Quantum Biology and the Future

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A collaboration between the Quantum Biology Tech Lab and Leverage

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QuBiT
Quantum Biology Tech Lab

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What Will Quantum Biology Disrupt?

Quantum physics has already changed our understanding of the universe and enabled fundamental new quantum technologies, such as magnetic resonance imaging, lasers, global positioning satellites, and the transistor. Yet quantum advances in biology promise to usher in an entirely new era, revolutionizing humanity's approach to health, medicine, and longevity, with vast impacts on biology, physics, and beyond.

For decades, scientists have been gathering evidence of quantum effects in biology. Quantum effects, such as electron tunneling and superposition, have already been shown in test tubes to contribute to photosynthesis, enzyme function, and mitochondrial respiration.[1] But this is likely just the tip of the iceberg, as indicated by the phenomenon of weak magnetic field effects.

Weak magnetic field effects are pervasive in biology, affecting many cells types in organisms across the tree of life.[2] Weak magnetic fields impact ion channel function,[3] the rate of DNA repair,[4] and even how birds can use the Earth's magnetic field to navigate during migration.[5] While some magnetosensitivity in organisms depends on chunks of magnetite or conduction channels, the best explanation in most cases depends on quantum phenomena like electron spin superpositions inside cells.

Quantum physicists are now planning to build the custom quantum microscopes needed to observe long-lasting quantum phenomena and confirm that biology is running on quantum.[6] If confirmed, they will then begin to probe the quantum-to-bio link, learning how to harness weak magnetic field effects to yield an abundance of precisely controlled outcomes, kicking off the quantum biology revolution in earnest.

The first advances unlocked by quantum biology will be in medicine and therapeutics. Weak magnetic fields are cheap and non-invasive, and quantum effects can potentially be used to speed up drug discovery and enhance the effects of pharmaceuticals.[7] With the fine-grained control quantum biology will bring, one can foresee advanced personalized therapeutics, including ones that holistically modulate cell function and use nature-tested strategies for longevity from other species.

Further advances are likely in the domain of biomanufacturing and even molecular nanotechnology. Weak magnetic fields affect mitosis rates;[8] with a deeper understanding of cell function, scientists may learn to precisely control cell division, yielding exponential gains. Lessons from

quantum biology might then be employed in advancing molecular nanotechnology and quantum computing, translating the lessons of how nature makes its own nanomachines and preserves coherence at room temperature to humanity's specific use cases.

There might be other lessons from nature on offer. Understanding quantum effects in biology may help us to be able to emulate neurons and even the entire brain,[9] and contribute ideas to artificial intelligence.[10] It may even help as humanity continues its journey to the stars, allowing spacefarers to create more habitable conditions, protected by magnetic fields like the one our species evolved within on the Earth. The quantum biology revolution has much to offer; the next step depends on the work of quantum physicists and is eagerly awaited.

QuBiT / Leverage

The QuBiT Lab seeks to test the Quantum Biology Hypothesis and unambiguously refute or establish the existence of a quantum-to-biology link.[11] If quantum phenomena impact biological systems, there are likely ways to use that link to cause beneficial effects and defend against harmful ones. Greater understanding of quantum effects in biology can contribute substantially to medicine,[12,13] chemical manufacturing,[14,15] drug discovery,[16] space exploration,[17] quantum computing,[18] and defense.[19] QuBiT was originally located at UCLA and is led by Clarice Aiello, the preeminent scientist in the field of quantum biology.

Leverage is providing operational support to QuBiT, helping it to obtain funding, and studying the bottlenecks in the field of quantum biology as part of its mission to advance areas in science and technology which have become stuck.[20,21] Leverage has more than a decade of experience overseeing and supporting complex research projects, providing as-needed help with hiring, fundraising, project planning, and research validation.

References

[1] McFadden, Johnjoe and Jim Al-Khalili. *Life on the Edge: The Coming of Age of Quantum Biology*. Penguin Random House (2016). ISBN 9780307986825.

[2] Binhi, Valdimir N., and Frank S. Prato. "Biological effects of the hypomagnetic field: An analytical review of experiments and theories." PLoS One 12, no. 6 (June, 2017). https://doi.org/10.1371/journal.pone.0179340

[3] Bertagna, F. et al. "Effects of electromagnetic fields on neuronal ion channels: a systematic review." Annals of the New York Academy of Sciences 1499 (2021). https://doi.org/10.1111/nyas.14597

[4] Zwang, Theodore J. et al. “A Compass at Weak Magnetic Fields Using Thymine Dimer Repair.” ACS Cent Sci. 4 (2018). https://doi.org/10.1021/acscentsci.8b00008

[5] Hore, P. J. and Henrik Mouritsen. “The Radical-Pair Mechanism of Magnetoreception.” Annual Review of Biophysics 45 (2016). https://doi.org/10.1146/annurev-biophys-032116-094545

[6] Aiello, Clarice and Arye Lipman. 2022. "The Future of Biology is Quantum." The Last Great Mystery (blog). May 12 2022. https://arye.substack.com/p/the-future-of-biology-is-quantum

[7] Timmins, G. and S.W. Choi. “Magnetodynamic activation of 13 C-acyl isoniazid and isoniazid and ethionamide derivatives.” US Patent 9,579,381, 2017.

[8] Zadeh-Haghighi, Hadi and Christoph Simon. "Magnetic field effects in biology from the perspective of the radical pair mechanism." J R Soc Interface 19 (2022). https://doi.org/10.1098/rsif.2022.0325.

[9] Sandberg, A. N. Bostrom. Whole Brain Emulation: A Roadmap, Technical Report #2008-3, Future of Humanity Institute, Oxford University. www.fhi.ox.ac.uk/reports/2008-3.pdf

[10] Castelvecchi, Davide. “The AI–Quantum Computing Mash-Up: Will It Revolutionize Science?” Nature, January 2024. https://doi.org/10.1038/d41586-023-04007-0

Further Reading

[11] Leverage & QuBiT Lab. “Testing the Quantum Biology Hypothesis,” version 1.7 (2024).

[12] Leverage & QuBiT Lab. “Quantum Biology and Health,” version 1.0 (2024).

[13] Leverage & QuBiT Lab. “Quantum Biology and Longevity,” version 1.0 (2024).

[14] Leverage & QuBiT Lab. “Quantum Biology and Biomanufacturing,” version 1.1 (2024).

[15] Leverage & QuBiT Lab. “Quantum Biology and Nanotechnology,” version 1.1 (2024).

[16] Leverage & QuBiT Lab. “Quantum Biology and Drug Discovery,” version 1.0 (2024).

[17] Leverage & QuBiT Lab. “Quantum Biology and Space Exploration,” version 1.2 (2024).

[18] Leverage & QuBiT Lab. “Quantum Biology and Quantum Computing,” version 1.3 (2024).

[19] Leverage & QuBiT Lab. “Quantum Biology and Defense,” version 1.0 (2024).

[20] Leverage & QuBiT Lab. “Quantum Biology and Whole Brain Emulation,” version 1.0 (2024).

[21] Leverage & QuBiT Lab. “Quantum Biology and Artificial Intelligence,” version 1.1 (2024).