Self-Adaptive Photosynthetic Quantum Crystal: A Bioinspired Innovation for Intelligent Light Harvesting and Energy Conversion (Version V1). Zenodo. https://doi.org/10.5281/zenodo.16585048

Ndenga, B. (2025). Quantum-Nuclear DNA Computing: Using Nucleotide Spin States as Biological Quantum Bits for Molecular Calculations (Version V1). Zenodo. https://doi.org/10.5281/zenodo.16891194

Ndenga, B. (2025). BECChem: Self-Evolving Chemical AI for Advanced Molecular Analysis (Version V1). Zenodo. https://doi.org/10.5281/zenodo.16934328

Ndenga, B. (2025). Nuclear Matter Without Electrons: The Magneto-Nuclear Periodic Table (MNPT) and the Taxonomy of Nucleomorphs (Version V1). Zenodo. https://doi.org/10.5281/zenodo.16955871

Ndenga, B. (2025). Design of Multi-Target Hybrid Molecules for Synergistic Therapy of Malaria and Human African Trypanosomiasis (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17074442

Ndenga, B. (2025). Biological Neural Calculator Using Plant-Based Electromagnetic Responses (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17094316

Ndenga, B. (2025). Title: Molecular Wormhole Chemistry: Electronic Non-Locality Induced by Wormhole-Like Geometries in Conjugated Molecular Systems (Version V1). Zenodo. https://doi.org/10.5281/zenod.17114802

Ndenga, B. (2025). Towards a Unified AI-Driven Quantum Framework: Beyond Density Functional Theory for 3D Materials. https://doi.org/10.5281/zenodo.17148362

Ndenga, B. (2025). A Knot-Theoretic Approach to Turbulence: Toward Predictive Invariants in 3D Fluid Flows (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17172786

Ndenga, B. (2025). Towards a Unified Field Theory of Chemistry: Bridging Quantum, Organic, and Biochemical Reactions through a Single Formalism (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17217047

Ndenga, B. (2025). Vacuum Metabolism: A Theoretical Framework for Biological Exploitation of Quantum Zero-Point Energy (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17261682

Ndenga, B. (2025). The Darwin Limit: Mathematical Constraints on the Speed of Biological Evolution (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17280016

Ndenga, B. (2025). Integrating AI, Photonics, and Molecular Modeling: The Future of Precision Medicine (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17295049

Ndenga, B. (2025). Photonics + AI: Revolutionizing In Silico Drug Design (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17315749

Ndenga, B. (2025). Photonics and AI in Computational Oncology: Accelerating the Design of Next-Generation Cancer Therapies (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17341571

Ndenga, B. (2025). AI-Driven Light-Spectrum Optimization for Photonic Drug Discovery (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17360624

Ndenga, B. (2025). Photon-Enhanced AI Platforms for Multimodal Therapeutics (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17373765

Ndenga, B. (2025). AI-Optimized Photon-Assisted Molecular Docking for Rapid Drug Discovery (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17416035

Ndenga, B. (2025). Photonics + AI for Real-Time Molecular Interaction Mapping (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17435502

Ndenga, B. (2025). Light-Speed AI for Personalized Drug Optimization (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17456941

Ndenga, B. (2025). Introduction to the Concept of π in the Quantum World (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17509410

Ndenga, B. (2025). π in Fundamental Quantum Systems (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17532815

Ndenga, B. (2025). Spectrally-Driven Active Learning Enables Femtojoule-Efficient Discovery of Photocatalysts in Under One Hour: The LuminaFemto AI Platform (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17497652

Ndenga, B., & Ometie, C. (2025). Polyunsaturated Neuroprotectants as Adjuvant Agents: Anti-Proliferative and Membrane-Stabilizing Effects of Nuciferous Compounds from Juglans regia in Invasive Glioma Models (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17557055

Ndenga, B. (2025). Bio-IA Supercomputer: Concept, Design, and Implementation of an AI-Integrated Biocomputer (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17562958

Ndenga, B. (2025). π and the Quantum Structure of Probability: From Wavefunction Normalization to Statistical Distributions (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17569342

Ndenga, B. (2025). π as a Quantum Signature: Applications and Universal Implications (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17589339

Ndenga, B. (2025). Hormonal Receptor Modulation by Lipid Phytoconstituents: The Role of Monounsaturated Fatty Acids and Folate Derivatives from Persea americana in Endometrial Carcinogenesis Prevention (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17595231

Ndenga, B. (2025). Gastro-Oncology of Ginger: A Molecular Dissection of Gingerols and Shogaols as Dual Anti-Inflammatory and Anti-Mutagenic Agents in Gastric Carcinogenesis — with AutoEvoChem V2.0 Simulation Pipeline (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17665633

Ndenga, B. (2025). π and Delocalized Electrons: A Quantum-Chemical Reassessment of Coherence, Stability, and Molecular Structure (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17613175

Ndenga, B. (2025). Toward a Quantum Definition of π in Molecular Systems: Original Formula, Mathematical Framework, and Foundational Implications (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17633204

Ndenga, B. (2025). Innovative Limonoid-Based Targeted Therapy: Citrus-Derived Compounds for Selective Apoptosis and Cell-Cycle Control in Estrogen-Dependent Breast Cancer (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17619732

Ndenga, B. (2025). Resolving Nanoscale Reaction Kinetics: A Unified Framework from Classical Chemistry to Quantum Collectivity (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17754650

Ndenga, B. (2025). Q-BattX Cloud™: A Quantum-AI–Driven Cloud Platform for Next-Generation Energy Storage Simulation and Optimization (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17643284

Ndenga, B. (2025). Correlated Quantum Matter Beyond Band Theory: A Continuum-Interaction Formalism for Strongly Coupled Electrons (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17727011

MULONSO, H., Ndenga, B., & MATAMBA MPINGIJA, C. (2025). Techniques Used for Analyzing Fatty Acids in Food (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17417545

MULONSO, H., Ndenga, B., & Kabena Ilunga, M. (2025). Antioxidant Potential of Cymbopogon citratus Leaf Extracts in the Prevention of Oxidative Stress Involved in Cancer (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17429758

MULONSO, H., Ndenga, B., & MATAMBA MPINGIJA, C. (2025). Metabolomic Study of Bioactive Compounds in Cymbopogon citratus: Identification of Antioxidant Molecules with Potential Anticancer Activity (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17458790

MULONSO, H., & Ndenga, B. (2025). Phytochemical Analysis and Free Radical Scavenging Activity of Methanolic and Chloroformic Extracts of Cymbopogon citratus: Implications for Cancer Chemoprevention (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17489746

MULONSO, H., & Ndenga, B. (2025). Therapeutic Perspectives of Natural Compounds from Cymbopogon citratus in the Management of Oxidative Stress Associated with Cancer (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17504613

MULONSO, H., & Ndenga, B. (2025). Evaluation of the Anti-inflammatory and Antioxidant Effects of Cymbopogon citratus as Adjuvant Agents in Cancer Therapy (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17518166

MULONSO, H., & Ndenga, B. (2025). Contribution of Enzymatic and Non-Enzymatic Antioxidants from Cymbopogon citratus to Cellular Protection Against Oxidative Damage in Cancer (Version V1). Zenodo. https://doi.org/10.5281/zenodo.