



THE GUY FOUNDATION

Magnetic Fields and Biology

Abstract proceedings of the 2026 Spring Series



Driving innovation in medicine through quantum biology

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(Eds.)**

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2026 SPRING SERIES

MAGNETIC FIELDS AND BIOLOGY

Introduction to the 2026 Spring Series

The Guy Foundation team

The Guy Foundation 2026 Spring Series on Magnetic Fields and Biology brought together an interdisciplinary group of researchers to explore the emerging science of magnetobiology and its implications for life, health, and medicine. Magnetobiology looks at how weak magnetic fields – from micro to nanotesla – interact with living systems, challenging the assumption that such fields are biologically negligible. Magnetic field effects in biological systems are a central topic of interest in quantum biology, where the radical pair mechanism provides a plausible route by which Earth-strength magnetic fields might influence spin-dependent chemical reactions and downstream biological processes. These effects have increasingly been linked to phenomena such as oxidative stress regulation, circadian rhythms, and cellular signalling.

The programme featured contributions from leading researchers across quantum physics, biology, and medicine and opened with a **foundational perspective**, outlining the conceptual and mechanistic basis of magnetic field interactions with biological matter. Professor Jonathan Woodward introduced the details of

the radical pair mechanism before presenting his research on the fluorescence properties of spin-correlated radical pairs, which are formed in many chemical and biological reactions. He shared exciting new experimental results that reveal clear responses to modulated magnetic fields, including astonishing changes in bacterial autofluorescence intensity that vary with cellular stress and glucose availability. Dr Brian Ross then presented his research, which involves developing magnetosensitive

Definitions

Strong magnetic fields: of the order of teslas, used, for example, in magnetic resonance imaging (MRI).

Weak magnetic fields: of the order of Earth-strength fields, in the range micro- to millitesla, the geomagnetic field ranges from roughly 20-70 microtesla.

Very weak or hypomagnetic fields: from zero to nanotesla strength fields, such as on the Moon or Mars.



proteins, motivated by a number of intriguing experimental results that have demonstrated magnetic field effects on organisms such as tadpoles, killifish and *E. coli*.

In the **second session** the focus moved from mechanisms to applications, with speakers discussing the therapeutic potential of magnetic fields. The session was introduced by Dr Rhys Mould, who shared insights from the research team's ongoing research into the role of magnetic fields in biology. He was followed by Dr Margit Egg, who presented her research on therapeutic nuclear magnetic resonance (tNMR), which involves the application of weak electromagnetic fields and is already used clinically in areas such as osteoarthritis, osteoporosis, and wound healing. Her talk highlighted how magnetic stimuli can influence metabolism, redox balance, and cellular timing. The session concluded with Professor Martyn A. Sharpe, who outlined how oncomagnetic therapy uses tailored magnetic fields to modulate mitochondrial function altering electron flux and reactive oxygen species generation, with profound effects observed in cancer models.

The **third session** opened with Sanika Ghayal, who presented some of the Foundation's research using mu-metal chambers to investigate the effects of hypomagnetic fields and how shielding static magnetic fields can significantly alter immune cell function, stress responses, cartilage cell morphology, and muscle cell proliferation and metabolism. She was followed by Professor Wendy Beane who provided a broader perspective on the complex and often contradictory literature surrounding magnetic field effects in biology. Drawing on her work with planarian regeneration, she showed how weak magnetic fields can modulate processes such as cytoskeletal dynamics, membrane voltage, ion flux, and reactive oxygen species (ROS) production. Her research demonstrates that biological responses are highly context-dependent – with different field strengths producing distinct effects on stem cell activity, gene expression, and tissue growth – and points toward integrated bioelectric–ROS signalling pathways as a key mechanism.

The **fourth session** featured Professor Massimo Maffei, who presented fascinating experimental evidence showing how variations in the geomagnetic field can significantly influence plant growth, metabolism, and reproduction. A major focus of the talk was the effect of Near-Null Magnetic Fields (NNMF), environments that simulate the extremely weak magnetic conditions found on the Moon or Mars. Professor Maffei showed that plants grown under NNMF conditions exhibit suppressed growth, delayed flowering, reduced biomass, and significantly lower seed production. He also discussed how ultra-weak magnetic environments rapidly disrupt photosynthetic processes, with effects occurring



too quickly to be explained by conventional gene expression changes alone. The session also explored how plants may sense magnetic fields through quantum biological mechanisms involving cryptochromes and radical-pair chemistry, linking geomagnetic conditions to hormonal regulation, oxidative stress pathways, circadian rhythms, and broader metabolic responses.

The **series concluded** with Professor Alistair Nunn reflecting on the implications of magnetobiology for medicine and space biology, and the shift towards recognising magnetic fields as a subtle but potentially fundamental component of the biological environment. This was followed by a stimulating round table discussion, insights from which are included in the Proceedings Closing Note.



Introduction to The Guy Foundation

Professor Geoffrey Guy

Founder and Chairman, The Guy Foundation

The Guy Foundation supports and promotes the investigation of quantum effects in biology, with the aim of improving our understanding of disease and thus medicine. Our belief is that significant quantum effects may well have been essential for the origins of life as well as the evolution of complex living organisms and thus a better understanding would help unlock new ways of tackling the health and disease issues that we see today.

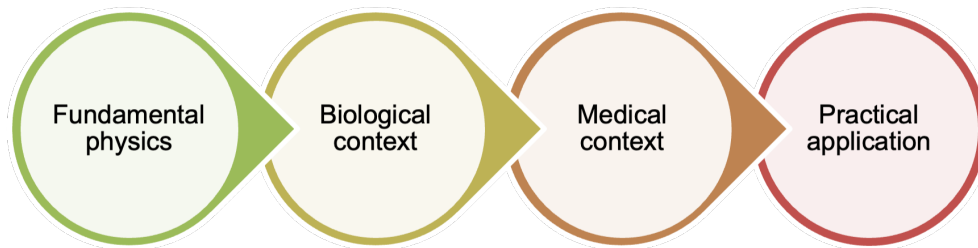
With the development of technology, the study of quantum effects in biology has been gaining rapid pace in recent years. Classical pharmacology-based explanations for the effects of medicines remain insufficient; we aim to develop research into the effects of electromagnetic fields (both endogenous and exogenous) on biological systems. This will expand the conventional 'ball and stick' or 'lock and key' mechanisms which dominate our understanding of physiological processes, including the action of many pharmaceutical interventions. To this end we focus on the role of intracellular bioenergetics and the role of mitochondria from the point of view of dissipative thermodynamic and quantum theories. In short, if significant quantum effects are part of life, the failure to maintain this state probably plays a role in disease and ageing, and will thus be of importance to medicine.

We have also identified space travel as a key area that will benefit from a greater knowledge of the role that fields play in biology. If life is dependent on significant quantum mechanisms to function, then optimal function will be coupled to the planetary environment in which it evolved: a "Goldilocks zone" of environmental conditions. The Foundation believes that a focus on the ways in which the electromagnetic, gravitational and other effects of the space environment can be potentially mitigated, will optimise the health of astronauts and future passengers. This research would also accelerate progress in quantum biology and the advancement of medicine in general.

It is clear to us that the next generation of significant steps in medicine will need to engage with quantum biology. Our role at the Foundation is to help facilitate this mindset shift to bring quantum biology into the mainstream of medicine for the benefit of healthcare issues including ageing, neurodegeneration, metabolic syndrome, neuropsychiatric disease in the young, cancer and others. The Guy Foundation thus leads, supports and contributes to quantum biological and related research with the ultimate aim of advancing the development of new medical diagnostics and therapeutics.



The Foundation believes this advancement can be achieved in a number of ways, which is reflected by the research we fund as well as the topics we address in our scientific symposia. Our approach is summarised as encompassing research from bench to bedside:



Our priorities encompass the spectrum of theoretical, experimental, and practical advances. Understanding the fundamental physics (e.g., quantum mechanics, electrodynamics, thermodynamics) is important. More specifically we aim to understand this physics within the biological and physiological contexts, with the emphasis on furthering the study of medicine. Overall, we would like to see this knowledge translated and applied in clinical practice.

The Foundation therefore aims to provide a platform and a forum for upstream push through and downstream pull through of the understanding of the role of quantum effects and bioenergetics in biology in health and disease.

We curate, lead and fund an inter-disciplinary theoretical and laboratory research programme and have published a number of peer-reviewed scientific papers and reports to further investigate these interests, to advance the course of useful knowledge towards the mainstream and bring it to the attention of more conventional funders. At the heart of our research programme is The Guy Foundation Quantum Biology and Bioenergetics Laboratory at the Central Laser Facility, Harwell Science and Innovation Campus, Oxford and the University of Westminster, London, which is complemented by selected collaborations with leading research groups internationally.

Over the past 8 years we have built an active inter-disciplinary network of over 400 scientists and institutions across the globe. We publish a Quarterly Review, convene regular online symposia and support conferences and meetings that bring together scientists from quantum biology and relevant disciplines to advance the field.

To find out more visit The Guy Foundation [website](#) or follow us on [LinkedIn](#).



Abstract Proceedings

These are abstracts of a series of talks, hosted by The Guy Foundation, that were given online to an invited audience during the Spring of 2026.

They have been written by the presenters and have not been formally peer-reviewed. We hope you enjoy them; video recordings of the lectures are available on the Foundation's website www.theguyfoundation.org. To receive notifications about new videos, subscribe to our [YouTube channel](#).



The Radical Pair Mechanism and Biology

Professor Jonathan R. Woodward

University of Tokyo

View the video recording [here](#).

If magnetic fields are to influence biological systems, a robust interaction mechanism between the field and fundamental biological processes must exist. A primary route for this interaction is through the modulation of the rate or outcome of critical biochemical reactions. At first glance, such an influence appears physically challenging; while molecules containing unpaired electrons are inherently magnetic, their interaction with external magnetic fields is typically negligible compared to thermal energy at room temperature. Consequently, classical theories of chemical thermodynamics and kinetics predict no measurable effects from weak to moderate magnetic fields.

However, the radical pair mechanism (RPM), established in the 1960s, provides a framework for how reactions involving short-lived intermediates – known as spin-correlated radical pairs (RPs) – can remain sensitive to even very weak magnetic fields, including the geomagnetic field. This unique sensitivity arises from the electron spin selectivity of RPs and the capacity of an external magnetic field to alter the efficiency of mixing between reactive and non-reactive spin states through a coherent quantum mechanical process.

This overview details how the RPM produces a distinctive dose-response curve characterized by three critical regions:

1. **Zero Magnetic Field:** Mixing is inefficient due to symmetry restrictions on the total angular momentum of the spin states.
2. **Weak Magnetic Field:** The applied field breaks this symmetry, increasing mixing efficiency.
3. **High Magnetic Field:** As intensity increases, certain non-reactive states become energetically isolated, rendering mixing inefficient once more.

By contextualizing the RPM within biological systems, I present research utilizing real-time autofluorescence in human cancer cells and bacteria. These studies demonstrate clear responses to modulated magnetic fields, including "giant" effects of over 10% on bacterial autofluorescence intensity. These responses report directly on cellular biochemical pathways, fluctuating according to cellular stress and the presence of glucose.



Relevant papers by the speaker

Ikeya N, Woodward JR. Cellular autofluorescence is magnetic field sensitive. *Proceedings of the National Academy of Sciences*. 2021;118(3). DOI: doi.org/10.1073/pnas.2018043118.

Ikeya N, Woodward JR. A fluorescence microscopy platform for time-resolved studies of spin-correlated radical pairs in biological systems. *Journal of the American Chemical Society*. 2026;148(13). DOI: doi.org/10.1021/jacs.5c21177.

Woodward JR. The low-field effect in radical pairs: a zero-field singlet-triplet basis picture. *bioRxiv*. [Preprint] 2026. URL: [biorxiv.org/content/10.64898/2026.04.05.716627v1](https://www.biorxiv.org/content/10.64898/2026.04.05.716627v1).

Bradlaugh A, Munro A, Kattnig D, Baines RA, et al. How the *Drosophila* Cryptochrome C-terminus mediates magnetosensitivity. *bioRxiv*. 2025;09.15.676315. DOI: doi.org/10.1101/2025.09.15.676315.

For more about Jonathan's research see [here](#).



Measuring the Effect of Weak Magnetic Fields in Live Cells

Dr Brian Ross

The Quantum Biology Institute

View the video recording [here](#).

The radical pair mechanism is one of the leading hypotheses to explain how living systems can be influenced by weak magnetic fields. Much of the attention in this area has focused on magnetoreception, the ability of organisms to sense the Earth's magnetic field. However, there is substantial evidence that weak magnetic fields can also affect a wide range of physiological processes beyond sensory systems, including cell cycle regulation, DNA repair, metabolism, and others. At the molecular level, further evidence has demonstrated that the fluorescence and activity of key flavoproteins can be modulated by weak magnetic fields. Our work builds on this foundation by applying methods from the field of technological quantum sensing to further investigate the magnetosensitivity of biomolecules within living systems, with the ultimate goal of connecting spin physics to biochemistry, to cell biology, to physiology. In particular, we aim to measure how long coherent spin superpositions can be maintained in the warm, wet environment of a living cell. The first step of such a project is to identify a suitable magnetosensitive protein that exhibits a strong fluorescence signal with high magnetosensitivity arising from the radical pair mechanism. MagLOV2 is an engineered flavoprotein designed to produce large changes in fluorescence intensity in response to weak magnetic fields. We characterize the magnitude of these fluorescence changes, known as the "magnetic field effect," as a function of the strength of an externally applied magnetic field in *E. coli* colonies expressing MagLOV2. We demonstrate that this relationship is non-monotonic at low field strengths and plateaus at higher field strength, both observations consistent with theoretical models of the radical pair mechanism.

Relevant papers by the speaker

Ross BL, Lodesani A, Aiello CD. The magnetic field-dependent fluorescence of MagLOV2 in live bacterial cells is consistent with the radical pair mechanism. *bioRxiv*. 2026. DOI: doi.org/10.64898/2026.02.18.706690.

Lodesani A, Anders G, Bougas L, Lins T, Budker D, Fierlinger P, Aiello CD. Weak magnetic field effects in biology are measurable—accelerated *Xenopus* embryogenesis in the absence of the geomagnetic field. *bioRxiv*. 2024. DOI: doi.org/10.1101/2024.10.10.617626.

For more about Brian's research see [here](#).



tNMR as a Resonant Modality within Therapeutic Weak Magnetic Fields

Dr Margit Egg

University of Innsbruck

View the video recording [here](#).

This contribution summarized the main published findings of our group on the cellular effects of therapeutic nuclear magnetic resonance (tNMR), a weak electromagnetic field application designed to generate water proton resonance conditions by combining a low-intensity sweep field with a perpendicular radiofrequency component at the ^1H Larmor frequency. Clinically, tNMR is already used in musculoskeletal indications such as osteoarthritis, osteoporosis, and wound healing.

The talk focused on biological processes directly relevant to such settings: the astronomical day and night cycle as a physiological timing cue, low oxygen environments that are realistic in cartilage, bone associated tissues, and healing contexts, and mitochondrial redox signaling as a determinant of cellular adaptation. Published data showed that tNMR modulates cellular clock gene oscillations as a function of time, indicating that responsiveness depends on the prevailing circadian redox state. In addition, therapeutic field effects were discussed in the context of intermittent hypoxia and of acute low oxygen exposure, modeled experimentally as 6 hours of tNMR treatment at 1% O_2 . Under these hypoxic conditions, tNMR shifted cellular metabolism away from glycolysis, including reduced lactate production and altered HIF-1 α associated regulation, while mitochondrial respiration remained preserved during reoxygenation. Magnetic field responses were further shown to involve compartment specific reactive oxygen species signatures, with superoxide emerging as a central mediator rather than a nonspecific oxidative stress signal. Together, these findings identify timing, oxygen availability, redox state, and mitochondria as major determinants of therapeutic responsiveness.

In a final outlook, the talk proposed that full tNMR, as the resonance based condition and the one most consistent with altered kinetics linked to proton transfer, may be particularly relevant for wound healing and ischemia–reperfusion settings, where reoxygenation injury is a major determinant of tissue outcome, with possible relevance for stratified oncologic applications.



Relevant papers by the speaker

Thöni V, Oliva R, Mauracher D, Egg M. Therapeutic Nuclear Magnetic Resonance affects the core clock mechanism and associated Hypoxia-inducible factor-1. *Chronobiology International*. 2021;38(8), 1120-1134. DOI: doi.org/10.1080/07420528.2021.1910288.

Thöni V, Mauracher D, Ramalingam A, Fiechtner B, Sandbichler AM, Egg M. Quantum based effects of therapeutic nuclear magnetic resonance persistently reduce glycolysis. *iScience*. 2022;25(12). URL: [cell.com/iscience/fulltext/S2589-0042\(22\)01808-9](https://cell.com/iscience/fulltext/S2589-0042(22)01808-9).

Thoeni V, Dimova EY, Kietzmann T, Usselman RJ, Egg M. Therapeutic nuclear magnetic resonance and intermittent hypoxia trigger time dependent on/off effects in circadian clocks and confirm a central role of superoxide in cellular magnetic field effects. *Redox Biology*. 2024;72. DOI: doi.org/10.1016/j.redox.2024.103152.

For more about Margit's research see [here](#).



Rotating Magnetic Fields and Cancer

Professor Martyn A Sharpe

Houston Methodist Hospital

View the video recording [here](#).

We have developed a way of generating rotating magnetic fields, based on the earlier work of Helekar and Voss¹. Our device, an oncoscillator, uses the rotation of a neodymium magnet to generate sOMF (spinning Oscillating Magnetic Fields). Oncomagnetic therapy exploits a quantum phenomenon to generate triplet/spin-forbidden states in paired biradical redox centers. We observe profound effects of sOMF on cancer cells *in vitro*, *in vivo*, and in end-stage glioma patients^{2,3}. Mechanistically, one of the major targets of sOMF is mitochondrial complex succinate dehydrogenase. Electron flux is inhibited by sOMF and during inhibition by sOMF, electrons are diverted into molecular oxygen, generating ROS⁴.

Diffuse intrinsic pontine glioma, now called diffuse midline glioma (DMG), comprise approximately half of all pediatric high-grade gliomas. These tumors are universally lethal, typically inoperable, and have a peak incidence in children between 6 and 8 years of age, although DMG also arises in adults, with similar miserable outcomes. Aggressive palliative radiation therapy is standard of care, and this prolongs survival by 3–6 months, to a median overall survival of only 9-11 months.

Oncomagnetic treatment of a 28-year-old woman who had undergone partial surgical excision and radiotherapy of a DMG in the mesencephalon and pons⁵. Treatment was initiated after the first recurrence of the tumor was well tolerated for more than 694 days by the patient. There was near-complete regression of the CET at 145 days with symptomatic relief and a partial regression at 554 days after an apparent progression at 518 days. On day 694 treatment had to be stopped due to an unrelated cause: the patient required a hospital admission due to injuries from a fall and disease progression, which then led to her death. We hope to introduce this effective, nontoxic, and noninvasive wearable device-based into clinic for the treatment of these deadly gliomas.



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DOI: doi.org/10.1016/j.jneumeth.2018.09.002.
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DOI: doi.org/10.3389/fonc.2021.708017.
- 3 Helekar SA, Hambarde S, Ijare OB, Pichumani K, Baskin DS, Sharpe MA. Selective induction of rapid cytotoxic effect in glioblastoma cells by oscillating magnetic fields. *J Cancer Res Clin Oncol*. 2021.
DOI: doi.org/10.1007/s00432-021-03787-0.
- 4 Sharpe MA, Baskin DS, Pichumani K, Ijare OB, Helekar SA. Rotating Magnetic Fields Inhibit Mitochondrial Respiration, Promote Oxidative Stress and Produce Loss of Mitochondrial Integrity in Cancer Cells. *Frontiers in Oncology*. 2021;11. DOI: doi.org/10.3389/fonc.2021.768758.
- 5 Helekar SA, Ijare OB, Sharpe MA, Pichumani K, Baskin DS. Case Report: A new noninvasive device-based treatment of a mesencephalic H3 K27M glioma. *Frontiers in Oncology*. 2025;15.
DOI: doi.org/10.3389/fonc.2025.1626516.

For more about Martyn's research see [here](#).



Hypomagnetic Field Effects in Biology

Dr Rhys Mould and Sanika Ghayal

The Guy Foundation Quantum Biology and Bioenergetics Laboratory

University of Westminster

View the video recordings [here](#) and [here](#).

As the prospects of long-distance space flight become increasingly realistic, research into the effects of the extraterrestrial environment on our biology grows more vital. Whilst the effects of orbital spaceflight, including hypo-gravity and perturb circadian rhythms are well-documented in our astronauts, the biochemical consequences of leaving the Earth's geomagnetic field (of approximately 50 μ T) are less understood. Using mu-metal chambers that block static magnetic fields, we study the effects of hypo-magnetic fields (<20 nT) on a variety of cell line models. Preliminary data suggests hypomagnetic field exposure alters immune cell function and stress response, cartilage cell morphology and muscle cell proliferation and mitochondrial metabolism. Our results further highlight the need to consider hypomagnetism as long distance space flight is considered, as well reveal novel mechanisms by which magnetism affects our biology.

Relevant papers by the speakers

Mould RR, Mackenzie AM, Kalampouka I, Nunn AVW, Thomas EL, Bell JD, Botchway SW. Ultra weak photon emission—a brief review. *Front. Physiol.* 2024;15:1348915. DOI: doi.org/10.3389/fphys.2024.1348915.

Mould RR, Kalampouka I, Thomas EL, Guy GW, Nunn AVW, Bell JD. Non-chemical signalling between mitochondria. *Front. Physiol.* 2023;14:1268075. DOI: doi.org/10.3389/fphys.2023.1268075.

For more about the Laboratory's work see [here](#) and [here](#).



Biological Effects of Magnetic Fields: Evidence from Animals and Humans

Professor Wendy Beane

Western Michigan University

View the video recording [here](#).

Research into the effects of magnetic fields (MF) on living systems has a long history. But the extant literature on human and animal model system data is a perplexing compilation of often contradictory results that has made it challenging to identify any underlying foundational cellular principles. However, there are solid biological reasons for this which should be taken into consideration as the field of magnetobiology expands into the quantum. First, there are several biologically-relevant areas where biological systems and MFs interact, from magnetoreception to bioelectromagnetic communication between cells. There are also numerous types of MF exposure, of which static weak MFs (WMFs) and extremely low frequency electromagnetic fields (ELF-EMF) are the most commonly studied. Even if research is narrowed to a specific area, such as our own research on external static WMF exposure during planarian regeneration¹, the cellular and molecular MF effects cover a range of signaling mechanisms. These include changes in cytoskeleton dynamics, membrane voltage and ion flux, and the generation of reactive oxygen species (ROS). To further complicate things, WMF effects vary by specific organ system, as cellular responses are context/tissue dependent, and dependent strongly on field strength. Our data show that planarian stem cells respond in a field-dependent manner to WMFs of < 1 mT due to changes in wound site superoxide levels². 500 μ T exposures increase, while 200 μ T inhibit, ROS levels and subsequent gene expression, stem cell proliferation, and new tissue growth³. In addition, our work reveals that many of these mechanisms are often integrated. We are currently investigating a bioelectric-ROS signaling pathway (including membrane depolarization and voltage-gated calcium channels) that is targeted by WMFs. This wide variety of MF conditions and cellular responses may make the initial synthesis of findings much more challenging, but simultaneously it promises great future potential for a variety of specific therapies.



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- 2 Kinsey LJ, Van Huizen AV, Beane WS. Weak magnetic fields modulate superoxide to control planarian regeneration. *Frontiers in Physics: Biophysics*. 2023;10:1086809. DOI: doi.org/10.3389/fphy.2022.1086809.
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For more about Wendy's research see [here](#).



The Evidence for Magnetobiology – Plants: Beyond Migration

Professor Massimo Maffei

Università di Torino

View the video recording [here](#).

This presentation highlights how variations in the Geomagnetic Field (GMF) significantly influence plant development. A primary focus is placed on Near-Null Magnetic Fields (NNMF), which simulate environments lacking a magnetosphere, such as the Moon (~300 nT) or Mars (~500 nT). Plants in NNMF exhibit suppressed growth, delayed flowering (anthesis), and reduced biomass during the transition to reproductive stages. This translates into a notable reduction in agricultural output, with approximately 22% fewer siliques and 19% less seed production in species like *Arabidopsis thaliana*. Furthermore, simulated lunar magnetic fields (<5 nT) disrupt photosynthetic carbon assimilation and affect iron homeostasis. These photosynthetic effects occur so rapidly (within seconds to minutes) that they are too fast to involve protein turnover or gene expression, suggesting direct physico-chemical impacts on electron transport or membrane potential.

The presentation details how plants sense and respond to magnetic fields through "quantum biology" mechanisms involving the Radical Pair Mechanism. This process is mediated by cryptochromes (CRY1/CRY2), blue-light receptors where magnetic field effects occur specifically during the dark re-oxidation period of the photocycle. In this phase, the magnetic field alters the reaction rate constant, thereby changing the lifetime of the activated signalling state. This quantum sensing triggers significant hormonal impairment; NNMF leads to increased Auxin (IAA) in roots but decreased levels in rosettes, and it downregulates Gibberellin (GA) biosynthetic genes, such as *GA20ox1-3*, which is directly linked to delayed flowering. Additionally, exposure to NNMF triggers a rapid reduction in root ion uptake and transport, affecting essential cations and anions.

Beyond hormones, the reduction of the GMF induces a transcriptomic and metabolomic shift related to oxidative stress and circadian rhythms. NNMF induces lower levels of Reactive Oxygen Species (ROS) like hydrogen peroxide compared to GMF conditions, a shift paralleled by the regulation of ROS-scavenging enzymes (e.g., peroxidases) and a progressive decrease in antioxidant polyphenols. The GMF also influences the circadian clock by altering the expression of clock-regulated genes, which impacts the timing of metabolic processes. Under NNMF, plants show a biphasic dose response, indicating a hormetic response where they utilize existing stress-response signalling networks to sense



the GMF. Understanding these rules is essential for future interplanetary colonization, as research into NNMF-robust crops is critical for sustainable Bioregenerative Life Support Systems on the Moon or Mars. Finally, terrestrial data from 1985–2015 shows a positive correlation between GMF intensity and crop yields, where a 1 mG increase corresponds to ~1.8% higher rice yields, suggesting that magnetic field technology could be a sustainable, eco-friendly tool for enhancing global food security.

Relevant papers by the speaker

Maffei ME. The radical pair mechanism and its quantum role in plant reactive oxygen species production under hypomagnetic fields. *Quantum Reports*. 2025;7(4). p.52. DOI: doi.org/10.3390/quantum7040052.

Maffei ME. Plant quantum biology: the quantum dimension of plant responses to stress. *Plant Stress*. 2025;17. p.100930. DOI: doi.org/10.1016/j.stress.2025.100930.

Maffei ME, Balestrini RM, Costantino P, *et al.* The physiology of plants in the context of space exploration. *Communications Biology*. 2024;7(1). DOI: doi.org/10.1038/s42003-024-06989-7.

For more about Massimo's research see [here](#).



Implications of Magnetobiology

Professor Alistair Nunn

The Guy Foundation and University of Westminster

View the video recording [here](#).

Life has been shown repeatedly to be sensitive to changes in the direction, strength and modulation of magnetic fields beyond that it evolved in, meaning it is canalised to function optimally in a “Goldilocks zone” and exhibits a “magnetic flight envelope”. When exposed to conditions outside of this envelope, there are changes in redox which signal stress, usually via reactive oxygen species (ROS), which induce an adaptive response often marked by enhanced antioxidant systems involving mitochondrial function and modulation of inflammation to restore homeostasis. This stress response is similar to that induced by other “outside the metabolic envelope” factors, such as physical activity, extremes of temperature and consumption of plant secondary metabolites, such as polyphenols, and generally follows the hormetic principle. This confirms that life is electrical, as it depends on the flow of charged particles, such as electrons and protons, and why we can use quantum mechanics to explain this interaction, for instance, through the property of quantum spin. Indeed, this relationship can be inferred from current theories on the origins of the Universe and life due to thermodynamics and quantum mechanics in relation to self-organisation of matter to dissipate energy potentials. In short, the flow of charged particles obeys the rules of entropy resulting in what we call life, which can be viewed as a means to accelerate the heat death of the universe. Critically, this flow of charge creates electric fields, which explains the origins of bioelectricity and morphogenetic fields, indicating that life has to be viewed in terms of both molecules and fields. The implications are far reaching. Pathologically, it suggests a multifactorial interaction between the various conditions that can perturb an organism/cell from its ideal homeostatic set point. For example, exercise induces a healthy mitochondrial reserve and ability to maintain an optimum redox set point, meaning it enhances robustness against other variables, such as viruses, a poor diet, hypoxia, the wrong photonic spectrum and circadian zeitgebers, radiation and changes in the magnetic field. Critically, this means that magnetic fields can be used clinically for conditions like cancer by preferentially perturbing tumour metabolism, but can enhance problems, for instance, on spacecraft going beyond the Earth’s magnetosphere, which likely applies to both animals and plants. In short, a lack of a magnetic field going to Mars could enhance the already observed acceleration of ageing seen in humans and other species in low Earth orbit, and could even be mission critical.



Relevant papers by the speaker

Adams B, Hassasfar A, Sinayskiy I, Nunn A, Guy G, Petruccione F. Quantum evolution: terrestrial fine-tuning of magnetic parameters. *arXiv*. 2026;2411.03316 [physics.bio-ph]. DOI: doi.org/10.48550/arXiv.2411.03316.

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For more about Alistair's research see [here](#) and The Guy Foundation's publications page [here](#).



Closing Note

Professor Geoffrey Guy

Founder and Chairman, The Guy Foundation

In retrospect, both the Autumn Series on Light and the Spring Series on Magnetic Fields converged on a shared theme: humans may have become too technologically sophisticated for their own biological good. In pursuit of efficiency and progress, modern societies have reshaped the environmental conditions in which life evolved – whether this is replacing broadband incandescent light with narrow-spectrum LEDs or extending our borders toward space environments with radically different magnetic field conditions. But our technological capability is advancing faster than our understanding of how biological systems integrate environmental influences that extend beyond accepted biochemistry.

The roundtable discussion reinforced this perspective, highlighting growing evidence that life is tuned to a specific range of environmental conditions that include not only gravity and light, but also the geomagnetic field. Even subtle magnetic perturbations may affect mitochondrial function, redox signalling, immune function, and cellular development and repair. The various presentations in the series also emphasised that these effects may operate across scales, from molecular interactions to organelle and systems-level processes. In addition to this, clinical and translational examples – including therapeutic nuclear magnetic resonance and oscillating magnetic field therapy – point to the fact that these principles already have measurable relevance in medicine.

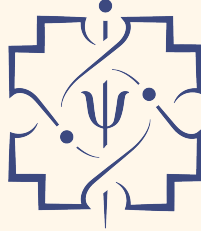
In previous discussions around the biological and health implications of changing light environments, there has been an emphasis on the need to better understand the optimal conditions at which light is beneficial. The Spring Series highlighted a similar issue with respect to magnetic fields, underscoring the need to untangle and systematise a complex and at times contradictory body of magnetobiological findings. This would entail clarifying how proposed mechanisms interact and standardising the effects of different types of magnetic field exposure, which vary widely in form, strength, and biological impact.

Magnetic field exposure is not monolithic. Even within defined systems responses can span cytoskeletal dynamics, membrane voltage changes, ion flux, and reactive oxygen species signalling, often in a strongly context- and tissue-dependent manner. Evidence further suggests pronounced field-strength dependence, with nonlinear effects on redox balance, gene expression, and regeneration, highlighting both the complexity and specificity of these magnetic interactions.



As we look towards the future, it is perhaps time to begin ‘joining the dots’ between these previously neglected fields of research. Rather than viewing light and magnetic fields as isolated quantum phenomena, we should be aware that biology depends on an integrated environmental framework in which multiple physical influences continuously shape cellular function and organismal health. The forthcoming 2026 Autumn Series, ‘Bioenergetics, Health, and the Quantum Environment’, will aim to explore how these factors collectively modulate living systems and to update prevailing ideas of bioenergetics through the lens of the quantum environment. In doing so, the series will seek to move beyond conventional biochemical models toward a broader understanding of how life has evolved within – and may remain fundamentally dependent upon – the complex physical environment of Earth.

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