

An Introduction To Quantum Computing, And Why It Matters

By Livia Dyring

Forty years after Richard Feynman suggested that quantum mechanics could be harnessed to build another, different kind of computer, quantum computing, once an ambition hovering around the margins, is rapidly gaining momentum.

Over the last two centuries, the computer has emerged as the machine that drives modern society. What began as an [Analytical Engine](#) designed by English computer pioneer [Charles Babbage](#) in the 19th century has evolved and solved countless problems as we strive to build the world we want. Since the first computers began to appear over the course of the 1900s, everything from our washing machines to our cars have come to rely on them to function, and both ourselves and our entire economic system are dependent on the tools they provide.

So, how does quantum computing differ from so called “classical” computing, and why, exactly, should we occupy precious brain cells on what possibilities a new quantum era could offer the world, when we have already come so far, using the powers possessed by everyday computers?

Before answering the first question, we should say that quantum computing is an extraordinarily complex subject, tricky even for experienced scientists and engineers. At its most basic, however, the quantum computer functions by the principles of quantum mechanics. Quantum mechanics, in turn, is a theory that successfully describes and predicts the nature of light and matter at the very small scale, which fundamentally behaves differently than the scale that we experience our physical world, described by Newtonian physics.

By using the principles of quantum mechanics, a quantum computer stores, manipulates data, and computes in ways that are fundamentally different from a classical computer. By being designed to solve for complex problems, a quantum computer can outmatch

even the most powerful supercomputers by computing hugely advanced calculations in mere seconds. Without them, it would take literally thousands of years to arrive at a solution.

In terms of why we should care about realizing the quantum computing dream, the answer lies with the fact that there are both old and emerging problems that humanity seeks to solve that even so-called supercomputers, as mentioned above, cannot perform fast enough.

To put things briefly, performing complex calculations are vital for several fields — but standard computing systems might not get us where we need to be. Massive challenges ahead within crucial areas such as climate change, cybersecurity, materials manufacturing, medicine, and artificial intelligence require more powerful computers to make progress. That is where quantum computing, with all its promises and trickiness, enters the picture.

Today, quantum computers are still comparatively small, and cannot yet perform at the level experts envision. Building larger, reliable quantum computers is an incredibly difficult technical undertaking, but the rewards may be hugely significant.

Quantum computers would enable significant cost reductions — by being much speedier — and be able to apply solutions across numerous sectors. Strides have already been made to tackle the challenges mentioned above, including within drug development, whose advances could save lives, and cybersecurity, an increasingly more important area as the world becomes more digitized. Experts have also suggested that quantum computing will eventually become part of the sustainable solutions we urgently need as our current climate crisis deepens.

The exciting solutions that quantum computers may be able to unlock has generated billions of dollars in investment, with more to come as quantum computing gets increasing attention. There are already twenty quantum computing businesses across Canada, and

Toronto has become the home base for several new companies and initiatives, such as Xanadu, Creative Destruction Lab, Agnostiq, and more.

So, healthcare, climate change, security — new quantum computing powers could help humanity unlock solutions previously beyond reach, and positively impact these areas and unimaginably more others. That future deserves attention from the science community and beyond.