International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Review Article)

Exploring the phenomenon of quantum teleportation of epigenetic information in plants: Implications for the transfer of genome-stored experiences to close relatives

Nishantha Muththanthirige *

Department of Agriculture, P. O. Box. 1, Peradeniya, Sri Lanka.

International Journal of Science and Research Archive, 2023, 09(01), 442–448

Publication history: Received on 02 May 2023; revised on 10 June 2023; accepted on 13 June 2023

Article DOI: https://doi.org/10.30574/ijsra.2023.9.1.0466

Abstract

Quantum teleportation is a fascinating phenomenon that has garnered significant attention in the field of physics. Recent research suggest that quantum teleportation may extend beyond the realm of fundamental particles and apply to complex biological systems. In this review article, the phenomenon of quantum teleportation of epigenetic information in plants and its potential implications for the transfer of genome-stored experience to close relatives is explored. The article begins by providing an introduction to the concept of quantum teleportation and its underlying principles. Then, the emerging field of epigenetics is delved into, discussing the role of epigenetic modifications in plant adaptation and response to environmental stimuli. Subsequently, the existing evidence for the transfer of epigenetic information between plants through horizontal gene transfer is presented, along with the exploration of the possibility of quantum teleportation as an alternative mechanism for such transfers. The implications of quantum teleportation for the transfer of genome-stored experience are discussed, including the potential impact on plant evolution and adaptation. Furthermore, the challenges and limitations in studying quantum phenomena in biological systems are addressed, and future directions for research in this exciting field are proposed. In conclusion, while the phenomenon of quantum teleportation of epigenetic information in plants holds promise, further investigation is required to fully understand its mechanisms and implications. This knowledge will provide insights into the feasibility and mechanisms of quantum teleportation in plants.

Keywords: Quantum teleportation; Epigenetic information; Horizontal gene transfer; Genome-stored experience; Adaptation

1. Introduction

Quantum teleportation is a process that allows the transfer of quantum states between two spatially separated particles without physical interaction [1]. This phenomenon has revolutionized the field of quantum information science and has potential applications in quantum computing and cryptography [2]. The fundamental principles of quantum teleportation involve the entanglement of particles and the transmission of quantum information through entangled states [3].

Epigenetic modifications play a crucial role in regulating gene expression and are influenced by environmental factors [4]. Plant epigenetics offer the intriguing potential to transmit acquired traits to future generations via non-genetic means by transferring heritable modifications in gene expression patterns without altering the DNA sequence [4, 5]. Therefore, plant epigenetics offer a new perspective on how plants adapt to environmental stimuli and how this adaptation can be transmitted across generations [6].

* Corresponding author: Nishantha Muththanthirige

In recent years, there has been growing interest in exploring the applicability of quantum teleportation to biological systems. While the phenomenon has primarily been studied in the context of fundamental particles, emerging evidence suggests that quantum effects may play a role in biological processes [7].

2. Quantum Teleportation: Principles and Mechanisms

Quantum teleportation is a process that allows the transfer of quantum information between two distant parties using shared entanglement [1]. Entanglement is a quantum phenomenon that creates a correlation between the quantum states of two or more particles, such that the state of one particle depends on the state of another, even if they are far apart [8]. This correlation enables the instantaneous transmission of information, overcoming the speed limit imposed by light [9].

The process of quantum teleportation involves three key steps: entanglement, measurement, and transmission [10]. In the first step, two particles become entangled, such that their quantum states are correlated [1]. This entanglement can be achieved through various methods, including the use of entangled photon pairs or the application of quantum gates [2].

The second step involves the measurement of the quantum state of the particle to be teleported, referred to as the "source" particle. This measurement collapses the quantum state of the source particle, providing information about its state to the other entangled particle, known as the "target" particle [1].

Finally, the quantum information obtained from the measurement is transmitted to the target particle, effectively recreating the quantum state of the source particle on the target particle. This transmission of information occurs through the entangled connection between the particles, allowing for instantaneous transfer regardless of the spatial separation [1].

Recently, a group of scientists demonstrated long-distance quantum teleportation from a photonic qubit (quantum bit) at telecom wavelength to a matter qubit, stored as a collective excitation in a solid-state quantum memory [11]. Researchers used an active feed-forward scheme to implement a conditional phase shift on the retrieved qubit, as required by the teleportation protocol. They also employed a time-multiplexed approach to increase the teleportation rate and achieve compatibility with the existing telecommunication networks. They demonstrated that their system could transfer quantum information over several kilometers of optical fibers and that the fidelity of the teleported qubits exceeds the classical limit. This work paved the way for quantum communication and networking.

2.1. Epigenetic Information and Plant Adaptation

Plants can adjust their gene expression patterns to cope with changing environmental conditions. Epigenetic is regulation one of the mechanisms that plants use to cope with environmental changes, which involves heritable and reversible modifications in the genome [12, 13, 14]. Epigenetic modifications are dynamic and responsive to external stimuli, such as abiotic stress factors, and can influence the phenotypic plasticity and adaptation of plants to adverse conditions, which can influence gene expression and phenotypic traits [4, 12, 13]. Epigenetic modifications include DNA methylation, histone modifications, and non-coding RNA activity, which can affect the accessibility and activity of chromatin, without changing the DNA sequence [15, 16]. Moreover, some epigenetic modifications can be inherited and transmitted to the offspring and can persist across multiple generations, allowing plants to pass on acquired traits to their progeny, to teach how to adapt to environmental changes [17, 18].

2.2. Transfer of Epigenetic Information in Plants

Traditionally, the transfer of genetic information between organisms has been attributed to vertical transmission, where genetic material is passed from parent to offspring. However, it has been observed that plants can also transfer genetic material horizontally, through mechanisms such as horizontal gene transfer (HGT) [19]. Horizontal gene transfer is a process that allows plants to acquire genetic material from other unrelated sources than their parents, bypassing traditional vertical transmission [19, 20]. The transfer of genetic material in plants through HGT can significantly contribute to the acquisition of advantageous traits, genetic diversity, adaptation and evolution [20, 21, 22].

An emerging topic in plant biology is the possibility of transmitting epigenetic information between plants through non-genetic mechanisms [23]. Recent studies have proposed that the transfer of epigenetic information between plants may occur through mechanisms beyond traditional genetic processes [24].

HGT can occur through various mechanisms, such as viral infection, plasmid transfer, or natural transformation [20]. Some studies have suggested that epigenetic information can be transferred between plants by grafting, stress, homologous DNA sequences and pollen-mediated gene flow [6, 25, 26] This transfer can have consequences for the gene expression and adaptation of the recipient plant [25, 26]. However, the molecular mechanisms and evolutionary implications of epigenetic information transfer are still poorly understood and require further investigation.

2.3. Quantum Teleportation of Epigenetic Information in Plants

Quantum teleportation is a phenomenon that allows the transfer of quantum information between two distant locations without physical transmission of the information [27]. Epigenetic information is a type of non-genetic information that can affect gene expression and phenotype in plants and other organisms [28]. It has been suggested that epigenetic information can be transferred between plants through various mechanisms [6]. While these two concepts seem unrelated, several studies have provided insights into the possible role of quantum phenomena, and epigenetic information transfer (EIT) in biological systems [29, 30, 31].

In the context of epigenetic information transfer, quantum teleportation could offer an intriguing possibility. Quantum teleportation, which relies on the entanglement of particles, is a possible mechanism for epigenetic information transfer in plants. It has been suggested that entangled particles could carry epigenetic information from one plant to another, thus affecting their gene regulation and traits [29, 30, 31].

Several possible mechanisms have been proposed for the transfer of epigenetic information via quantum teleportation in plants. One possibility is that the coherent electromagnetic fields could serve as the entangled states required for quantum teleportation [32, 33]. These fields have been suggested to facilitate the non-local transfer of epigenetic information [32]. This mechanism has been inspired by the experimental demonstration of quantum teleportation over long distances using entangled photons [32, 33].

Another possible mechanism for the transfer of epigenetic information via quantum teleportation in plants is through the involvement of microtubules. Microtubules are hollow cylindrical structures found in the cytoplasm of cells, and they play a critical role in cell division and intracellular transport. Recent studies have suggested that microtubules may be capable of supporting quantum coherence and entanglement [34, 35].

Some studies have proposed that quantum coherence in plant proteins and DNA molecules could be involved in epigenetic information transfer through quantum teleportation [29, 36, 37]. Moreover, quantum entanglement and teleportation of photosynthetic pigments, which are involved in capturing and transferring light energy, have been shown to exhibit quantum entanglement and teleportation properties, and have been suggested as possible mechanisms for quantum communication within plants [37, 38, 39].

Also, some researchers have proposed that quantum teleportation could occur through biological wires, such as bacteria, chloroplasts, or micro-bubbles, that form connections between plant cells or tissues. These biological wires could act as quantum channels that transmit quantum states and information between plants [40]. Alternatively, quantum teleportation could occur through gravitational micro-bio-holes or holographic micro-bio-systems, which are hypothetical structures that could link quantum particles in different locations [40]. Also, some authors suggested that biological systems like cells, bacteria, chloroplasts and other micro-organisms could exchange quantum particles like electrons, photons and gravitational waves and have large distant information teleportation [41].

These findings indicate that quantum phenomena may play a significant role in biological systems. This could have implications for agriculture and plant evolution, as it could allow plants to enhance their traits and adapt to changing conditions. It could potentially accelerate the spread of beneficial epigenetic modifications throughout a plant population, enabling rapid responses to changing environmental conditions. This could enhance the survival and reproductive success of plants in dynamic and challenging ecosystems.

3. Discussion

This discussion will explore the implications of quantum teleportation for the transfer of epigenetic information in plants, as well as the challenges and future directions of this exciting field.

One of the key implications of quantum teleportation of epigenetic information is its potential impact on plant evolution and adaptation. Epigenetic modifications play a crucial role in plant responses to environmental stimuli, allowing them to adapt to changing conditions. The transfer of epigenetic information through traditional genetic processes, such as horizontal gene transfer, has been proposed as a mechanism for transmitting acquired traits. However, quantum teleportation could offer an alternative mechanism that potentially accelerates the spread of beneficial epigenetic modifications within a plant population. This rapid transmission of adaptive traits could enhance the survival and reproductive success of plants in dynamic and challenging environments.

Furthermore, the possibility of quantum teleportation of epigenetic information challenges our understanding of inheritance and evolution. The traditional view of inheritance is based on the transmission of genetic material from parent to offspring through DNA replication and recombination. However, if quantum teleportation can facilitate the transfer of epigenetic modifications, it suggests a more direct and instantaneous transmission of acquired traits. This challenges the strict demarcation between genetic and non-genetic inheritance and raises questions about the role of epigenetic information in shaping evolutionary processes.

Despite the exciting prospects, there are several challenges and limitations in studying quantum phenomena in biological systems. First and foremost, the identification and characterization of quantum effects in living organisms require advanced experimental techniques and methodologies. The detection and measurement of quantum states and processes in biological contexts demand high levels of precision, sensitivity, and control. Developing experimental approaches that allow for the manipulation and observation of quantum phenomena in living systems is a crucial step in advancing our understanding of quantum teleportation in epigenetic information transfer.

Secondly, the mechanisms underlying the entanglement and quantum teleportation of epigenetic information in plants remain largely unknown. While quantum coherence and entanglement have been observed in various biological systems, understanding how these quantum effects interact with the epigenetic machinery of plants requires further investigation. It is essential to elucidate the specific molecular and cellular mechanisms that enable the entanglement and transfer of epigenetic information. This knowledge will provide insights into the feasibility and mechanisms of quantum teleportation in plants.

Another important aspect to consider is the stability and fidelity of quantum teleportation in biological systems. Quantum states are highly sensitive to decoherence, which refers to the loss of quantum coherence due to interactions with the environment. Decoherence can disrupt entanglement and compromise the accuracy of quantum teleportation. In the context of epigenetic information transfer, it is crucial to understand how biological factors, such as temperature, fluctuations in molecular environments, and interactions with other molecules, affect the stability and fidelity of quantum states. This knowledge will help determine the feasibility and limitations of quantum teleportation in preserving and transferring epigenetic information.

The exploration of quantum teleportation of epigenetic information in plants opens up exciting possibilities for understanding the transfer of genome-stored experiences to close relatives. The potential for instantaneous and direct transmission of acquired traits through quantum entanglement challenges our traditional notions of inheritance and evolution. However, further research is needed to unravel the mechanisms, stability, and functional significance of quantum teleportation in epigenetic information transfer. The integration of experimental and theoretical approaches, advancements in quantum technologies, and interdisciplinary collaborations will drive progress in this field and shed light on the fascinating interplay between quantum phenomena and biological systems.

4. Conclusion

The phenomenon of quantum teleportation of epigenetic information in plants presents exciting possibilities for the transfer of genome-stored experiences to close relatives. The potential implications of this process for plant inheritance, adaptation, and evolution challenge our traditional understanding of genetic and non-genetic inheritance.

The identification and characterization of quantum effects in living organisms require advanced experimental techniques and methodologies. The mechanisms underlying the entanglement and quantum teleportation of epigenetic information in plants are largely unknown. Furthermore, the stability and fidelity of quantum teleportation in biological systems, as well as the functional significance of transferred epigenetic modifications, need further investigation.

Technological advancements in quantum computing and quantum communication may also contribute to the progress in this field. In future, quantum computing can be utilized to simulate and model the dynamics of quantum states involved in epigenetic information transfer. Furthermore, advancements in quantum communication technologies may facilitate the development of novel experimental approaches for manipulating and measuring quantum states in living organisms.

The study of quantum phenomena in biological systems presents challenges, yet through interdisciplinary collaborations and technological advancements, a deeper understanding of quantum teleportation and its implications for the transfer of genome-stored experience to close relatives can be achieved. Unravelling the mysteries of quantum biology may provide insights into the fundamental principles that shape life on Earth.

Compliance with ethical standards

Disclosure of conflict of interest

The author declares that there is no conflict of interest.

References

[1] Bennett CH, Brassard G, Crépeau C, Jozsa R, Peres A, Wootters WK. Teleporting an unknown quantum state via dual classical and Einstein-Podolsky-Rosen channels. Physical Review Letters. 1993, 70(13):1895-9.

[2] Gisin N, Ribordy G, Tittel W, Zbinden H. Quantum cryptography. Reviews of Modern Physics. 2002, 74(1):145-95.

[3] Bouwmeester D, Pan J-W, Mattle K, Eibl M, Weinfurter H, Zeilinger A. Experimental quantum teleportation. Nature. 2000, 390(6660):575-9.

[4] Berger SL, Kouzarides T, Shiekhattar R, Shilatifard A. An operational definition of epigenetics. Genes & development. 2009, 23(7):781-3.

[5] Henderson IR, Jacobsen SE. Epigenetic inheritance in plants. Nature. 2007, 447(7143):418-24.

[6] Latzel V, Zhang Y, Karlsson Moritz K, Fischer M, Bossdorf O. Epigenetic variation in plant responses to defence hormones. Annals of botany. 2012, 110(7):1423-8.

[7] Lloyd S. Enhanced sensitivity of photodetection via quantum illumination. Science. 2008, 321(5895):1463-5.

[8] Einstein A, Podolsky B, Rosen N. Can quantum-mechanical description of physical reality be considered complete? Physical review. 1935, 47(10):777.

[9] Lipka-Bartosik P, Skrzypczyk P. Catalytic quantum teleportation. Physical Review Letters. 2021, 127(8):080502.

[10] Bouwmeester D, Zeilinger A. The physics of quantum information: basic concepts: Springer, 2000.

[11] Lago-Rivera D, Rakonjac JV, Grandi S, Riedmatten Hd. Long distance multiplexed quantum teleportation from a telecom photon to a solid-state qubit. Nature Communications. 2023, 14(1):1889.

[12] Thiebaut F, Hemerly AS, Ferreira PCG. A role for epigenetic regulation in the adaptation and stress responses of non-model plants. Frontiers in plant science. 2019, 10:246.

[13] Guarino F, Cicatelli A, Castiglione S, Agius DR, Orhun GE, Fragkostefanakis S, et al. An epigenetic alphabet of crop adaptation to climate change. Frontiers in Genetics, 2022.

[14] Köhler C, Springer N. Plant epigenomics—deciphering the mechanisms of epigenetic inheritance and plasticity in plants. BioMed Central, 2017.

[15] Lloyd JP, Lister R. Epigenome plasticity in plants. Nature Reviews Genetics. 2022, 23(1):55-68.

[16] Stam M. Epigenetic Regulation in Plants [Internet]. Netherlands: University of Amsterdam, © 2019. Available from: https://sils.uva.nl/content/research-groups/epigenetic-regulation-in-plants/epigenetic-regulation-in-plants.html.

[17] Euronews. Plants teach their offspring how to adapt to climate change, scientists find [Internet]. France: Euronews, © 2022 [cited 23 Nov 2023]. Available from: https://www.euronews.com/green/2022/11/23/plants-teach-their-offspring-how-to-adapt-to-climate-change-scientists-find.

[18] Latzel V, Rendina González AP, Rosenthal J. Epigenetic memory as a basis for intelligent behavior in clonal plants. Frontiers in plant science. 2016, 7:1354.

[19] Bock R, Timmis JN. Reconstructing evolution: gene transfer from plastids to the nucleus. Bioessays. 2008, 30(6):556-66.

[20] Keeling PJ, Palmer JD. Horizontal gene transfer in eukaryotic evolution. Nature Reviews Genetics. 2008, 9(8):605-18.

[21] Bock R. The give-and-take of DNA: horizontal gene transfer in plants. Trends in plant science. 2010, 15(1):11-22.

[22] Richards TA, Dacks JB, Jenkinson JM, Thornton CR, Talbot NJ. Evolution of filamentous plant pathogens: gene exchange across eukaryotic kingdoms. Current Biology. 2006, 16(18):1857-64.

[23] Horsthemke B. A critical view on transgenerational epigenetic inheritance in humans. Nature communications. 2018, 9(1):2973.

[24] Molinier J, Ries G, Zipfel C, Hohn B. Transgeneration memory of stress in plants. Nature. 2006, 442(7106):1046-9.

[25] Yaish MW. Epigenetic modifications associated with abiotic and biotic stresses in plants: an implication for understanding plant evolution. Frontiers Media SA, 2017.

[26] Jablonka E, Lamb MJ. The inheritance of acquired epigenetic variations. International journal of epidemiology. 2015, 44(4):1094-103.

[27] Bouwmeester D, Pan J-W, Mattle K, Eibl M, Weinfurter H, Zeilinger A. Experimental quantum teleportation. Nature. 1997, 390(6660):575-9.

[28] Grant-Downton RT, Dickinson HG. Epigenetics and its implications for plant biology 2. The 'epigenetic epiphany': epigenetics, evolution and beyond. Annals of Botany. 2006, 97(1):11-27.

[29] Lambert N, Chen Y-N, Cheng Y-C, Li C-M, Chen G-Y, Nori F. Quantum biology. Nature Physics. 2013, 9(1):10-8.

[30] Lloyd S, editor Quantum coherence in biological systems. Journal of Physics-Conference Series, 2011.

[31] Cifra M, Fields JZ, Farhadi A. Electromagnetic cellular interactions. Progress in biophysics and molecular biology. 2011, 105(3):223-46.

[32] Ma X-S, Herbst T, Scheidl T, Wang D, Kropatschek S, Naylor W, et al. Quantum teleportation over 143 kilometres using active feed-forward. Nature. 2012, 489(7415):269-73.

[33] Herbst T, Scheidl T, Fink M, Handsteiner J, Wittmann B, Ursin R, et al. Teleportation of entanglement over 143 km. Proceedings of the National Academy of Sciences. 2015, 112(46):14202-5.

[34] Mavromatos NE, editor Quantum coherence in (brain) microtubules and efficient energy and information transport. Journal of Physics. IOP Publishing: Conference Series, 2011.

[35] Craddock TJA, Friesen D, Mane J, Hameroff S, Tuszynski JA. The feasibility of coherent energy transfer in microtubules. Journal of the Royal Society Interface. 2014, 11(100):20140677.

[36] D'Acunto M. Quantum biology. π–π entanglement signatures in protein-DNA interactions. Physical Biology. 2022, 19(3):036003.

[37] Engel GS, Calhoun TR, Read EL, Ahn T-K, Mančal T, Cheng Y-C, et al. Evidence for wavelike energy transfer through quantum coherence in photosynthetic systems. Nature. 2007, 446(7137):782-6.

[38] Sarovar M, Ishizaki A, Fleming GR, Whaley KB. Quantum entanglement in photosynthetic light-harvesting complexes. Nature Physics. 2010, 6(6):462-7.

[39] Panitchayangkoon G, Hayes D, Fransted KA, Caram JR, Harel E, Wen J, et al. Long-lived quantum coherence in photosynthetic complexes at physiological temperature. Proceedings of the National Academy of Sciences. 2010, 107(29):12766-70.

[40] Fioranelli M, Sepehri A, Flavin D, Roccia MG, Beesham A. Quantum information teleportation through biological wires, gravitational micro-bio-holes and holographic micro-bio-systems: A hypothesis. Biochemistry and Biophysics Reports. 2021, 26: 101011.

[41] Sepehri A. Quantum information teleportation between cells and microbes through biological molecules, spinning micro-bubbles, quantum particles and gravitational micro/nano wormholes [Internet]. Switzerland: Zenodo, © 2021 [cited 11 Apr 2021]. Available from: https://zenodo.org/record/4679381.