Molecular imaging in cells and live animals for biomedical research

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Most of the biological events taking place inside a eukaryotic cell depend on the coordinated assembly of multi-component biological machineries. In particular, all DNA transactions in the cell's nucleus (replication, recombination, repair and transcription) are carried out by multi-molecular protein and nucleic acid complexes that assemble in a timely, regulated manner in specific subnuclear locations. Recent advances in live imaging microscopy and the possibility of tagging biological molecules with fluorescent probes or quantum dots now permit the visualization of these events inside the living cells and in real time. Among several available techniques, fluorescence resonance energy transfer (FRET) permits the visualization of direct protein-protein interactions; fluorescence recovery after photobleaching (FRAP) monitors protein trafficking inside different subcellular compartments; fluorescence correlation spectroscopy (FCS) studies the diffusion of molecules inside biological microenvironments.

The in vivo application of imaging techniques would allow the visualization of molecular and cellular processes in living organisms, thus representing a powerful tool to understand the mechanisms underlying biological and pathological events. The exploitation of visible light imaging in whole organisms, however, is rather limited by the adsorption properties of several body constituents. To overcome these limitations, imaging is performed in the near-infrared range (NIR), using radioactive tracers (PET, SPECT) or by exploiting the magnetic resonance properties of the tissues (MRI). Some of these techniques are already extensively used in clinics (PET, CT-SPECT, MRI); NIR imaging is currently limited to animal research, although its prompt transposition to humans is highly desirable and expected over the next few years.

In this presentation, I will review some of our applications of the above mentioned imaging techniques in the field of HIV-1 research and gene therapy for cardiovascular disorders.