Title :

Mutation Landscape and Error Correction in Q-DNA : Correlated Errors, Structural Redundancy, and Topological Self-Correction in a Tetra-Stranded Hereditary Polymer

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Abstract

Error accumulation is a fundamental limitation of any hereditary polymer. Canonical duplex DNA mitigates replication noise through enzymatic proofreading and repair, but remains vulnerable to independent, local errors. In this work, I develop a theoretical framework for **mutation, noise, and error correction in Q-DNA**, defined as a **canonical tetra-stranded hereditary polymer**. I show that tetra-strand coupling generically produces **correlated error patterns** and enables **structural and topological error-correction mechanisms** unavailable to duplex systems. I derive theoretical error rates under correlated noise, analyze majority- and consensus-based correction schemes, and identify structural motifs capable of **intrinsic self-correction**. These results position Q-DNA as a system in which error correction may be partially embedded in geometry and topology rather than relying exclusively on enzymatic machinery.

1. Introduction: Noise as a Fundamental Constraint on Heredity

Replication is an inherently noisy process. For a genetic system to remain viable, its **mutation rate must remain below a critical threshold** beyond which information is lost faster than selection can act. This principle, formalized by Eigen, applies to all hereditary polymers, independent of chemistry.

In duplex DNA:

- most mutations are **local and independent,**
- correction relies heavily on **enzymatic proofreading and repair,**
- redundancy is limited to complementary pairing.

For Q-DNA, the central question is different:

> Does a tetra-stranded canonical architecture enable new modes of error suppression through structural redundancy and correlation?

2. Error Models: Independent vs Correlated Noise

2.1 Independent error model (duplex baseline)

In duplex DNA, replication errors are often modeled as independent events with per-site error probability (p). The probability of an error escaping correction scales approximately linearly with genome length.

This independence assumption underlies the classical **error threshold**.

2.2 Correlated error model in Q-DNA

In Q-DNA, strands are **structurally coupled**. A perturbation affecting one strand may:

- propagate mechanically or geometrically,
- affect multiple strands simultaneously,
- or be constrained by global topology.

I model errors as **correlated multi-strand events**, characterized by:

- single-strand error rate ($p1$),
- pairwise correlated error rate ($p2$),
- higher-order correlated events (pk).

This breaks the independence assumption.

3. Mutation Landscape in Q-DNA

3.1 State space of mutations

A local Q-DNA unit can exist in:

- correct multi-strand configuration,
- partially corrupted configurations,
- topologically inconsistent states (energetically disfavored).

The **mutation landscape** is therefore structured, not flat.

3.2 Energetic filtering of mutations

Many mutation patterns are **structurally forbidden** or energetically unstable. This produces a **mutation bias** toward:

- reversible local errors,
- correlated but detectable faults,
- exclusion of isolated, silent errors.

This bias is absent in duplex DNA.

4. Structural Redundancy as an Error-Correction Resource

4.1 Redundancy without alphabet expansion

Q-DNA does not require a larger chemical alphabet. Redundancy arises from:

- multi-strand encoding,
- geometric constraints,
- topological admissibility.

Information is distributed across strands, not duplicated verbatim.

4.2 Majority and consensus rules

For a tetra-stranded unit, I define:

- **Majority rule:**
  the correct state is inferred from the configuration shared by ≥3 strands.
- **Consensus rule:**
  only configurations consistent with all admissible inter-strand constraints are allowed.

These rules are **structural**, not enzymatic.

5. Topological Error-Correction Mechanisms

5.1 Topological exclusion of inconsistent states

Certain error combinations create:

- strand crossings,
- incompatible twists,
- impossible registry states.

These are **topologically forbidden** and cannot persist without global deformation.

Thus, topology acts as a **hard error filter.**

5.2 Error relaxation pathways

Errors may relax via:

- local rearrangement,
- strand swapping,
- re-alignment driven by mechanical stress.

Correction can occur **without explicit repair enzymes**, driven by energy minimization.

6. Theoretical Error Rates

6.1 Effective error probability

Let (p) be the raw per-strand error probability. Under correlated majority correction:

$$p_{\text{eff}} \approx \sum_{k\geq 3} \binom{4}{k} p^k (1-p)^{4-k}$$

This scales as $\mathcal{O}(p^3)$, not $\mathcal{O}(p)$.

6.2 Comparison to duplex DNA

System	Raw error scaling	Effective error scaling
Duplex DNA	p	p (without enzymes)
Q-DNA	p	(p^2) – (p^3) (structural)

This represents a **qualitative change**, not a small improvement.

7. Predicted Self-Correcting Motifs

Prediction P1 — Error clustering

Mutations will appear as **clusters**, not isolated events.

Prediction P2 — Forbidden mutation patterns

Certain single-strand mutations will be statistically suppressed.

Prediction P3 — Auto-correcting domains

Specific tetra-strand motifs will show spontaneous error relaxation after perturbation.

Prediction P4 — Reduced error threshold sensitivity

Q-DNA systems may tolerate higher raw error rates without catastrophic information loss.

8. Discussion

8.1 Relation to error-correcting codes

Q-DNA resembles:

- **majority codes**,
- **consensus decoding**,
- **constraint-based codes**.

But these are implemented **physically**, not symbolically.

8.2 Implications for evolution

A Q-DNA system may:

- evolve more slowly,
- but be more mutation-resilient,
- enabling longer genomes or harsher environments.

This offers a new angle on the **Eigen paradox.**

8.3 Informational falsification

Q-DNA fails this test if:

- errors remain independent,
- no structural bias is observed,
- correction does not outperform duplex baselines.

9. Conclusion

I have shown that a canonical tetra-stranded hereditary polymer generically supports **correlated mutation patterns and structural error-correction mechanisms** unavailable to duplex DNA. By embedding redundancy in geometry and topology, Q-DNA may reduce effective error rates without relying exclusively on enzymatic repair. This work establishes noise suppression and error correction as a central axis for evaluating tetra-stranded heredity.

Figures

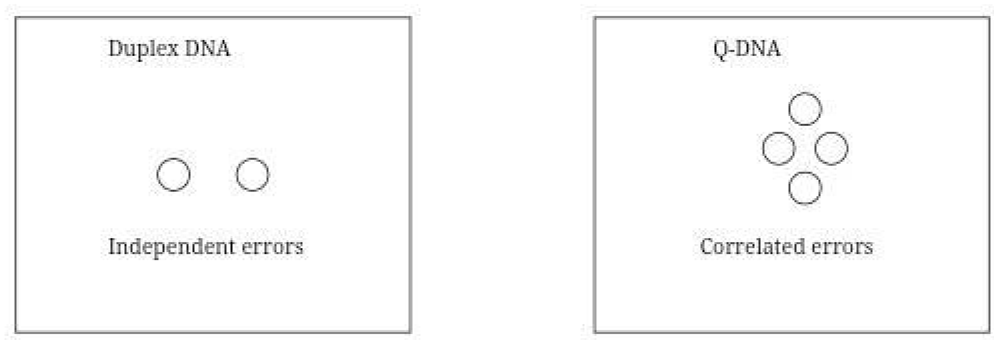

Figure 1 — Independent vs correlated errors

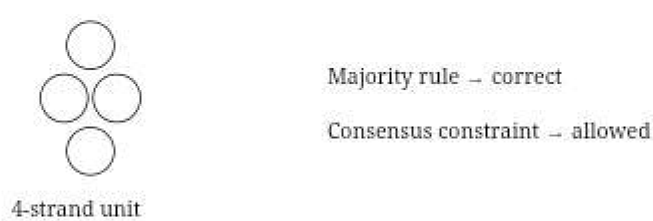

Figure 2 — Majority and consensus correction

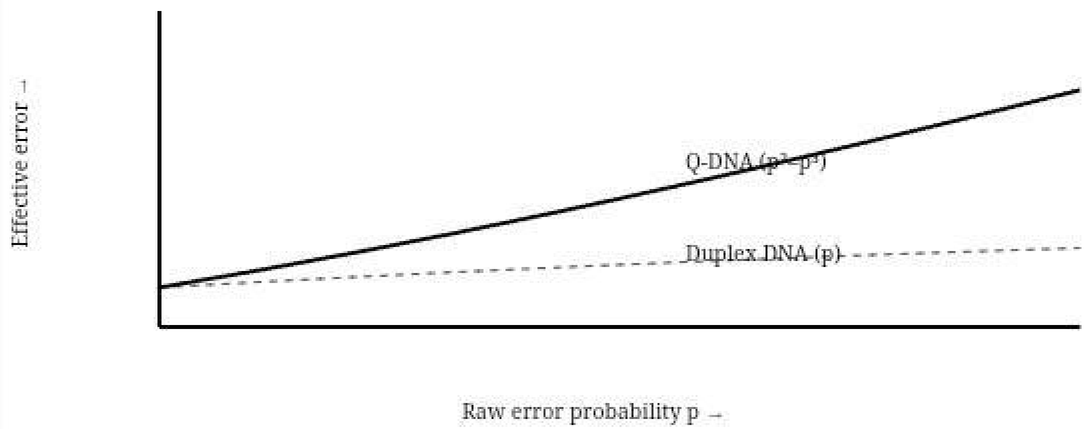

Figure 3 — Error rate scaling

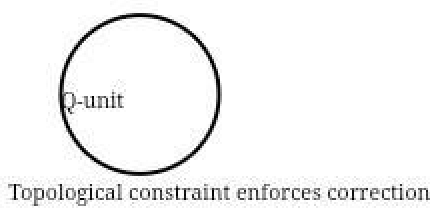

Figure 4 — Self-correcting motifs

References

Eigen M. Selforganization of matter and the evolution of biological macromolecules. Naturwissenschaften (1971).

Shannon CE. A Mathematical Theory of Communication. Bell Syst Tech J (1948).

Cover TM, Thomas JA. Elements of Information Theory.* Wiley (2006).

Adami C. Information theory in molecular biology. Phys Life Rev (2004).

Battail G. Information theory and error-correcting codes in genetics. IEEE IT (2010).

Drake JW et al. Rates of spontaneous mutation. Genetics (1998).

Benner SA, Sismour AM. Synthetic biology. Nat Rev Genet (2005).

Holliger P, Taylor AI. Towards a synthetic genetics. ChemBioChem (2014).

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). Beyond Body Mass Index: Development of the Adjusted Central Corpulence Index (ICCA) Integrating Age, Sex, and Abdominal Adiposity for Cardiometabolic Risk Assessment (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17955316

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). Information-Driven Order Formation in Natural and Artificial Systems (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17970157

Ndenga, B. (2025). Information-Theoretic Capacity of a Tetra-Stranded Hereditary Polymer : Effective Alphabets, Encoding Density, and Readout Constraints in Q-DNA (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18056935

Ndenga, B. (2025). Catalogue of Tetra-Stranded Helical Architectures: Classes, Topological Invariants, and Structural Transitions (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18028731

Ndenga, B. (2025). Q↔D Kinetics: Nucleation, Propagation, and Kinetic Traps in a Tetra-Stranded Hereditary Polymer (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18054763

Ndenga, B. (2025). Thermodynamics of a Tetra-Stranded Genome: Stability, Thresholds, and Entropic Constraints (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18036881

Ndenga, B. (2025). Q-DNA: A Formal Definition of a Canonical Tetra-Stranded Hereditary Polymer Beyond the Double Helix (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18015887

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., & Sharma, H. (2025). Information Against Entropy: Toward a Governing Principle of Organization in Complex Systems (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17944808

Ndenga, B., & Himanshi, . sharma . (2025). Microcapsule-Enabled Self-Healing Silicon Anodes for Next-Generation Lithium-Ion Batteries: A Conceptual Design, Materials Framework, and Technical Feasibility Study (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17981741

Ndenga, B. (2025). Rigidity, Torsion, and Mechanical Response of a Tetra-Stranded Genome : A Unified Theoretical and Experimental Framework for Q-DNA Elasticity (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18052220

Ndenga, B. (2025). Legume-Derived Anti-Angiogenic Networks Targeting Renal Cell Carcinoma: Mechanistic Insights into Polyphenol–Saponin–Fiber Bioactive Complexes from Phaseolus vulgaris (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18005392

Ndenga, B. (2025). Climate-Adaptive Batteries: Passive Thermal Regulation of Lithium-Ion Batteries Using Thermochromic Functional Surface Films (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17999867

Ndenga, B. (2025). Atomistic Stability of Q-DNA: Molecular Dynamics Simulations and Structural Persistence Criteria (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18047941

Ndenga, B. (2025). Four-Strand Pairing Beyond Watson–Crick: Interaction Hypergraphs, Controlled Degeneracy, and Sequence Constraints (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18040162

Ndenga, B. (2025). Information, Entropy, and System Dynamics: A Unified Framework Toward an Extended Thermodynamic Principle of Organization Across Physical, Biological, and Computational Systems (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17924903

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). On Organizational Efficiency and the Limits of Non-Equilibrium Thermodynamics Toward an Information-Centered Theory of Organization (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17931806

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). Electrostatics of a Tetra-Stranded Polymer: Ionic Condensation and Nonlinear Screening (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18044219

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). The IOE Ratio: Quantifying Organizational Potential in Complex Systems (Version V1). Zenodo. https://doi.org/10.5281/zenodo.17956802

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). Carotenoid Signaling and Mitochondrial Protection at the Crossroads of Cardio-Oncology: Lycopene as a Dual Modulator of Cardiovascular and Cancer Risk (Version V1). Zenodo. https://doi.org/10.5281/zenodo.18009606

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.