

# BEYOND THE ATOM: QUANTUM MECHANICS RESHAPING MEDICINE

Anushka Srivatsan

**I**N the world of science, biology and quantum physics have often been seen as distinct disciplines with little overlap. Biology, the study of life at the macroscopic level, and quantum physics, the exploration of the subatomic world, appear to inhabit separate realms of scientific inquiry. However, as our understanding of both fields advances, it becomes increasingly clear that these seemingly disparate domains are more interconnected than we might have imagined.

Quantum mechanics has gradually infiltrated various fields beyond the confines of theoretical physics. The intriguing phenomena and principles of quantum mechanics, such as superposition, entanglement, and tunnelling, have applications in diverse areas, including healthcare.

Before delving into the applications of quantum physics in the human body, it is essential to grasp some fundamental principles of quantum mechanics:

- **Wave-Particle Duality:** quantum particles, such as electrons and photons, can exhibit both wave-like and particle-like behaviour. This concept is vital in understanding the behaviour of subatomic particles within biological systems.
- **Superposition:** quantum particles can exist in multiple states simultaneously, a phenomenon known as superposition. This principle becomes significant when discussing the role of quantum states in biochemical reactions.
- **Quantum Tunnelling:** particles can tunnel through energy barriers that classical physics would suggest are insurmountable. Quantum tunnelling is crucial in understanding enzymatic reactions within cells.

While still in its infancy, quantum mechanics has the potential to revolutionise medicine when it comes to imaging, diagnostics and certain treatments.

## Medical Imaging and Quantum Mechanics

Quantum principles also have applications in medical imaging, such as Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET), which rely on the behaviour of quantum particles to generate detailed images of the human body.

### 1. Magnetic Resonance Imaging (MRI)

Commonly known as MRI, it is a remarkable medical imaging technique that has revolutionised the field of diagnostics. By harnessing the principles of quantum mechanics, MRI allows us to peer inside the human body with astonishing precision and detail. Quantum mechanics

explains the behaviour of atomic nuclei in strong magnetic fields, allowing for precise imaging of tissues and organs within the human body. The quantum attribute at play here is the magnetic moment of atomic nuclei, which is exploited to create detailed images for medical diagnosis.

### 2. Positron Emission Tomography (PET)

PET is an advanced medical imaging technique that offers unique insights into the inner workings of the human body, particularly in the realm of metabolic activity and disease detection. At its core, PET relies on the principles of quantum mechanics, particularly the phenomenon of positron-electron annihilation. This remarkable process involves the collision and simultaneous destruction of a positron (a positively charged electron) and an electron, leading to the emission of two gamma rays travelling in opposite directions. By detecting and analysing these gamma rays, PET scans provide detailed images of metabolic processes, making them an invaluable tool for diagnosing conditions like cancer, heart disease, and neurological disorders.

## Quantum Mechanics in Sensing and Diagnostics

Quantum sensors, based on the principles of superposition and entanglement, have the potential to revolutionise healthcare diagnostics. For instance, quantum sensors can be used to detect subtle variations in biomarkers, offering early detection of diseases such as cancer, diabetes, and infectious diseases. Quantum sensors have ultra-high sensitivity, which can detect even trace amounts of substances in biological samples, making them a valuable asset in medical diagnosis.

## Quantum Computing for Genomic Analysis

Genomic analysis is fundamental in understanding diseases and tailoring treatments to individual patients. Quantum computing harnesses the superposition and entanglement properties of quantum bits (qubits) to process complex genomic data exponentially faster than classical computers. This not only accelerates the analysis of large genomic datasets but also enables more accurate and personalised treatment plans.

## Quantum Computers and Analysis

Quantum computing, which harnesses the unique properties of quantum bits, has the potential to revolutionise the organisation of healthcare systems. Quantum computers can analyse vast datasets and simulate complex biological processes with unprecedented speed and accuracy. This capability has applications in genomics and the development of personalised medicine.