Nobel Prize in Chemistry 2023

For Prelims: Nobel Prize in Chemistry 2023, Quantum Dots, **Quantum technology**, Nanomaterials**,** LEDs.

For Mains: Applications of Quantum Dots.

Source: IE

Why in News?

The **Royal Swedish Academy of Sciences** awarded the **Nobel Prize in Chemistry 2023** to **Moungi G Bawendi, Louis E Brus, and Alexei I Ekimov** for their groundbreaking discovery and synthesis of **quantum dots**.

How did Scientists Discover Quantum Dots?

- **Background:**
  - Traditionally, **all pieces of a pure element**, regardless of size, were believed to have **identical properties** due to the uniform distribution of electrons.
    - However, about forty years ago, scientists discovered that nanoparticles on the nanoscale, **typically 1 to 100 billionths of a meter in size,** exhibited distinct behaviors different from their larger counterparts of the same element, **challenging this conventional belief.**
- **The Nobel Laureates' Contributions:**
  - **Alexei Ekimov:** In around 1980, Alexei Ekimov was the first to observe the **anomalous behavior in Copper Chloride** nanoparticles.
    - He successfully manufactured these nanoparticles, **showcasing their distinctive properties.**
  - **Louis Brus:** American scientist Louis Brus made a similar discovery involving **Cadmium Sulphide** nanoparticles.
    - Like Ekimov, he could create these **nanoparticles with altered properties.**
  - **Moungi Bawendi:** Moungi Bawendi, who initially collaborated with Louis Brus, later played a pivotal role in **simplifying the production methods for nanoparticles with unique characteristics.**
    - His work paved the way for efficient and controlled manufacturing of nanoparticles displaying desired deviant behaviors.
- **Factor Responsible for Distinctive Properties of Nanoparticles:**
  - The unconventional behavior of small nanoparticles is a result of the **emergence of quantum effects.**
  - Despite nanoparticles being considerably larger than individual atoms, a crucial insight emerged in the 1930s, that **when particles are reduced to the nanoscale, quantum effects can come into play.**
    - This is primarily because, under such conditions, **electrons within atoms find themselves confined within a limited space.**

        - Typically, electrons move within a relatively spacious area outside the nucleus of an atom.
        - However, as particle size drastically decreases, **electrons experience increasing constraints,** leading to the manifestation of these peculiar quantum effects.
    - This profound understanding, as **observed and demonstrated by the Nobel Laureates, Ekimov and Brus in their laboratories,** resulted in the creation of nano-sized particles with distinct behaviors compared to their larger counterparts of the same element.
        - These remarkable nanoparticles, possessing unique properties, came to be known as **quantum dots.**
- **Feature of Quantum Dots:** Quantum dots are **nanoscale particles,** typically ranging in size from **1 to 100 nanometers**. These minuscule structures possess unique properties that are **governed by their size.**
    - Notably, the size of quantum dots determines the **colour of light they emit,** with smaller dots emitting blue light and larger ones shining in **yellow and red.**

Note

- **Quantum Effect:** Quantum refers to the fundamental behavior of matter and energy at the smallest scales, where **classical physics no longer applies.**
    - Quantum effects are the phenomena that occur at the quantum level, where particles like electrons exhibit **behaviors such as superposition and entanglement,** which are distinct from classical physics.
- **Quantum Technology:** Quantum technology harnesses the unique properties of quantum mechanics to create innovative tools and applications, including quantum **computing, quantum cryptography, and quantum sensors,** with the potential to revolutionize various fields.

What can be the Applications of Quantum Dots?

- **Display Technology**: Quantum dots can enhance the quality of displays, such as LED **lamps and television screens,** by emitting clear and vibrant light.
- **Medical Imaging: They can illuminate tumor tissue during surgery,** aiding surgeons in precise removal.
    - Their nanoscale size makes them ideal for use in **tiny sensors.**
- **Flexible Electronics:** Quantum dots hold promise for **flexible electronics,** paving the way for innovative and adaptable devices..
- **Slimmer Solar Cells:** Quantum dots could lead to more **efficient and compact** solar cells, improving renewable energy solutions.
- **Encrypted Quantum Communication:** Quantum dots might play a role in developing **secure** quantum communication **technologies,** protecting sensitive information.

Who are the Other Recent Nobel Laureates in the Field of Chemistry?

- **2022**
    - **Carolyn R. Bertozzi, Morten Meldal and K. Barry Sharpless** “for the development of **click chemistry** and **bioorthogonal chemistry”**
- **2021**
    - **Benjamin List and David MacMillan** “for the development of **asymmetric organocatalysis”**
- **2020**
    - **Emmanuelle Charpentier and Jennifer A. Doudna** “for the development of a method for **genome editing”**
- **2019**
    - **John B. Goodenough, M. Stanley Whittingham and Akira Yoshino** “for the development of **lithium-ion batteries”**

- **2018**
  - **Frances H. Arnold** “for the directed **evolution of enzymes”**
  - **George P. Smith and Sir Gregory P. Winter** “for the phage display of **peptides and antibodies”**

Reference to Other Announcements of the Nobel Prizes 2023: Physics , Physiology or Medicine