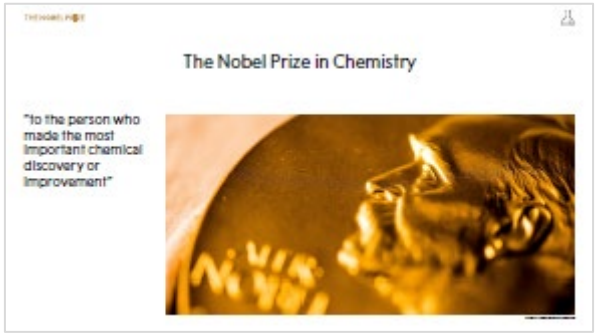
THE NOBEL PRIZE

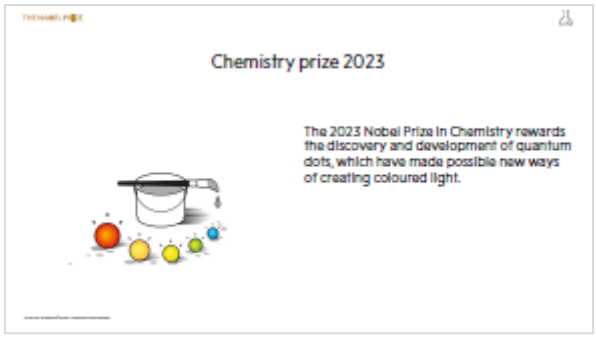
Speaker's manuscript – Chemistry prize 2023
They added colour to nanotechnology

The Nobel Prize in Chemistry



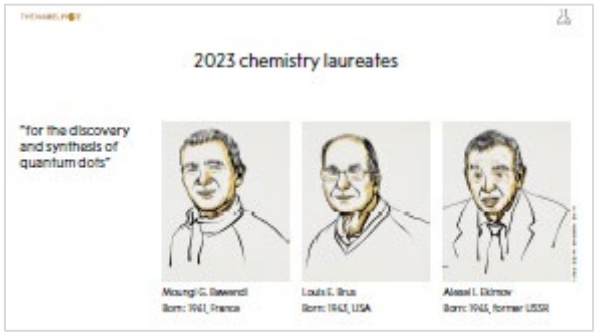
- The Nobel Prize in Chemistry is one of the five prizes founded by Alfred Nobel and awarded on 10 December every year.
- Before Alfred Nobel died on 10 December 1896, he wrote in his will that the largest part of his fortune should be placed in a fund. The yearly interest on this fund would pay for a prize given to "those who, during the preceding year, shall have conferred the greatest benefit to humankind."
- The interest would be divided into five equal parts, with one part awarded "to the person who shall have made the most important chemical discovery or improvement".
- The Nobel Prize in Chemistry is thus awarded to people who have made discoveries or improvements that have given us knowledge about the structure of various substances and how they are created and changed.

The 2023 chemistry prize



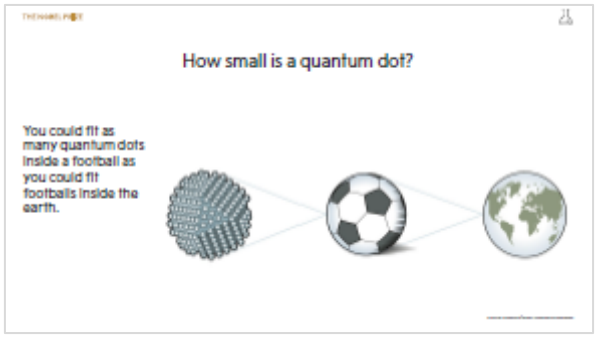
- The 2023 Nobel Prize in Chemistry is awarded for the experimental discovery of quantum dots, which are nanoparticles made of semiconductor material.
- Nanoparticles are extremely small particles of various substances. They are on the order of 10^{-9} m (one billionth of a metre) in size. To try to understand how small that is, we can compare with the head of a pin: a nanoparticle is about a million times smaller.
- The laureates have been pioneers in the exploration of the nano world, and their work has been pivotal in the development of nanotechnology. Among other uses, quantum dots have given us new ways of creating coloured light.

The 2023 chemistry laureates



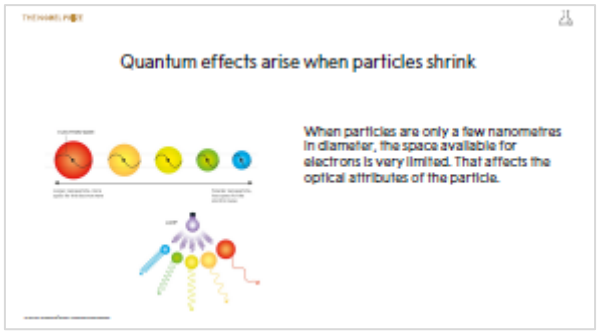
- Independently of each other, Aleksey Yekimov and Louis Brus have succeeded in synthesising (creating) quantum dots and demonstrating that their size determines their quantum mechanical properties.
- Moungi Bawendi revolutionised the methods used to create quantum dots so that they can now be made with very high quality. This made it possible for quantum dots to be utilised widely in nanotechnology.
- Aleksey Yekimov used to be the Chief Scientist at Nanocrystals Technology Inc. in the United States.
- Louis Brus is a professor at Columbia University in the United States.
- Moungi Bawendi is a professor at the Massachusetts Institute of Technology (MIT) in the United States.

How small is a quantum dot?



- A quantum dot is often made up of only a few thousand atoms.
- It is as big in comparison to a football as a football is to the earth. In other words, you could fit as many quantum dots inside a football as you could fit footballs inside the earth.

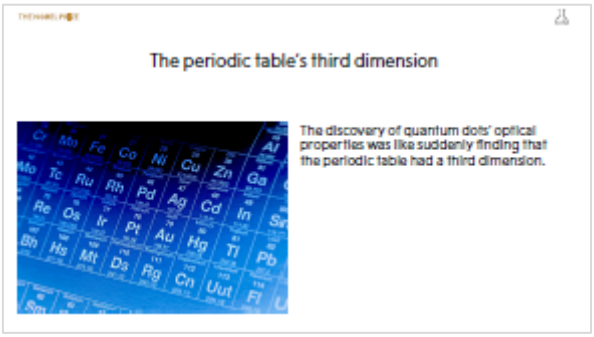
Quantum effects arise when particles shrink



- In the nano world, things behave differently. When we start measuring the sizes of materials in millionths of a millimetre, strange phenomena arise – so-called quantum effects – that run counter to our understanding of how the world works and how it appears to us.
- When particles are only a few nanometres in diameter, the space available for electrons to move around in shrinks. That affects the particle's optical attributes, among other things.
- Quantum dots absorb light, and then they emit light of different wavelengths depending the size of the dots. That means that they absorb a wide spectrum of light but emit light of a specific wavelength. Larger quantum dots emit longer wavelengths, which produces a redder light, while small quantum dots emit shorter wavelengths, which produces bluer light.

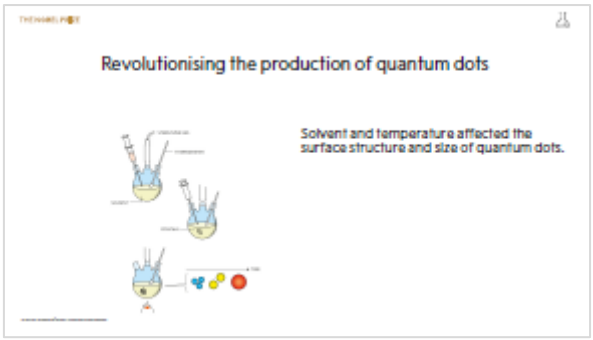
- As a result, we can determine which light a given particle will emit just by changing its size.
- This size-dependent quantum effect was observed by Aleksey Yekimov and Louis Brus independently of each other. They worked with different substances, and both made the discovery that the size of quantum dots influences the colour of the light they emit.

The periodic table's third dimension



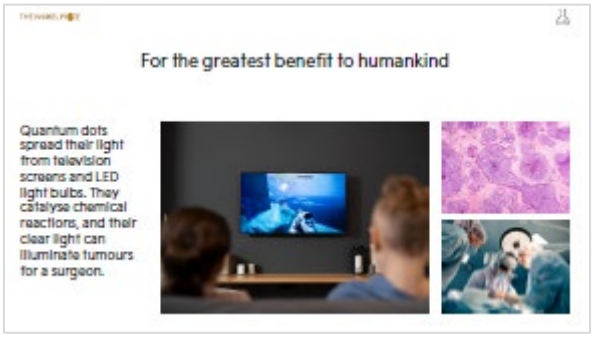
- To understand the magnitude of Aleksey Yekimov's and Louis Brus's discovery, imagine stumbling upon the realisation that the periodic table has a third dimension. The properties of each element are determined by the number of electron shells it has and how many electrons there are in the outermost shell, but it now became clear that, on the nano level, size also matters. Thus, for chemists who wanted to discover new materials, there was now another factor to experiment with.
- The optical changes in quantum dots demonstrated that a substance takes on totally new properties when the size of those dots changes. The optical properties of the substance are determined by its electrons. The same electrons determine other attributes as well, such as the material's ability to catalyse chemical reactions or to conduct electricity.
- There was only one problem: the methods used for creating quantum dots often resulted in particles of poor quality. The quantum dots produced were often defective and varied widely in size.

Revolutionising the production of quantum dots



- This was a problem this year's third laureate decided he was going to solve. Moungi Bawendi laboured intensively to develop better methods for manufacturing quantum dots. He worked with various solvents and varied the temperature in order to produce quantum dots of a particular size. He also developed a method for giving the quantum dots a smooth and even surface.
- The choice of solvent influenced the dots' surface structure, and the temperature influenced their size.
- This was a major breakthrough. The quantum dots Bawendi produced were practically perfect and gave rise to very clear quantum effects. In addition, his manufacturing methods were inexpensive and simple to use.

For the greatest benefit to humankind



- The luminosity of quantum dots is utilised in television and display screens that rely on so-called QLED technology, in which the Q stands for quantum dot. In this kind of screen, blue light is produced with the help of the kind of energy-efficient diodes that were awarded the Nobel Prize in Physics in 2014. Then quantum dots are used to change the colour of some of the blue light to red or green. In this way, we can generate the three basic colours of light that are used to produce all the colours that are needed in a television.
- Similarly, quantum dots are utilised in certain LED lighting to modify the diodes' cold light. That means the light can be as energising as cold daylight or as calming as the warm glow emitted by a dimmed incandescent light bulb.
- Chemists use the catalytic properties of quantum dots to drive chemical reactions, and doctors have begun exploring the possibility of using quantum dots to identify cancerous tissue in the human body.

"This is a collaborative effort."

- In conjunction with the announcement of the 2023 Nobel Prize in Chemistry, Louis Brus spoke about other researchers with whom he has collaborated over the years and who were important in the development of nanotechnology.