Quantum Biology and Quantum Computing

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A collaboration between the Quantum Biology Tech (QuBiT) Lab and Leverage

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Can Nature Teach Us to Manage Noise?

Quantum phenomena typically decohere quickly at room temperature in natural environments. It is for this reason that quantum computers are built in extremely cold and well-controlled environments. The cold and carefully controlled conditions allow for a longer period of quantum coherence — something essential for practical quantum computation.

Nevertheless, there are naturally occurring quantum bits where quantum coherence lasts longer than expected, including at room temperature. The most famous of these are nitrogen vacancy centers in diamond, which are used as part of today's most sophisticated quantum sensors.[1] Less well known is the possibility — maintained by quantum biologists — that quantum objects within biological systems can maintain quantum coherence for far longer than expected, also at room temperature.[2]

The evidence that quantum phenomena are relatively long-lived in biological systems is currently circumstantial. There is substantial evidence that biological systems respond to weak magnetic fields in ways consistent with those systems using electron spin superpositions as natural quantum sensors.[3] Yet no one has built the quantum microscopes needed to look inside cells and verify directly whether such superpositions last long enough to have relevant biological effects.

Despite the lack of direct observational evidence, many groups are rushing ahead to take advantage of the presumably quantum-derived effects occurring in biological systems. Most notable are companies that are using weak magnetic fields to treat tumors,[4] though there are now an increasing number of organizations that recognize a commercial interest in quantum biology.

Quantum computing companies may be the next to recognize the potential for quantum effects in biology to translate into faster research progress and, ultimately, profit. The core of the promise is the possibility that nature has figured out how to do something that our best scientists, clever as they are, may not have thought of yet.[5]

If quantum phenomena, like electron spin superpositions, exist for long enough inside cells to cause macroscopic biological effects, it is likely nature has worked out a way to beneficially manage noise — for instance, maintaining coherence for longer or taking advantage of noise-assisted processes.

How much can quantum computing learn from quantum biology? New technologies frequently take inspiration from nature, following it more or less closely. The dual-wing approach to flight was inspired by birds, and today's generation of AI models use an architecture that were originally inspired by the human brain. Quantum computers are unlikely to imitate biology in every regard. But the lessons from quantum biology may be extremely valuable and worth the price to learn.

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The QuBiT Lab seeks to test the hypothesis that quantum phenomena influence the macroscopic functioning of cells (i.e., the "Quantum Biology Hypothesis") and unambiguously refute or establish the existence of a quantum-to-biology link.[6] If quantum phenomena impact biological systems, there are likely ways to use that link to cause beneficial effects and defend against harmful ones. At the limit, one can imagine a greater understanding of quantum effects in biology contributing to medicine,[7] chemical manufacturing,[8] drug discovery,[9] space exploration,[10] quantum computing, and defense.[11] QuBiT was originally located at UCLA and has been funded by the US Army, which was interested in potential applications in healing and performance enhancement.

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.[12,13,14]

References

[1] Doherty, Marcus et al. "The nitrogen-vacancy colour centre in diamond." Physics Reports 528 (2013). https://doi.org/10.1016/j.physrep.2013.02.001

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[3] Kattnig, Daniel R. et al. "Chemical amplification of magnetic field effects relevant to avian magnetoreception." Nature Chemistry 8 (2016): 384-391. https://doi.org/10.1038/nchem.2447

[4] National University of Singapore. "Magnetic therapy pioneered by NUS researchers enhances chemotherapy treatment of breast cancer." May 3, 2022. https://news.nus.edu.sg/magnetic-therapy-enhances-chemotherapy-treatment-of-breast-cancer/

[5] Aiello, Clarice, "Why nature is the ultimate quantum engineer." New Scientist (Sept. 2023). https://www.newscientist.com/article/2390076-why-nature-is-the-ultimate-quantum-engineer/

Further Reading

[6] Leverage & QuBiT Lab. "Testing the Quantum Biology Hypothesis," version 1.6 (2024).

[7] Leverage & QuBiT Lab. "Quantum Biology and Applications in Health," version 1.0 (2024).

[8] Leverage & QuBiT Lab. "Quantum Biology and Biomanufacturing," version 1.0 (2024).

[9] Leverage & QuBiT Lab. "Quantum Biology and Drug Discovery," version 1.0 (2024).

[10] Leverage & QuBiT Lab. "Quantum Biology and Longevity in Space," version 1.0 (2024).

[11] Leverage & QuBiT Lab. "Quantum Biology and Defense," version 1.0 (2024).

[12] Leverage & QuBiT Lab. "Quantum Biology and Brain Function," version 1.0 (2024).

[13] Leverage & QuBiT Lab. "Quantum Biology and Artificial Intelligence," version 1.0 (2024).

[14] Leverage & QuBiT Lab. "Quantum Biology as an Experiment in Open Science," version 1.0 (2024).