

Quantum Biology and Quantum Computing

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

To learn more about our Bottlenecks
Program, please visit our [website](#).

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	0	1	2	3	4	5
55920	$2^1 \cdot 3 \cdot 5 \cdot 7 \cdot 131$	55021	$2^2 \cdot 11 \cdot 41 \cdot 61$	3 \cdot 18345	$2^3 \cdot 19 \cdot 181$	57 \cdot 31 \cdot 51
55926	$2^2 \cdot 3^2 \cdot 1019$	$7^2 \cdot 1123$	$2^2 \cdot 13 \cdot 757$	$3 \cdot 13 \cdot 17 \cdot 83$	$2 \cdot 5 \cdot 5503$	113 \cdot 41
55932	$2^3 \cdot 2293$	11 5003	2 \cdot 7 \cdot 3031	$3^2 \cdot 13 \cdot 17 \cdot 83$	$2^2 \cdot 13709$	47 \cdot 137
55938	2 \cdot 3 \cdot 9173	23 2939	$2^6 \cdot 5 \cdot 43$	3 \cdot 51	2 \cdot 13 \cdot 29 \cdot 73	19 \cdot 209
55944	$2^2 \cdot 3^2 \cdot 11 \cdot 139$	5 \cdot 101 \cdot 109	2 \cdot 17 \cdot 1619	3 \cdot 51	$2^3 \cdot 7 \cdot 983$	85 609
55950	$2^2 \cdot 3 \cdot 5^2 \cdot 363$	55089	$2^2 \cdot 17 \cdot 163$	3 \cdot 51	$2^3 \cdot 7 \cdot 983$	85 609
55956	$2^2 \cdot 3^2 \cdot 57$	55087	$2^2 \cdot 17 \cdot 163$	$3^2 \cdot 13 \cdot 17 \cdot 83$	$2 \cdot 27521$	5 \cdot 117 \cdot 11
55962	$2^2 \cdot 3^2 \cdot 7 \cdot 19 \cdot 23$	55179	$2^2 \cdot 17 \cdot 163$	$3^2 \cdot 13 \cdot 17 \cdot 83$	$2^2 \cdot 13753$	53 \cdot 137
55968	$2^2 \cdot 3 \cdot 13 \cdot 353$	7 7867	2 \cdot 5 \cdot 5507	$3^2 \cdot 13 \cdot 17 \cdot 83$	$2 \cdot 27521$	53 \cdot 137
55974	2 \cdot 3 \cdot 67 \cdot 137	$5^2 \cdot 2203$	$2^2 \cdot 7^2 \cdot 281$	3 \cdot 51	$2 \cdot 27521$	53 \cdot 137
55980	$2^2 \cdot 3^2 \cdot 5 \cdot 17$	19 23 \cdot 223	2 \cdot 27541	3 \cdot 51	$2^2 \cdot 47 \cdot 293$	9 \cdot 23 \cdot 47
55986	2 \cdot 3 \cdot 9181	31 1777	$2^4 \cdot 11 \cdot 313$	3 \cdot 51	2 \cdot 5 \cdot 787	89 439
55992	$2^2 \cdot 3^2 \cdot 499$	37 1489	$2^2 \cdot 13^2 \cdot 163$	3 \cdot 51	$2^3 \cdot 71 \cdot 97$	9 \cdot 23 \cdot 97
55998	$2^2 \cdot 3^2 \cdot 3061$	11 5089	$2^2 \cdot 5^2 \cdot 19 \cdot 29$	3 \cdot 51	$2 \cdot 27554$	85 109
56104	$2^2 \cdot 3 \cdot 7 \cdot 41$	5 \cdot 101 \cdot 107	2 \cdot 59 \cdot 467	$3^2 \cdot 13 \cdot 17 \cdot 83$	$2^2 \cdot 23 \cdot 899$	85 109
56110	2 \cdot 3 \cdot 5 \cdot 11 \cdot 167	7 7873	$2^2 \cdot 83^2$	$3 \cdot 13 \cdot 17 \cdot 83$	$2 \cdot 17 \cdot 1621$	9 \cdot 73 \cdot 111
56116	$2^2 \cdot 3^2 \cdot 1351$	55117	2 \cdot 7 \cdot 31 \cdot 127	$3 \cdot 5 \cdot 19 \cdot 87$	$2^2 \cdot 5 \cdot 13 \cdot 53$	11 \cdot 6011
56122	$2^2 \cdot 3^2 \cdot 199 \cdot 317$	55119	$2^2 \cdot 5 \cdot 19 \cdot 87$	$3 \cdot 5 \cdot 19 \cdot 87$	$2 \cdot 43 \cdot 641$	55 1227
56128	$2^2 \cdot 3 \cdot 2207$	59 1981	2 \cdot 3 \cdot 37 \cdot 169	$3 \cdot 5 \cdot 19 \cdot 87$	$2 \cdot 43 \cdot 641$	55 1227
56134	$2 \cdot 3^2 \cdot 1021$	5 \cdot 11007	$2^2 \cdot 13 \cdot 17 \cdot 23$	$3 \cdot 5 \cdot 19 \cdot 87$	$2 \cdot 19 \cdot 1451$	57 1241
56140	$2^2 \cdot 3 \cdot 919$	67 823	$2 \cdot 79 \cdot 349$	$3^2 \cdot 5 \cdot 17$	$2^3 \cdot 61 \cdot 113$	89 41 \cdot 61
56146	2 \cdot 3 \cdot 7 \cdot 13 \cdot 101	55147	$2^2 \cdot 17 \cdot 811$	$3 \cdot 5 \cdot 19 \cdot 87$	$2 \cdot 5^2 \cdot 113$	131 41 \cdot 61
56152	$2^2 \cdot 3^2 \cdot 383$	7 7879	$2 \cdot 11 \cdot 23 \cdot 151$	$3 \cdot 5 \cdot 19 \cdot 87$	$2^2 \cdot 13789$	19 \cdot 209
56158	2 \cdot 3 \cdot 29 \cdot 317	13 4249	$2^2 \cdot 5 \cdot 7 \cdot 197$	$3 \cdot 5 \cdot 19 \cdot 87$	$2 \cdot 27581$	85 113
56164	$2^2 \cdot 3 \cdot 4597$	5 \cdot 11 \cdot 17 \cdot 59	2 \cdot 27583	$3 \cdot 7 \cdot 37 \cdot 71$	$2^2 \cdot 431$	43 1203
56170	$2 \cdot 3^2 \cdot 6 \cdot 613$	55171	$2^2 \cdot 13 \cdot 1061$	$3 \cdot 5 \cdot 19 \cdot 87$	$2 \cdot 7^2 \cdot 563$	57 1227
56176	$2^2 \cdot 3 \cdot 11^2 \cdot 19$	23 2399	2 \cdot 47 \cdot 587	$3^2 \cdot 11 \cdot 19$	$2^2 \cdot 5 \cdot 11 \cdot 89$	7 \cdot 7093
56182	2 \cdot 3 \cdot 17 \cdot 941	139 397	$2^4 \cdot 3449$	$3 \cdot 5 \cdot 19 \cdot 87$	$2 \cdot 41 \cdot 673$	11 \cdot 29 \cdot 47
56188	$2^2 \cdot 3^2 \cdot 7 \cdot 73$	229 247	$2 \cdot 5 \cdot 5515$	$3 \cdot 5 \cdot 19 \cdot 87$	$2^2 \cdot 6989$	97 609
56194	2 \cdot 3 \cdot 919	9 \cdot 17 \cdot 83	$2^2 \cdot 13799$	$3 \cdot 5 \cdot 19 \cdot 87$	$2 \cdot 11 \cdot 13 \cdot 193$	179 101
56200	$2^2 \cdot 3^2 \cdot 505$	55201	$2 \cdot 13 \cdot 193$	$3 \cdot 5 \cdot 19 \cdot 87$	$2^2 \cdot 59 \cdot 273$	19 \cdot 209
56206	$2^2 \cdot 3^2 \cdot 3067$	55207	$2^2 \cdot 67 \cdot 103$	$3 \cdot 7 \cdot 11 \cdot 239$	$2 \cdot 5 \cdot 1651$	13 \cdot 61
56212	$2^2 \cdot 3 \cdot 43 \cdot 107$	55213	$2 \cdot 19 \cdot 1453$	$3^2 \cdot 5 \cdot 409$	$2^2 \cdot 7 \cdot 17 \cdot 20$	85 113



LEVERAGE

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.

QuBiT / Leverage

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>

² 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>

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).