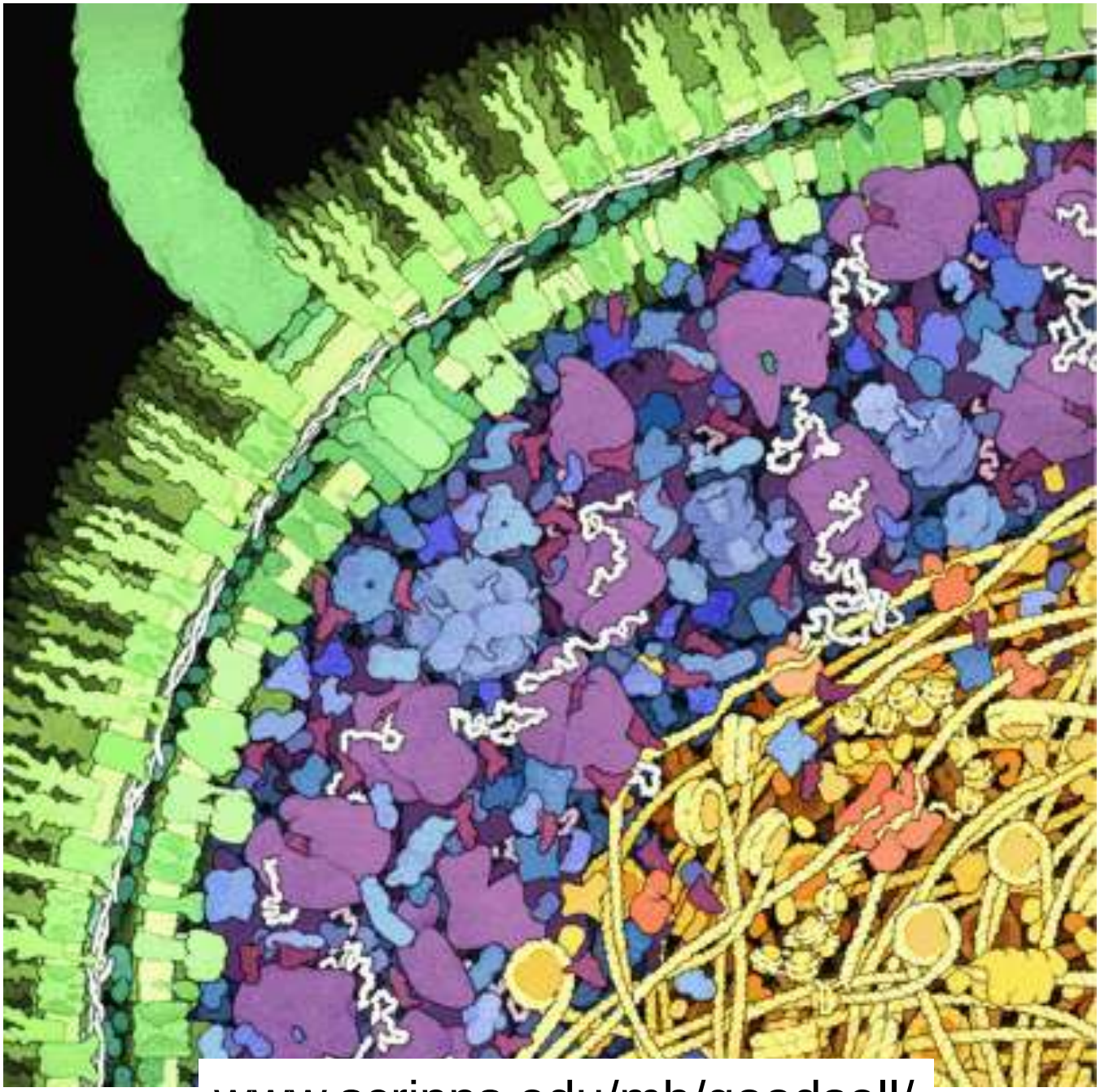
Frontier Applications of X-Ray Science in Biology

The Energy Recovery Linac X-Ray Source

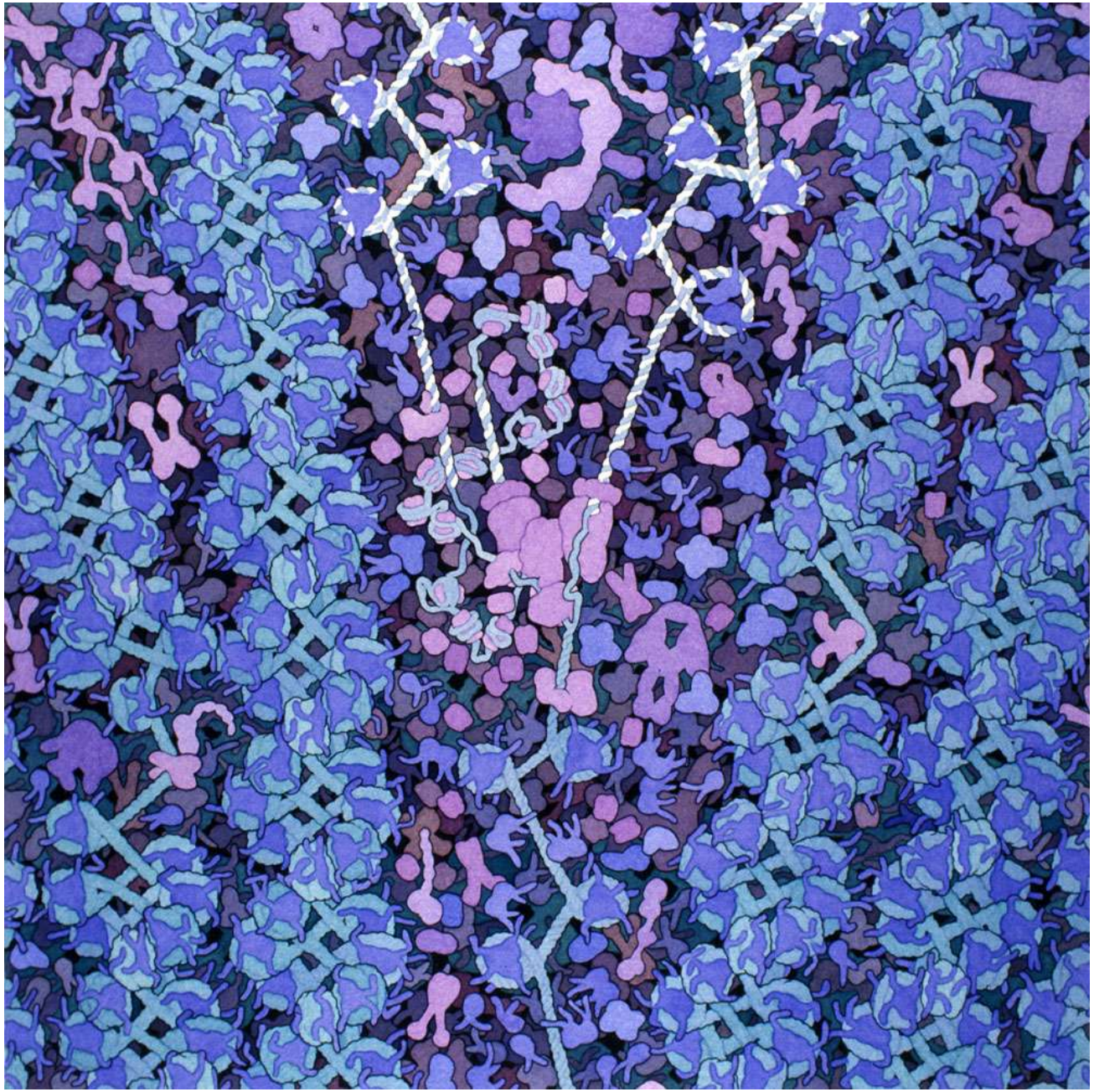

Ottawa
Montréal
Toronto
hicago
Chicago River
New York
Manhattan Island
Philadelphia
Washington D.C.
H


Hoboken
New York
Manhattan Island
Image © 2006 DigitalGlobe


MetLife

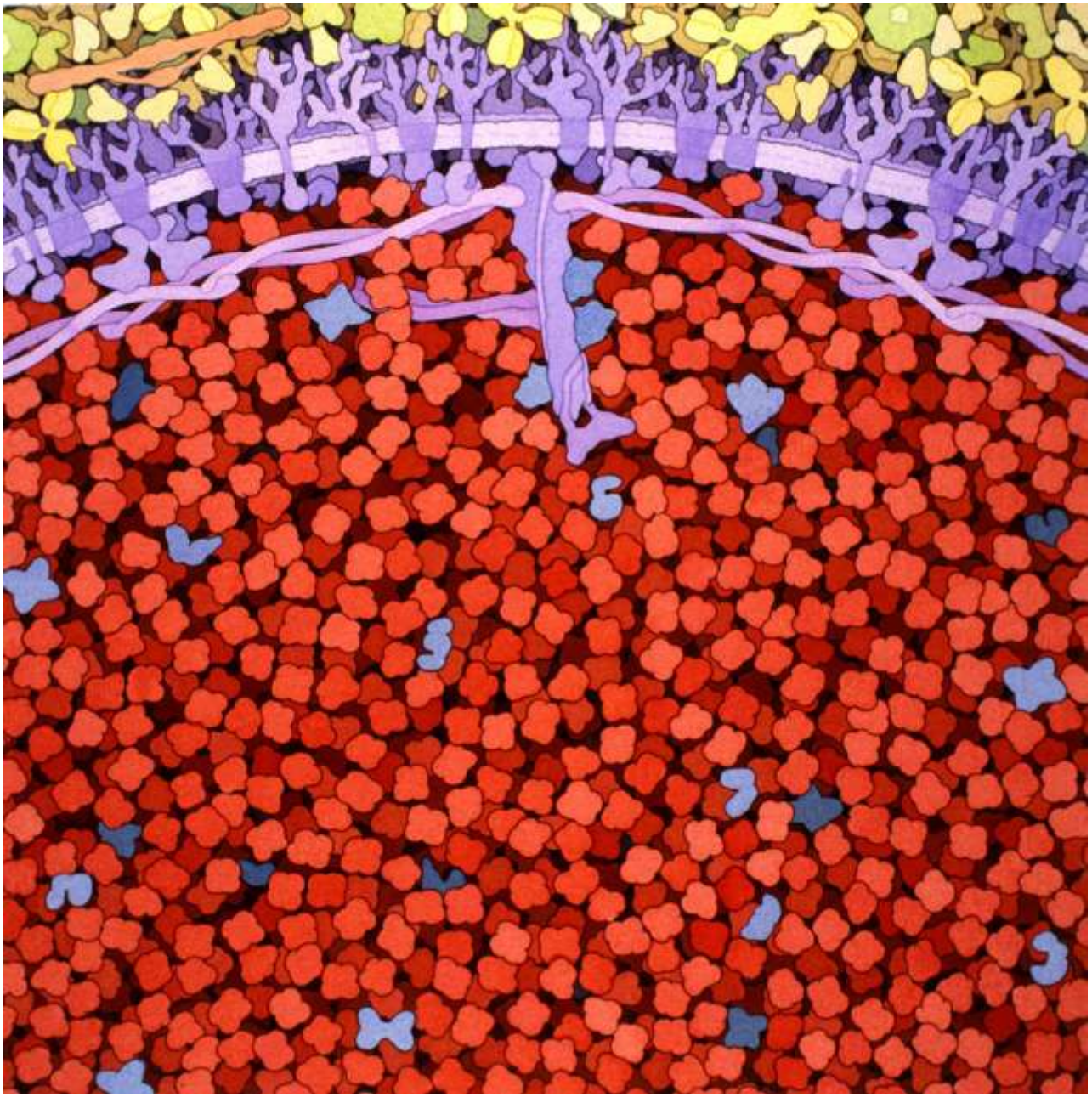


www.scripps.edu/mb/goodsell/



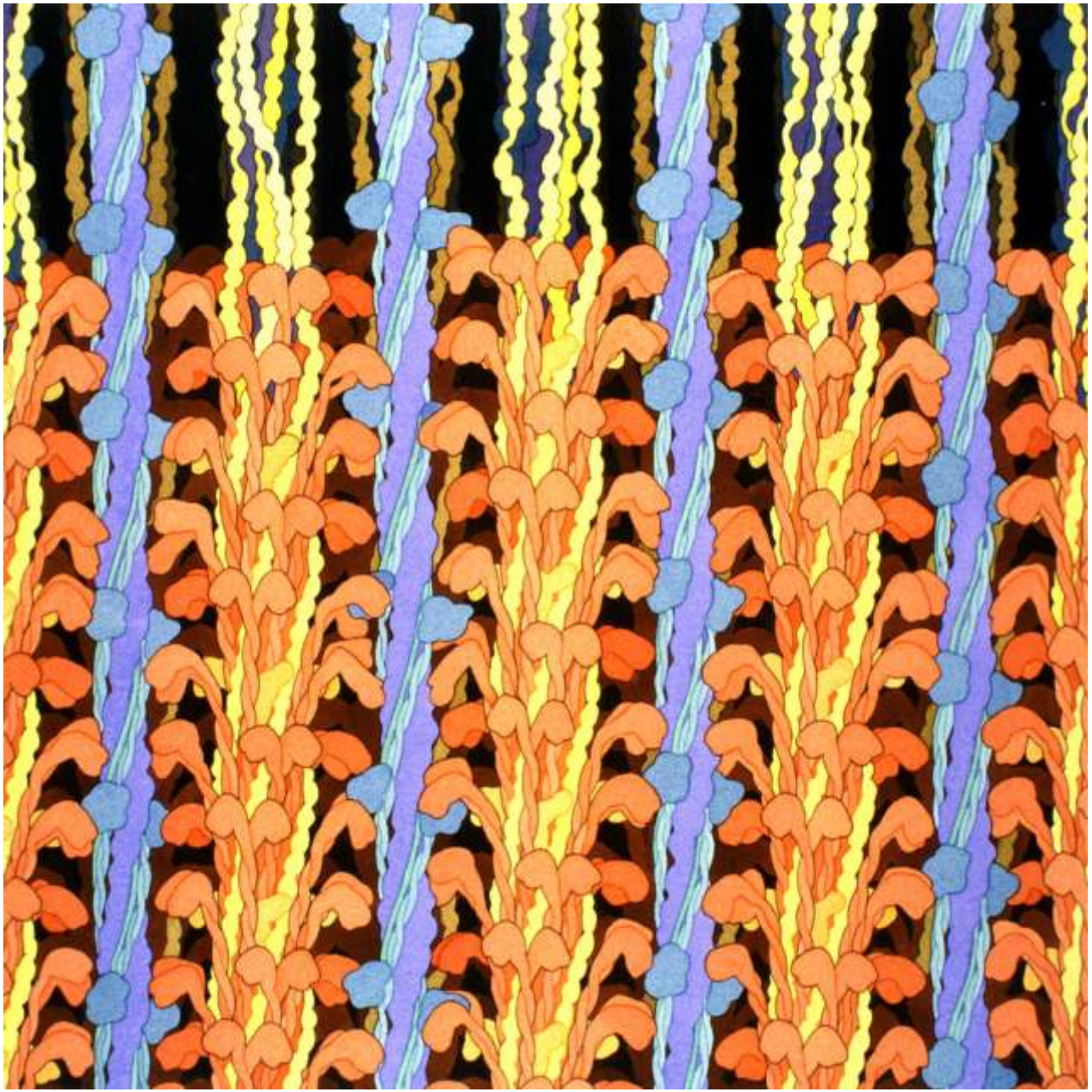
Nucleus

This view shows DNA being replicated in the nucleus. DNA polymerase is shown at the center in purple, with a DNA strand entering from the bottom and exiting as two strands towards the top. The new strands are shown in white. Chromatin fibers are shown at either site of the replication fork.



Red Blood Cell

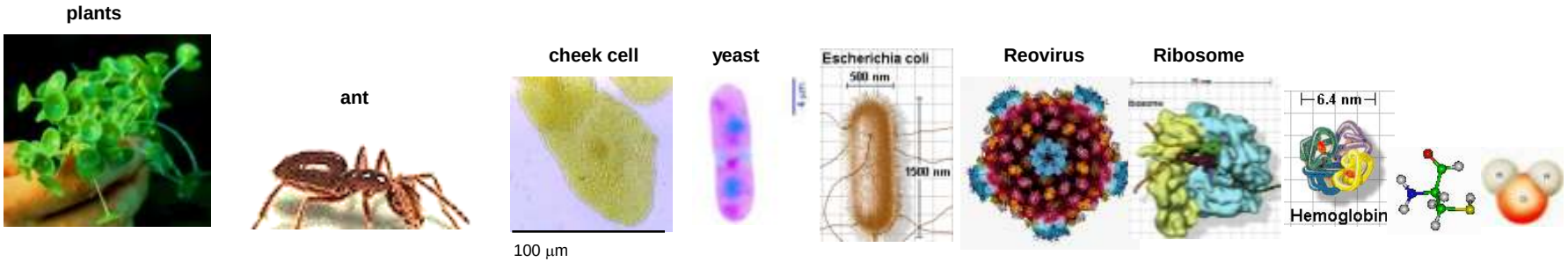
A portion of a red blood cell is shown in this illustration, with the cell membrane at the top, and lots of hemoglobin (red) at the bottom.



Muscle

Part of a muscle sarcomere is shown here, with actin filaments in blue and myosin filaments in red. The long yellow proteins are the huge protein titin.

Structural biology is a branch of molecular biology concerned with the study of the architecture and shape of biological macromolecules -- proteins and nucleic acids in particular -- and what causes them to have the structures they have. This subject is of great interest to biologists, because macromolecules carry out most of the functions of a cell, and because typically it only is by coiling into a specific three-dimensional shape that they are able to perform their functions. —Wikipedia



Spectroscopies (fluorescence, polarization, anisotropy, etc.)

Neutron crystallography & scattering

Atomic force microscopy

X-ray scattering (fibers, powers, solutions)

Dynamic light scattering

Circular dichroism

What are we still missing?

- the gap between atomic structure and cellular structure
- seeing molecules in vivo (instead of trapped in a crystal lattice)
- molecular flexibility and disorder (instead of average over structures)
- time evolution, resolve the steps in the process (no average over time)
- need still higher resolution (importance of slight motions)
- see transient interactions with other proteins

Workshop Goals:

- Become familiar with the ERL capabilities
- ***What are the "killer apps" in your field? (grand challenges?)***
- How do we convey their importance to the average taxpayer?
- What are the beam requirements for your experiments?
- What types of beamlines should we have? (soft x-ray?, windowless?)
- What other equipment/technological advances are needed?
- How hard is it to do this elsewhere or with other methods?
- Have we left out any important areas?

What does an ERL do best?

- high spectral brightness (high-flux, collimated nanobeams)
- VERY collimated (push SAXS to larger sizes!)
- coherent x-rays
- fully tunable energy
- very small source size (can produce 1-10nm beams)
- round source size (horizontal and vertical polarization!)
- high stability (CW-like, No beam decay, No need for refills!)
- high rep rate (> 1 Ghz)
- fast pulses (as low as 50 fs)
- deterministic programmable pulses

Wednesday, June 21st		
8:00 – 8:30 a.m.	Breakfast and Sign-In	
8:30 – 9:00	Workshop Introduction and Goals	**Richard Gillilan,** Cornell University
9:00 – 9:30	ERL Project Summary and ERL Characteristics	**Sol Gruner**, Cornell University
9:30 – 10:15	Micron and Nanometer-sized Beams for Crystallography	**Christian Riekel,** European Synchrotron Radiation Facility
10:315- 10:45	Break	
10:45 – 11:15	Thresholds in Protein Crystallography: Finding the Limits of Conventional Techniques to Inspire Unconventional Thinking	**James Holton,** Lawrence Berkeley National Laboratory
11:15 – 12:00	Radiation Damage, Small Protein Crystals and the Cornell ERL	**Colin Nave,** Daresbury Laboratory
12:00 – 12:15	Group Photo	
12:15 – 13:15	Lunch	
13:15 – 14:00	Femtosecond Time-resolved Laue Crystallography: Using an ERL to Watch Proteins Function on the Chemical Scale	**Philip Anfinrud,** National Institute of Diabetes & Digestive & Kidney Diseases, National Institutes of Health
14:00 – 14:30	Challenges and Opportunities for Time-resolved Crystallography at the Next Generation X-Ray Sources	**Reinhard Pahl,** Advanced Photon Source, Argonne National Laboratory
14:30 – 15:00	Time-Resolved SAXS Studies of Macromolecular Folding	**Lois Pollack,** Cornell University
15:00 – 15:30	Break	
15:30 – 16:00	Soft X-Ray Spectromicroscopy Studies of Microbial Processes at Environmental Interfaces	**Gordon Brown,** Stanford University and Stanford Synchrotron Radiation Laboratory
16:00 – 16:30	Subcellular Imaging of Trace Metal Distribution and Chemistry by X-ray Microfluorescence	**Barry Lai,** Advanced Photon Source, Argonne National Laboratory
16:30 – 17:00	Intracellular Localization of Titanium-DNA Nanocomposites	**Gayle Woloschak,** Northwestern University Medical School
18:00	Cocktail Reception & Dinner	

Thursday, June 22nd		
8:00 – 8:30 a.m.	Breakfast and Sign-In	
8:30 – 9:00	Welcome to Day II	**Richard Gillilan,** Cornell University
9:00 – 9:30	TBD	**Sol Gruner,** Cornell University
9:30 – 10:00	XANES-based Comparative Chemistry in the Anatomical Evolution of Living and Fossil Plants	**Charles Kevin Boyce,** University of Chicago
10:00 – 10:30	Imaging Cells Beyond X-ray Optics Limits: Status and Possibilities	**Chris Jacobsen,** Brookhaven National Laboratory
10:30 – 11:00	Break	
11:00 – 11:30	Structural Systems Biology using Future Coherent Light Sources	**Thomas Earnest,** Lawrence Berkeley National Laboratory
11:30 – 12:00	A Proposal to use Multiphoton Correlation Measurements to Solve the Phase Problem in X-ray Crystallography	**Kenneth Frankel,** Lawrence Berkeley National Laboratory
12:00 – 12:30	Scanning Photoelectron Spectromicroscopy (SPES): Topography and Chemistry of Natural Specimens with 1 nm Resolution	**Pupa Gilbert,** University of Wisconsin
12:30 – 13:30	Lunch	
13:30 – 14:00	Phase-Contrast Imaging for the Study of Small Animal Physiology	**Wah-Keat Lee,** Advanced Photon Source, Argonne National Laboratory
14:00 – 15:00	Beamline Configuration Discussion	**Richard Gillilan,** Cornell University
15:00 – 16:30	Breakout Sessions / Writeups	
16:30 – 17:00	Meeting Wrap-up	
17:00 – 17:30	Board bus at RPCC	
17:30 – 18:00	Cocktails Taughannock Farms Inn on Cayuga Lake	
18:00 – 20:30	Dinner Taughannock Farms Inn	
20:30	Board bus back to Cornell