



RESONANCE

BRIEFING

QUANTUM AND LIFE SCIENCES

The biotech opportunity in quantum

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SUMMARY

02

Quantum reaches biology before it reaches most other industries

Molecules obey quantum mechanics, so a quantum computer is a more natural model of a drug candidate than a classical approximation is. That structural fit is why life sciences shows up in every national quantum strategy, and why one of the first quantum computers built for a single industry was built for healthcare.

The near-term question is who owns the infrastructure when the devices are ready.

01 The value pool is real

McKinsey puts quantum computing's value at stake in pharmaceuticals and medical products at \$80bn to \$400bn by 2035, up to 12 percent of projected industry gross sales. The spread is wide because the upside depends on new business models.

02 Hybrid workflows are already producing results

Nobody is waiting for fault tolerance. The working pattern is classical systems handling scale and a quantum routine handling the part classical methods approximate badly, an active site, a transition state, a hard combinatorial subproblem.

03 Optimization pays first, chemistry pays most

Scheduling, trial design, and cold chain routing fit today's hardware and deliver measurable operational gains now. Molecular simulation carries the larger prize and arrives later. A serious program funds both.

04 Proximity to the machine is the differentiator

Cloud access is commoditized. What Cleveland Clinic bought in 2021 was not compute; rather it was co-location of clinicians, algorithm developers, and hardware engineers in one building, which produced 50 joint projects, a startup program, and two frontier results in 2026.

05 North America is behind Europe on readiness

On The Quantum Insider's Quantum Index, European life sciences companies score 560 against North America's 370. Boehringer Ingelheim, Merck, Roche, and Sanofi built internal teams early. The gap is institutional, and it is closable.

Sources: McKinsey & Company, Quantum Technology Monitor 2026. The Quantum Insider, Quantum Index 2025. IBM Research, May 2026. Resonance analysis.

Quantum could unlock \$80bn to \$400bn of value in pharmaceuticals by 2035

That is 2 to 12 percent of a projected \$3,100bn revenue base, arriving through four levers. Research and drug design carry most of it at both ends: \$50bn of the \$80bn floor and \$300bn of the \$400bn ceiling. Clinical and production savings make up the rest. Those are engineering problems, and they arrive whatever happens to the science.

Value unlocked from quantum computing in pharmaceuticals, by lever, 2035

\$ billion. Each lever applies McKinsey's impact hypothesis to that lever's 2035 baseline. Bars share one scale, and the total is the sum of the four.



Source: McKinsey & Company, Quantum Technology Monitor 2026. Baselines from S&P Global Comparative Industry Service; R&D taken as 22 percent of revenue and clinical trials as two thirds of R&D. Savings are measured against the current state, not against future classical alternatives. McKinsey notes the impact overlaps with generative AI, so quantum value is not additive to AI value.

Three properties of biology map onto three things quantum computers do well

Life sciences combines quantum-mechanical systems, very large combinatorial search spaces, and high-dimensional data. Each maps to a distinct class of quantum method, with a distinct maturity.

PATHWAY ONE

Quantum chemistry and molecular simulation

Density functional theory scales poorly with molecular size and handles transition metals, excited states, and strongly correlated electrons badly. Quantum algorithms represent the electronic wavefunction directly. This is where binding energy accuracy, metal center treatment, pKa prediction, and difficult reaction steps live.

Maturity: frontier research, results now at protein scale

PATHWAY TWO

Optimization across discovery and operations

Trial site selection, manufacturing schedules, cold chain routing, and portfolio allocation all reduce to quadratic unconstrained binary optimization or close relatives. Annealers and quantum-inspired solvers handle these at industrial scale today, which makes this the most credible near-term application in any sector.

Maturity: production pilots, measurable gains

PATHWAY THREE

Quantum machine learning

Quantum circuits used as learning models, for molecular property prediction, omics and imaging classification, and generative molecular design. The evidence is mixed. Batra et al (2021) benchmarked quantum models against classical baselines and found comparable performance with fewer parameters on small data sets, which matters in rare disease and early clinical work where annotated data is scarce. Smaldone et al (2025) and Avramouli et al (2023) survey the field. Treat it as a research bet.

Maturity: mixed evidence, promising on small data

Where a quantum processor enters the pipeline

A quantum computer takes delivery of two or three specific steps inside the drug discovery stack. Classical CPUs and GPUs handle the rest.

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6
Preprocessing	Simulation setup	Machine learning	Molecular simulation	Optimization	Analysis
Assays, omics, and imaging inputs assembled into a modeling data set	Target and ligand libraries, simulation conditions, initial parameters	Train predictive models to triage candidates on efficacy, toxicity, developability	Higher-fidelity protein and ligand interaction and reaction simulation	Combinatorial choices across formulation, trial design, scheduling, network	Outputs unified into portfolio prioritization and go, no-go decisions
CPU	CPU	GPU, LATER QPU	GPU AND QPU	QPU	CPU

Source: Resonance analysis. Compute type indicates where each step is best executed as hardware matures; steps 4 and 5 are the workloads currently offloaded to a quantum processor in published pilots.

Six results that moved the field from demonstration to workflow

Each of these ran on real hardware against a real problem, and each reported a number. A speedup against a prior quantum benchmark is a different claim from a speedup against the best classical method, and none of this has produced an approved drug. What they establish is that the workflows run and the results are checkable.

AstraZeneca

IONQ, AWS, NVIDIA · JUN 2025

End-to-end simulation of a **Suzuki-Miyaura reaction** step, a workhorse transformation in small molecule synthesis. IonQ Forte QPU orchestrated through NVIDIA CUDA-Q on Amazon Braket, with H200 GPUs on AWS ParallelCluster. The most complex chemical simulation run on IonQ hardware to date.

>20×

Faster time to solution than prior benchmarks. Expected runtime moved from months to days.

Boehringer Ingelheim

PSIQUANTUM · JAN 2025

Resource estimates for fault-tolerant simulation of **cytochrome P450**, central to drug metabolism, and **FeMoco**, the nitrogenase cofactor. Used Active Volume architecture with BLISS and tensor hypercontraction to cut the quantum resources required.

234×

Speedup for cytochrome P450, and 278× for FeMoco, against prior quantum algorithms.

Pfizer

QUANTUMBASEL, D-WAVE · 2025

Hybrid quantum-classical annealing applied to **production planning** at the Freiburg manufacturing site, a proof of technology against both Pfizer's baseline system and a new classical HPC optimizer. No machine overlaps, priority conflicts, or deadline violations in the hybrid solution.

66%

Reduction in makespan against baseline, with 33% fewer constraint violations.

Merck and Amgen

DELOITTE, QUERA · APR 2025

Quantum reservoir computing applied to **clinical trial prediction** on small, complex data sets where classical machine learning underperforms. Higher accuracy and more stable results at 100 to 200 samples. The advantage narrowed as data sets grew.

100–200

Sample range where quantum reservoir computing beat classical baselines.

Novonesis

KVANTIFY · APR 2024

First calculation of an **enzymatic reaction** using quantum and classical hardware together, characterizing carbonic anhydrase with the FAST-VQE algorithm. Enzyme catalysis is exactly the strongly correlated chemistry classical methods approximate worst.

First

Enzymatic reaction characterized on quantum computing hardware.

Google Quantum AI

WILLOW · OCT 2025

The **Quantum Echoes** algorithm on the Willow chip produced a verifiable quantum advantage claim on molecular structure workloads at sizes that strain classical simulation. A benchmark result rather than a drug program. Chemistry is the domain where hardware crosses over first.

Verifiable

First quantum advantage claim on a molecular workload that others can reproduce.

Sources: IonQ investor release, June 9 2025. PsiQuantum and Boehringer Ingelheim, January 2025, via The Quantum Insider. QuantumBasel, 2025. HPCwire, April 10 2025. The Quantum Insider, April 2024. Google Quantum AI, October 2025. Resonance analysis.

Cleveland Clinic bought a quantum computer in 2021. It is a strong reference model for a research campus.

The Discovery Accelerator was announced with IBM in 2021 as a ten-year partnership, funded through Cleveland Clinic's **\$300 million commitment to the Cleveland Innovation District**, a \$565 million public-private program with MetroHealth, University Hospitals, Case Western Reserve, and Cleveland State, targeting roughly 20,000 jobs. The machine was the anchor tenant of an innovation district.

DISTRICT PROGRAM	JOINT PROJECTS	OHIO JOBS TARGET
\$565m	50+	7,500
Five institutions. Cleveland Clinic contributed \$300m.	Cancer, vaccine development, Alzheimer's, since 2021	By 2034, plus 1,000 at the Clinic by 2029

What five years bought

2021	Discovery Accelerator announced Ten-year Cleveland Clinic and IBM partnership across high-performance computing, AI, and quantum, anchored in the Cleveland Innovation District.
Mar 2023	IBM Quantum System One installed at the Lerner Research Institute The first on-site, private-sector, IBM-managed quantum computer in the United States, and the first machine anywhere dedicated to healthcare research.
Nov 2023	Quantum Innovation Catalyzer opens to startups Twelve-month program offering up to \$250,000, expert collaboration, and access to the machine. The 2026 cohort covers rare disease, drug toxicity prediction, and cardiovascular simulation.
Fall 2025	Eagle processor replaced with Heron, HPC cluster connected First major processor upgrade, roughly ten times better on quality and speed. The System One was joined to the Clinic's on-premises HPC cluster, so researchers run genuine hybrid workloads in one environment.
Mar 2026	Trp-cage: electronic structure of a 303-atom miniprotein Hybrid workflow on Heron r2 combining wave function embedding with sample-based quantum diagonalization. Small for a protein, but it carries the hydrophobic core and hydrogen bonding that larger biomolecules do.
May 2026	12,635-atom protein-ligand complex, with RIKEN and IBM The largest protein known to have been simulated with quantum computers. Forty times the system size of the March result and a 210-fold accuracy improvement on a key workflow step, using the EWF-TrimSQD algorithm.

WHAT THE CAMPUS MODEL DELIVERED

Cloud access to the same IBM machines was available to every hospital system in America for the entire period. Cleveland Clinic got **clinicians, algorithm developers, and hardware engineers in the same building**. That produced a startup pipeline, a training program for healthcare professionals, a Wellcome Leap Quantum for Bio win with Algorithmiq on photon-activated cancer therapy, and two frontier publications inside four months. It also moved the Clinic to **second place in the Quantum Innovation Index for life sciences**, ahead of every pharmaceutical company except Boehringer Ingelheim.

Sources: Cleveland Clinic Newsroom, March 2023, November 2023, May 2026. IBM Newsroom, May 2026. Lerner Research Institute, 2025. Crain's Cleveland Business. The Quantum Insider, Quantum Index 2025. Resonance analysis.

Capability follows leadership sponsorship more closely than budget size

The Quantum Innovation Index scores organizations on workforce, research output and quality, and deployed use cases. The organizations at the top put a named team and an executive sponsor behind the question early. Company size did not predict position.

Life sciences quantum readiness, leading organizations

#1	Boehringer Ingelheim Pharma	
#2	Cleveland Clinic Health system	
#2	Merck Group Pharma	
#3	Roche Pharma	
#3	Moderna Biotech	
#4	Amgen Biotech	

Below the top four sits a broad band of large pharmaceutical groups, active but exploratory, monitoring the market or engaging vendors selectively. **The two organizations at the top are the two that built dedicated internal capability first.** One of them is a hospital system.

Source: The Quantum Innovation Index, The Quantum Insider. Scored on workforce, research output and quality, and deployed use cases. Bars indicate relative rank position, not score magnitude.

THE REGIONAL GAP

Summed readiness of the top-ranked life sciences companies by region: **Europe 560, North America 370.** Europe leads on quantum readiness in most industries, backed by strong private initiatives and national programs. North America leads on the number of quantum technology companies, and on finance adoption, but not on life sciences.

Source: McKinsey Quantum Technology Monitor 2026, using The Quantum Insider Quantum Index 2025.

ENGAGEMENT MODELS IN USE

- **Vendor pilots.** Bounded proofs of concept on cloud or hybrid platforms. Lowest commitment, fastest learning.
- **Academic collaboration.** Roche with Cambridge Quantum, Boehringer Ingelheim with Google Quantum AI.
- **Co-funded consortia.** SEEQC, Merck and Innovate UK on the QuPharma quantum device.
- **Dedicated infrastructure.** Cleveland Clinic with IBM. Highest cost, highest option value.

Every major quantum strategy names health and the window is short

Life sciences is written into the missions.

- **United States.** The NIH Quantum Innovation Initiative targets biomedical imaging, genomics, and drug discovery.
- **United Kingdom.** Mission 3 of the National Quantum Strategy names life sciences as a national strategic use case.
- **European Union.** The Quantum Flagship covers biomedical sensing, imaging, and drug discovery.
- **Japan.** The national plan applies quantum to medicine, chemistry, and drug discovery.
- **France.** The Hybrid Quantum Initiative builds sector libraries including health.
- **Germany.** Joint funding with the UK names faster drug discovery and new diagnostics.
- **India.** The National Quantum Mission emphasizes life sciences R&D.
- **Denmark, Korea, Australia, Switzerland.** All name healthcare imaging, medical sensing, or diagnostics.

Source: Resonance analysis of published national quantum strategies. Non-exhaustive.

The distance between the opportunity and the organizations able to take it is institutional

The hardware is good enough for hybrid workflows, the algorithms are published, and the machines are available by the hour. **What separates the organizations producing results from the ones producing reading lists is how the work is set up.**

-
- 01

A named problem, not a technology mandate

Every result on page 5 started from one specific bottleneck: a single reaction step, a single plant schedule, a single small clinical data set. Programs that begin with a bottleneck produce numbers. Programs that begin with an interest in quantum produce reading lists.
 - 02

Two clocks

Optimization pilots return inside a budget cycle. Chemistry capability compounds over years. Funded from one pot, the slower track is always the one cut, which is how organizations arrive five years in with operational savings and no scientific capability.
 - 03

Proximity, not access

Cloud access to the same quantum machines was available to every hospital system in America for the whole period. What Cleveland Clinic bought was clinicians, algorithm developers, and hardware engineers in one building.
 - 04

An executive sponsor and a standing team

The organizations at the top of the readiness table assigned named people early and kept them. Capability outlives individual experts only where it was institutional to begin with.
 - 05

A separate track for cryptographic readiness

Patient records, trial data, and molecular IP must stay confidential well past 2035, which makes post-quantum migration a live security program now. It belongs to security and governance, on its own budget, and should not compete with the pilots for funding.
-

Florida has the hardware and the clinical problems, and nothing joining them

Quantum capability in life sciences has clustered in pharmaceutical R&D organizations and, so far, one hospital system. The academic medical complexes, which hold the largest concentrations of clinical problems, are almost entirely absent. **Florida is the clearest case of the gap, because there the hardware arrived first.**

HARDWARE IN STATE	CLINICAL SCALE	PROGRAMS JOINING THE TWO
\$20m Florida Atlantic University's commitment for an on-site D-Wave Advantage2, the first quantum computer hosted by a Florida university	7,500 Team members at Moffitt, Florida's only NCI-designated Comprehensive Cancer Center, with \$2.4bn of economic impact	0 Publicly announced life sciences quantum programs connecting Florida's health systems to that hardware

What is already in place

- **A machine, on a campus.** D-Wave moved its global headquarters and US research hub to the Boca Raton Innovation Campus in January 2026, into the building where IBM engineers built the first personal computer. FAU is installing an on-site Advantage2.
- **The right class of hardware.** An annealer is the optimization machine that pays first. Trial site selection, operating room and bed scheduling, and cold chain routing are its natural first problems.
- **Health systems that run those problems at scale.** AdventHealth, Orlando Health, Baptist Health, Jackson Health, and UHealth each operate the scheduling and logistics workloads an annealer is built for.

What is missing

- **A clinical sponsor.** The hardware sits with an engineering faculty. Cleveland Clinic's results came from clinicians setting the problems, not from the machine being nearby.
- **A named first problem.** Condition 01 applies here as much as anywhere. No Florida health system has published a bottleneck it wants a quantum method to attack.
- **A route from optimization to chemistry.** Moffitt, Sylvester, and UF Scripps hold the molecular work. UF Scripps sits in Palm Beach County, the same county as D-Wave's new headquarters, and none of it connects to the machine.

THE JUDGMENT

The \$80 to \$400 billion goes to whoever holds the clinical problems, the data, and the people, sitting close enough to the machine to iterate. **Cleveland Clinic committed in 2021, took delivery in 2023, and published at protein scale in 2026.** That is a five-year clock, and it started when the hardware was worse than it is now. Florida's clock has not started, and the machine is already here.



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SOURCES

Sources. McKinsey & Company, Quantum Technology Monitor 2026. The Quantum Insider, Quantum Innovation Index and Quantum Index 2025. Cleveland Clinic and IBM newsrooms, 2023 to 2026. Lerner Research Institute, 2025. IonQ investor release, June 2025. PsiQuantum and Boehringer Ingelheim, January 2025. QuantumBasel, 2025. HPCwire, April 2025. Google Quantum AI, October 2025. Florida Atlantic University and D-Wave, January 2026. Moffitt Cancer Center. Published national quantum strategies. Resonance analysis.

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