No tug-of-war within the cell

Cooperation, it seems, has some very deep roots. Researchers at the University of Illinois at Urbana-Champaign and at the University of California, San Francisco, have found that opposing molecular motors — kinesin and dynein — will work together to transport organelles such as peroxisomes within cells, combining their efforts to boost transport speeds by 10 times.

"The fact that multiple kinesins or dyneins can work together is really new and unexpected," said Vladimir I. Gelfand, a research team member who was at the University of Illinois. He is now a professor of cell and molecular biology at the Feinberg School of Medicine at Northwestern University in Evanston, Ill.

The researchers were able to spot this cooperation in living cells because of a recent advance in fluorescence technology that improved temporal and spatial resolution 400 times.

In their work, the investigators cultured *Drosophila* cells that expressed enhanced GFP in the peroxisome. They used total internal reflection microscopy on an Olympus microscope to excite the fluorophores in the cells and captured the resulting signal using an electron-multiplying CCD from Andor Technology of South Windsor, Conn.

Paul R. Selvin, a physics and biophysics professor at the University of Illinois, noted that the GFP-tagged peroxisomes are so bright that they can be seen by eye in a microscope, emitting 5000 to 10,000 photons in about 1 ms.

Because of the number of photons produced and the speed of the camera, the scientists were able to locate the GFP-labeled peroxisomes to within 1.5 nm in

space in as little as 1.1 ms.

They then used these measurements to monitor the organelles' movement within the living cells. Kinesin and dynein move organelles along microtubules within the cell, with kinesin moving in one direction and dynein in the other. They tracked the movement of the organelles over hundreds of steps in both directions.

When the scientists plotted the data, they found constant step sizes, indicating that the two molecular motors were not engaged in a tug-of-war. That was in agreement with previous results. In further confirmation, they determined the motor step size to be about 8 µm, with a minimum speed of about 1.5 µm/s.

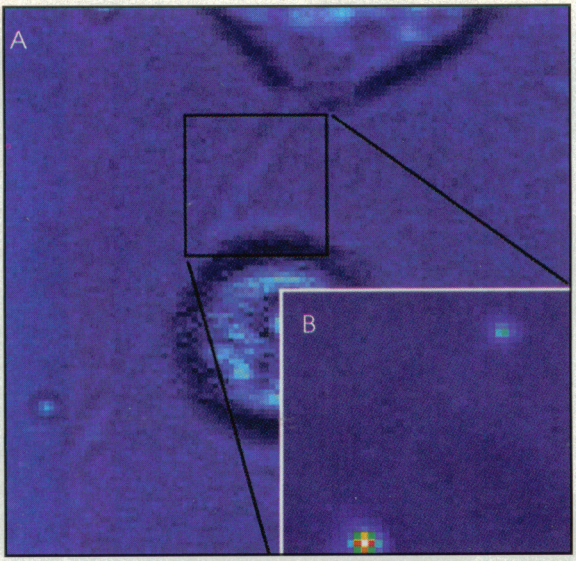
However, they also found speeds of up to around 12 µm/s, with spikes at about 1.2-µm/s intervals. This implied that as many as 11 kinesins or 11 dyneins were cooperating to move the peroxisomes, which had not been observed before.

There are several possible explanations for this teamwork, including the existence of a molecular signal that turns the motors on and off, the relative strength of the two opposing motors or the characteristics of the linkage between the motor and the organelle. Determining which, if any, of these factors is responsible is the goal of future research.

"We would like to know what are the molecular components involved in the coordination of multiple motors and how these components control the work of motor proteins," Gelfand said. □

Hank Hogan

Sciencexpress, April 7, 2005.



***This bright-field image shows a cell with a thin process (A). The inset (B) shows a fluorescence image of the GFP-labeled peroxisomes within the process. The researchers located GFP-labeled peroxisomes with an accuracy within 1.5 nm in as little as 1.1 ms. Reprinted with permission of* Sciencexpress.**