KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Physics 2018 "for groundbreaking inventions in the field of laser physics" with one half to **Arthur Ashkin** "for the optical tweezers and their application to biological systems" and the other half jointly to **Gérard Mourou** and **Donna Strickland** "for their method of generating high-intensity, ultra-short optical pulses".

The Nobel Prize 2018 **in Physics**

Tools made of light

The inventions being honoured this year break new ground in laser physics. Small biological objects and incredibly rapid processes are now being seen in a new light, and advanced precision instruments are opening up unexplored areas of research and a multitude of industrial and medical applications.

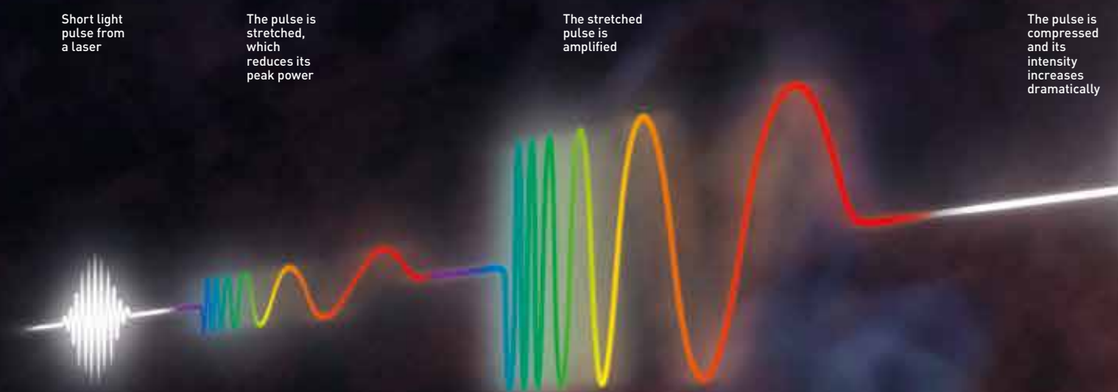
Arthur Ashkin invented optical tweezers that grab particles, atoms, bacteria and other living cells with their laser beam fingers. This new tool allowed Ashkin to realise an old dream of science fiction – using the radiation pressure of light to move physical objects. He succeeded in getting laser light to push small particles and grasp them by focusing the beam. Optical tweezers had been invented.

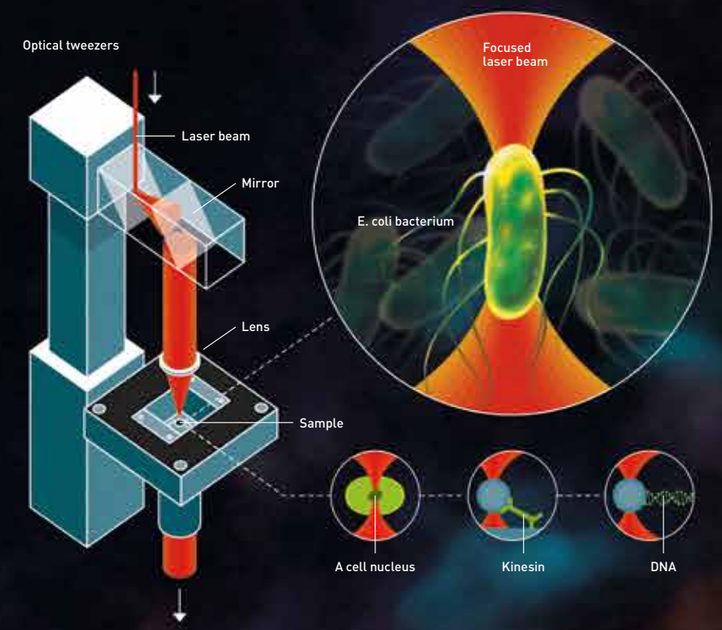
A major breakthrough came in 1987, when Ashkin used the tweezers to capture living bacteria without harming them. He immediately began studying biological systems and optical tweezers are now widely used to investigate the machinery of life.

Gérard Mourou and **Donna Strickland** paved the way towards the shortest and most intense laser pulses ever created by humankind. Their revolutionary article was published in 1985 and was the foundation of Strickland's doctoral thesis. Using an ingenious approach, they succeeded in creating ultrashort, high-intensity laser pulses without destroying the amplifying material. First they stretched the laser pulses in time to reduce their peak power, then amplified them, and finally compressed them. If a pulse is compressed in time and becomes shorter, then more light is packed together in the same tiny space – the intensity of the pulse increases dramatically.

Strickland and Mourou's newly invented technique, called *chirped pulse amplification*, CPA, soon became standard for high-intensity lasers. Its uses include the millions of corrective eye surgeries that are conducted every year with the sharpest of laser beams.

The innumerable areas of application have not yet been completely explored. However, these inventions already allow us to rummage around in the microworld in the best spirit of Alfred Nobel – for the greatest benefit to humankind.





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A bacterium trapped in the optical tweezers' fixed grip. Arthur Ashkin demonstrated that not only bacteria, but also other living cells and their contents can be studied in a microscope where they are trapped by a focused laser beam. Optical tweezers make it possible to observe, turn, cut, push and pull – without touching the objects being investigated.

Ashkin paved the way for the many applications of the optical tweezers. Some objects are trapped directly in the laser beam, while others, like the motor molecule kinesin or a DNA strand, are first attached to a small sphere that is held in the tweezers.

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The CPA technique revolutionised laser technology. It enabled the emission of very intense, short laser pulses using an intricate method to avoid the risk of destroying the amplifying material. Instead of amplifying the light pulse directly, it is first stretched in time, reducing its peak power. Then the pulse is amplified and when it is compressed more light is collected in the same tiny space – the light pulse becomes extremely intense.

The CPA technique is now being broadly applied to develop even shorter and more intense laser pulses. It has opened up new research fields and many applications in physics, chemistry and medicine.

Arthur Ashkin
Born 1922 in New York, USA. Formerly Researcher at Bell Laboratories, Holmdel, USA.

Gérard Mourou
Born 1944 in Albertville, France. Professor at École Polytechnique, Palaiseau, France and University of Michigan, Ann Arbor, USA.

Donna Strickland
Born 1959 in Guelph, Canada. Professor at University of Waterloo, Canada.

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