X-ray Tomography of Biological Cells

abstract

X-ray tomography generates 3D images of whole, hydrated, biological specimens up to 10 microns thick with a spatial resolution better than 50 nm. Soft X-ray microscopy uses photons with energies between the K shell absorption edges of carbon (284 eV, λ=4.4 nm) and oxygen (543 eV, λ=2.3 nm). These photons readily penetrate the aqueous environment while encountering significant absorption from carbon- and nitrogen-containing organic material. In this energy range, referred to as the ‘water window,’ organic material absorbs approximately an order of magnitude more strongly than water, producing a quantifiable natural contrast and eliminating the need for contrast enhancement procedures to visualize cellular structures.

The high penetrating power, coupled with a near absence of reflection at the interface of dissimilar materials, makes X-rays an ideal probe for studying cellular morphology and examining the location of labeled proteins in single cells. We have used this imaging approach to reveal remarkable details of the nuclear and cytoplasmic architecture of fully hydrated whole cells. We have also localized molecules using immunogold labeling protocols. We are developing additional labels uniquely suited to x-ray imaging to enable simultaneous localization of multiple proteins. Using the x-ray linear absorption coefficient, quantitative information about cellular structures and molecular distributions can be obtained from the reconstructed data.


Refreshments to follow in Room 2-222
- Leonard Lounge - Knudsen