Three-Dimensional Coherent Diffraction Imaging of Materials and Cells

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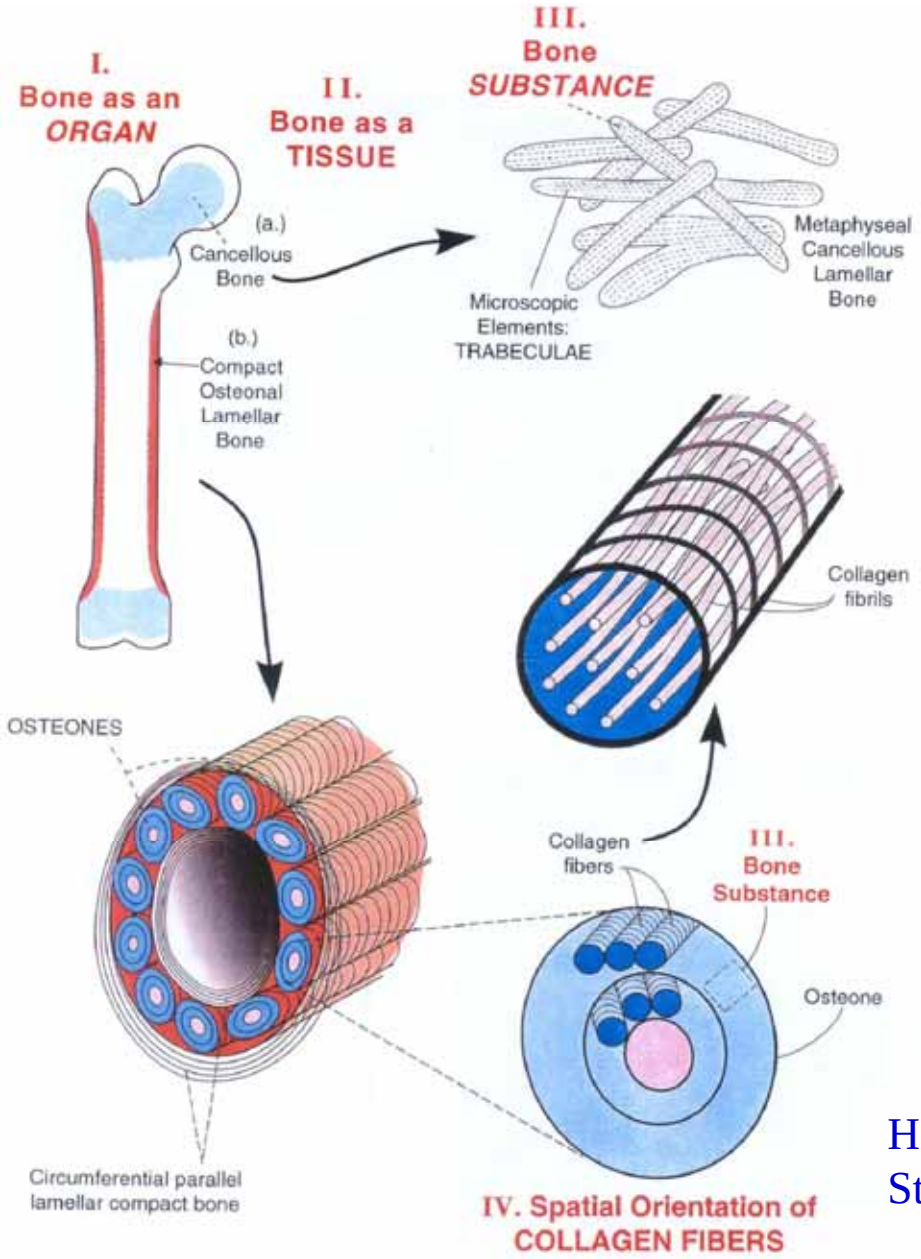
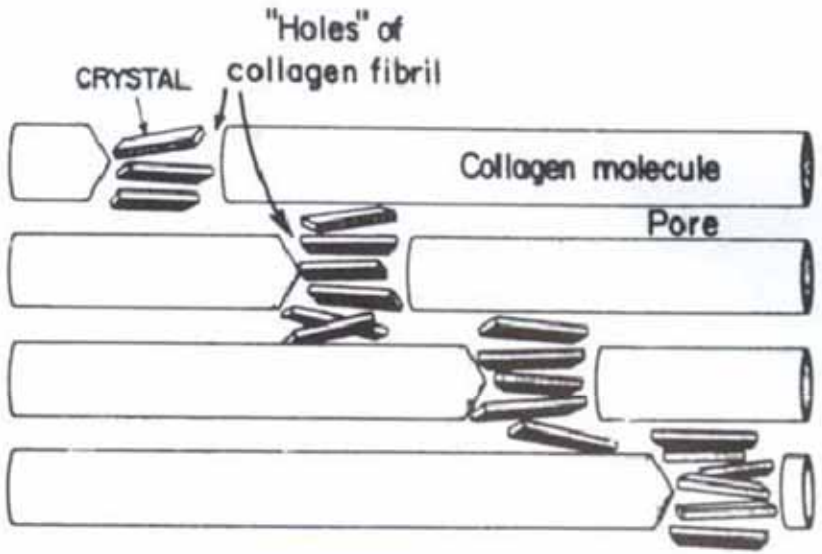
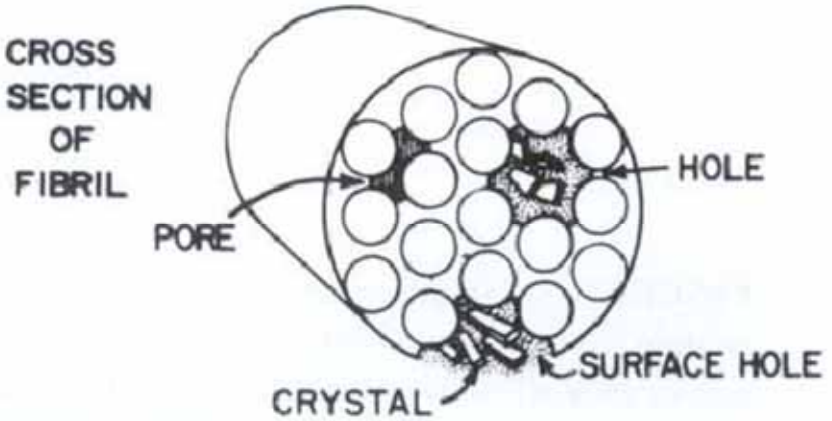
Workshop on Diffraction Microscopy, Holography and Psychograph using Coherent Beams, Ithaca, NY, June 6-7, 2011

Hierarchical Structure in Bone

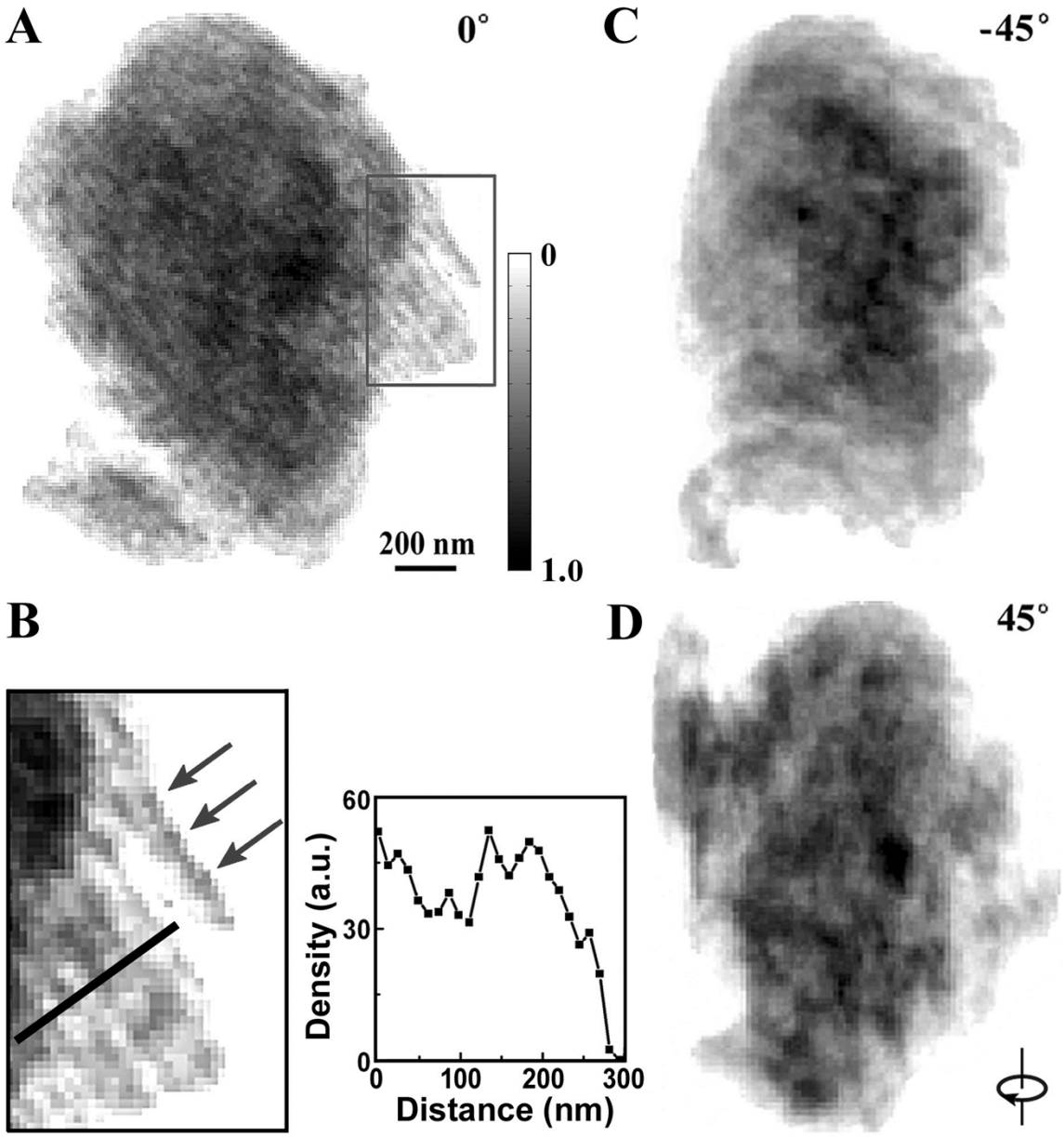




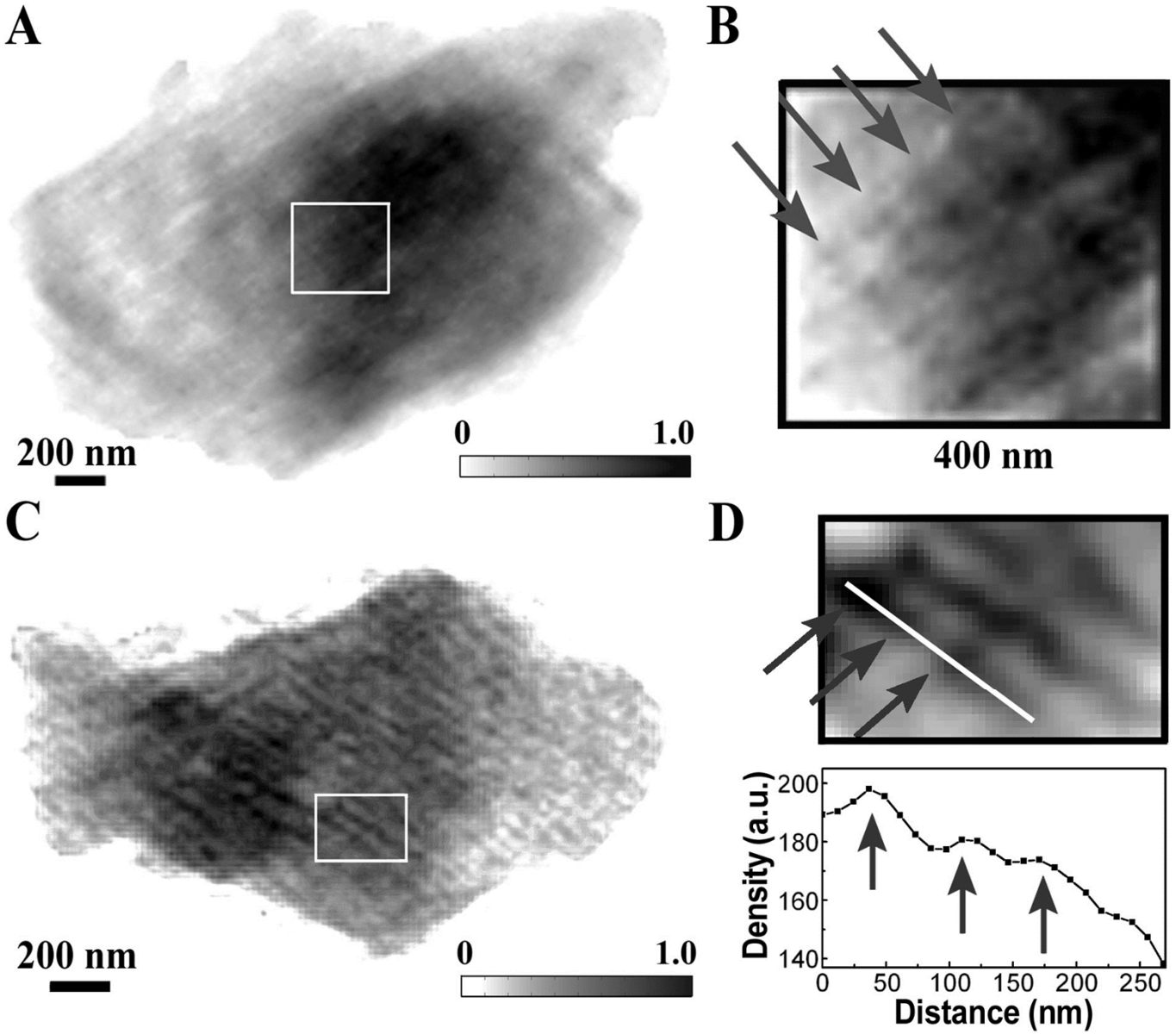


Hodge & Petruska (1963) in Aspects of Protein Structure, Ed. Ramachandran, pp 289-300.

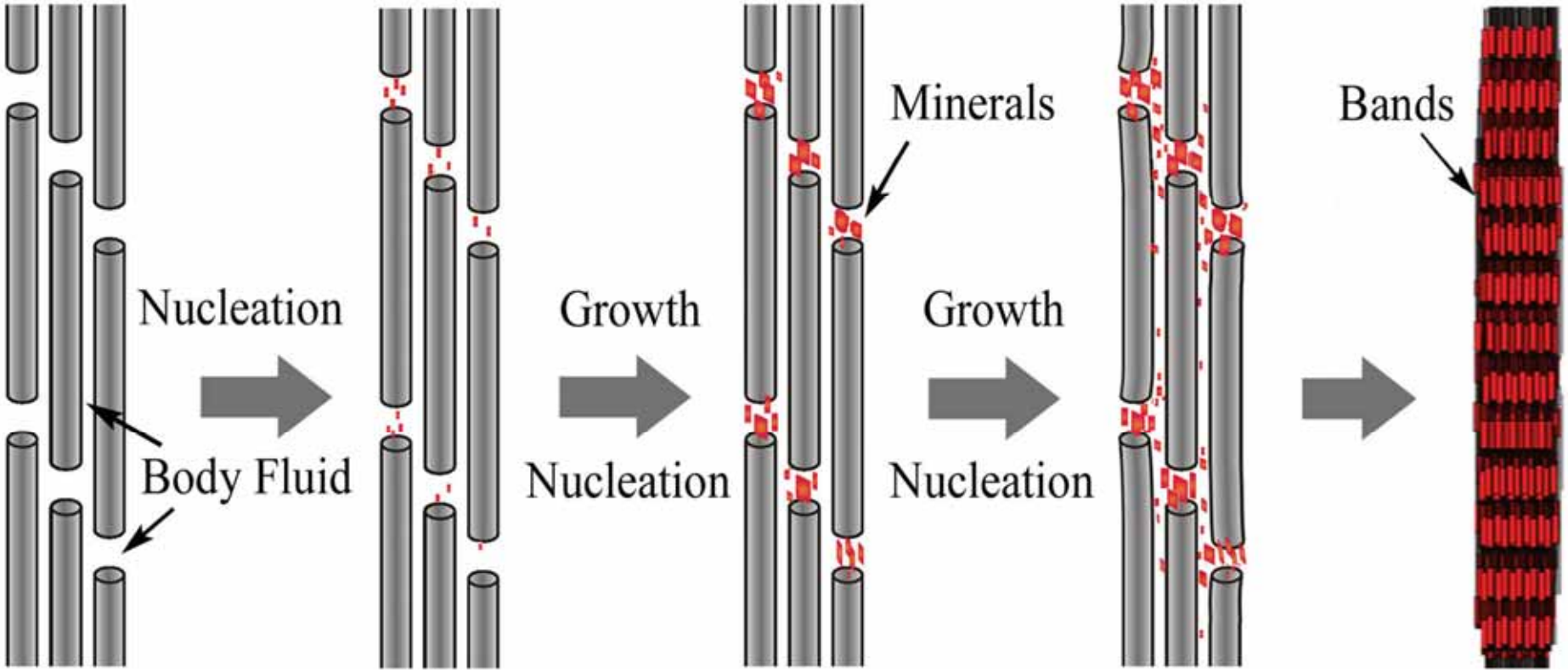
Coherent X-ray Diffraction Imaging of Low Mineralized Bone Particles



Coherent X-ray Diffraction Imaging of Highly Mineralized Bone Particles

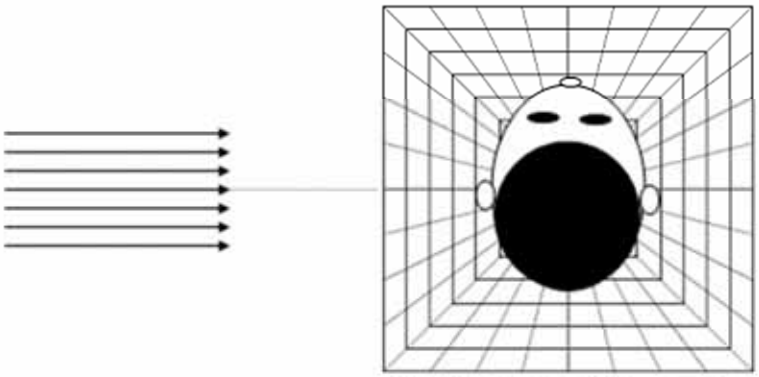


Dynamic 3D Structure Model of the Mineral Phase in Bone



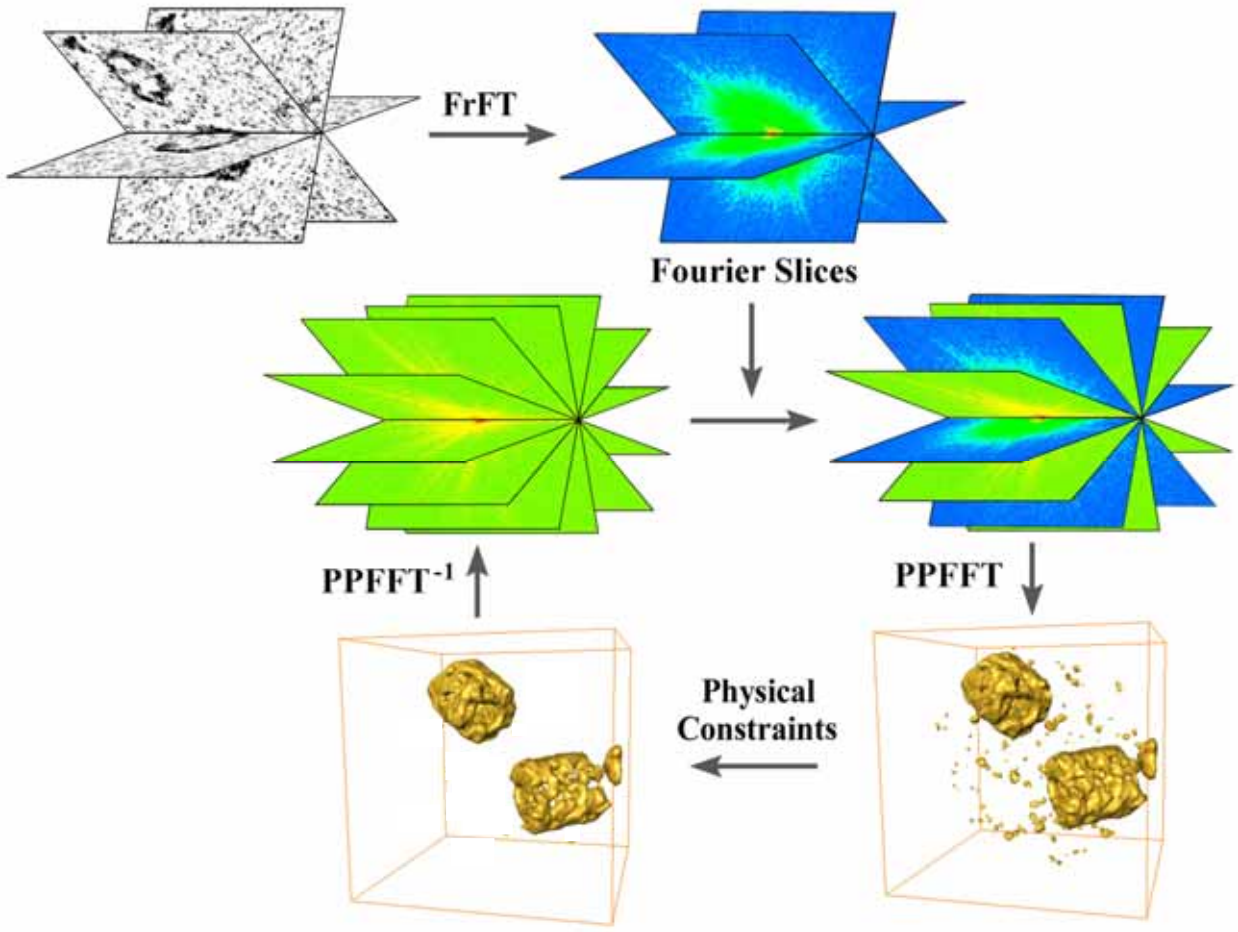
Jiang, Ramuno-Johnson, Song, Amirbekian, Kumara, Nihshino, Takahashi, Ishikawa & Miao , *PRL* **100**, 038103 (2008).

Equally-Sloped Tomography (EST)



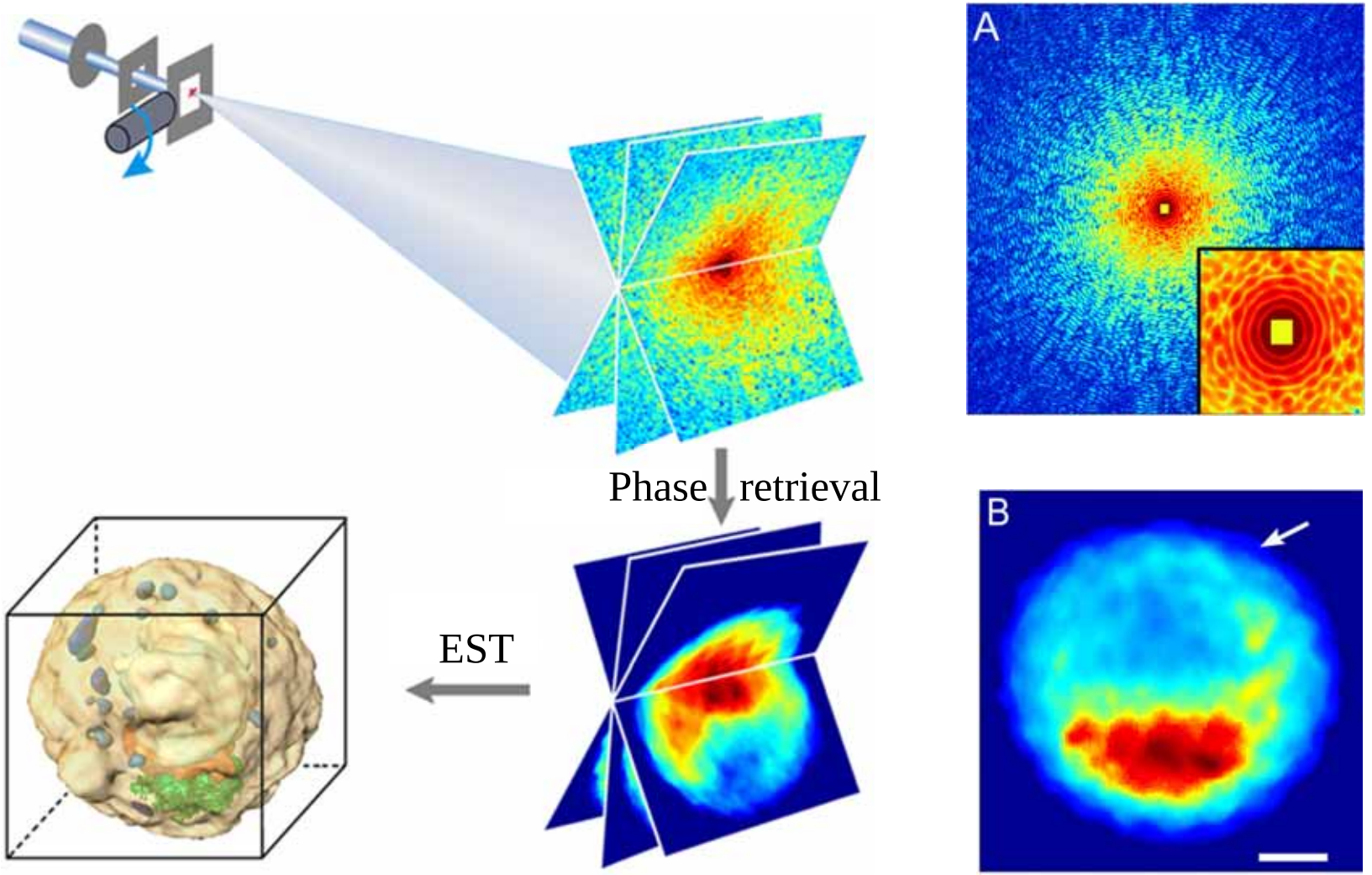
Miao, Förster & Levi, *Phys. Rev. B.* **72**, 052103 (2005).

Iterative EST Algorithm

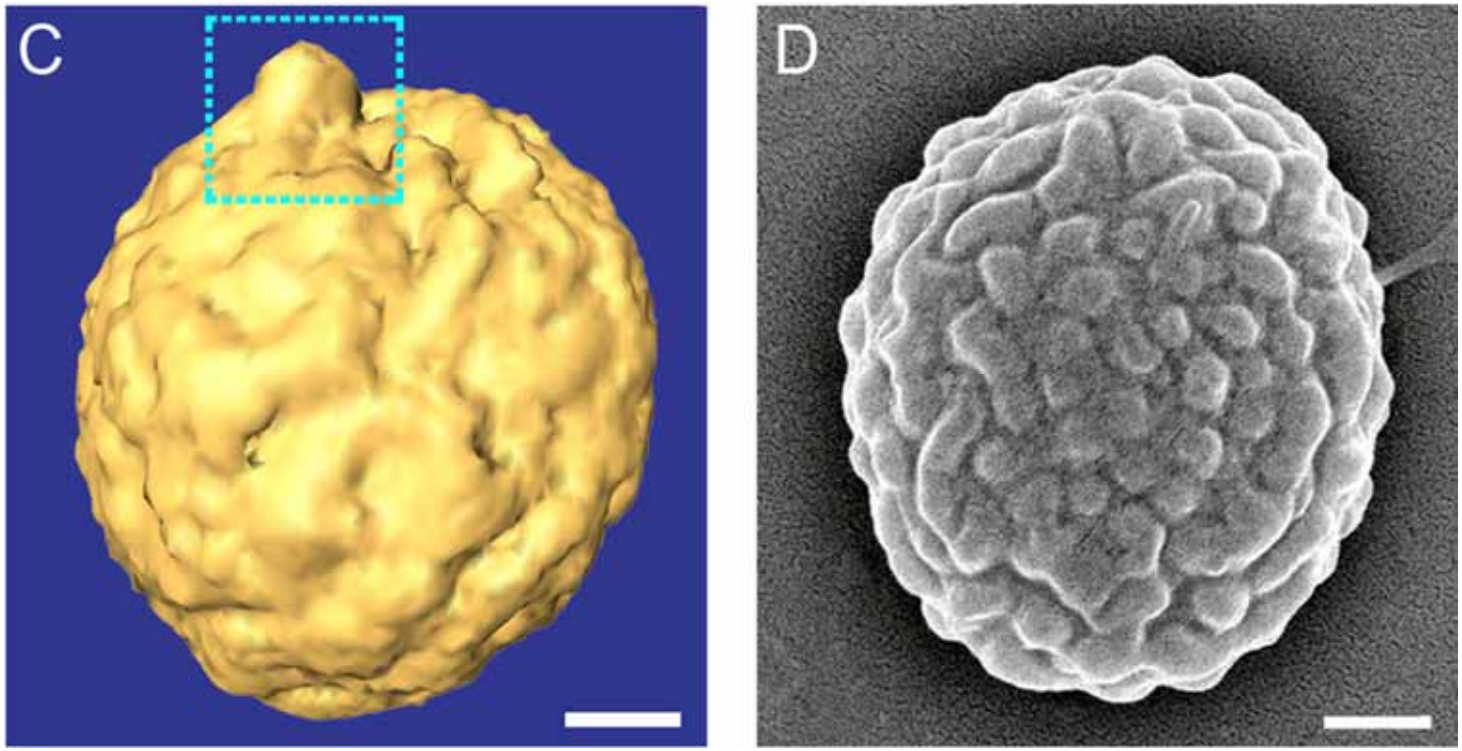


Miao, Chen, Song, Nishino, Kumara, Ishikawa *et al*. *PRL* **97**, 215503 (2006).
Lee *et al*., *J. Struct. Biol*. **164**, 221 (2008).
Mao, Bahamian, Osher, Miao, *IEEE Trans. Image Processing* **19**, 1259 (2010).
Bahamian, Mao, Clemens, Miao, *Phys. Med. Biol*. **55**, 5383 (2010).

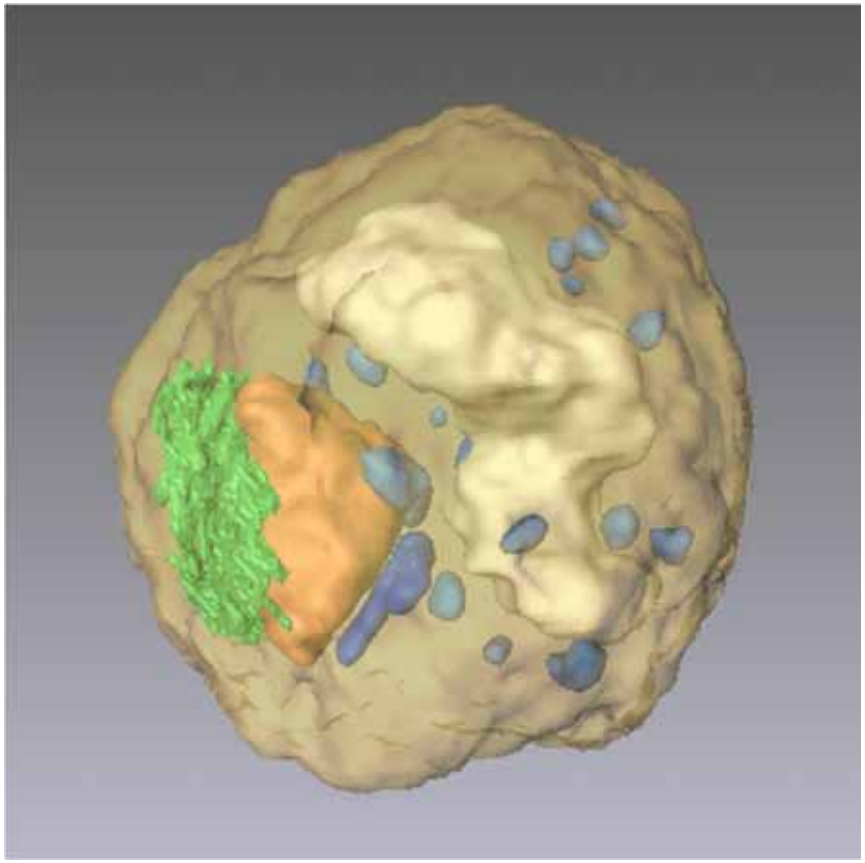
Coherent Diffraction Imaging of a Fission Yeast Spore



Iso-Surface Rendering of the Yeast Spore Cell

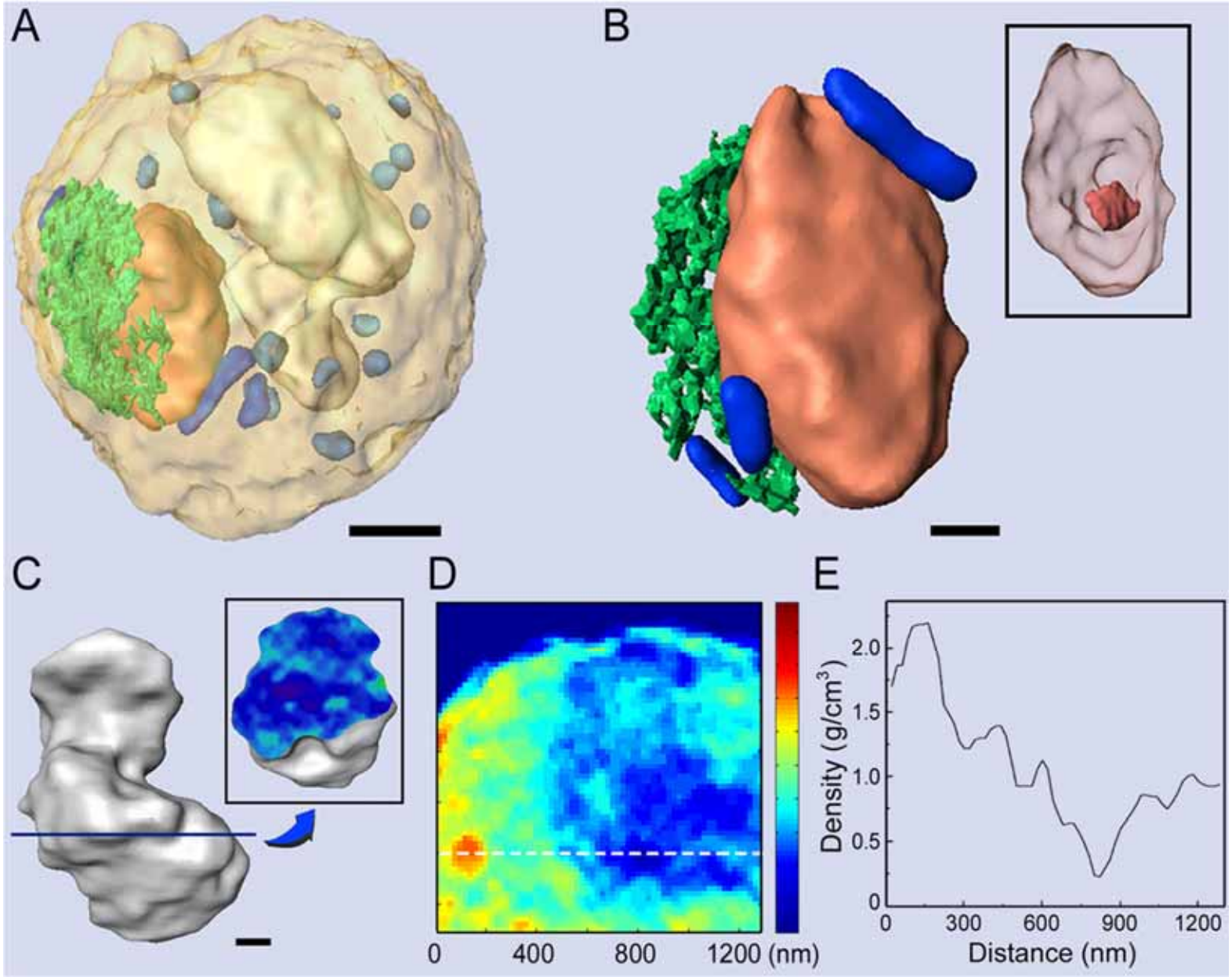


3D Internal Structure of the Yeast Spore Cell



Jiang, Song, Chen, Xu, Raines, Bahamian, Lu, Lee, Nakashima, Urano, Ishikawa, Tamanoi & Miao, *PNAS* **107**, 11234 (2010).

3D View of Intercellular Organelles



Ankylography: 3D Structure Determination from a Single View

Ankylography: Derived from Greek words *ankylos* - ‘curved’ and *graphein* - ‘writing’.

Raines, Salha, Sandberg, Jiang, Rodríguez, Bahamian, Kapteyn, Du, Miao, *Nature* **463**, 214-217 (2010).

(Source Codes: www.physics.ucla.edu/research/imaging/Ankylography)

Super-resolution crystallography: Schroder, Levitt, Brunger, *Nature* **464**, 1218-1222 (2010).

Discrete tomography: Van Aert et al., *Nature* **470**, 374–377 (2011).

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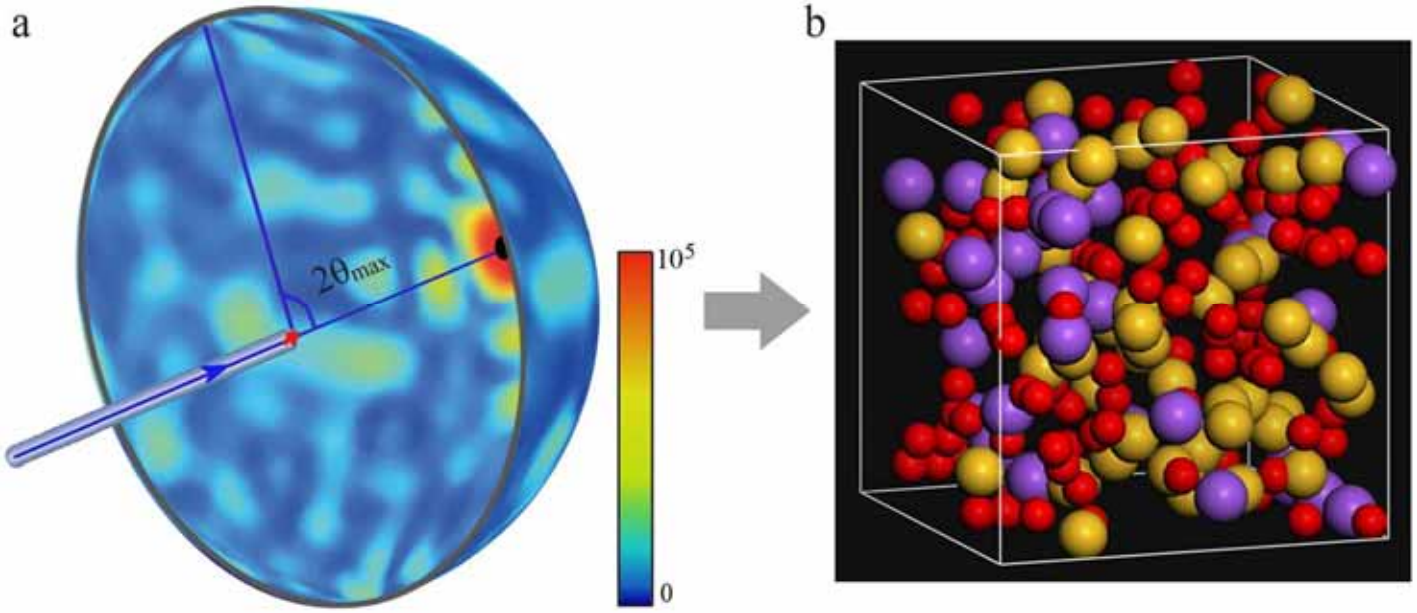


The way of our thinking should not be confined by the Fourier transform.

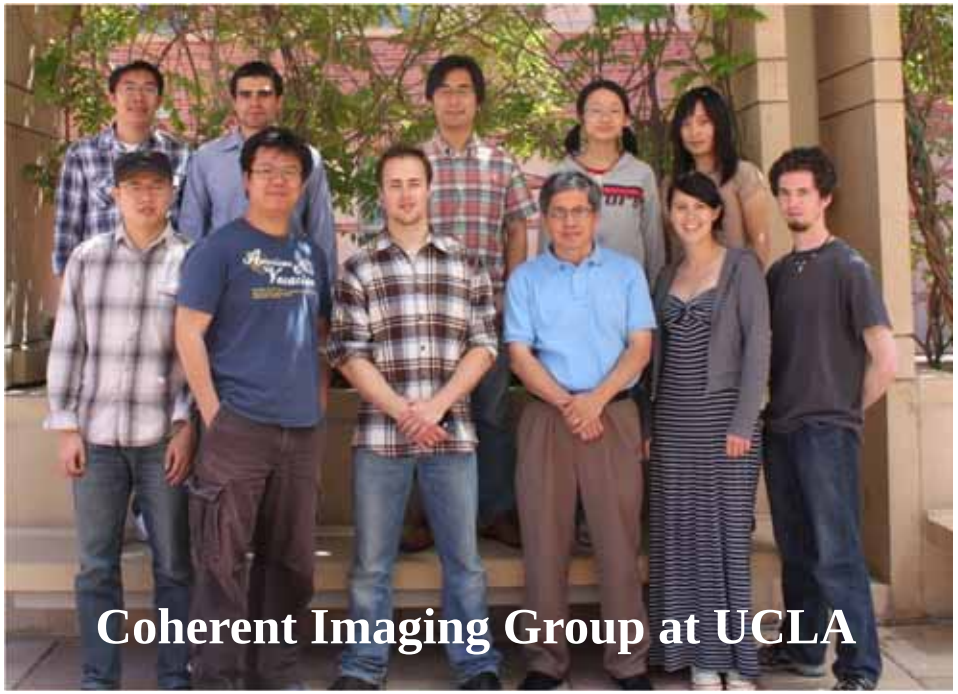
Summary

- **Applied CDI to the understanding of bone structure. A dynamic 3D structure model of the mineral phase in bone was suggested.**
- **Developed EST for tomographic reconstructions with a limited # of projections and a missing wedge. EST has been combined with phase retrieval for 3D coherent diffraction imaging.**
- **CDI has been used to quantitatively characterize the 3D structure of materials at extreme conditions.**
- **3D imaging of a whole, unstained cell at a resolution of 50–60 nm and the 3D internal cellular structures are identified.**
- **Ankylography: 3D structural determination of small objects from a single view.**
- **With ERLs, it is safe to predict that CDI can be applied to characterize materials at sub-1 nm resolution and image whole cells and cellular organelles at 5-10 nm resolution in 3-dimensions.**

Acknowledgements

RIKEN/SPring-8	***T. Ishikawa, C. Song, Y. Kumara, M. Yamamoto, K. Yonekura***
Univ. of Colorado, Boulder	***M. M. Murnane, H. C. Kapteyn***
APS, ANL	***I. McNulty***
UCLA Microbiology, Immunology, and Molecular Genetics	***F. Tamanoi, Z. H. Zhou***
UCLA, Molecular and Medical Pharmacology	***R. Sun***
Carnegie Institution of Washington	***H.-K. Mao, W. Yang***
ESRF	***E. Brun, A. Bravin***
Shandong Univ.	***H. Jiang***
Keio Univ.	***M. Nakasako***
Los Alamos National Lab	***R. L. Sandberg***
Hokkaido Univ.	***Y. Nishino***
Academia Sinica, Taiwan	***T. K. Lee***
Univ. of North Texas	***J. Du***
Osaka Univ.	***Y. Takahashi***

Supported by NIH/NIGMS, UC Discovery, Tom Soft Inc. & RIKEN



Coherent Imaging Group at UCLA