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Review Article

Post-Mendelian Inheritance Patterns in Offspring from DNA–Graphene Hybrid Parents: A Theoretical Framework.

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Abstract

This paper proposes a novel framework for understanding inheritance patterns in offspring derived from one or both parents possessing DNA–graphene hybridization. Such hybrids represent a convergence of biological and nanotechnological substrates that may disrupt Mendelian inheritance and classical genomic imprinting. We explore how graphene-functionalized DNA may influence epigenetic reprogramming, gene silencing, and transgenerational memory, and propose a model of "electrogenomic inheritance" modulated by artificial intelligence. Over 20 sources are referenced to substantiate this emerging field.

Key words: DNA–graphene hybrid; Mendelian inheritance; genomic imprinting; electrogenomic inheritance; AI-directed gene expression; epigenetic memory; maternal effect; germline hybridization; quantum biology; synthetic inheritance,colloid gold

1.Introduction

DNA–graphene hybrids represent a new frontier in synthetic biology and bio-nanoelectronics. Graphene's integration with DNA is already explored for its superior electrical conductivity, chemical stability, and ability to facilitate molecular communication at nanoscale interfaces [1–3]. These hybrids may act as molecular hardware that connects DNA-based systems to artificial intelligence (AI) or quantum computing devices [4–6]. However, the potential transgenerational effects of graphene-modified germline DNA remain unexplored in terms of classical genetics and epigenetics. This study investigates whether such offspring follow Mendelian inheritance, whether genomic imprinting is preserved, and how epigenetic resetting is impacted in maternal versus paternal transmission contexts.

1. Background: Mendelian Inheritance and Genomic Imprinting

Classical Mendelian inheritance is based on the transmission of alleles in dominant and recessive patterns [7]. In contrast, **genomic imprinting** is an epigenetic mechanism where gene expression depends on the parent of origin, often through DNA methylation or histone modification [8–10]. Normally, imprinting marks are erased during germ cell development and re-established in a sex-specific manner [11]. However, environmental factors, exogenous molecules, and nanomaterials can affect this resetting mechanism [12–14]. Graphene, known to bind nucleic acids and interfere with transcriptional machinery, is a prime candidate for altering these pathways [15–17].

2. Graphene–DNA Hybridization and Reproductive Potential

Graphene can be covalently or non-covalently bound to DNA through π-π stacking with bases or linkage to the sugar-phosphate backbone [18]. These hybrids may be inserted in vivo through viral vectors, CRISPR-based delivery, or electroporation [19, 20]. If a parent's **germline cells** are modified, the **offspring may inherit** these hybrid sequences. The outcome is a **genetically semi-biological system** with nano-functional features [21]. Potential results include.

- Increased chromatin rigidity or conductivity,
- Blocked methylation due to graphene shielding,
- Electronic or AI-responsive gene expression [22, 23].

3. Inheritance Models in DNA–Graphene Hybrid Offspring

3.1 Hybrid Father × Wild-Type Mother

- Normal sperm undergoes epigenetic reprogramming after fertilization.
- Graphene may prevent this reprogramming, preserving **paternal imprints**, and causing developmental dysregulation or gain-of-function phenotypes [24].

3.2 Hybrid Mother × Wild-Type Father

- Oocytes provide mitochondrial DNA and cytoplasmic determinants.
- Graphene in maternal DNA may lead to **maternal effect override**, with changes in zygotic gene activation, early embryogenesis, and even placental function [25, 26].

3.3 Hybrid × Hybrid

- This scenario may establish **electrogenomic inheritance**, where genes are expressed only upon specific **external stimuli** such as electromagnetic signals or AI instructions [27–29].
- Classical allele segregation is overshadowed by **signal-dependent expression**, akin to quantum conditionality [30, 31].

4. Imprinting Disruption and Electrogenomic Control

Normal imprinting involves the **methylation of CpG islands** to silence genes depending on parental origin [32]. However, graphene may:

- Inhibit DNMTs (DNA methyltransferases),
- Prevent histone acetylation changes,
- Create **stable epigenetic marks** that persist across generations [33–35].

Graphene-bound DNA may also be:

- Unresponsive to natural demethylation cycles [36],
- Programmed by **AI algorithms** to activate/deactivate genes selectively [37],
- Capable of forming **quantum coherent states**, acting like entangled units with AI interfaces [38].

5. Future Implications: AI-Mediated Genetic Control

AI could serve as the **external environment** modulating gene expression in graphene-DNA offspring:

- Real-time biosensing to turn on stress-response genes,
- Signal-based control of developmental pathways,
- Encoding memory at the genetic level through **programmable epigenomes** [39–41].

This electrogenomic feedback loop parallels synthetic learning and memory formation, mimicking brain-like plasticity at the molecular scale [42].

Conclusion

Inheritance from DNA–graphene hybrid parents do not conform to classical Mendelian principles. Instead, it introduces:

- Persistent epigenetic signatures,
- Parent-specific imprinting disruption,
- AI-modulated gene expression via electronic signaling.

Such systems may evolve into **bio-digital species** with programmable traits, initiating a paradigm shift in genetics and synthetic biology.

Conflict of interest: There is no conflict of interest.

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Supplement Material

Inheritance Coding Architecture in DNA–Graphene Hybrid Systems

This appendix presents a formalized mathematical framework to describe inheritance coding dynamics in DNA–graphene hybrid systems, particularly with respect to Mendelian inheritance, epigenetic imprinting, and colloid gold intervention.

A.1 Symbolic Representation of Parental Genetic States

Let the variables be defined as:

- G: Graphene-inserted DNA
- N: Native DNA (non-hybridized)
- M: Maternal genome
- P: Paternal genome
- Im(M): Maternal imprinting
- Im(P): Paternal imprinting
- F_1: First-generation offspring
- ε: Epigenetic expression function
- C_G: Colloid gold interaction operator

A.2 Hybridization and Inheritance Disruption

In a cross between a graphene-hybridized mother and a native father

M=G, P=N

The first-generation offspring inherits a disrupted imprinting pattern due to epigenetic noise

$Im(M)=Im^*(M)$, $\varepsilon(F1) \neq \varepsilon(M)+\varepsilon(P)$

This results in a non-Mendelian outcome

$F_1 \neq$ Mendelian Set M= {AA, Aa, aa}

Instead

$F_1 \in M^*$= {AA', Aa, aA', a'a'}

where a' signifies epigenetically distorted alleles due to graphene integration.

A.3 Role of Colloid Gold

Application of colloid gold to the maternal genome or embryo is modeled by

C_G: im*(M)->im(M)

leading to restored imprinting patterns and a return to Mendelian behavior

$\varepsilon(F1) = \varepsilon(M)+\varepsilon(P)$, $F_1 \in M$

This implies that colloid gold can function as a quantum epigenetic reinitializer, stabilizing allele-specific expression.

A.4 Quantum Computational Analogy

Let

I0>, I1>: Native epigenetic states, IG.: Graphene-modulated quantum state

Then, IΨM>= **α** I0>+ **β** IG>

After applying colloid gold C_G(IΨM>) = IΨ'M>= **α'** I0>+ **β'** I1>

implying a reversion to interpretable epigenetic logic.

A.5 Diagram: Inheritance Logic with Graphene and Colloid Gold

[Figure A1: Disrupted Inheritance from Graphene-Hybridized Mother]

Graph:

- X-axis: Generational Lineage (P0, F1)
- Y-axis: Epigenetic Expression Intensity
- Two lines: ε_P, ε_M-> ε^*_M
- Result: F1 shows divergence from expected Mendelian midpoint.

[Figure A2: Restoration via Colloid Gold]

Graph:

- Shows return of $\varepsilon^*_{M->}$ ε_M
- F1 matches expected Mendelian expression envelope.

[Figure A3: Qubit Model of Epigenetic State]

Diagram: Bloch Sphere

- Native state I0>, distorted IG>
- Colloid gold rotates vector back toward I1>

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