Establishing Innovative Space Research Partnerships with Biotechnology & Pharmaceutical Companies

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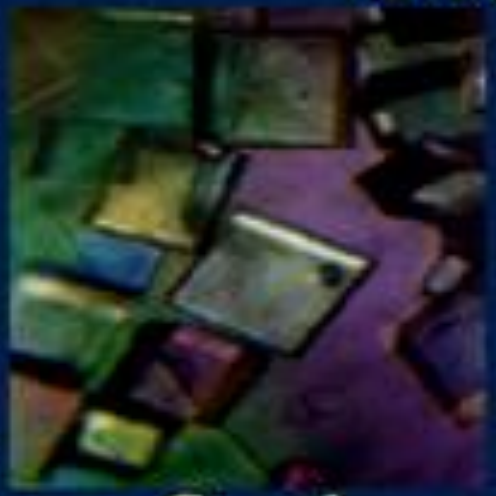
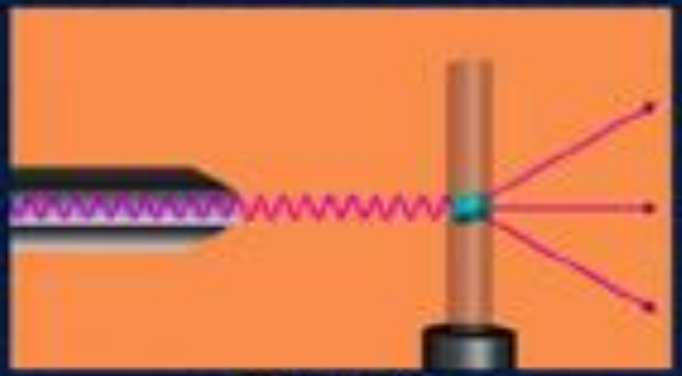
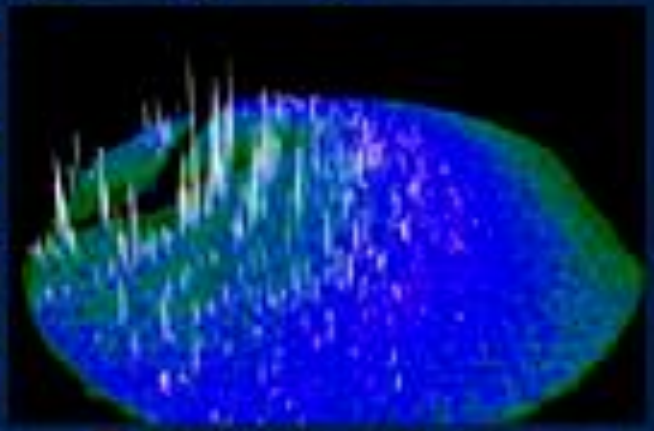
Protein Crystallography



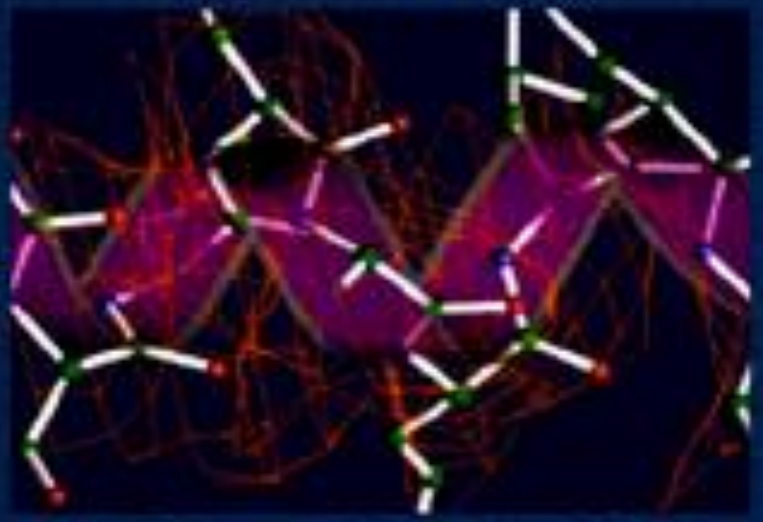
Crystals



X-rays



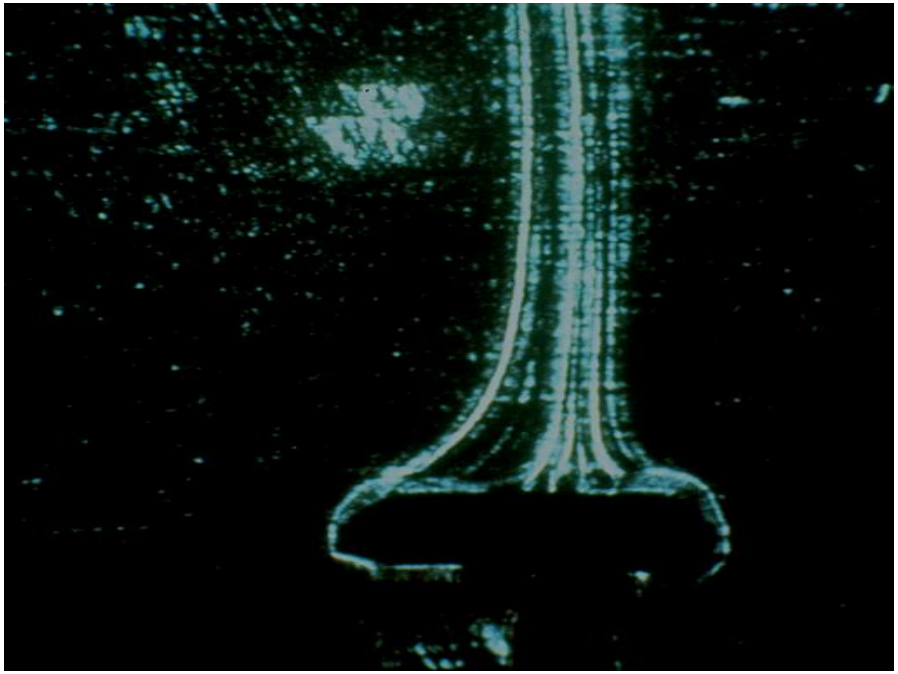
Diffraction Pattern

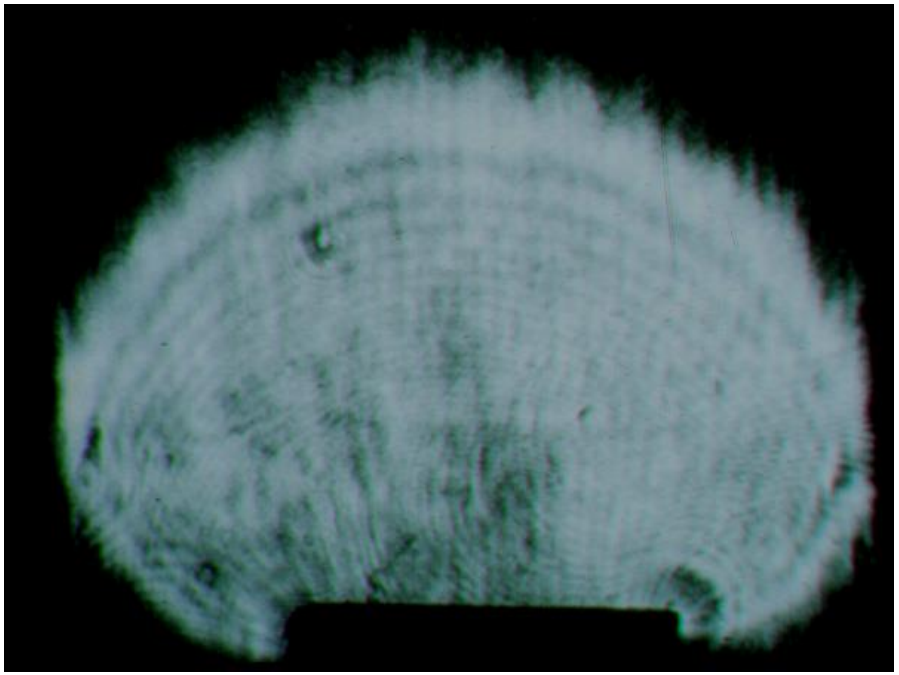


Electron Density Map

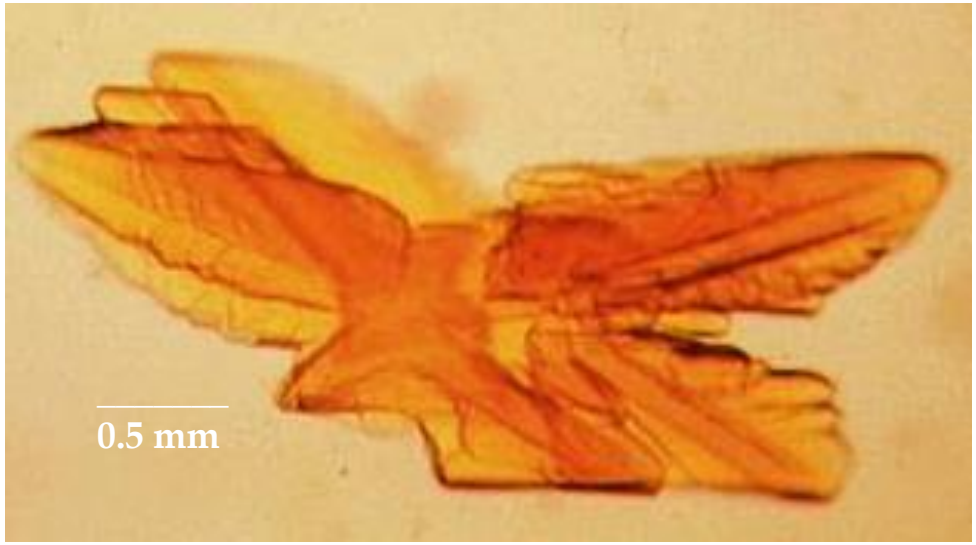
Protein Structure

Presentation by Dr. Roger Kroes, MSFC

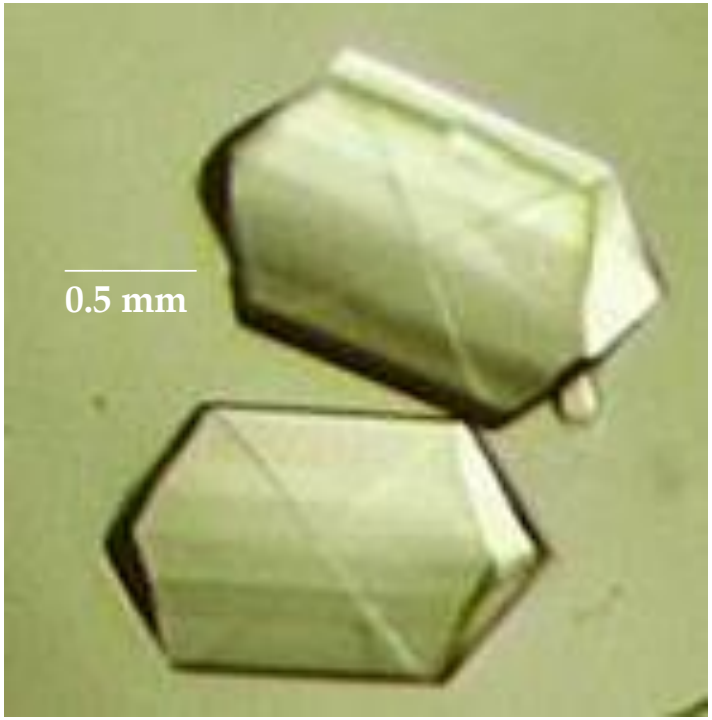




Isocitrate Lyase Crystals

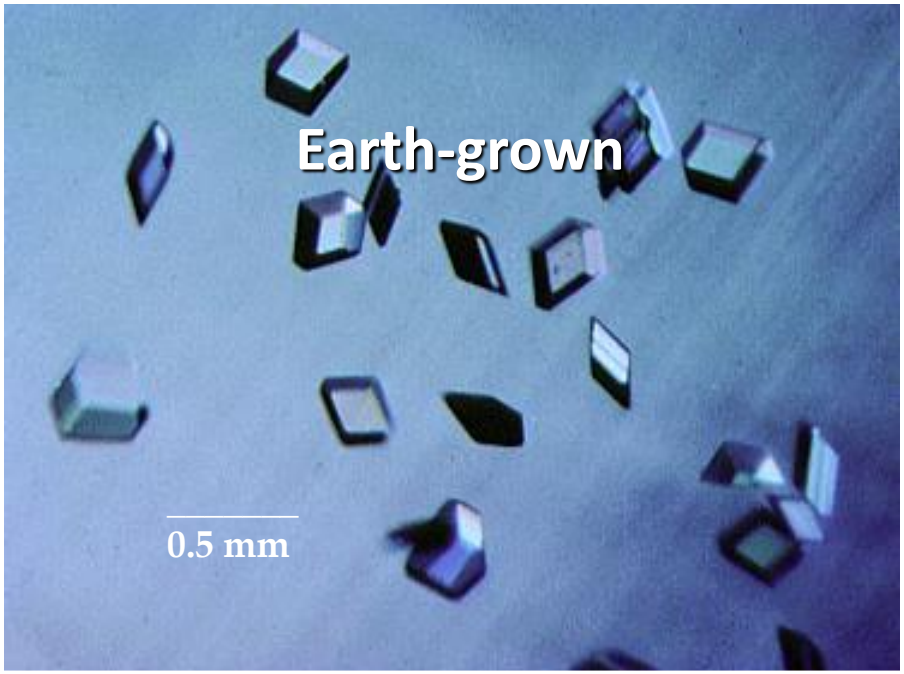


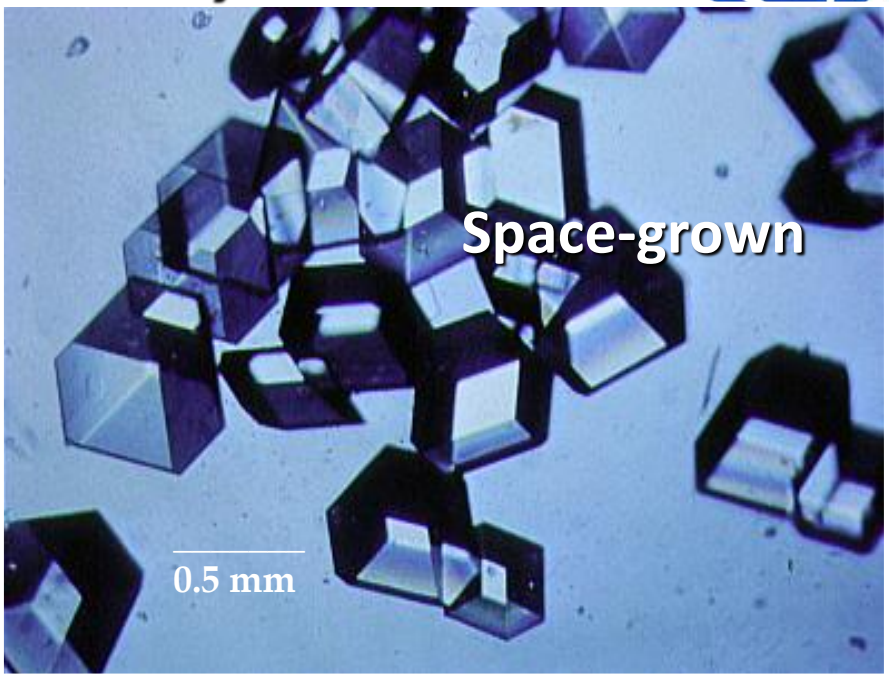
Earth-grown crystals

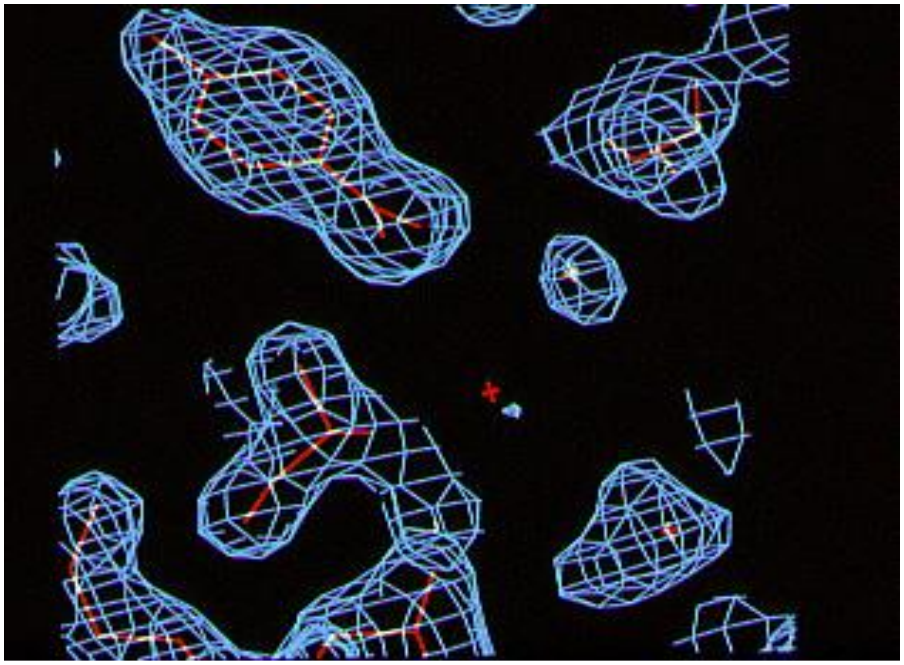


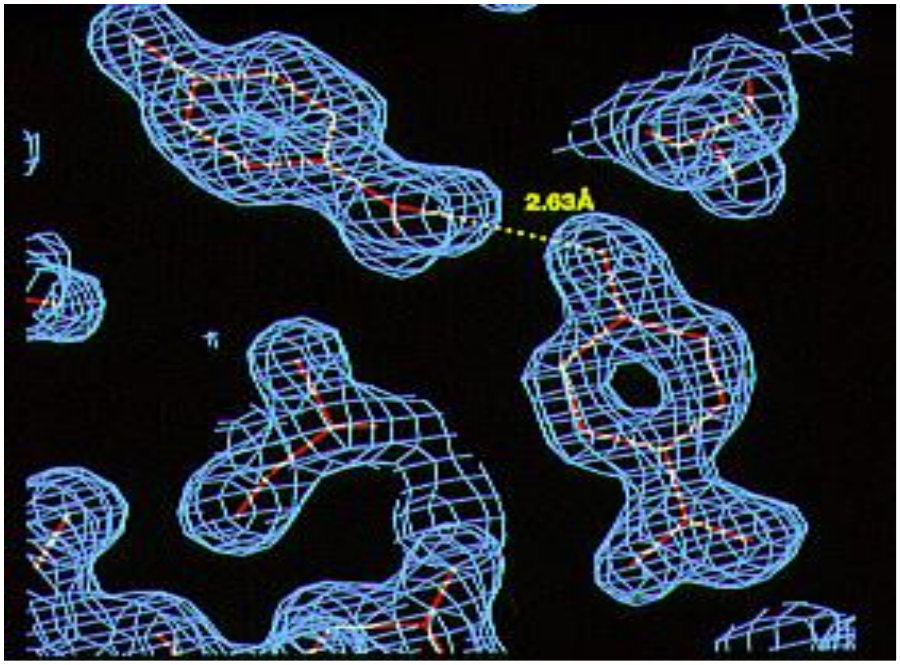
Microgravity-grown crystals

Human Insulin Crystals









Transition of our Crystallography Laboratory to a NASA Commercial Space Center

1984 - Senator Howell Heflin

1985 – protein crystallization performed on 4 space shuttle flights

1986 – NASA Selects 6 Commercial Space Centers

<u>Commercial Space Center Evaluation Criteria</u>

- ***Each Center required to submit an annual Business Plan for the new year plus an annual report detailing accomplishments for the past year***
  - ***Must involve existing companies in space research***
  - ***Commercial Funding (cash and in-kind) to Support Center's Program***
  - ***Technology spin-out***
  - ***Patents***
  - ***Spin-out of New Companies***
  - ***Peer-Reviewed Publications***
  - ***Graduate Student Involvement***
  - ***Educational Outreach***

Center for Macromolecular Crystallography (CMC) Established in 1986

- Philosophy for Engaging Biotechnology and Pharmaceutical Companies in Space Research

- Initial Accomplishments:
  - *Averaged 1.0 Million/yr. in commercial cash investments in CMC and ~$10 million in in-kind contributions*
  - *Formed only publically-traded Alabama pharmaceutical company (BioCryst Pharmaceuticals, Inc.)*
  - *Averaged 10 peer-reviewed publications/yr.*
  - *Submitted several patents on novel pharmaceuticals*
  - *Established partnerships with two major pharmaceutical companies and more than 15 university laboratories involved in protein crystallography research*

Transition of CMC to Center for Biophysical Sciences and Engineering (CBSE)

- ***Hire Aerospace Engineers***

Space-flight Hardware Development

- Semi-automated protein crystal growth hardware
- USML-1 glovebox crystallization hardware
- Incubators
- Crystallography Facility
- -20C and -160C freezers

1994-2007 CBSE Accomplishments

- Spin-out of 3 new companies (total of 4 spinout companies) valued in excess of $100 million
- More than 75 new patents for novel biotechnologies and pharmaceuticals
- Averaged $16 million/yr. in funding to CBSE (from NIH, Foundations, DoD, NASA and pharmaceutical/biotech companies)
- Averaged $3.0million/yr. and more than $75million in *in-kind* funding from pharmaceutical/biotechnology companies
- Developed novel biotechnologies that are today used by pharmaceutical/biotechnology and university labs throughout the world
- At its peek the CBSE employed ~90 scientists, 60 aerospace engineers and 10 administrative support staff
- Averaged 80 peer-reviewed publications/yr. and 5 PhD graduates/yr. in multiple departments/disciplines including molecular biology, chemistry, microbiology, biomedical engineering and mechanical engineering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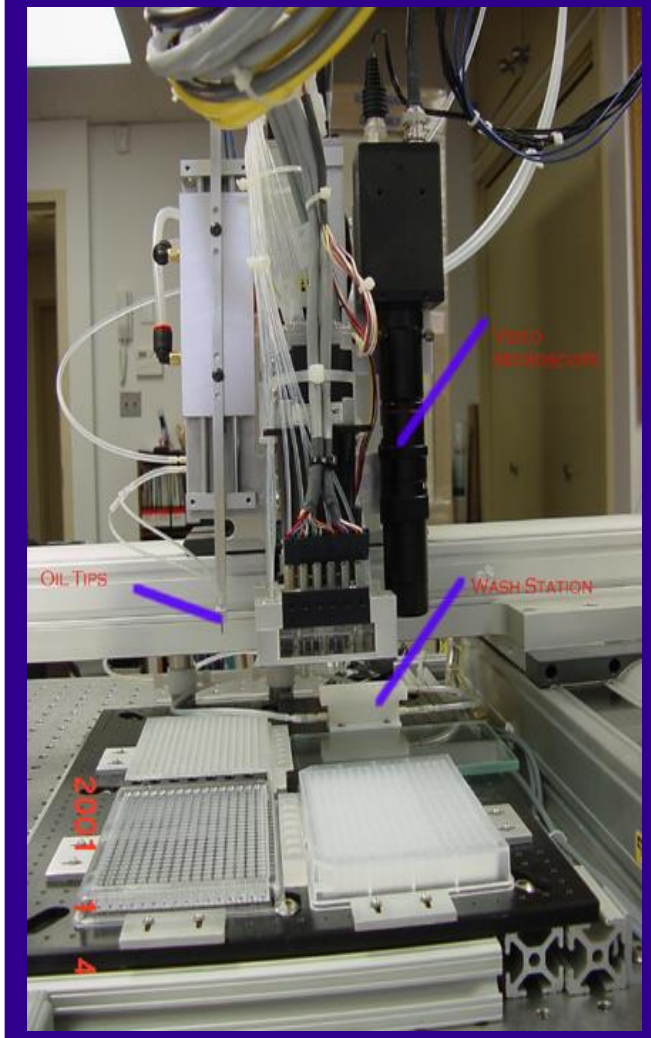
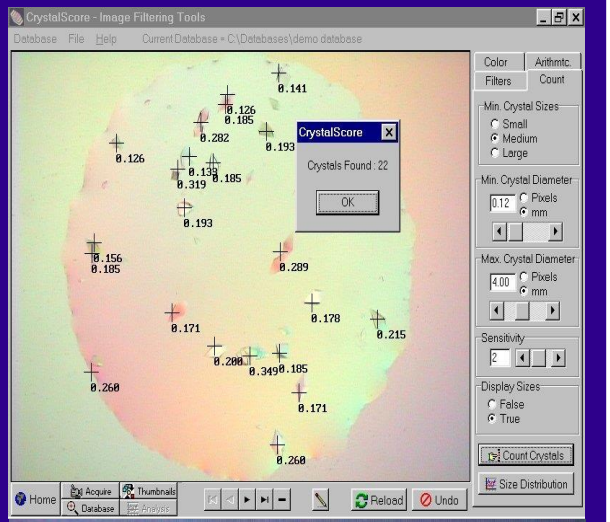
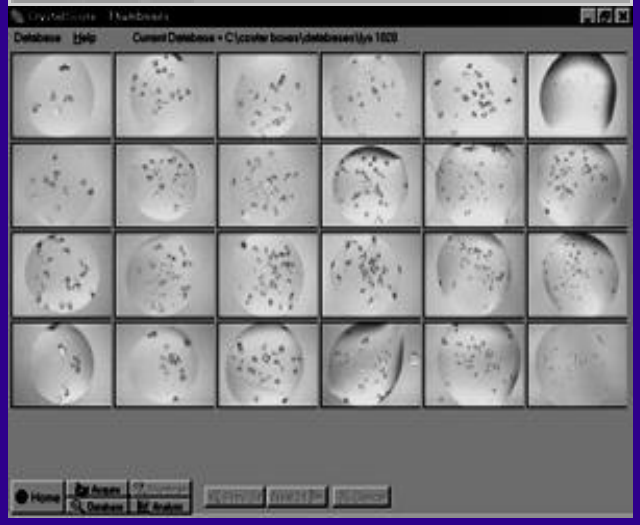
NanoScreen & CrystalScore

Integrated System for High Throughput Protein Crystallization at the Nanoscale







VaporPro

Automated image acquisition and control of vapor diffusion experiments for optimization

CBSE Flight Hardware