THE FUTURE OF QUANTUM IN LIFE SCIENCES

4 actions life sciences organizations can take to enable a scalable quantum computing strategy

LAYING THE FOUNDATION

Over the past six decades, the life sciences industry has seen a dramatic increase in R&D spending, sending the cost of bringing a new drug to market to new highs.

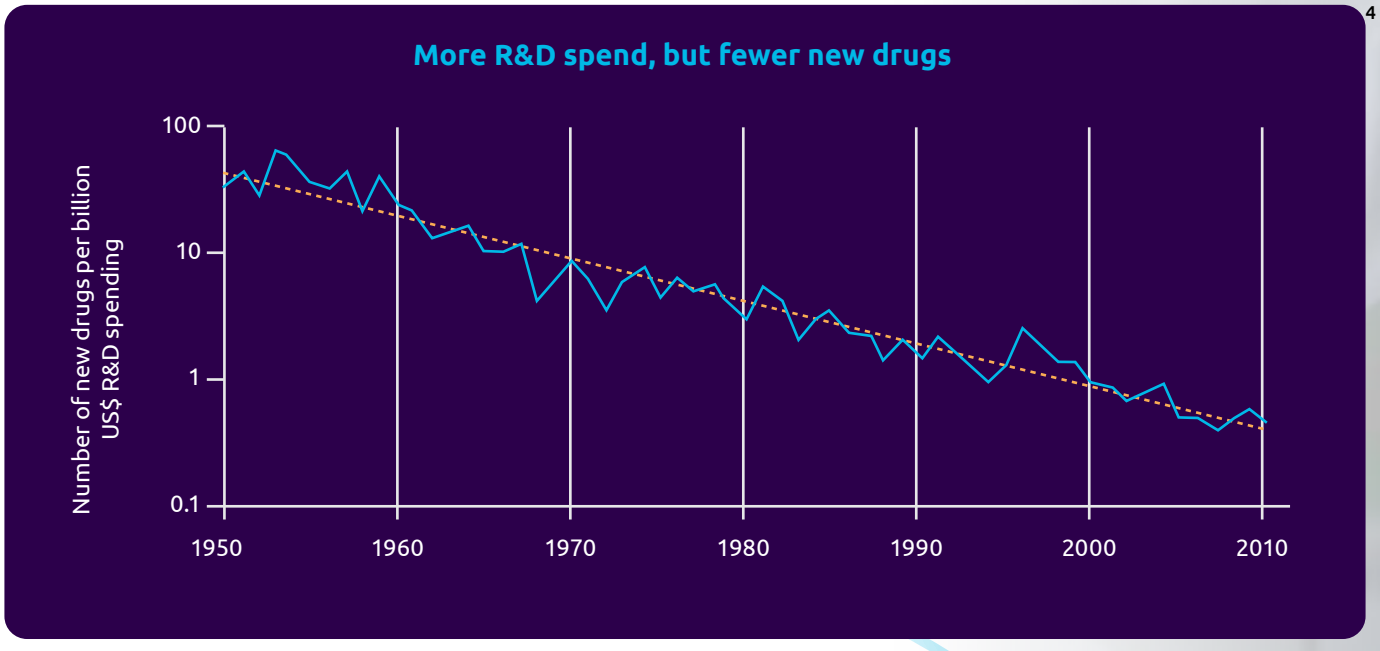
In the coming decade, quantum – an entirely new paradigm of compute – shows promise for introducing novel therapies faster and more efficiently. But while the technology presents a great opportunity to companies, it also raises important questions in terms of where and when to invest and how to position those investments in a way that drives value over time. These issues are explored in our recent CRI Report: Quantum Technologies: How to prepare your organization for a quantum advantage now.

In this paper, we offer life sciences executives a primer on this rapidly advancing technology and outline four clear actions they can take to begin laying the foundation for a scalable quantum computing program of the future.

95%[1]
Drugs fail during development

10 years[2]
average drug development timeline

$1bn[3]
Cost of developing a drug and getting it to market



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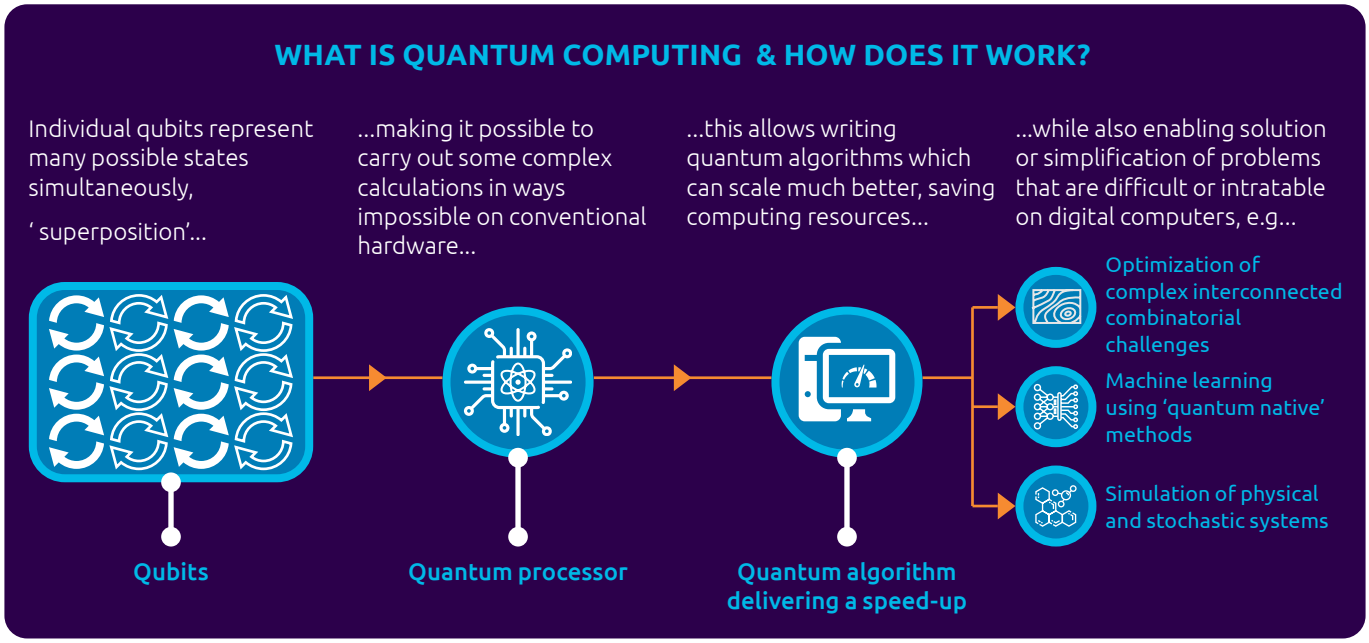
EXPLORING THE PROMISE OF QUANTUM FOR BRINGING NEW THERAPEUTICS TO MARKET

In an industry dominated by experiment, the ability to simulate, optimize and orchestrate processes or portions thereof has the power to cut timelines, lower costs, and reduce the rate of failures. There are several opportunities to apply quantum computing across the entire pharma value chain – from the early stages of R&D to creating manufacturing capacity at scale and every step in between.

One of the clearest opportunities for quantum is in the discovery and optimization of drug molecules. The interactions of potential drug candidates with biological targets are fundamentally governed by quantum mechanics. As such, the ability to simulate nature with unprecedented accuracy and scale is a key driver of excitement about quantum computing in the life sciences industry.

Beyond the simulation of drug-target interactions, quantum computing could help in the early stages of molecular discovery by identifying lead compounds. This involves the use of quantum machine learning approaches to enable virtual screening and in silico property prediction.



In addition, quantum optimization, which has far-reaching applications, could find particular value in molecular design during the lead optimization phase. When exploring changes to lead molecules that provide improvements, the ability to identify the best selections to synthesize and test is crucial to cutting timescales.

The more companies can optimize the drug discovery and development process and use in silico techniques to augment or replace laboratory assays, the more quickly they can identify and optimize lead molecules and commit to strong drug candidates. This reduces experimental effort by allowing research teams to focus on a smaller, more focused pool of molecules while dedicating compute techniques to the most promising aspects. This in turn cuts down on development timelines and also helps lower costs.

At the core quantum could:

- Reduce timescales for drug discovery and development through enhanced modelling and process optimization
- Commit to drug candidates with a higher chance of success in clinical trials and late-stage development
- Cut costs associated with bringing novel therapeutics to market through experiment augmentation and replacement

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QUANTUM IN LIFE SCIENCES: WHERE ARE WE NOW... AND WHAT'S NEXT?

Despite a high degree of fanfare within the tech community, quantum computers have not yet reached the scale to deliver commercial advantage in any industry. As of 2022, quantum hardware is rapidly developing, with IBM providing a 127-qubit quantum processor based on superconducting circuits. While today's quantum computers can perform calculations which are not accessible on conventional hardware, the limitations in qubit number, qubit quality and speed of operation put commercial adoption out of reach for now. Error correction techniques will allow increasingly complex calculations to be performed, but these in turn will require larger numbers of qubits to be available.

That said, the scale of quantum computers has grown exponentially in recent years and this trend is expected to continue in the future. With a constant stream of new investment flowing into the startup industry and major tech players like IBM and Google dedicating significant resources to the development of quantum hardware, there is reason to believe that the promise of quantum is nearer than you think.

If we consider the future of quantum in terms of numbers alone, the industry expects quantum computers with more than 1000 qubits to be available on demand via cloud services by the end of 2023. Assuming corresponding advancements in terms of quality and speed of operation, initial commercial applications could be available within 3-5 years; significant advances are expected over 5-10 years. From this point, it will be possible to tackle some problems intractable to digital computing and have quantum integrated into enterprise systems and the tech stack.

Potential quantum timeline

1-2 years
Quantum computers with more than 1000 qubits available on demand via cloud

3-5 years
Initial commercial applications

5-10 years
Advanced commercial applications

10+ years
Full integrations into enterprise systems and tech stack

Quantum computing presents multiple approaches to tackle challenges in life sciences

Quantum Optimization

- Short listing candidate molecules from large combinational spaces
- Selecting feature subsets for interpretable models
- ...

Quantum Machine Learning

- Quantum native modelling of simplified quantum systems using quantum embeddings
- New, flexible models for classification and regression for in silico predictions
- ...

Quantum Simulation

- Quantum chemistry simulation for molecular fragments
- Embedding full configuration interaction simulations within larger approximate models
- ...

3

BREAKING THE QUANTUM HYPE CYCLE

From the smallest startup to the biggest tech players, there is no shortage of enthusiasm for quantum. But as excitement sometimes gives way to exaggeration, the timeline for the development and maturity of this technology has often been misrepresented, leading to a false sense of urgency and calls for outsized investments.

In quantum, as with any nascent technology, investment is a matter of balance. On one hand, the opportunity provided by quantum across the drug development lifecycle is undeniable; the impact will be profound. On the other, it is expected to take a decade or more to get to the stage where quantum computing is commoditized.

What this means for life sciences companies is that they should take calculated, measured, and strategic actions that prepare their business to capitalize once the technology reaches a point of maturity. Here we share four key actions life sciences companies can take to prepare themselves for the quantum future.

Action 1: Calibrate the R&D investment

At this juncture, it is neither necessary nor wise for organizations to dedicate their entire innovation budget to quantum or even make it a foundational element at this point. At the same time, quantum is an undeniably promising technology that will play an important role in drug development in the future. Companies should begin to build their capabilities and make modest, but strategic, investments in this area. This will allow organizations to be ready to generate a competitive advantage from some of the most promising early use cases and have the right skills and processes in place to grow with the technology.

Beyond the commitment of resources, it is important to ensure that the investment is incorporated within the long-term R&D plan so that it can be flexed and scaled as the technology develops and progresses.

Action 2: Develop a quantum roadmap

While quantum needs to be incorporated within the long-term R&D plan, it is also worthy of its own roadmap. This includes activities like planning out proofs of concept and articulating the associated outcomes the business hopes to achieve. While quantum use cases have been identified across industries, understanding in detail where the impact will lie for a particular organization, the possible timescales for development, the future skills needed, and the wider change management is a journey rather than an isolated exercise.

A word of caution: The life sciences industry is no stranger to proof-of-concept fatigue. As a nascent technology, quantum will certainly be subject to the pitfalls and risks that often accompany a new capability.

Some organizations may fall into the trap of continuing to pursue use cases beyond the point where useful value can be derived. Others may make a significant but short-lived investment to explore the technology and then stop, thus not retaining the value of the investment. To that end, it is critical that companies select use cases that maximize the opportunity and develop the related capabilities to scale programs to deliver long-term value.

We often recommend that our clients adopt a “fail fast and learn” approach, wherein investments are made strategically, and progress is monitored and measured consistently. From there, the organization should adapt the program as necessary to continue to enhance business value or set the use case aside until the technology and related capabilities are mature enough to deliver the desired impact.

Action 3: Build quantum skills and expertise

Computing is but one aspect of the drug development process. Competitive advantage will not just be in hardware. It will rest firmly on the shoulders of people to be able to develop the algorithms and applications that run on this new hardware.

With quantum gaining more and more attention across industries, the importance of an early and active workforce strategy cannot be understated. It is important for companies to use their long-term R&D plan and quantum-specific plan to attract and retain talent that share their passion and dedication.

Since it is expected that there will be a shortage of quantum physicists and quantum scientists at the PhD level, it may also be necessary and optimal to reorient some members of the existing R&D team around this capability, especially as demand in this area continues to grow. This will involve identifying staff with relevant backgrounds and experience, such as experts in data science or artificial intelligence. For example, one common idea is to take mathematical experts with experience in the life sciences domain and integrate them within the quantum team to translate business problems into the space of quantum algorithms.

Action 4: Develop a partner ecosystem

At this point, it is unclear what quantum architecture will dominate in the future. There is a fear, not unfounded, that companies that make significant investments now carry the risk of backing what turns out to be the "wrong" technologies – which is to say those that get beaten in the race to market.

As with any advanced technology, the quantum landscape is complex and constantly evolving. One of the best ways to remain in step with new developments is to engage the right partner that will serve as a conduit to other members of the value chain and help guide investments as the landscape changes.

In addition, strategy, implementation, and change management will be crucial aspects of any quantum roadmap. Developing a trusted relationship with a transformation partner is one way to help streamline non-technical, but critical, plan components and build connections and relationships within the quantum ecosystem.

The risk of doing nothing

Given the technology and implementation risks discussed above and the timeline for the technology itself, some companies may consider putting off a quantum investment until the return is more certain. This is rarely a winning strategy – especially in this case since life sciences R&D applications are often highly customized to the needs of the organization. Companies that delay an investment are not reducing risk, so much as ignoring an important competitive advantage. The steps taken today help assure success of tomorrow.

CONCLUSION

The future of quantum may not be imminent, but it is certain. The rapid rate of hardware development will allow exploration at rapidly growing scales over the next few years. Most pharma R&D organizations are exploring opportunities in quantum at some level today, which not only drives competition, but also creates demand as it relates to talent, exclusive partnerships, and more.

While quantum technology is still in the process of maturing, companies should begin preparing their strategy now to ensure they are able to seize the opportunity and scale investments when the time comes. As seen most recently during the global pandemic, the life sciences industry is capable of exponential, rapid growth in new technologies when need and opportunity arise. Action today means an advantage tomorrow.

Invest → **Experiment** → **Advantage**

The path to Quantum readiness with Capgemini

Capgemini is well placed to support life sciences organizations in their quantum journey. Our dedicated Quantum Lab, combined with our deep industry knowledge, in both pharma as medtech, allows us to explore how this ground-breaking technology will impact the life sciences industry and deliver real value to our clients.

Next to that, our long-term partnership with IBM Quantum, a recognized leader in hardware provision, along with our deep bench of quantum engineers are two important components of early-stage quantum strategies.

Capgemini Quantum Lab	**Deep bench of computing engineers and industry insiders**	**Established IBM Quantum partnership**	**Deep Life Sciences Industry knowlegde**

SOURCES

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