Super-resolution imaging technology reveals inner workings of living cells

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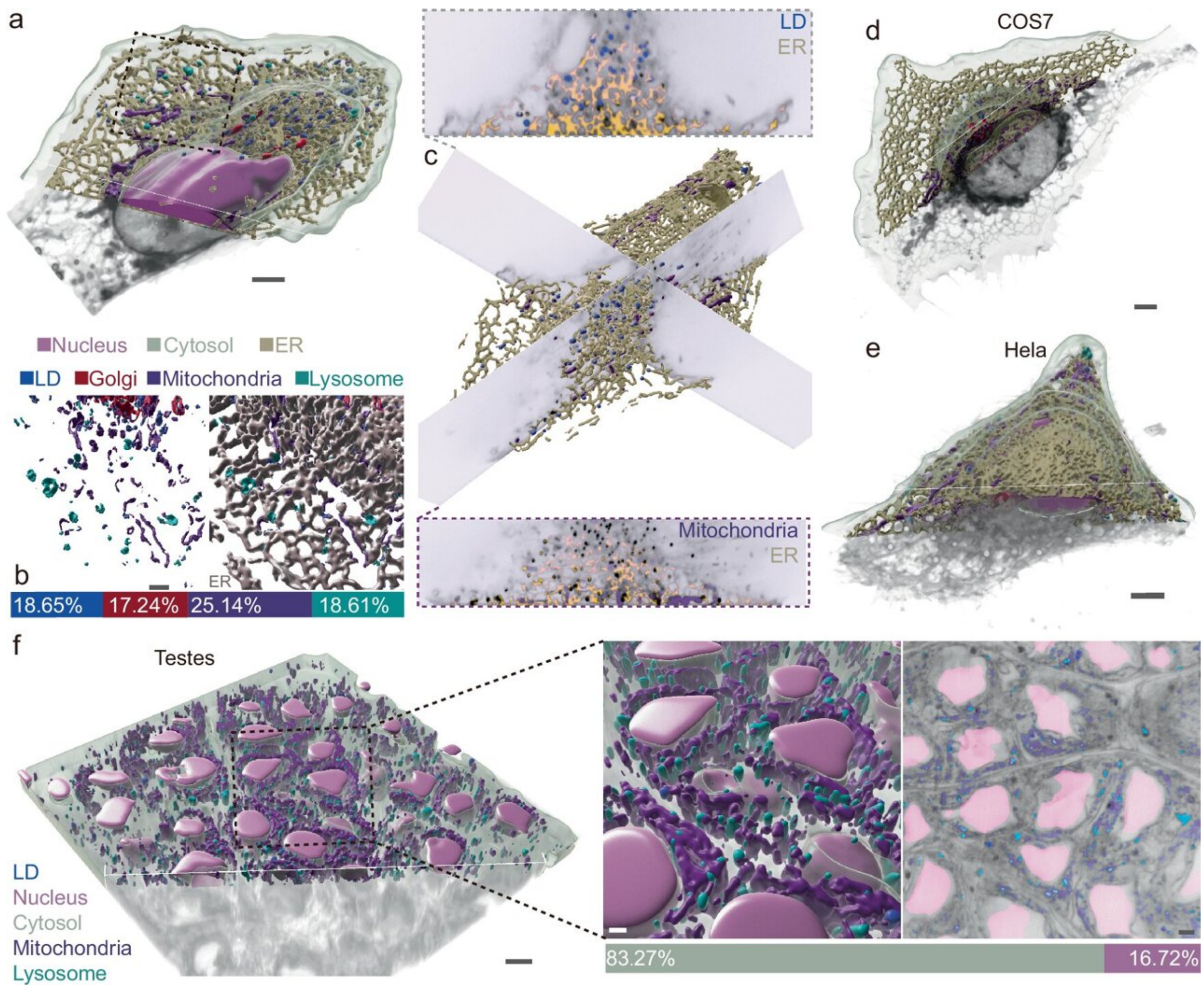


Organelle segmentation on different biology samples by the universal lipid staining and deep learning. Credit: *Nature Communications* (2025). DOI: 10.1038/s41467-025-57877-5

A breakthrough in imaging technology promises to transform our understanding of the inner workings of living cells, and provide insights into a wide range of diseases.

The study, recently published in the journal Nature Communications, unveils an innovative approach that combines super-resolution imaging with artificial intelligence and deep learning to reveal subcellular structures and dynamics. It was led by researchers from Peking University, Ningbo Eastern Institute of Technology and the University of Technology Sydney.

"It's like taking an airplane over a city at night and watching all the live interactions," said UTS Distinguished Professor Dayong Jin. "This cutting-edge technology will open new doors in the quest to understand the intricate world within our cells."

Many diseases and health conditions arise from problems within cells. By visualizing cellular processes, scientists will be able to better understand the root causes of diseases like cancer, neurodegenerative disorders and metabolic conditions, leading to improved treatments.

The new technique overcomes some of the key problems with current imaging tools used to visualize structures within living cells.

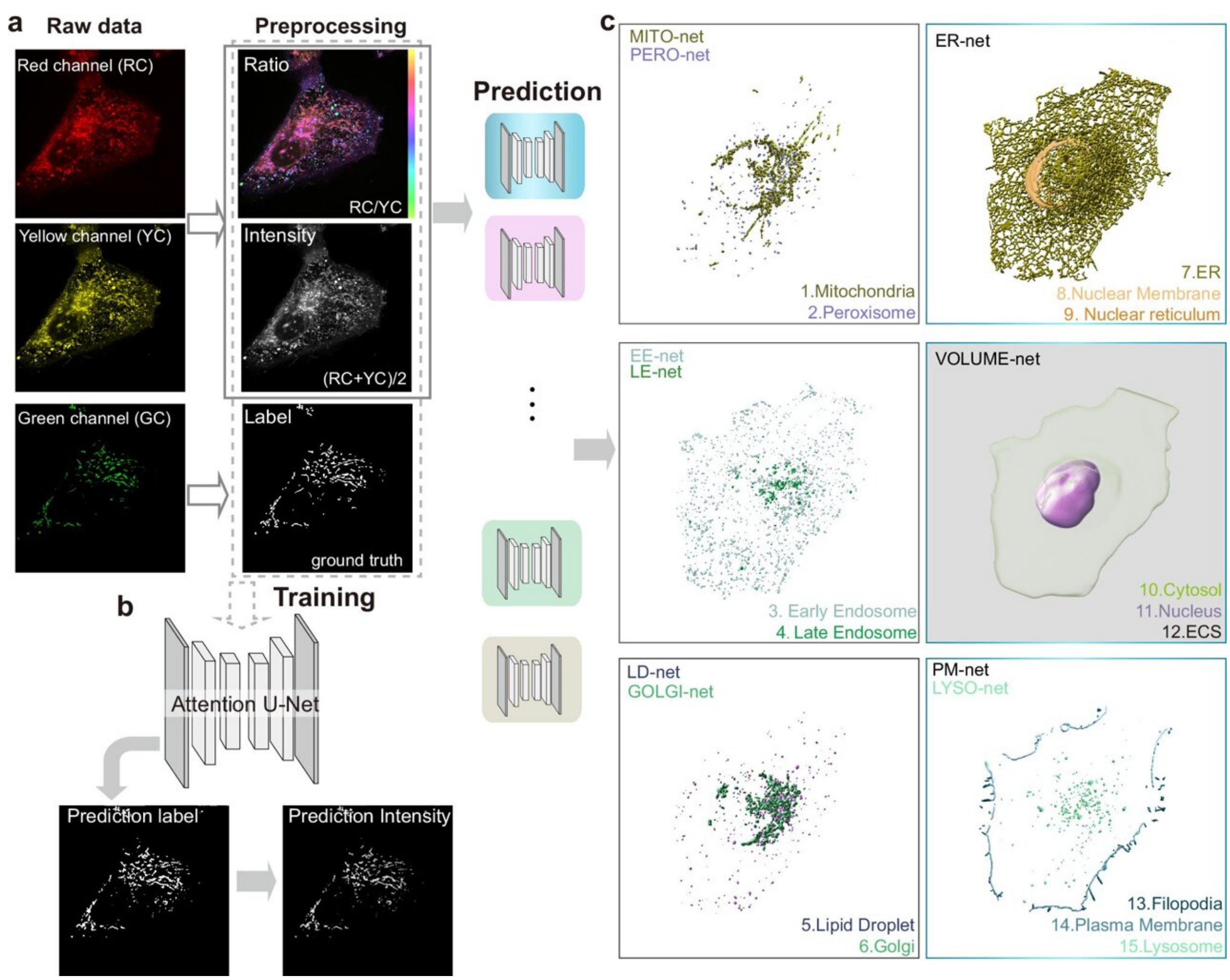
"Current tools such as fluorescence microscopy have limitations in resolution that make it difficult to see the tiny structures within cells or track detailed cellular processes," said Professor Jin, Director of the UTS Institute for Biomedical Materials & Devices.

"Traditional methods can also cause phototoxicity and photobleaching—damage to a cell due to light exposure—and they struggle to simultaneously show multiple structures within a cell due to restrictions in the number of colors that can be used."

The new method can predict 15 different subcellular structures with a high degree of accuracy using just one laser and two detection channels.

The breakthrough not only overcomes the constraints of using multiple colors by using a single dye label but it also significantly speeds up the imaging process.

The high-resolution images accurately capture the differences between organelles (cell compartments), essentially acting as an "optical fingerprint." The technology is also highly adaptable and can be applied to various microscopes, cell types, and even complex living tissues.



Fast imaging of live cell anatomy of 15 intracellular structures by the universal lipid staining and deep learning segmentation using a spinning disk confocal microscope with an extended resolution. Credit: *Nature Communications* (2025). DOI: 10.1038/s41467-025-57877-5

This adaptability allows scientists to explore and understand the 3D structure of live cells during different stages of cell division and observe the rapid interactions among intracellular compartments.

Professor Jin said the team is currently working with a number of medical research institutes, including virologists exploring virus-cell interactions and cell defense mechanisms, and scientists imaging cardiomyocytes to better understand heart disease. They hope the technology will lead to new insights and advances in medical research.

More information: Karl Zhanghao et al, Fast segmentation and multiplexing imaging of organelles in live cells, *Nature Communications* (2025). DOI: 10.1038/s41467-025-57877-5

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