

What is Quantum Dot ...

- Quantum dots is semiconductor particles a few nanometres in size with optical and electronic properties that differ from those of larger particles via quantum mechanical effects.
- They are a central topic in nanotechnology and materials science. (extracted from Wikipedia)
- Quantum dots - have their applications ranging from medicine to agriculture and have extensive potential in changing the industrial scenario.
- The change in size and surface modulation of quantum dots usually pronounce their potential and can be exhibited through their discrete energy level and bandgap.
- This newly emerging nanometric application in agriculture is growing day by day be it as a growth enhancer or diagnosing plant diseases. (extracted from <https://www.sciencedirect.com/science/article/abs/pii/B978032391908100016X#:~:text=QDs%20are%20also%20effective%20in,light%20source%20in%20greenhouse%20cultivation.>)

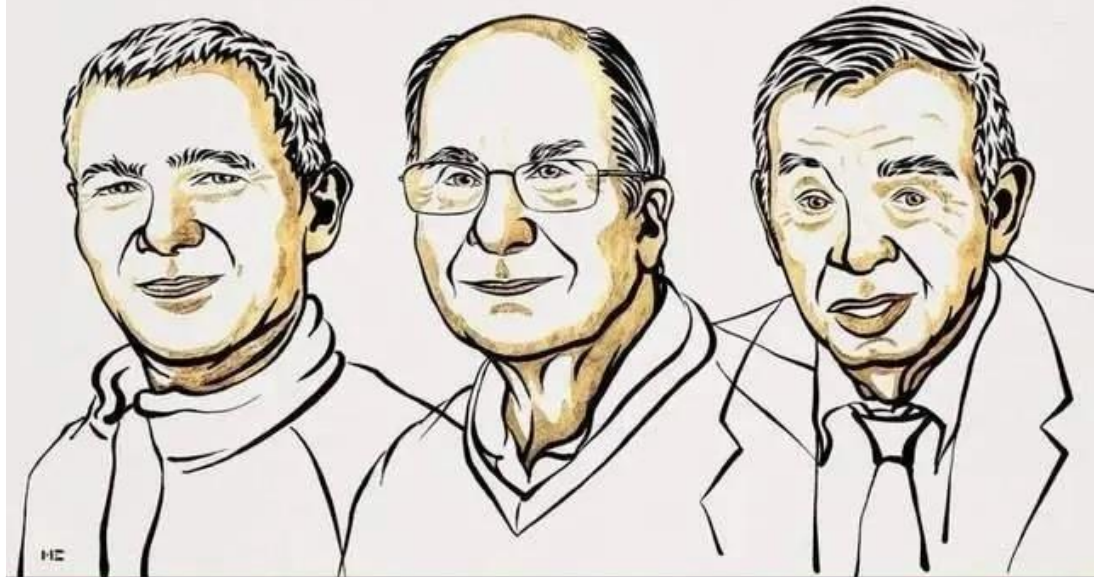
Is it a big deal?

- The 2023 Nobel Prize in Chemistry was awarded to three scientists for the discovery of quantum dots.
- These are nanoparticles **so small that their size controls their many properties...**
- This makes Quantum Dot invaluable in applications ranging from large color displays to energy production..

(extracted from [scientificamerican.com](https://www.scientificamerican.com))

发现与合成量子点

THE NOBEL PRIZE
IN CHEMISTRY 2023



Mounqi G.
Bawendi

Louis E.
Brus

Alexei I.
Ekimov

“for the discovery and synthesis of quantum dots”

Quantum dots are a milestone in materials



- Quantum dots can be considered a milestone in the entire field of nanotechnology.

— Heiner Linke, member of the Nobel Prize Committee in Chemistry and member of the Royal Swedish Academy of Sciences —
- So far, no natural quantum dots have been discovered.
- This is a huge breakthrough for humans to control material properties and an important milestone in the field of artificial materials.

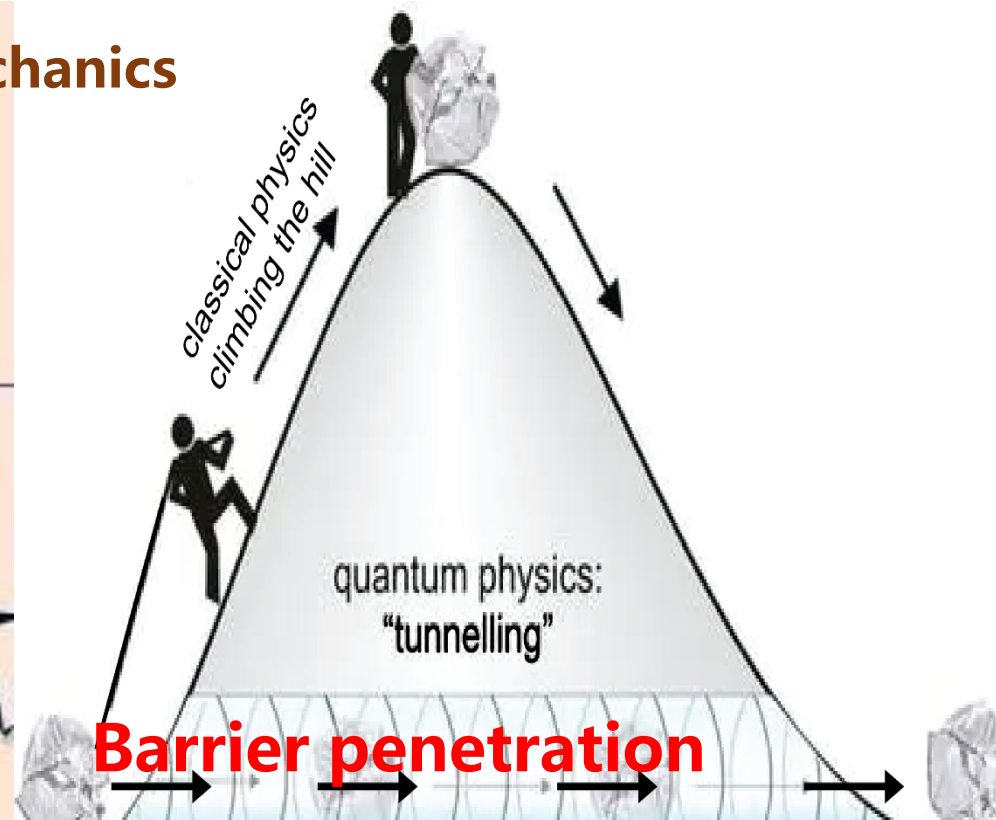
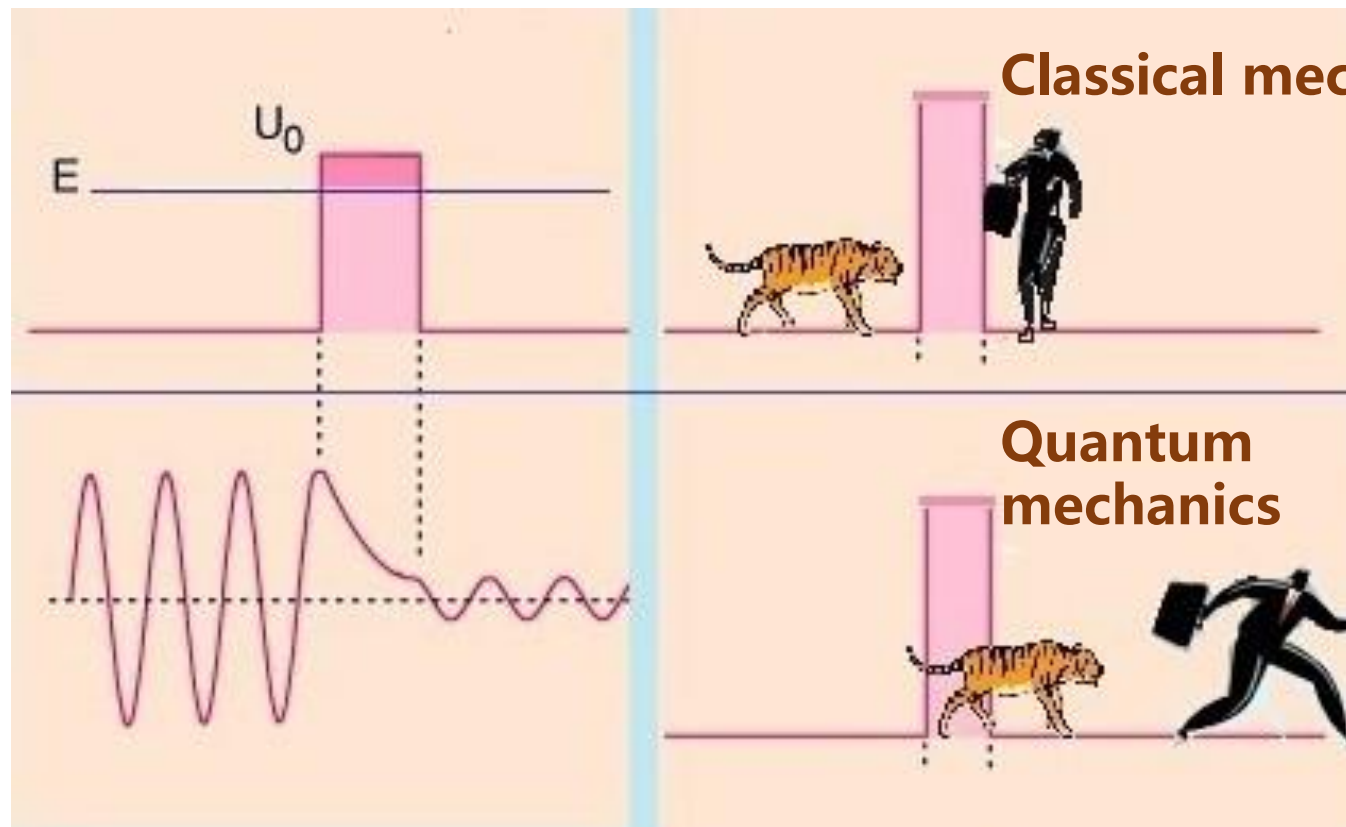
Key concept – Quantum Dot Confinement

- Quantum confinement effects describe electrons in terms of energy levels, potential wells, valence bands, conduction bands, and electron energy band gaps.
- The quantum confinement effect is observed when the size of the particle is too small to be comparable to the wavelength of the electron. and significantly depends on the material properties.
- In the case of nanoparticles with **diameters of ca. 2–10 nm**, the bandgap is increased due to the quantum size effect compared with the bulk semiconductor, and it leads to various fluorescent colors reflecting small differences in the particle size. (extracted from <https://www.sciencedirect.com/topics/engineering/quantum-confinement-effect>)

Another key concept – Quantum Tunnelling

- Quantum tunnelling (or barrier penetration) is a quantum mechanical phenomenon in which an object such as an electron or atom passes through a potential energy barrier.
- Tunneling is a consequence of the wave nature of matter.
- **The probability of transmission of a wave packet through a barrier** decreases exponentially with the barrier height, the barrier width, and the tunneling particle's mass, so tunneling is seen most prominently in low-mass particles such as electrons or protons tunneling through microscopically narrow barriers. (extracted from Wikipedia)

量子点隧道效应 (Quantum dots tunnelling effect)



量子点隧道效应 (Quantum dots tunnelling effect)

Farmour (black particles)

可作为 **荧光探针**

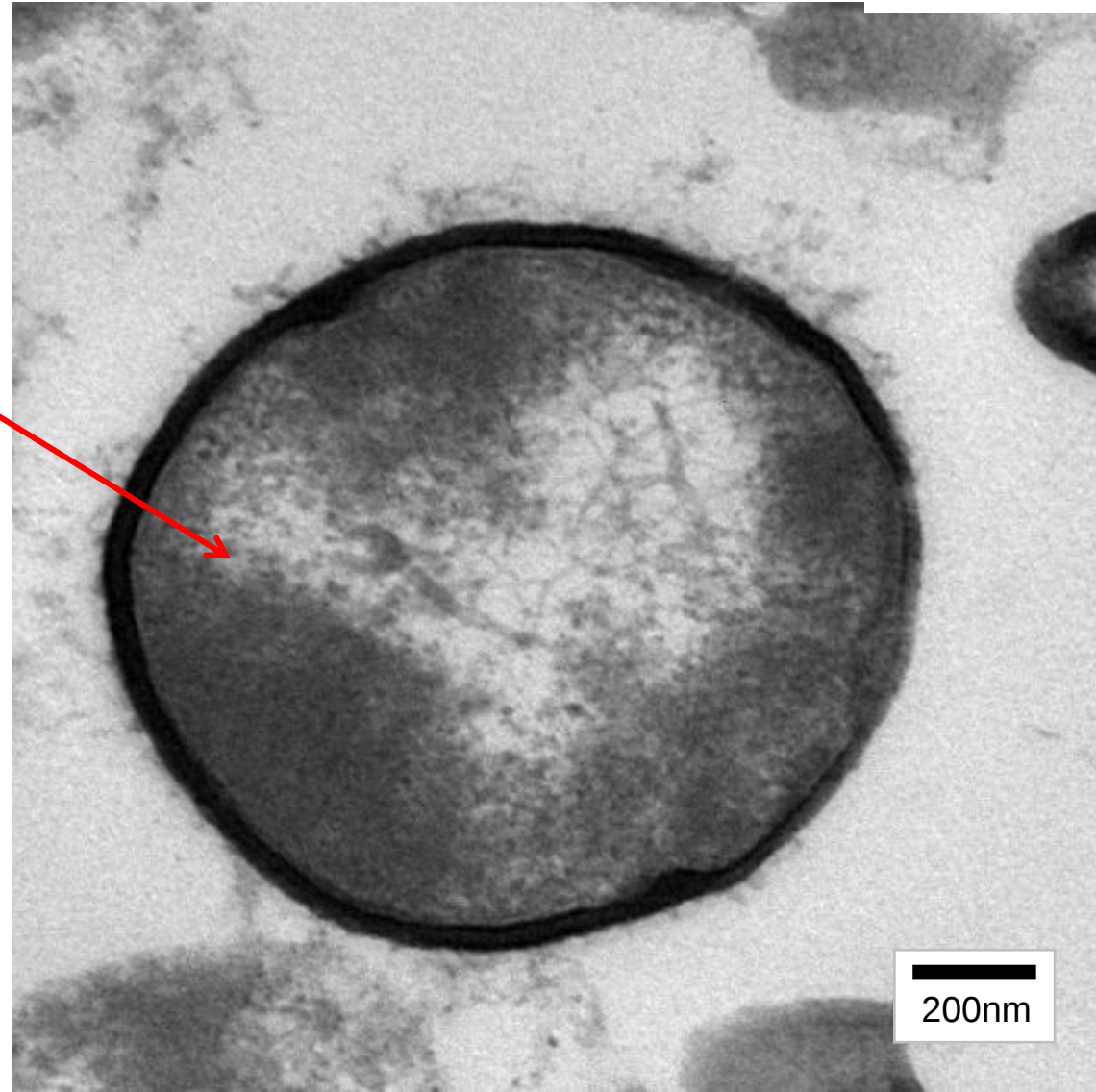
Can be used as a **fluorescent probe**

Transmembrane

穿过细胞壁（膜）进入细胞内

Pass through the cell wall

(membrane) enter cells



Just to share a few major applications ...

- Being zero-dimensional, quantum dots have a sharper density of states than higher-dimensional structures. As a result, they have superior transport and optical properties. They have potential uses in diode lasers, amplifiers, and biological sensors
- Quantum dots can have antibacterial properties (*eg using ZnO as material*) similar to nanoparticles and can kill bacteria in a dose-dependent manner.
- The use of quantum dots for tumor targeting under in vivo conditions employ two targeting schemes: active targeting and passive targeting. In the case of active targeting, quantum dots are functionalized with tumor-specific binding sites to selectively bind to tumor cells. (extract from Wikipedia)

Quantum Dot technology open up “undiscovered properties of material” by creating a new man made material which has unique properties that can help human to make things so much better and more efficient.