Navigating the cellular landscape with new optical probes, imaging strategies and technical innovations

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Emerging visualization technologies are playing an increasingly important role in the study of numerous aspects of cell biology, capturing processes at the level of whole organisms down to single molecules. Recent developments in probes, techniques, microscopes and quantification are dramatically expanding the areas of productive imaging. Photoactivatable fluorescent proteins (PA-FPs) have been particular fruitful in this regard. They become bright and visible upon being exposed to a pulse of UV light. This allows selected populations of proteins to be pulse-labeled and tracked over time. Used for *in cellulo* pulse chase experiments, the PA-FPs have helped clarify mechanisms for biogenesis, targeting, and maintenance of organelles as separate identities within cells. PA-FPs have further permitted the development of single molecule-based superresolution (SR) imaging, which dramatically improves the spatial resolution of light microscopy by over an order of magnitude (~10-20 nm resolution). Involving the controlled activation and sampling of sparse subsets of photoconvertible fluorescent molecules, single molecule SR imaging offers exciting possibilities for obtaining molecule scale information on biological events occurring at variable time scales. Here, I discuss the new fluorescent imaging techniques and the ways they are helping researchers navigate through the cell to unravel long-standing biological questions. Among the biological questions addressed will be how cells crawl; how cells destroy damaged components; and how single molecules move and arrange themselves on the cell surface.