

Optical Trapping

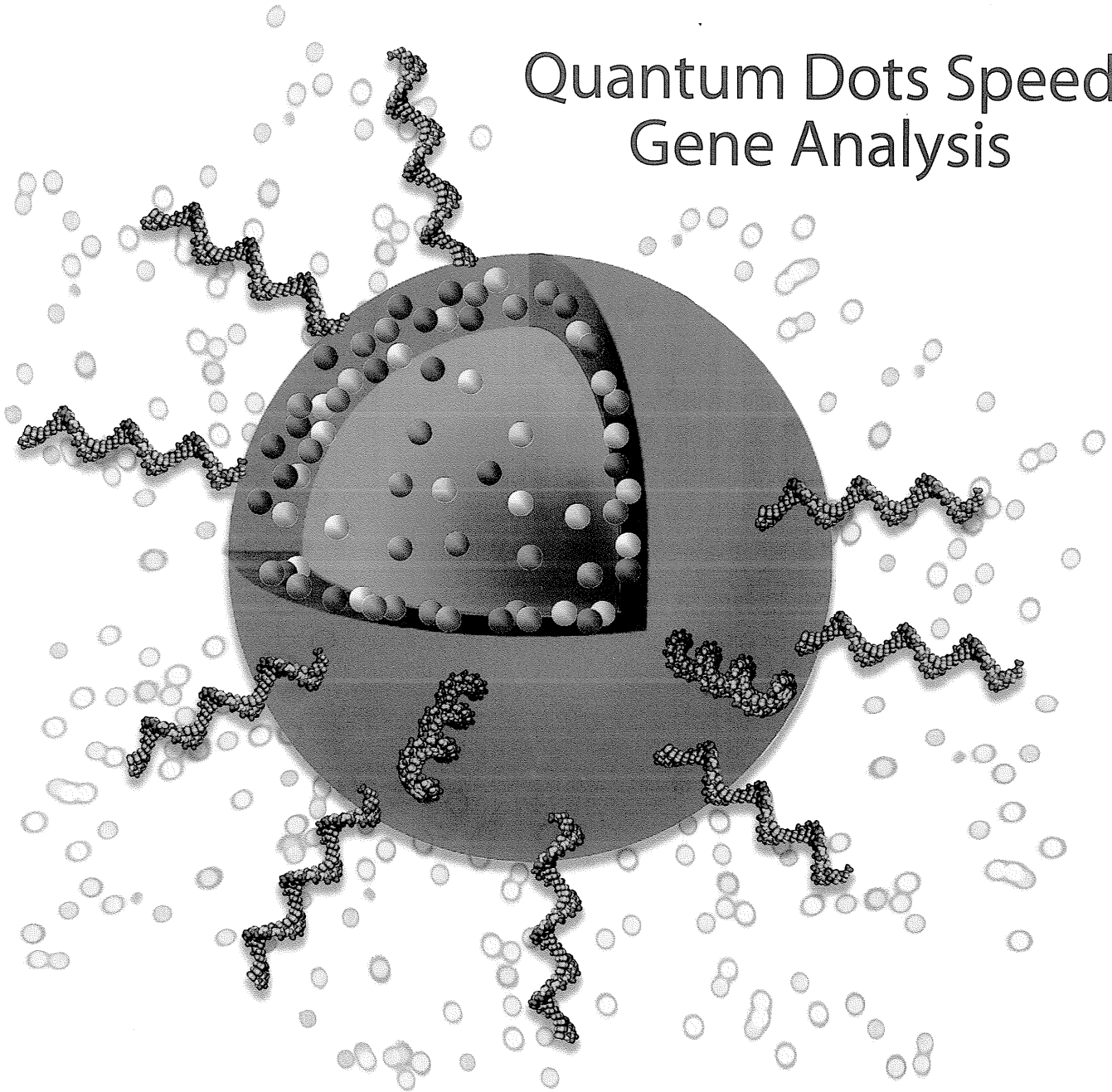
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Optical Traps Illuminate the Subcellular World

by Lauren I. Rugani, Contributing Editor

Improved spatial resolution enables the study of biological systems on the nanometer scale.

Optical trapping has been utilized in endeavors as varied as micro-fabrication, particle sorting and the study of nonequilibrium thermodynamics. The technique, also known as optical tweezing, is particularly beneficial for studies on the cellular level because it can isolate a system of interest from its environment, and it provides a noninvasive, nondamaging method for analysis.

Continuous innovation and instrument refinement have overcome many challenges in the field of optical trapping, allowing investigators to study the smallest biological systems that operate within

a cell. Observing the chemical, structural and physical properties of subcellular entities eventually will help answer some of the most fundamental questions about living beings.

Characterizing chromosomes

One benefit of optical trapping is its ability to hold objects away from a surface. Suspending an object in an optical trap enables more accurate analysis because it reduces the amount of surface-induced background noise, or morphological effects. This is especially useful when the object of interest is easily affected by in-

terference, as are human chromosomes.

Chromosomes typically are identified by stain-based techniques that can alter the molecular state of the chromosome, thereby compromising its accurate analysis. As reported in the June 12 issue of *Optics Express*, Yong-Qing Li and a team of researchers at East Carolina University in Greenville, N.C., applied laser tweezers and Raman spectroscopy to trap individual human chromosomes and to identify them by their spectral patterns.

The capability of Raman spectroscopy to reveal molecular structure will enable the development of techniques for the detection of chromosomal aberrations that cannot be detected by staining. "Our technique will also allow for rapid, automated screening and diagnosis for cancers caused by or related to chromosomal abnormalities and changes in activation status," said Thomas J. McConnell, a biology professor at the university.

Because chromosomes are only about 3 μm in size, it is highly advantageous to isolate them from other parts of the cell prior to collection of Raman spectra. To accomplish this, the researchers engineered a slide with three wells — the first larger than the other two — connected by a series of canals. They used the beam from a 785-nm frequency-stabilized semiconductor laser made by Sacher Lasertechnik GmbH of Marburg, Germany, directed through a Nikon inverted microscope, to trap and maneuver the chromosomes away from debris.

The process began with the trapping of individual chromosomes in the first well. There, the same laser was used at 50 mW for Raman spectroscopy. The average

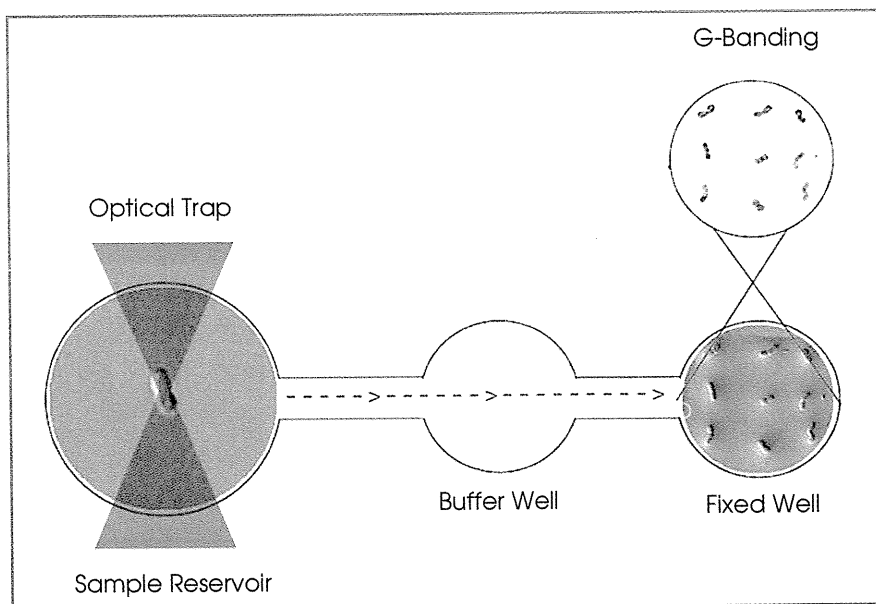


Figure 1. On a three-well slide, chromosomes are trapped in the sample reservoir for Raman spectroscopy, maneuvered through the buffer well to avoid debris and, finally, adhered in the fixed well for G-banding.

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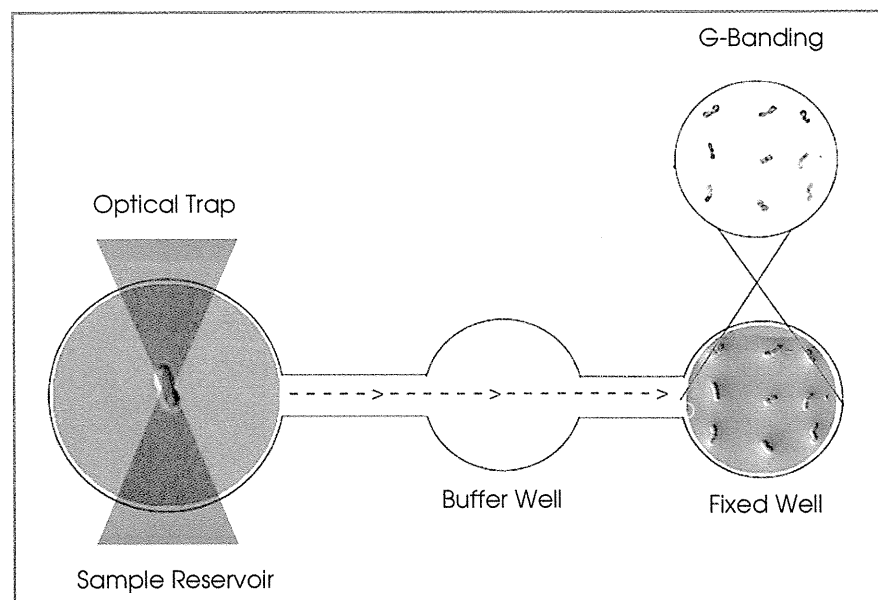
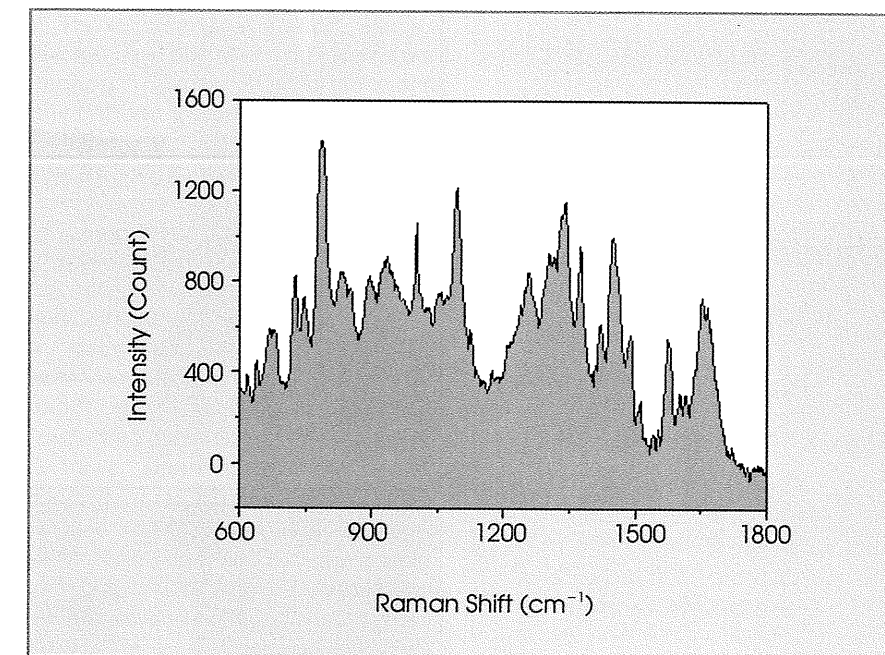


Figure 1. On a three-well slide, chromosomes are trapped in the sample reservoir for Raman spectroscopy, maneuvered through the buffer well to avoid debris and, finally, adhered in the fixed well for G-banding.

Figure 2. The Raman spectra of an individual chromosome are related to positive identification by G-banding. The variance among spectra allows for discriminate identification of individual chromosomes.



Raman spectra over two 30-s readings were collected and recorded by a Horiba Jobin Yvon spectrometer equipped with a liquid-nitrogen-cooled CCD detector. To avoid attracting debris, the laser operated at 10 mW to maneuver each trapped chromosome through the middle well and into the third well, where the chromosomes adhered to the bottom of the slide (Figure 1).

After recording the position of each chromosome in the third well, the investigators employed G-banding to identify them. This staining technique enabled

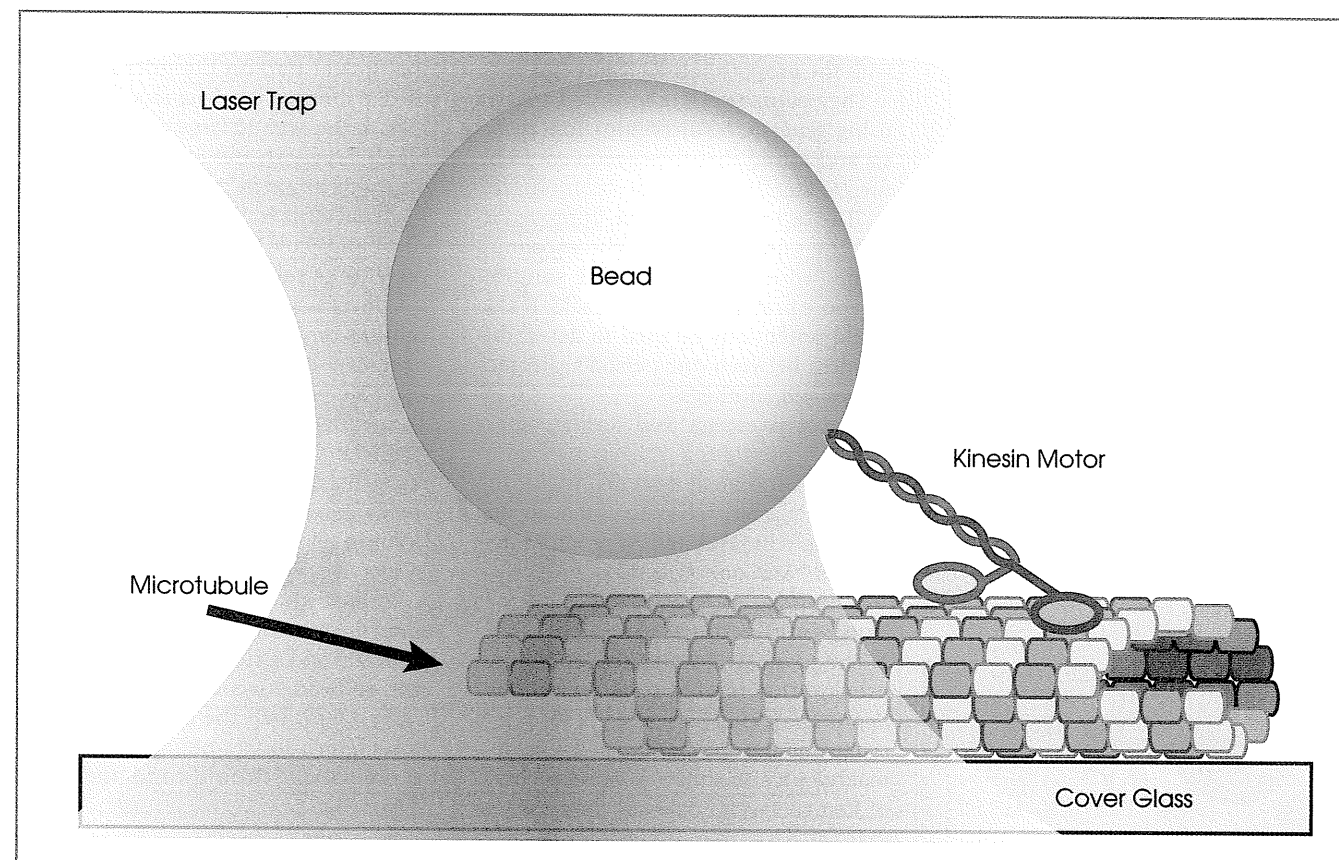


Figure 3. A 0.5- μm polystyrene bead is held in an optical trap and bound to one end of a kinesin molecule. The position of the bead is monitored as the two heads of the kinesin motor bind and move along a surface-bound microtubule.