QUANTUM DOTS: A NOBEL PRIZE-WORTHY DISCOVERY IN CHEMISTRY

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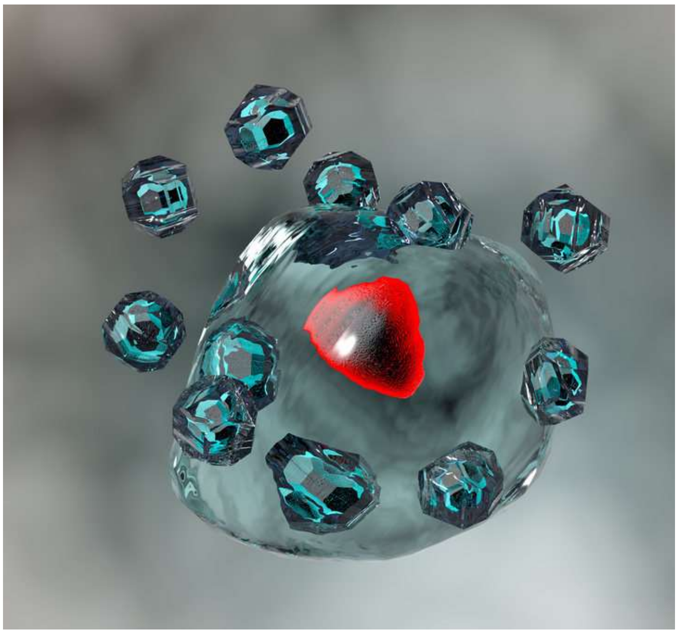
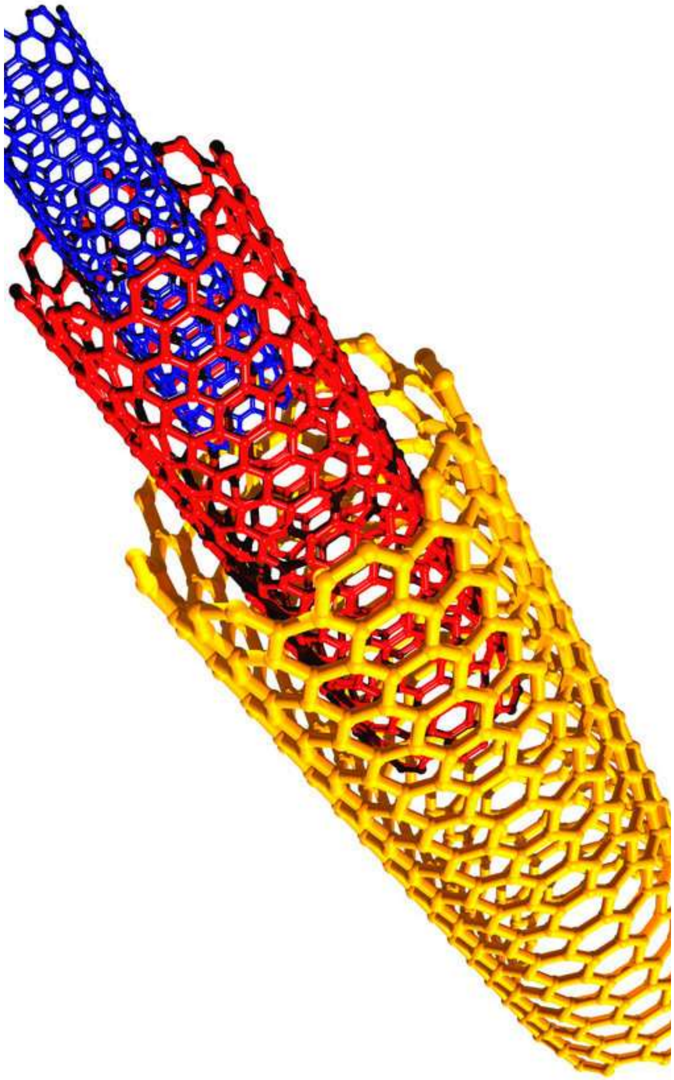
This year, the Nobel Prize in Chemistry 2023 was awarded to Moungi G. Bawendi, Louis E. Brus, and Alexei I. Yekimov for the discovery and synthesis of quantum dots. The Nobel Committee praised their work as “a new class of materials, different from molecules,” that have “many fascinating and unusual properties” and that are "bringing the greatest benefit to humankind.

The Nobel Prize was shared by three scientists for their contributions in the field of quantum dots. In the early 1980s, Alexei Ekimov succeeded in creating size-dependent quantum effects in colored glass. He demonstrated that the particle size affected the color of the glass via quantum effects. A few years later, Louis Brus was the first scientist in the world to prove size-dependent quantum effects in particles floating freely in a fluid. In 1993, Moungi Bawendi developed a technique to make quantum dots of well-defined sizes with high optical quality.



This quantum dot term was coined in the mid-1980s, revolutionized the field of nanotechnology, and garnered attention from various scientific communities. Quantum dots are nanoscale semiconducting crystals that have unique optical, electronic, and optoelectronic properties due to quantum confinement effects. They can emit different colors of light depending on their size and shape. They are typically composed of materials such as cadmium selenide (CdSe), cadmium telluride (CdTe), or indium arsenide (InAs). The properties of quantum dots depend on their size, shape, composition, structure, surface, and environment. Band gap, luminescence, quantum yield, stability, toxicity, and biocompatibility are some of the important properties of quantum dots. By modifying these properties, quantum dots can be utilized for specific applications.

For example, quantum dots with narrow band gaps and high quantum yields can be used for efficient light emission and conversion, while quantum dots with low toxicity and high biocompatibility can be used for safe and effective bioimaging and drug delivery.
Quantum dots' size-dependent bandgap allows for precise tuning of their light absorption and emission characteristics. This property makes them invaluable in optoelectronic devices such as light-emitting diodes (LEDs), solar cells, and photodetectors. fluorescence properties that have revolutionized biological imaging.
Their size-tunable emission spectra, higher brightness, and photostability make them excellent probes for cellular imaging, drug delivery vehicles, and disease diagnosis. Quantum dots, with their ability to trap and manipulate single electrons, show potential as qubits (quantum bits) in quantum computing architectures. Figure 1 shows the applications of quantum dots in different technologies (adapted from Garcia et al., 2021).



Although quantum dots are still a relatively new field of research, they have challenges like stability, efficiency, and safety issues in the fields of biomedicine and environmental engineering applications. The future prospects of these quantum dots involve the integration of quantum dots with other nanomaterials, such as carbon nanotubes, graphene, nanowires, and nanorods, and creating novel nanostructures and devices with enhanced performance and versatility. The utilization of quantum mechanical properties such as entanglement, coherence, and superposition and using them for quantum computing, cryptography, and information processing is also a new field of research for the scientific community. The regulatory framework for quantum dots and nanotechnology, in general, is still evolving. Ensuring proper safety assessments, labeling, and disposal guidelines is essential to mitigating potential risks.

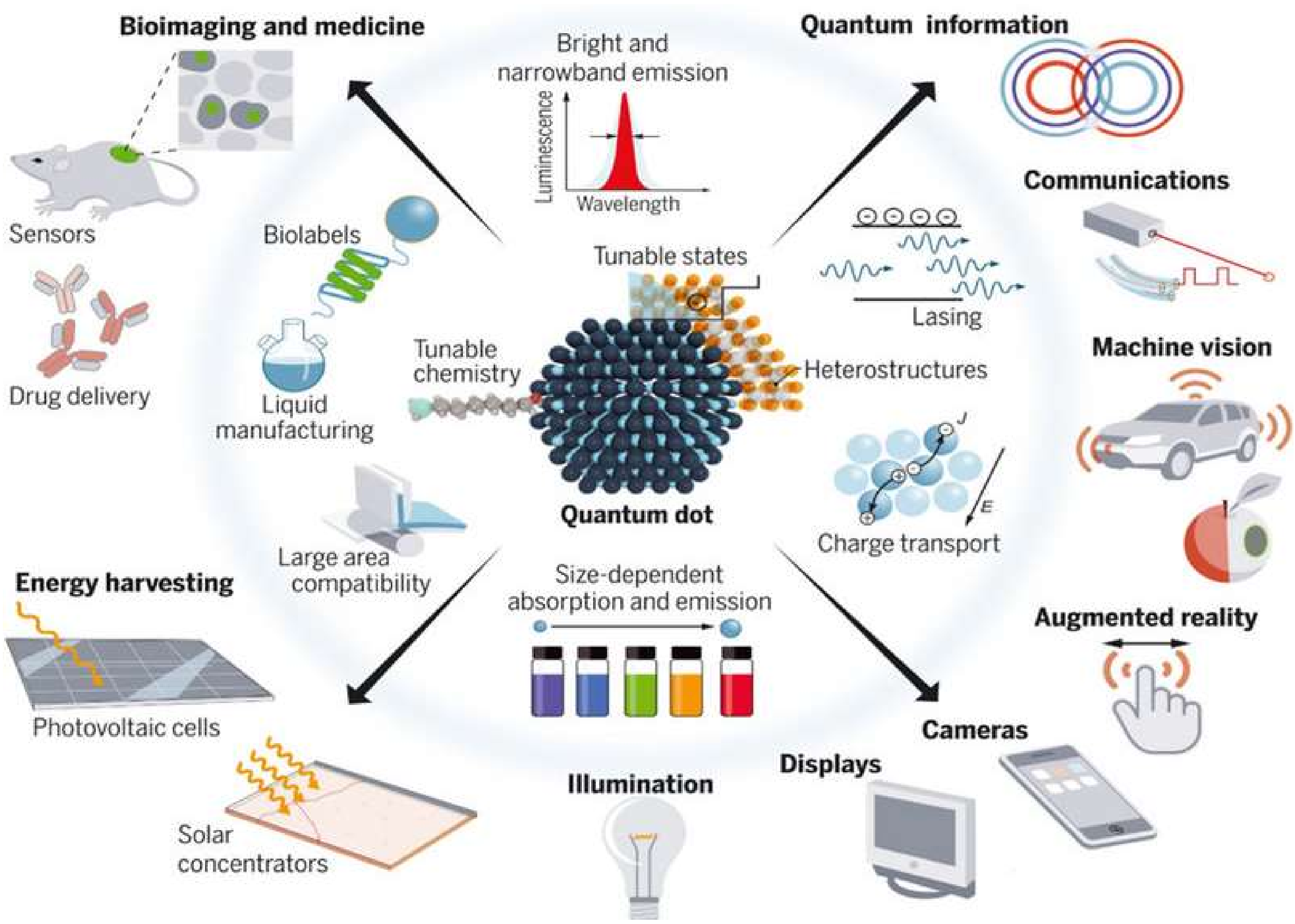


Figure 1. Applications of quantum dots in different technologies (adapted from Garcia et al., 2021).

The author is presently working as an assistant professor of chemistry at Navyug Kanya Mahavidyalaya. Her expertise includes essential oils and their applications. She has published 27 research articles in journals of national and international repute. She has authored and coauthored eight book chapters with national and international publishing houses. She has attended a total of 35 conferences and webinars of national and international repute and delivered more than 20 invited talks and oral presentations. She is also an active member of the Association of Chemistry Teachers (India), the International Clinical Aromatherapy Network, and the Global Harmonization Initiative.

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