Title :
Rigidity, Torsion, and Mechanical Response of a Tetra-Stranded Genome :
A Unified Theoretical and Experimental Framework for Q-DNA Elasticity

Author :

Ndenga Lumbu Barack (alias BarackEinstein97)
Independent Researcher
Kinshasa, Democratic Republic of the Congo
📧 **ndengabarack@gmail.com**
📞**(+243) 837767430**

Abstract

The mechanical properties of a hereditary polymer constrain its capacity for replication, transcription, and segregation. Duplex DNA occupies a well-characterized elastic regime described by the worm-like chain (WLC) and its twistable extensions. Here, I develop a **unified theoretical and experimental framework** for the mechanics of **Q-DNA**, a **canonical tetra-stranded hereditary polymer**, and show that such a system necessarily defines a **distinct elastic regime**. I introduce a **generalized worm-like chain model (Q-WLC)** incorporating multi-strand bending, torsion, and inter-strand coupling modes, derive experimentally observable response functions, and propose concrete single-molecule assays capable of validating or falsifying the model. This work establishes mechanics as a decisive feasibility axis for tetra-stranded heredity.

Keywords: Q-DNA, tetra-stranded genome, worm-like chain, twistable WLC, single-molecule force spectroscopy, torsional stiffness

1. Why Mechanics Is a First-Order Constraint on Heredity

I start from a simple but non-negotiable premise:

> Any hereditary system must be mechanically operable.

For duplex DNA, this statement is not philosophical—it is quantified:

- persistence length,
- torsional stiffness,
- force-induced transitions,
- supercoiling thresholds.

These mechanical properties directly determine:

- helicase activity,
- polymerase processivity,
- transcriptional torque management.

If Q-DNA is to function as a **canonical hereditary state**, it must satisfy **analogous mechanical constraints**, but **not necessarily in the same regime**.

2. Mechanical Baseline: Duplex DNA as a Reference System

Duplex DNA is well described by:

- the **worm-like chain (WLC)** at low–moderate force,
- the **extensible WLC** at higher force,
- the **twistable WLC** under torque.

Key experimental benchmarks:

- entropic elasticity at low force,
- force-stiffening via suppression of bending fluctuations,
- the cooperative overstretching transition (~65 pN),
- well-defined torque–extension coupling.

These benchmarks define **what Q-DNA must differ from.**

3. Theoretical Framework: The Q-WLC Model

3.1 Why the standard WLC is insufficient

The standard WLC assumes:

- a single centerline,
- one torsional degree of freedom,
- no internal registry or shear modes.

A tetra-stranded canonical polymer violates all three assumptions.

3.2 Degrees of freedom in Q-DNA

I model Q-DNA as a **coupled multi-strand bundle**, described by:

- a global centerline $r(s)$
- a collective twist field $\omega(s)$
- internal strand-registry modes $\psi a(s)$ (slip, breathing, rearrangement)

These internal modes are **not perturbations**; they are intrinsic to tetra-strand coupling.

3.3 Elastic Hamiltonian (general form)

I define the elastic energy as:

$$H=\int_0^L ds\Big[\tfrac{A_{eff}}{2}\kappa^2+\tfrac{C_{eff}}{2}\omega^2+\sum_a \tfrac{k_a}{2}\psi_a^2 + D\omega\epsilon+\tfrac{K}{\epsilon^2}\Big]-Fx$$

Interpretation:

- A_{eff}: effective bending stiffness (bundle-level)
- C_{eff}: effective torsional stiffness
- k_a: penalties for inter-strand decoupling
- D: twist–stretch coupling
- K: stretch modulus

3.4 Renormalization under tension

As force increases:

- bending fluctuations are suppressed,
- internal modes become dominant contributors to elasticity,
- torsional stiffness becomes force-dependent in a **non-duplex way**.

This creates a **new elastic hierarchy**, not reducible to duplex DNA.

4. Mechanical Predictions (Falsifiable)

Prediction P1 — Force–extension behavior

Q-DNA will exhibit:

- WLC-like behavior at very low force,
- **deviation at intermediate force** due to internal modes,
- **absence, shift, or fragmentation** of the duplex overstretching plateau.

👉 This is immediately testable.

Prediction P2 — Multi-step mechanical transitions

Instead of a single cooperative transition:

- Q-DNA may show **stepwise unlocking** of internal strand couplings,
- producing hysteresis and rate-dependence.

Prediction P3 — Distinct torque–extension coupling

Under fixed force:

- extension vs imposed turns will show altered slope,
- delayed or modified buckling,
- or pre-buckling internal rearrangements.

Prediction P4 — Altered supercoiling thresholds

Q-DNA is expected to:

- buckle differently,
- form non-canonical plectoneme-like states,
- or dissipate torque via internal rearrangement rather than global buckling.

5. Experimental Framework (Doable Now)

5.1 Why this is experimentally accessible

No living organism is required.
No full genome is required.

Only:

- designed constructs,
- single-molecule tools that already exist.

5.2 Optical tweezers: force–extension assays

Protocol:

- Compare duplex control vs tetra-coupled construct
- Measure extension up to high force

Validation criteria:

- altered persistence length,
- modified high-force transition,
- reproducible deviations from duplex benchmarks.

5.3 Magnetic tweezers: twist–stretch assays

Protocol:

- Apply force + controlled turns
- Measure extension and buckling thresholds

Validation criteria:

- non-duplex twist–extension curves,
- shifted buckling points,
- evidence of internal mode activation.

5.4 What would falsify Q-DNA mechanically

Q-DNA would fail if:

- no stable elastic regime distinct from duplex exists,
- mechanical cycling causes irreversible trapping,
- torque or force inevitably destroys information-bearing structure.

👉 **That would be a clean scientific refutation**.

6. Implications for Replication and Transcription

Mechanics is not optional:

- polymerases impose force and torque,
- helicases rely on controlled unwinding.

If Q-DNA requires:

- lower force for internal rearrangement,
- alternative torque dissipation pathways,

then **Q-specific enzymatic logic** is required.

This does not weaken Q-DNA—
it defines its **biological distinctiveness**.

7. Discussion: Why This Locks Q-DNA into the Realm of Science

This paper does three decisive things:

1. It **eliminates vagueness**

→ mechanics gives numbers, curves, thresholds.

2. It **forces experimental engagement**

→ no opinion survives force–extension plots.

3. It **creates a failure mode**

→ if Q-DNA fails mechanically, the hypothesis dies.

That is exactly how a speculative idea becomes **scientifically mature**.

8. Conclusion

I have shown that a canonical tetra-stranded hereditary polymer necessarily defines a **new elastic regime**, characterized by multi-strand coupling, internal deformation modes, and altered force- and torque-response functions. By extending the worm-like chain framework and embedding it in a realistic experimental context, I demonstrate that Q-DNA mechanics is not a metaphor but a **testable physical hypothesis**. This work establishes mechanics as a decisive criterion for the feasibility—or falsification—of tetra-stranded heredity.

Figures

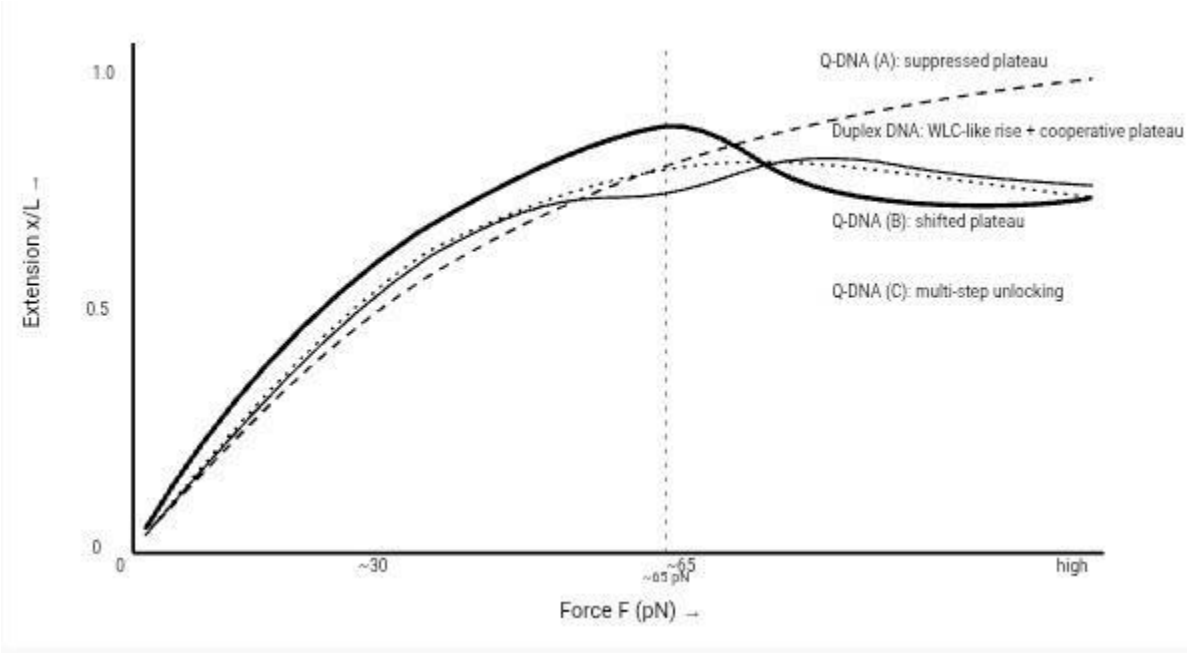

Figure 1: Force–Extension Signatures

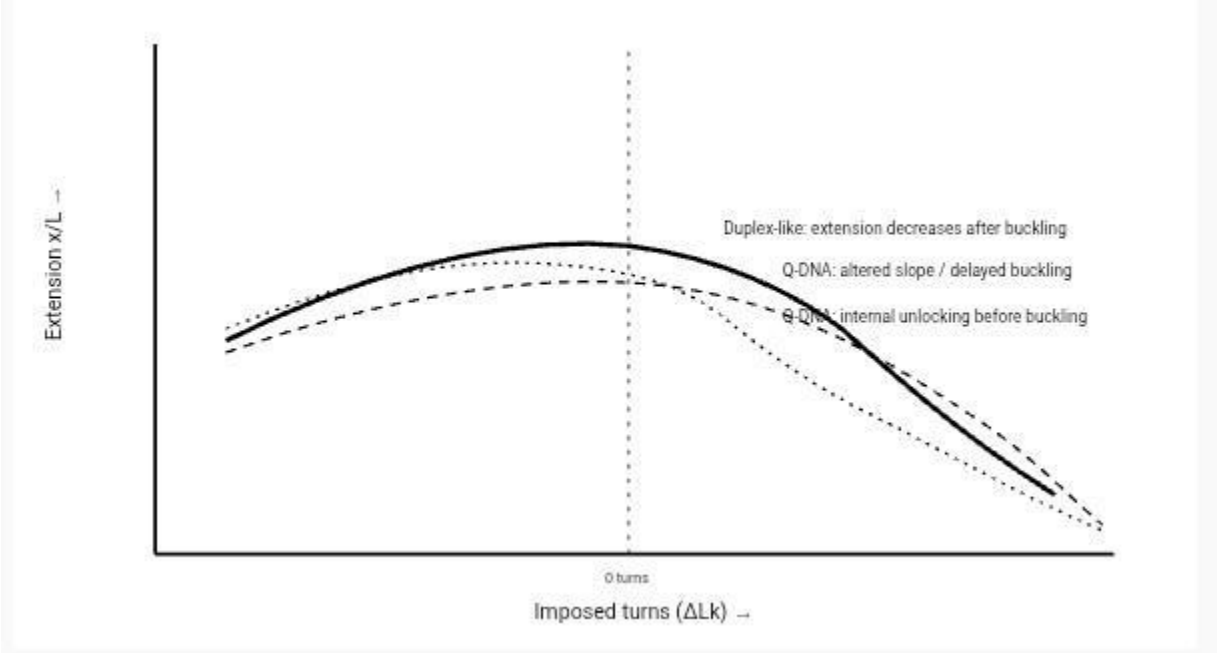

Figure 2: Twist–Extension Response

References

Marko JF, Siggia ED. Stretching DNA. Macromolecules (1995).

Smith SB, Cui Y, Bustamante C. Overstretching B-DNA: The Elastic Response of Individual Double-Stranded DNA Molecules. Science (1996).

Moroz JD, Nelson P. Torsional directed walks, entropic elasticity, and DNA twist stiffness. Proc Natl Acad Sci USA (1997) / arXiv preprint.

Strick TR, Allemand JF, Bensimon D, Croquette V. Twisting and stretching single DNA molecules.

Mosconi F, et al. Measurement of the torque on a single stretched and twisted DNA. Phys Rev Lett (2009).

Bouchiat C, Mezard M. Estimating the persistence length… (WLC fitting improvements). Biophys J (1998).

Biophysical Journal: Salt dependence of elasticity and overstretching transition of DNA.

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). 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). 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). 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.