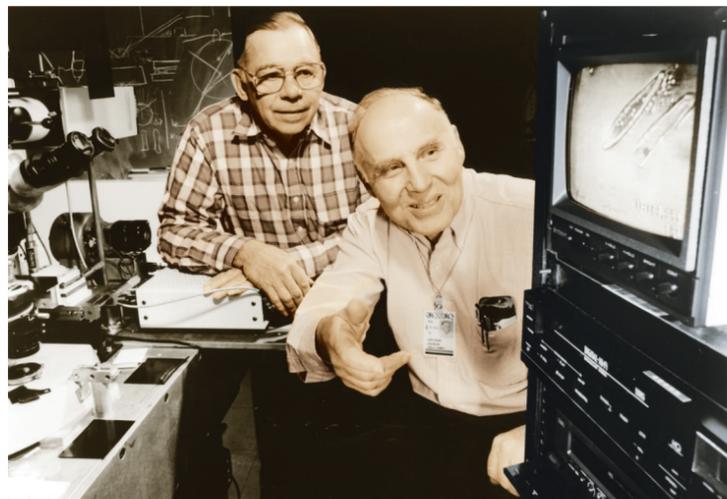


then

Ashkin and the First Optical Trap

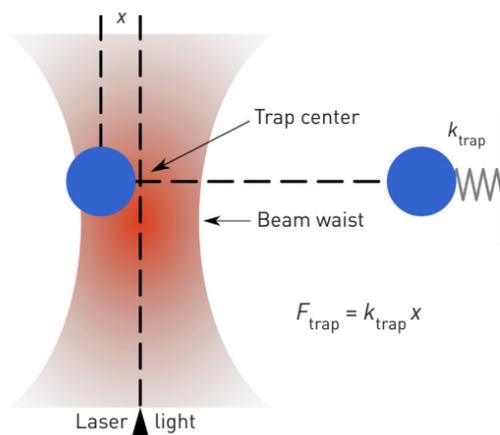
Nearly a half-century ago, optical forces were first used to capture and manipulate bits of matter. The technology has come a long way since then.



Dziedzic (left) and Ashkin demonstrate the first application of optical trapping to the biological sciences. (AIP Emilio Segrè Visual Archives, Physics Today Collection)

1970–71: Ashkin and radiation pressure

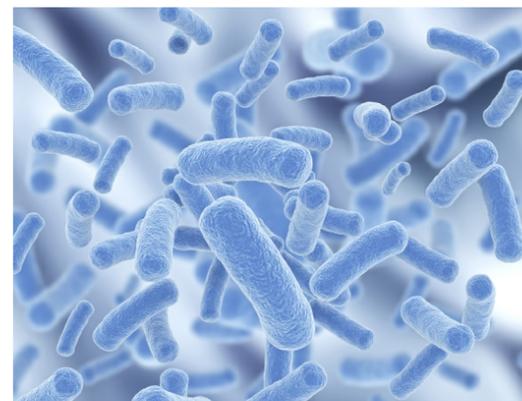
In a landmark paper in 1970, Arthur Ashkin, a researcher at Bell Laboratories, USA, shows how to use radiation pressure to accelerate and trap individual particles in both air and water. The following year, Ashkin and colleague J.M. Dziedzic demonstrate the optical levitation trap in air—the first single-beam 3-D trap.



1986: All-optical single-beam trap

Ashkin and three Bell Labs colleagues publish a seminal paper documenting implementation of an all-optical single-beam gradient force trap—the device that came to be known as optical tweezers. They show that, counterintuitively, tightly focusing a laser beam using a microscope attracts particles toward the beam rather than pushing them away.

Optical trap / Wikimedia Commons



Getty Images

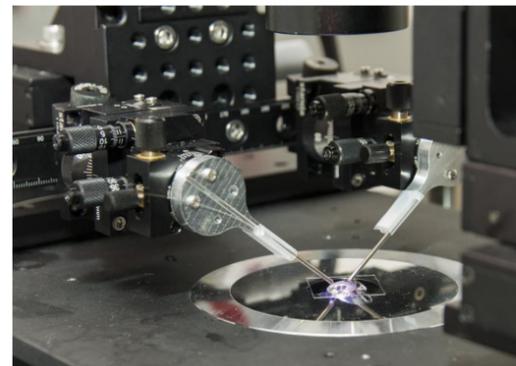
Late 1980s: Forays into biology

Following the invention of optical tweezers, Ashkin and others immediately begin investigating their use in the biological realm. In the late 1980s, optical tweezers are used to trap and manipulate viruses and living cells, as well as to explore the mechanics of biological motors, like bacterial flagella.

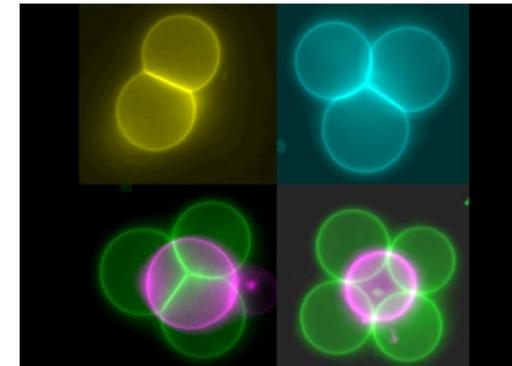
now

Tweezers in Biology and Beyond

Optical tweezers have become essential for breaking new ground in biophysics, micromechanics and more. Here's a tiny sample of some interesting recent work.



Optical fiber tweezers. (Worcester Polytechnic Institute)



Artificial cells in a range of structures. (Imperial College London)

2017: Tweezers for cancer detection

Researchers at Worcester Polytechnic Institute have designed a miniaturized, objective-lens-free, fiber-based optical-tweezers platform that, the team believes, opens the door to devices small enough to be inserted into the bloodstream to trap individual cancer cells and diagnose cancer in its earliest stages.

2018: Synthetic biology

A research team at Imperial College London and Loughborough University, U.K., has used optical tweezers to “drag and drop” cell-sized vesicles to connect, arrange and merge artificial cells. The ability to build artificial vesicle networks, the team says, has implications for soft-matter materials, synthetic biology, and drug delivery systems.



OSA Members Tongcang Li (left) and Jonghoon Ahn of Purdue University, USA, used optical tweezers to trap and spin “nanodumbbells” at frequencies of 1.1 to 1.6 GHz. (Purdue University/Vincent Walter)

2018: Rotating micromachines

Work by multiple international research groups has employed optical tweezers to trap and rotate a 2.48-micron-diameter sphere immersed in a critical liquid mixture around the beam axis at rates of more than a thousand revolutions per minute (rpm), and to whip dielectric nanoparticles around an axis at rates approaching 60 billion rpm.

The future

These examples barely hint at the innovative power of optical trapping and laser micromanipulation—a power that allows researchers to explore the boundary between physics and biology, create optically driven micromachines, optically map brain circuitry and simulate quantum systems. In recognition of the tool's extensive reach, 2009 OSA Honorary Member Arthur Ashkin was awarded half of the 2018 Nobel Prize in Physics.

For a list of references and further resources on optical tweezers, go online: www.osa-opn.org/then-now/tweezers.