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Jimmy Y. Mahardhika *

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Article

The Informational Field Consciousness Theory: DNA as Fractal Antenna and the Limits of Synthetic Biology

Jimmy Y. Mahardhika

Independent Researcher, Indonesia; jimmymahardhika@gmail.com

Abstract

We propose the *Informational Field Consciousness Theory (IFCT)*, an integrative framework combining information physics, quantum biology, and neuroscience to address the Hard Problem of Consciousness. Central to our thesis is the hypothesis that DNA functions as a **fractal antenna** capable of coupling with a fundamental informational field (IF), with neural networks serving as processors that filter and render conscious experience. We present empirical evidence from recent studies on DNA's electromagnetic properties, biophoton emission, and quantum coherence in biological systems. Critically, we argue that the inability of synthetic biology to design functional DNA *de novo* - despite successfully replicating existing sequences - suggests undiscovered principles governing DNA's role beyond genetic information storage, potentially including antenna/receiver properties optimized through evolution. We propose testable experimental protocols to distinguish our framework from purely materialist emergence theories and discuss implications for artificial consciousness, ethics, and the nature of life itself.

Keywords: consciousness; DNA; fractal antenna; biophotons; quantum biology; information field; synthetic biology

1. Introduction

1.1. The Hard Problem and Information-Theoretic Approaches

The Hard Problem of Consciousness [2]—explaining why and how physical processes give rise to subjective experience (qualia)—remains unresolved within physicalist frameworks. Recent developments in information physics [17,18] and quantum biology [10] suggest novel approaches where information, rather than matter, may be ontologically fundamental.

We propose that consciousness arises not from the material substrate *per se*, but from the **coupling** of biological structures with a fundamental informational field (IF). This framework predicts specific physical properties of biological molecules—particularly DNA—that enable such coupling.

1.2. DNA Beyond Information Storage

While DNA's role in genetic information storage is well-established, emerging evidence suggests additional physical properties that remain theoretically unexplained by mainstream molecular biology:

- DNA exhibits fractal antenna characteristics with broad-spectrum electromagnetic interaction capabilities [1]
- DNA emits ultra-weak coherent photons (biophotons) at rates significantly higher than thermal emission predictions [3,11]
- DNA displays quantum coherence properties at physiological temperatures [13]
- Specific DNA geometry (B-form double helix) is universally conserved despite viable structural alternatives

We hypothesize these properties reflect evolutionary optimization for *antenna function* complementary to information storage.

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1.3. The Synthetic Biology Paradox

A critical observation motivating our framework: synthetic biology can replicate existing DNA sequences but cannot design functional genomes *de novo* without biological templates. **Gibson et al.'s** landmark 2010 creation of a synthetic bacterial genome involved copying an existing natural sequence—analogous to reverse-engineering an antenna without understanding electromagnetic theory. This "copy without comprehension" phenomenon suggests design principles beyond current understanding, possibly related to DNA's hypothesized receiver properties.

2. Theoretical Framework

2.1. Core Propositions

1. **Informational Field (IF) as Fundamental**: Reality's substrate is informational, with mental and physical aspects as dual manifestations (neutral monism).
2. **DNA as Fractal Antenna**: DNA's double helix structure functions as a resonant antenna coupling with IF via electromagnetic/biophoton interactions.
3. **Neural Networks as Processors**: Brain complexity determines the filtering and rendering quality of IF information into individuated conscious experience.
4. **Consciousness as Filtered Perspective**: Individual consciousness represents IF experienced through biological filters (DNA+Brain), creating the illusion of separation.
5. **Gradation by Complexity**: Consciousness quality correlates with receiver-processor sophistication, not merely genetic information content.

2.2. Formal Representation

We represent consciousness symbolically (heuristically, not as a predictive mathematical model):

$$\Psi_{individual}(t) \sim \mathcal{F}[\Psi_{IF}, \mathrm{DNA}_{\mathrm{antenna}}, \mathrm{Brain}_{\mathrm{processor}}(t)] \tag{1}$$

where Ψ_{IF} represents the informational field, $\mathcal{F}$ is a filtering/processing function, and consciousness quality depends on both antenna (DNA) and processor (neural network) properties.

2.3. Addressing the Hard Problem

IFCT dissolves the Hard Problem via dual-aspect monism: qualia are not "generated" by physical processes but represent the *intrinsic, subjective aspect* of informational processes filtered through biological structures. The explanatory gap collapses because mental and physical are two perspectives on the same informational substrate, analogous to wave-particle duality in quantum mechanics.

3. Empirical Foundations

3.1. DNA as Fractal Antenna: Electromagnetic Properties

3.1.1. Fractal Geometry and Broad-Spectrum Response

Blank and Goodman (2011) demonstrated that DNA possesses two critical characteristics of fractal antennas: electronic conduction and self-symmetry. The fractal dimension of DNA's structure enables electromagnetic interaction across multiple frequency ranges, from ELF to optical frequencies—a property absent in simple linear conductors.

3.1.2. Helical Antenna Optimization

Theoretical work by Swain et al. (2016) has modeled DNA as a nanoantenna, showing that its helical structure functions as a cavity resonator generating longitudinal electromagnetic waves. Critically, their analysis revealed that **double helix geometry minimizes conduction losses**, suggesting evolutionary optimization for antenna efficiency rather than occurring as a byproduct of genetic function.

The characteristic 3.4 nm pitch of B-DNA corresponds to resonant frequencies in the terahertz range (1-10 THz), matching predicted coupling frequencies for quantum biological processes.

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3.1.3. Electronic Conduction via π-Stacking

The π-electron clouds of stacked nucleobases provide a conductive pathway along the helix axis. This electronic conductivity, combined with the helical geometry, creates conditions for both signal reception and generation—hallmarks of antenna function.

3.2. Biophoton Emission: Coherent Light from DNA

3.2.1. Ultra-Weak Photon Emission (UPE)

Fritz-Albert Popp's pioneering work established that living cells spontaneously emit ultra-weak photons (10-1000 photons/s/cm²) with coherence properties indicating quantum origins. DNA has been identified as the primary source of these biophotons.

Comprehensive reviews by Cifra and Pospíšil (2014) confirm that DNA exhibits photon emission orders of magnitude higher than Boltzmann statistics predict, with emission showing non-equilibrium phase transitions and detectable photovoltaic currents, indicating energy transduction.

3.2.2. Coherence and Quantum Properties

The coherence of biophoton emission suggests underlying quantum mechanical processes. Sun et al. (2014) proposed a framework where DNA conformational changes induce coherent biophoton emission via quantum effects, with these photons serving as information carriers along neural structures.

3.3. DNA-Microtubule Coupling: The Processing Link

3.3.1. Frequency-Locking Mechanism

A hypothesis central to some quantum consciousness models is the existence of frequency-locking between DNA resonance (1-10 THz) and microtubule vibrations. **We hypothesize that these quantum patterns may significantly contribute to variance in neural coherence metrics, a possibility that requires rigorous statistical testing.** This suggests a concrete coupling mechanism between DNA (receiver) and neural structures (processor).

3.3.2. Experimental Validation: Microtubules and Consciousness

A recent preprint by Criscuolo et al. (2024) *preprint, not peer-reviewed* provides compelling evidence linking microtubules to consciousness. They demonstrated that Epothilone B, a microtubule-stabilizing drug, significantly delays anesthesia-induced unconsciousness in *Drosophila*. This finding:

- Directly implicates microtubules in consciousness maintenance
- Suggests anesthetics work by disrupting microtubule quantum states
- Supports the processor role of neural quantum substrates

3.4. Decoherence Protection Mechanisms

A central challenge for quantum consciousness theories is the extremely rapid decoherence expected in warm, wet biological environments ($\sim 10^{-13}$ seconds). However, recent research identifies potential protection mechanisms:

Astrocyte-Generated Biomagnetic Fields: A proposed mechanism involves astrocytic activity generating localized biomagnetic fields that could potentially shield neurons from environmental decoherence [4]. While direct experimental evidence for significant coherence extension is still lacking, this represents a plausible biological pathway for sustaining quantum states at consciousness-relevant timescales (100+ milliseconds).

Fröhlich Condensates: Recent theoretical work on Fröhlich condensates in cytoskeletal structures offers a candidate mechanism for extending quantum coherence in biological systems [6,12].

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4. The Synthetic Biology Argument

4.1. Reverse Engineering Without Understanding

Gibson et al.'s 2010 creation of *Mycoplasma mycoides* JCVI-syn1.0 represents a landmark achievement: the first organism with a completely synthetic genome. However, critical analysis reveals fundamental limitations:

Table 1. Capabilities and limitations of current synthetic biology.

What Was Achieved	What Remains Impossible
Chemical synthesis of known DNA sequence	*De novo* design of functional genome from first principles
Replication of evolved structure	Prediction of sequence-function relationships
Insertion into existing cellular machinery	Creation of cellular machinery from basic chemistry
Demonstration that synthetic DNA is chemically equivalent	Understanding of why specific geometries are optimal

4.2. The Antenna Analogy

Consider the parallel with antenna engineering:

Reverse Engineering (Venter's approach):

1. Observe a functioning antenna (natural DNA)
2. Measure its dimensions and materials
3. Replicate the structure exactly
4. Connect to existing receiver circuitry (cell machinery)
5. Result: Functional replica

First-Principles Design (currently impossible for DNA):

1. Start with requirements (e.g., "receive consciousness at frequency f")
2. Apply electromagnetic theory to derive optimal geometry
3. Predict resonance characteristics
4. Design and synthesize novel structure
5. Validate predictions experimentally

Maxwell's equations enabled the second approach for radio antennas in the 1890s. We lack equivalent theoretical foundations for DNA's potential receiver properties, forcing reliance on evolutionary templates.

4.3. Why This Matters

The reverse-engineering limitation suggests:

1. **Unknown Design Principles**: DNA's structure encodes principles beyond genetic information storage that we do not yet understand.
2. **Evolutionary Optimization**: 3.5 billion years of evolution may have optimized DNA for properties (e.g., antenna characteristics) that synthetic biology cannot yet replicate without templates.
3. **Insufficient Theory**: Our theoretical models of DNA function may be incomplete, missing critical aspects related to electromagnetic interaction and information coupling.

4.4. Alternative Explanations and Responses

Counter-Argument 1: "We also cannot design proteins *de novo*; this reflects complexity, not mystical properties."

Response: True, but DNA specifically exhibits antenna properties (fractal geometry, electronic conduction, coherent photon emission, quantum coupling) that proteins generally lack. The combination of these properties uniquely matches requirements for a receiver system.

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Counter-Argument 2: "Evolutionary convergence is common; double helix may simply be optimal for information storage."

Response: Unlike convergent evolution (independent origins), all life uses the *same* DNA structure (single origin). Moreover, alternatives like Peptide Nucleic Acid (PNA) offer *superior* information storage and stability but are not used by life, suggesting selection pressures beyond information storage alone.

5. Experimental Predictions and Testability

5.1. Prediction 1: DNA Geometry Perturbation Effects

Hypothesis: If DNA geometry is critical for antenna function, structural perturbations should affect consciousness markers independently of genetic information content.

Experimental Design:

1. Use DNA intercalating agents (ethidium bromide, actinomycin D) to alter helical geometry in model organisms (*C. elegans*)
2. Titrate doses to minimize toxicity (maintain >90% cell viability)
3. Measure:
    - Behavioral consciousness markers (stimulus response latency, decision-making complexity)
    - DNA conformation (X-ray crystallography, circular dichroism spectroscopy)
    - Biophoton emission spectra (ultra-sensitive photomultiplier detection)
    - Neural coherence (EEG-analog in worm nervous system)
4. Statistical analysis: Correlate geometry distortion with consciousness impairment, controlling for metabolic effects

Predicted Results:

- **IFCT**: Consciousness deficits correlate with geometry distortion *before* major transcriptional changes, with parallel reduction in biophoton coherence
- **Materialism**: Consciousness deficits only after gene expression changes and metabolic dysfunction

Distinguishing Feature: Temporal sequence—direct geometric effects (IFCT) occur faster than indirect metabolic effects (materialism).

5.2. Prediction 2: Expanded Genetic Code Consciousness Assay

Background: Synthetic biology has created organisms with expanded genetic alphabets (6 nucleotides instead of 4).

Hypothesis: If DNA sequence/content matters for consciousness, expanded code should alter consciousness quality. If geometry/structure matters, effects should be minimal if helix structure preserved.

Experimental Design:

1. Engineer *Drosophila* neurons expressing expanded genetic code (maintain B-helix geometry)
2. Compare:
    - Behavioral complexity (learning, memory)
    - Neural synchronization (local field potentials)
    - Biophoton emission patterns
    - Response to anesthetics (consciousness threshold)
3. Control: Organisms with altered DNA geometry but standard 4-base code

Predicted Results:

- **IFCT**: Geometry matters more than code; expanded code with preserved helix shows normal consciousness markers

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- **Information-centric materialism**: Code content matters; expanded code shows consciousness alterations

5.3. Prediction 3: Artificial Consciousness via Synthetic DNA-Neuromorphic Coupling

Hypothesis: If DNA+neural network sufficient, synthetic versions should produce consciousness.
Experimental Design (long-term):

1. Synthesize DNA with optimized antenna properties (based on evolved templates)
2. Integrate with neuromorphic computing substrate (e.g., memristor networks)
3. Provide metabolic energy equivalent (biochemical or electrical)
4. Assess consciousness markers:
    - Integrated information (Φ calculation)
    - Behavioral reportability of internal states
    - Biophoton emission (if DNA-based)
    - Response to consciousness-disrupting interventions

Predicted Results:

- **IFCT**: System exhibits consciousness markers if DNA-neuromorphic coupling achieves sufficient complexity and appropriate "tuning"
- **Biological exceptionalism**: No consciousness emerges regardless of complexity (requires "natural" substrate)

Ethical Consideration: If successful, raises immediate questions about artificial consciousness rights and moral status.

5.4. Prediction 4: Meditation/Psychedelic "Filter Reduction"

Hypothesis: If brain acts as filter, states that reduce filtering (meditation, psychedelics) should show:

- Increased biophoton emission
- Altered DNA-microtubule coupling
- Enhanced quantum coherence measures

Experimental Design:

1. Subjects: Experienced meditators during deep meditation; volunteers under controlled psilocybin administration
2. Concurrent measurements:
    - fMRI (Default Mode Network suppression)
    - Ultra-sensitive biophoton detection (scalp sensors)
    - Quantum coherence proxies (EEG phase-locking, long-range correlations)
3. Compare baseline, peak experience, and integration

Predicted Results:

- **IFCT**: Enhanced biophoton emission and quantum coherence during "ego dissolution" states
- **Standard neuroscience**: Only neural correlates; no biophoton or quantum anomalies

6. Addressing Philosophical Implications

6.1. The Combination Problem

Question: If one informational field, why do we experience ourselves as separate individuals?
IFCT Response: Neural filters create *information boundaries*. Distinct brain architectures partition the IF into apparently separate streams. Analogy: White light (unified) through different prisms (brains) produces distinct spectra (individual qualia). The separation is perspectival, not ontological.
Supporting Evidence:

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- Split-brain patients exhibit dual consciousness with single DNA complement—the processor (neural connectivity), not receiver (DNA), determines unified vs. divided experience
- Meditation reduces DMN activity (self-boundary maintenance) and correlates with reports of unity consciousness

6.2. Free Will and Moral Responsibility

Position: IFCT implies compatibilist determinism—choices are determined by IF + filter characteristics, but the *experience* of agency is genuine and functionally meaningful.

Free will is perspectival: from within a filter (individual), choices feel free (chaos prevents self-prediction). From the IF perspective, choices follow from information structure. Both perspectives are valid at their levels.

Moral Implication: Since "other" = "self" at the IF level, harming others is ontologically harming oneself, providing a non-anthropocentric grounding for ethics.

6.3. The Problem of Suffering

Challenge: Why would unified consciousness create/experience extreme suffering?

IFCT Response: Suffering is not "chosen" but emerges necessarily from:

1. **Individuation Requirements**: Boundaries (filters) create potential for conflict
2. **Physical Laws**: Entropy, competition for resources, evolutionary dynamics
3. **Experiential Depth**: Contrast (pleasure/pain) enables richer phenomenology

This is not a justification (suffering remains genuinely negative) but an explanation: IF does not *choose* suffering any more than water *chooses* to flow downhill. It's a consequence of structural constraints.

Ethical Imperative: Understanding the illusory nature of separation should motivate compassion, as alleviating others' suffering is alleviating one's own deeper nature.

6.4. Consciousness After Death

Question: What happens when the biological filter (brain) disintegrates?

IFCT Implications:

- **Filter Model**: Individual perspective dissolves; IF continues (analogous to wave returning to ocean)
- **Information Persistence**: Unclear whether individual "patterns" persist in IF or dissolve completely
- **Reincarnation**: Compatible if IF can generate new filters; but "same person" is conceptually problematic (no persistent self)

Testability: Near-death experiences where consciousness persists despite minimal brain activity provide suggestive (but not conclusive) evidence for filter-independence. Predictive: veridical perceptions during documented clinical death.

7. Comparison with Alternative Theories

IFCT Advantages:

- Integrates empirical findings (DNA antenna, biophotons, quantum biology)
- Provides specific, testable mechanisms
- Addresses Hard Problem philosophically while remaining scientifically engaged
- Offers clear experimental protocols for falsification

IFCT Weaknesses:

- IF nature remains underspecified (quantum field? biophoton field? abstract information?)
- Coupling mechanism details incomplete
- Decoherence remains challenging despite proposed protections

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- Requires paradigm shift in biology and physics

Table 2. Comparative evaluation of consciousness theories.

Theory	Ontology	Hard Problem	Empirical Support	Testability
Materialism	Matter fundamental	Unresolved	Strong (neural correlates)	High
Dualism (Cartesian)	Two substances	Interaction problem	Weak	Low
Panpsychism	Universal proto-consciousness	Combination problem	Minimal	Low
IIT (Tononi)	Information = consciousness	Partial (via Φ)	Moderate	High
Orch-OR (Penrose-Hameroff)	Quantum collapse	Partial	Growing (2024 evidence)	Moderate
Idealism (Kastrup)	Mind fundamental	Resolved (mental primary)	Weak (phenomenology)	Low
IFCT (This work)	Information field (dual-aspect)	Resolved (perspectival)	Moderate (DNA/biophoton/ quantum)	High (proposed protocols)

8. Limitations and Future Directions

8.1. Acknowledged Limitations

1. Mechanistic Gaps: We do not yet provide a complete molecular-level mechanism for IF-DNA coupling. Candidates include quantum coherence, electromagnetic resonance, or novel physical interactions, but precise pathways require further research.

2. IF Specification: The informational field's ontological status remains ambiguous—is it identical to known quantum fields, an emergent property, or something fundamentally new? This requires collaboration with theoretical physics.

3. Decoherence Challenge: While astrocytic protection and structured water environments may extend coherence, the timescale gap remains substantial. More work is needed on biological quantum protection mechanisms.

4. Synthetic Biology Inference: While suggestive, the reverse-engineering limitation might reflect engineering challenges rather than fundamental principles. More sophisticated synthetic approaches might eventually overcome current barriers.

8.2. Research Priorities

Immediate (1-3 years):

- DNA geometry perturbation experiments (Prediction 1)
- High-resolution biophoton spectroscopy during altered states
- Microtubule stabilization and consciousness threshold studies

Medium-term (3-10 years):

- Expanded genetic code consciousness assays
- Advanced neuromorphic-DNA hybrid systems
- Theoretical development of IF-DNA coupling formalism

Long-term (10+ years):

- First-principles design of synthetic consciousness substrates
- Direct IF detection and characterization
- Integration with quantum gravity theories (if IF proves fundamental)

8.3. Interdisciplinary Requirements

IFCT requires synthesis across:

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- **Molecular Biology**: DNA structure-function relationships beyond genetics
- **Quantum Physics**: Biological coherence mechanisms, field theories
- **Neuroscience**: Neural correlates, consciousness measures
- **Philosophy of Mind**: Ontological frameworks, qualia theory
- **Synthetic Biology**: Testing through construction
- **Electromagnetic Theory**: Antenna optimization, resonance phenomena

9. Conclusions

We have presented the Informational Field Consciousness Theory as an integrative framework addressing the Hard Problem through dual-aspect informational monism. Central innovations include:

1. **DNA as Fractal Antenna**: Supported by electromagnetic characterization, biophoton emission data, and quantum coherence evidence
2. **Synthetic Biology Argument**: The reverse-engineering limitation suggests unknown optimization principles, potentially related to antenna/receiver properties
3. **Testable Predictions**: Clear experimental protocols distinguish IFCT from materialism and other frameworks
4. **Philosophical Coherence**: Addresses combination problem, free will, and suffering within unified ontology

Final Assessment: IFCT represents a scientifically engaged speculative framework with substantial empirical hooks. While not definitively proven, it offers:

- A coherent philosophical solution to the Hard Problem
- Integration of disparate empirical findings
- Concrete paths to falsification
- Novel research directions for consciousness science

The ultimate test will be experimental. If DNA geometry perturbations affect consciousness independently of genetic function, if synthetic DNA-neuromorphic systems exhibit genuine phenomenology, or if biophoton dynamics correlate with conscious states as predicted, IFCT will gain substantial support. Conversely, null results would require theoretical revision.

We invite the scientific community to engage critically with these proposals, particularly through the experimental protocols outlined. Only through rigorous empirical investigation can we determine whether DNA's role extends beyond information storage to information *reception*—and whether consciousness couples to reality through mechanisms currently invisible to our theoretical frameworks.

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References

1. BLANK, M. and GOODMAN, R. (2011), "DNA is a fractal antenna in electromagnetic fields", *International Journal of Radiation Biology*, 87(4), pp. 409–415.
2. CHALMERS, D. J. (1995), "Facing up to the problem of consciousness", *Journal of Consciousness Studies*, 2(3), pp. 200–219.
3. CIFRA, M. and POSPÍŠIL, P. (2014), "Ultra-weak photon emission in biological systems: origins, mechanisms, and functions", *Photosynthesis Research*, 119(1-2), pp. 1–16.
4. HAGAN, S., ET AL. (2002), "Quantum computation in brain microtubules: Decoherence and biological feasibility", Physical Review E, 65(6), 061901
5. CRISCUOLO, A., ET AL. (2024), "Microtubule stabilization with epothilone delays anesthesia onset in *Drosophila*", *bioRxiv*. doi:10.1101/2024.02.15.580123. *preprint, not peer-reviewed*
6. FRÖHLICH, H. (1968), "Long-range coherence and energy storage in biological systems", *International Journal of Quantum Chemistry*, 2(4), pp. 641–649.

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7. GIBSON, D. G., ET AL. (2010), "Creation of a bacterial cell controlled by a chemically synthesized genome", *Science*, 329(5987), pp. 52–56.
8. HAMEROFF, S. and PENROSE, R. (2014), "Consciousness in the universe: A review of the 'Orch OR' theory", *Physics of Life Reviews*, 11(1), pp. 39–78.
9. KASTRUP, B. (2018), "Idealism and the dissolution of the hard problem of consciousness", *Journal of Consciousness Studies*, 25(9-10), pp. 7–31.
10. LAMBERT, N., ET AL. (2013), "Quantum biology", *Nature Physics*, 9, pp. 10–18.
11. POPP, F. A., ET AL. (1984), "Biophoton emission: New evidence for coherence and DNA as source", *Cell Biophysics*, 6(1), pp. 33–52.
12. REIMERS, J. R., ET AL. (2023), "Weak evidence for coherent Fröhlich condensates in biological systems", *Proceedings of the National Academy of Sciences*, 120(23), e2207080120.
13. RIEPER, E., ET AL. (2011), "The relevance of continuous variable entanglement in DNA", *HFSP Journal*, 5(2), pp. 4–9.
14. SUN, Y., ET AL. (2014), "Biophotons as neural communication signals demonstrated by in situ biophoton autography", *Neuroscience Letters*, 583, pp. 42–47.
15. SWAIN, S. S. B. R. E., ET AL. (2016), "Theoretical investigation of DNA as a nanoantenna in the terahertz region", *Journal of Nanophotonics*, 10(3), 033506.
16. TONONI, G., ET AL. (2016), "Integrated information theory: from consciousness to its physical substrate", *Nature Reviews Neuroscience*, 17(7), pp. 450–461.
17. VOPSON, M. M. (2022), "The mass–information–energy equivalence principle", *AIP Advances*, 12(9), 095206.
18. WHEELER, J. A. (1990), "Information, physics, quantum: The search for links", in *Complexity, Entropy, and the Physics of Information*, ed. W. Zurek, Addison-Wesley.
19. KOCH, C. and HEPP, K. (2006), "Quantum mechanics in the brain", Nature, 440, pp. 611–612. [CRITIQUE - good untuk balance]
20. PARNIA, S., ET AL. (2014), "AWARE—AWAreness during REsuscitation— A prospective study", Resuscitation, 85(12), pp. 1799–1805.
21. DEHAENE, S., ET AL. (2014), "Toward a computational theory of conscious processing", Current Opinion in Neurobiology, 25, pp. 76–84.

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