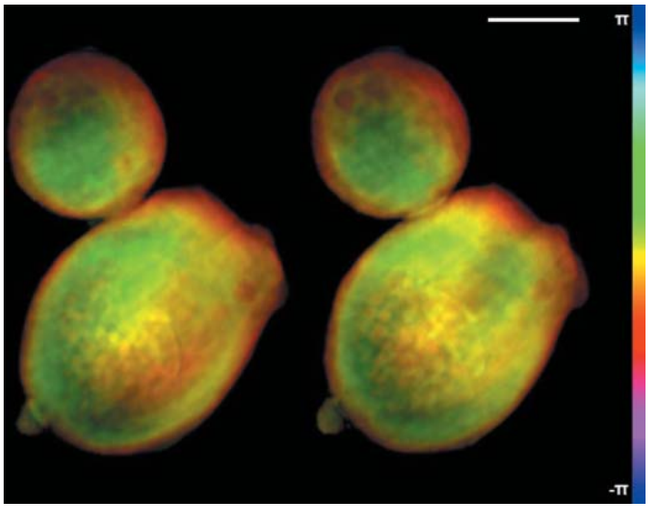

Figure 9.3.3.3
Stereo image of a budding yeast cell. This budding yeast cell was chemically fixed with gluteraldehyde and dehydrated in acetone. The images have an angular separation of 10° and a pixel size of 11 nm. The three-dimensional arrangement of a group of small vesicles in the mother cell can be visualized when viewed stereoscopically (with the viewer's focus in front of the image). The scale bar is 500 nm.

to imaging, although this change does not seem to alter the relative arrangement of organelles. The development of low-dose techniques will allow for the direct observation of these radiation-induced changes. In the long run, it is cryogenic protection that provides the most valuable structural information, since the cells are maintained in a near living state. Ultra-high-resolution three-dimensional imaging will still require the development of low-dose techniques, as cryoprotected samples have also been observed to suffer from mass loss with the accumulation of very high X-ray doses ($>10^{10}$ Gy). These imaging techniques are currently under development at the ALS in collaboration with Stony Brook University and elsewhere. Alternatively, X-ray free-electron lasers (FELs) promise the highest resolution imaging of living cells that is possible by any means; indeed, it has been proposed that sub-nanometre resolution is possible (Bergh *et al.*, 2008). The ultra-short and ultra-bright pulses of an X-ray FEL will encode the structural information from a living cell before it is destroyed by the pulse.

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