KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Chemistry 2023 "for the discovery and synthesis of quantum dots" to **Moungi G. Bawendi**, Massachusetts Institute of Technology (MIT), Cambridge, MA, USA, **Louis E. Brus**, Columbia University, New York, NY, USA and **Aleksey Yekimov**, Nanocrystals Technology Inc., New York, NY, USA.

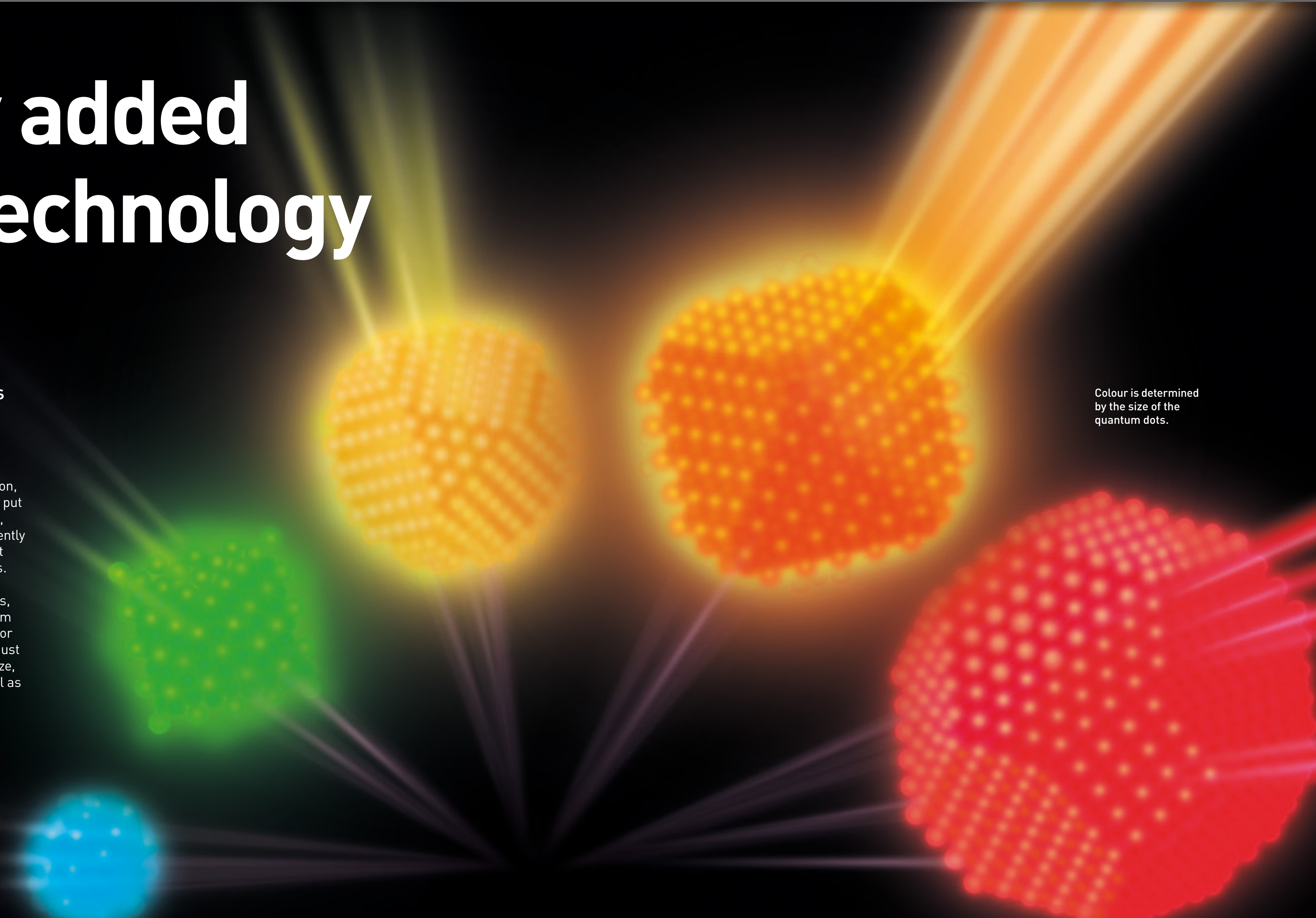
The Nobel Prize 2023 **in Chemistry**

Their discovery added colour to nanotechnology

The Nobel Prize in Chemistry 2023 rewards the discovery and development of *quantum dots*. These nanoparticles have unique properties and their light now glows from television screens and LED lamps. Biochemists use them when mapping the inside of cells and medical researchers are investigating whether quantum dots can help surgeons see tumour tissue in the body.

Anyone who studies chemistry learns that a substance's properties are determined by the atoms it is made from. However, when matter shrinks to nanodimensions, phenomena called *quantum effects* start happening; these are governed by size. Quantum effects can give matter spectacular properties, including particles having different colours depending on their size, despite being made from the same material.

Physicists had long known that in theory, size-dependent quantum effects could arise in nanoparticles, but until the 1970s, it was practically impossible to sculpt an exact structure in nanodimensions. For this reason, few people thought this knowledge would be put to practical use. However, in the early 1980s, Aleksey Yekimov and Louis Brus – independently of each other – discovered size-dependent quantum phenomena in tiny nanoparticles. Moungi Bawendi then revolutionised the methods for manufacturing these particles, which are now called quantum dots. Quantum dots are crystals made from only hundreds or a few thousand atoms. Their diameters are just millionths of a millimetre and, in terms of size, they have the same relationship to a football as a football does to the Earth.



A bright future for quantum dots

Quantum dots now illuminate computer and television screens that are based on QLED technology. They also optimise the light of LED lamps, and biochemists and medical researchers use them to map biological tissue. Researchers believe that in the future, quantum dots could contribute to flexible electronics, miniscule sensors, slimmer solar cells and perhaps encrypted quantum communication – so we have only just begun to discover the potential of these tiny particles.

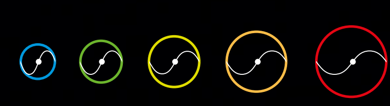
Moungi G. Bawendi
Born 1961 in Paris, France. Professor at Massachusetts Institute of Technology (MIT), Cambridge, MA, USA.

Louis E. Brus
Born 1943 in Cleveland, OH, USA. Professor at Columbia University, New York, NY, USA.

Aleksey Yekimov
Born 1945 in the former USSR. Formerly Chief Scientist at Nanocrystals Technology Inc., New York, NY, USA.

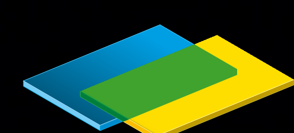
Quantum phenomena – when electrons are squeezed together

When particles become extremely small, the electrons' particle waves are compressed, which affects the electrons' energy levels. This drastically changes the matter's properties. For example, the colour of quantum dots varies with the particle size, but other properties are also affected, such as the particles' conductivity and melting point.



Yekimov uses quantum dots to colour glass

In 1981, Aleksey Yekimov succeeded in creating size-dependent quantum effects in coloured glass, where the colour came from nanoparticles of copper chloride trapped in the glass. The particles were different sizes depending on the temperature Yekimov had used to make the glass, and he was able to show that different sized particles led to different colours. The smaller they were, the bluer the glass. Yekimov quickly realised that the changing colour was due to size-dependent quantum effects.



Brus discovers quantum dots in a beaker

In 1983, Louis Brus became the first scientist in the world to prove size-dependent quantum effects in particles floating freely in a liquid. He was aiming to develop semi-conducting nanoparticles that could catalyse chemical reactions. As he worked, he realised that the optical properties of very small particles changed if they had been left on the lab bench for a while, probably because they had grown. The larger particles turned out to absorb light at wavelengths that shifted towards red, a phenomenon that Brus explained in terms of quantum effects.

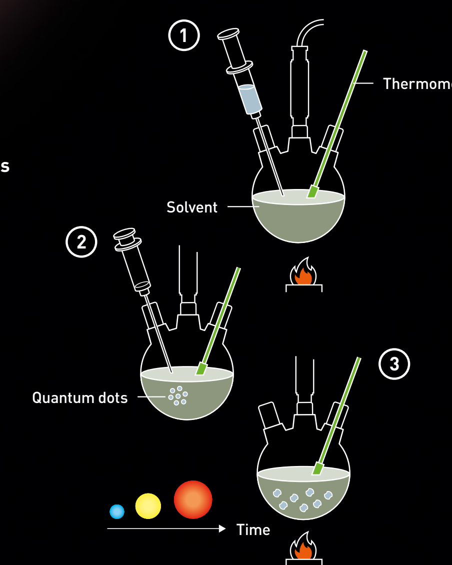
Bawendi creates almost perfect quantum dots

In 1993, Moungi Bawendi revolutionised the chemical manufacturing of quantum dots. The ones he produced were almost perfect, which was necessary if they were to be usable. This is what he did:

1. He injected substances that can form cadmium selenide into a carefully chosen hot solvent. The volume was enough to saturate the solvent around the needle.

2. Small crystals of cadmium selenide immediately formed, but because the injected mixture was quickly diluted, the crystals stopped growing.

3. When Bawendi increased the temperature of the solvent, the crystals once again started to grow. By carefully controlling the temperature and time, he could produce crystals with a precise and predictable size.



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More information about the Nobel Prize in Chemistry 2023 is available at *www.kva.se/nobelchemistry2023* and *www.nobelprize.org*, with video and detailed information about the prize and the laureates.

Editors: Peter Brzezinski, Heiner Linke and Johan Åqvist, Nobel Committee for Chemistry, Royal Swedish Academy of Sciences; Ann Fernholm, science writer; Clare Barnes, translator; Sara Rylander, editor, Royal Swedish Academy of Sciences. **Graphic design:** IVY Agency **Illustrations:** Johan Jarnestad/Infographics.se **Print:** Åtta45

Printing and distribution made possible by VOLVO