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# Multidisciplinary Science in a Modern Research University

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# How multidisciplinary research grew at Cornell

- History and examples from the natural sciences.
- Characteristics of effective collaboration.
- Why mixing of disciplines can produce better science.
- Lessons learned.



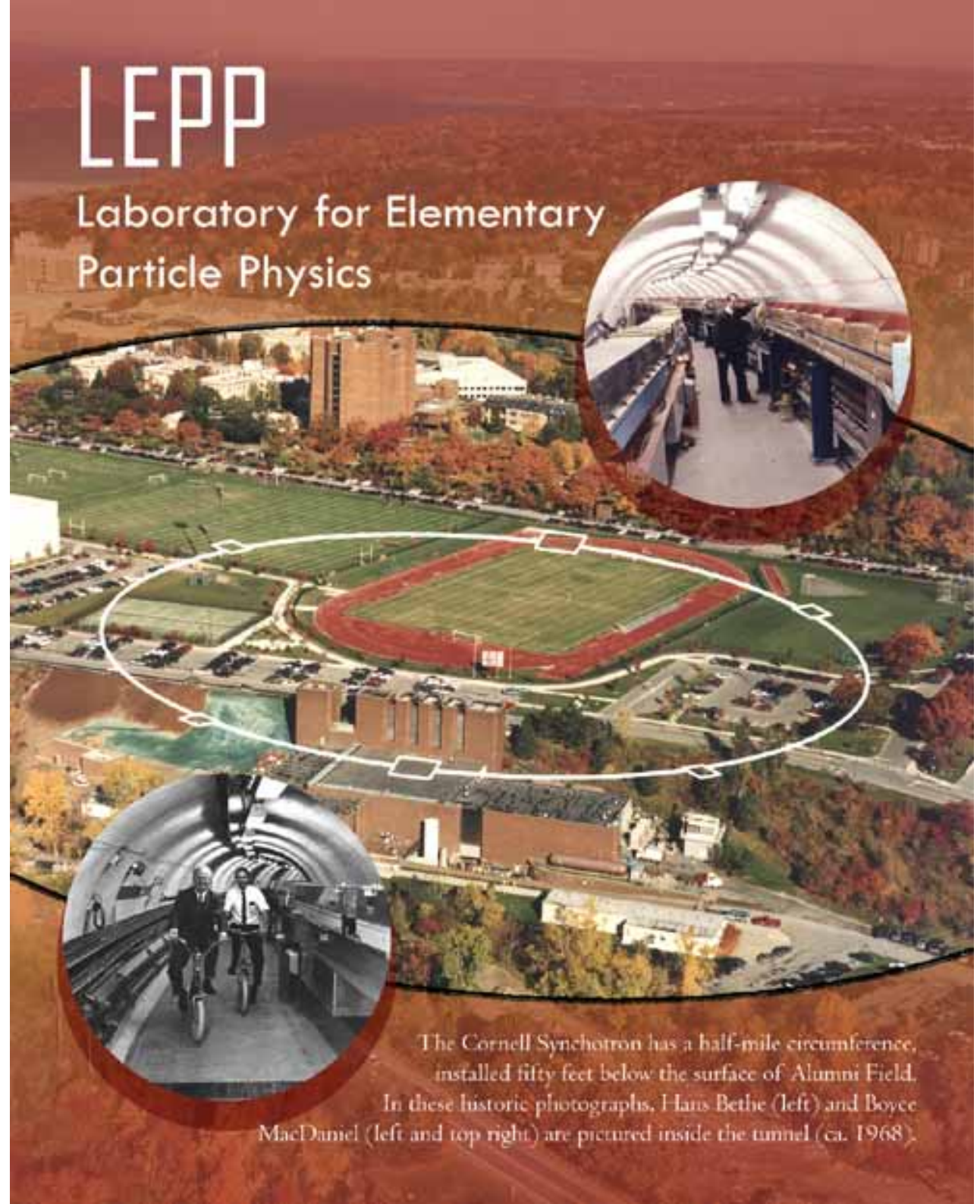
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Laboratory began in 1948. Historical basis for multidisciplinary research at Cornell.

- Accelerator designed for high energy physics.
- Buried under athletic field. Circumference is 1/2 mile (805 m)
- (Note Hans Bethe in lower picture.)

# LEPP

Laboratory for Elementary Particle Physics



The Cornell Synchrotron has a half-mile circumference, installed fifty feet below the surface of Alumni Field. In these historic photographs, Hans Bethe (left) and Boyce MacDaniel (left and top right) are pictured inside the tunnel (ca. 1968).





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X-rays are generated when the electron path in synchrotron is bent.

- The first Synchrotron x-rays were observed in 1956 at Cornell.
- The high intensity x-rays are the most effective for studying matter such as living cells. (700 visitors each year)

# CHESS

Cornell High Energy Synchrotron Source

CHESS staff and facilities collect millisecond data from rapidly growing materials using ultra-high flux x-rays.



R. Headrick, CHESS staff, and Cornell scientists use x-rays to monitor the growth of materials in real time.

Construction of the G-line, containing the highest total x-ray flux producing insertion device in the United States.



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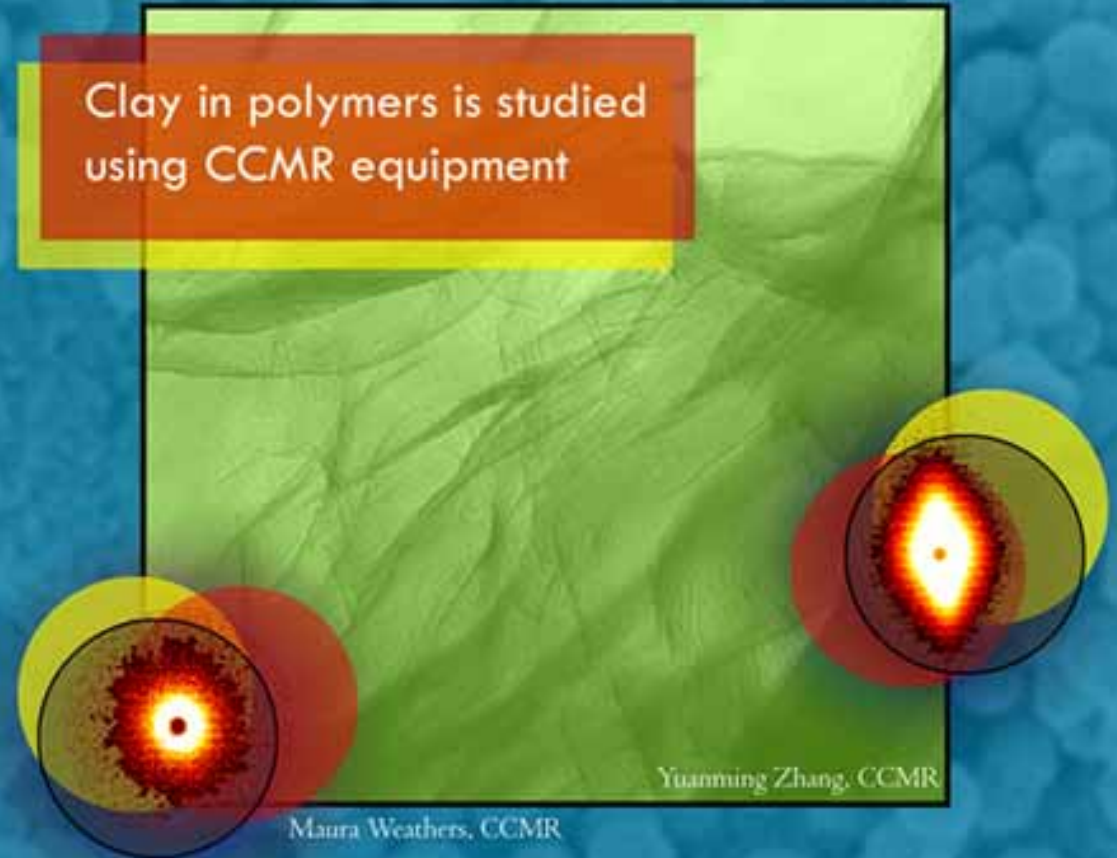
## Materials Research Center (1960):

- First US funded multidisciplinary program at Cornell.
- Physics, chemistry, electrical and materials engineering.
- Developed effective collaborative methods between traditionally separate departments and colleges.

# CCMR

Cornell Center for Materials Research

Clay in polymers is studied using CCMR equipment



Clay layers captured using CCMR's LEO 992 Energy Filter Transmission Electron Microscope

Left and Right: Small-angle X-ray scattering from intercalated clay





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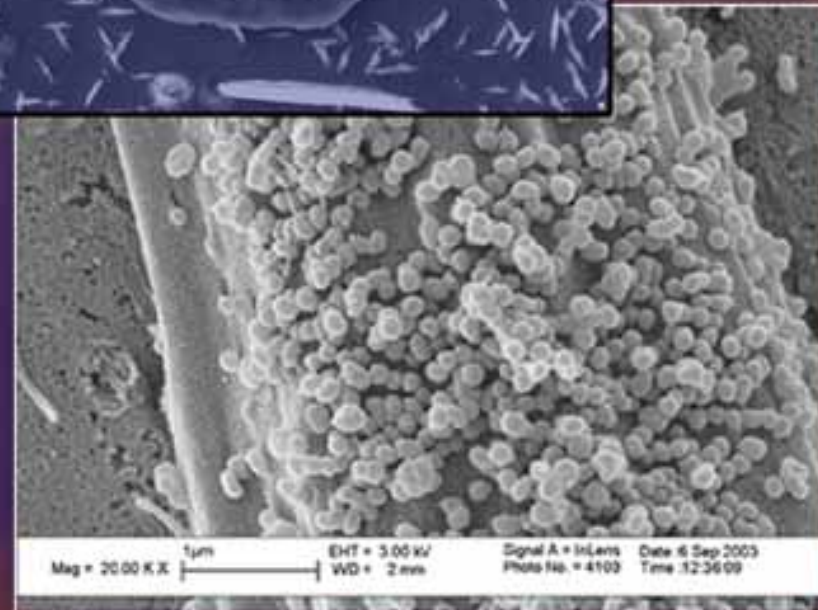
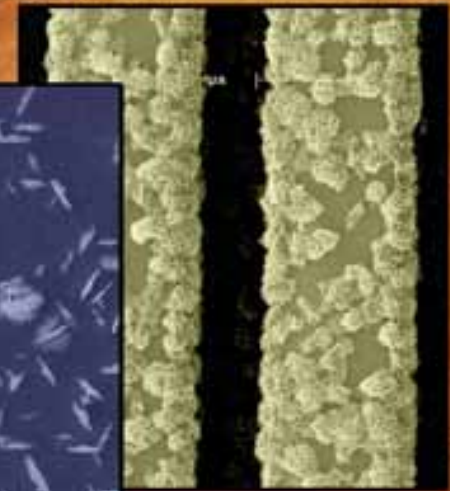
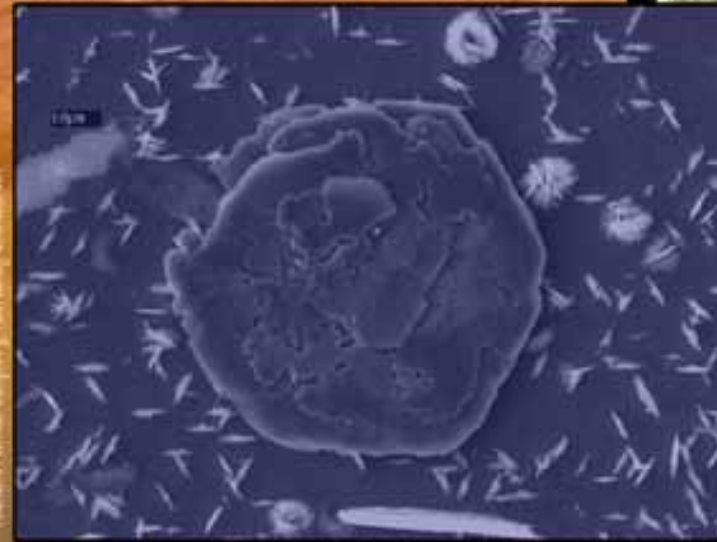
## Materials (continued)

- Shared facilities are a key to collaboration. Electron microscope images here show growth of HIV virus.
- Center has equipment valued at more than \$100M acquired over 40 years of joint planning.

# CCMR

## Cornell Center for Materials Research

Elemental composition of materials  
is studied at CCMR facilities.



HIV, with a block in the final stage of budding from the membrane of the host cell.  
Marc Johnson, Molecular Biology and Genetics



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Nanoscale Facility  
founded in 1979 with  
NSF funding.

- National multi-discipline fabrication center. (1400 users per year.)
- Disciplines include all of the materials disciplines plus biology, agriculture, and all engineering fields.

CNF

Cornell NanoScale Facility



Photo: Daniel Woodie, CNF staff

CNF's new Clean Room in Duffield Hall





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## NanoScale Facility (continued)

- Multiple lithography and imaging techniques are used to make structures as small as a few atoms.
- Technology transfer is an important mission of the center.

# CNF

## Cornell NanoScale Facility

Images from CNF's Scanning Electron Microscope

8 $\mu$ m and 25 $\mu$ m-radius  
membrane structures

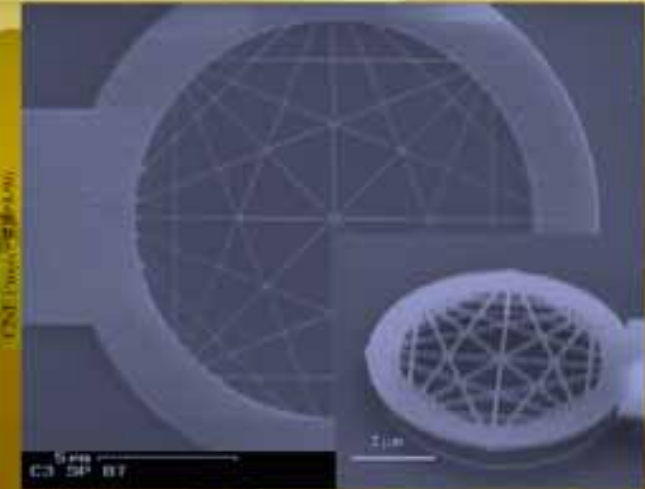
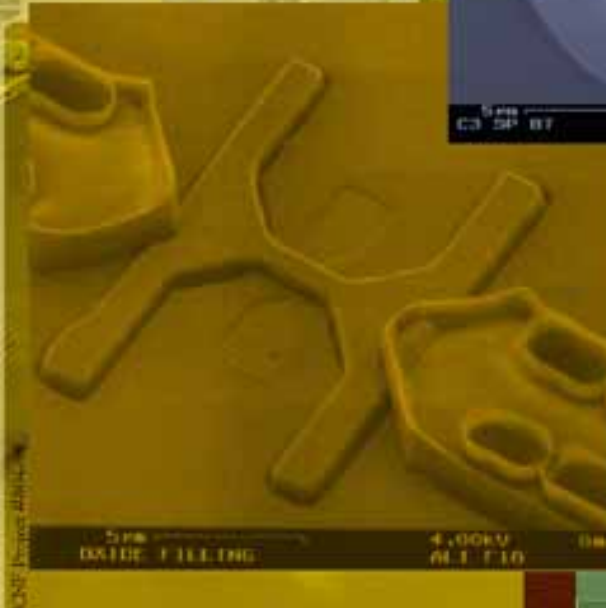
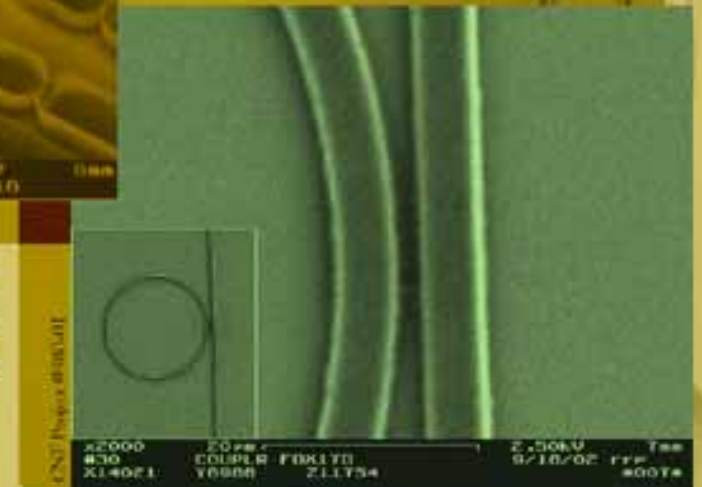


Image of a partially  
processed device



10 $\mu$ m single crystal  
silicon ring coupled  
to the waveguide







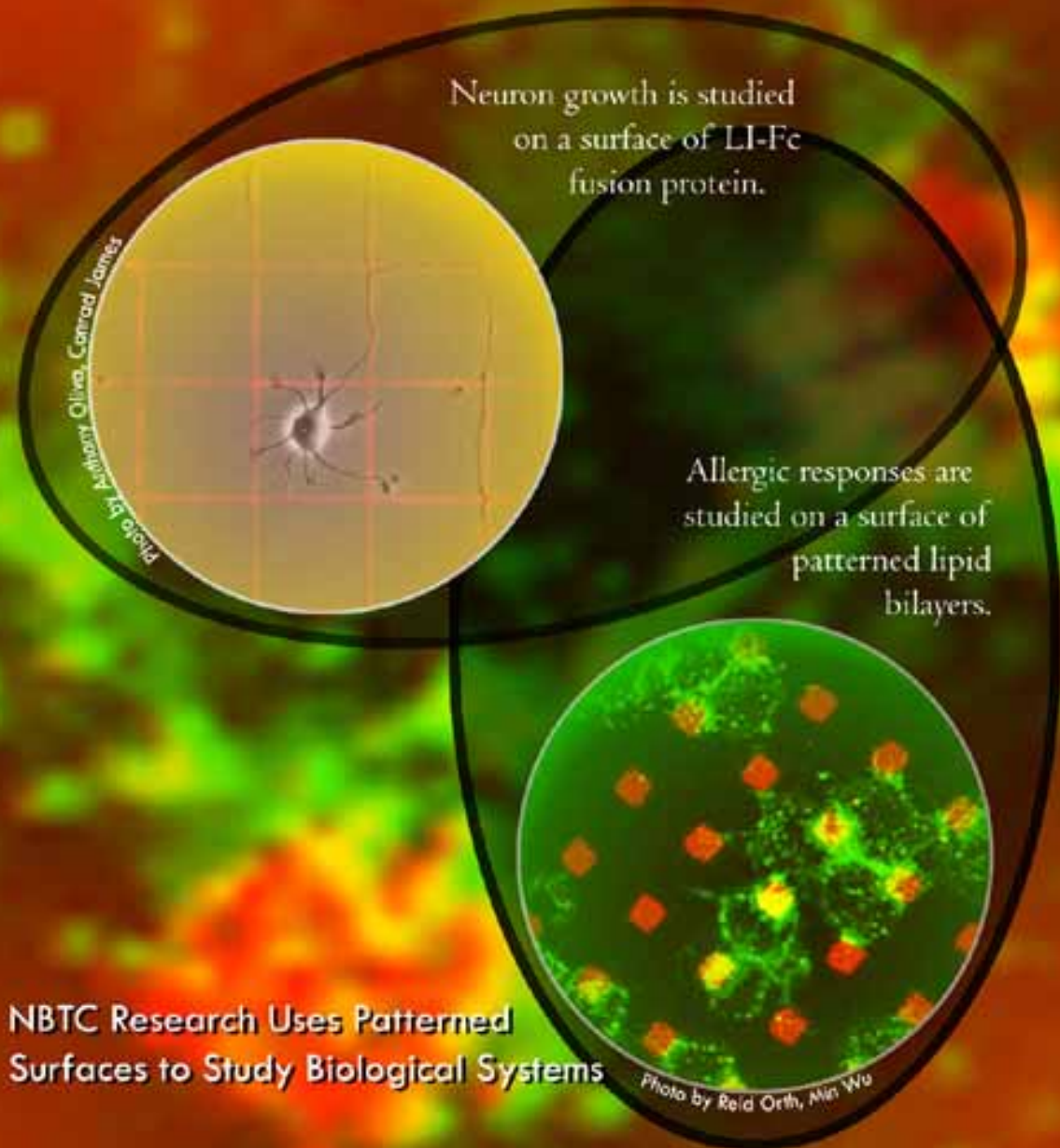
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## Nanobiotechnology (NSF 1997)

- A fusion of biology with the nanoscale technology.
- Partners with -- 4 universities, 18 corporations, and 3 national laboratories.
- Cornell faculty from 5 colleges and 15 departments.

# NBTC

## Nanobiotechnology Center





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## Nanobiotechnology (continued)

- All Cornell centers have a responsibility for public science education. The image shows a display for young children prepared at Cornell for Science Museums.

# NBTC

Nanobiotechnology Center



The NBTC and the Sciencenter have created an interactive museum exhibition that introduces children and their families to the biological wonders of the nano world.

Photo provided  
by Sciencenter





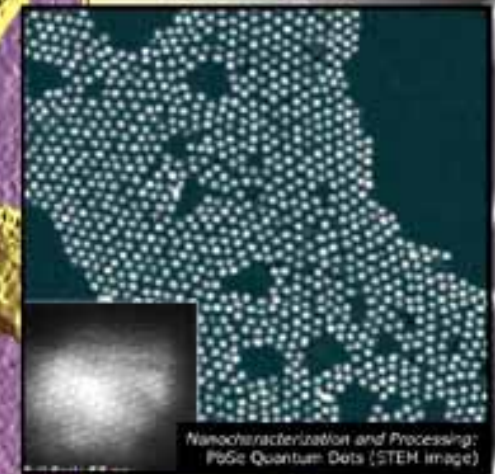
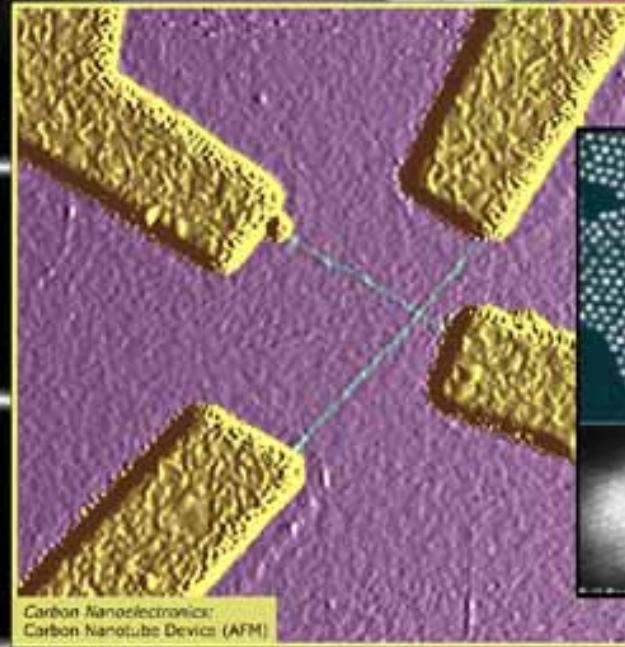
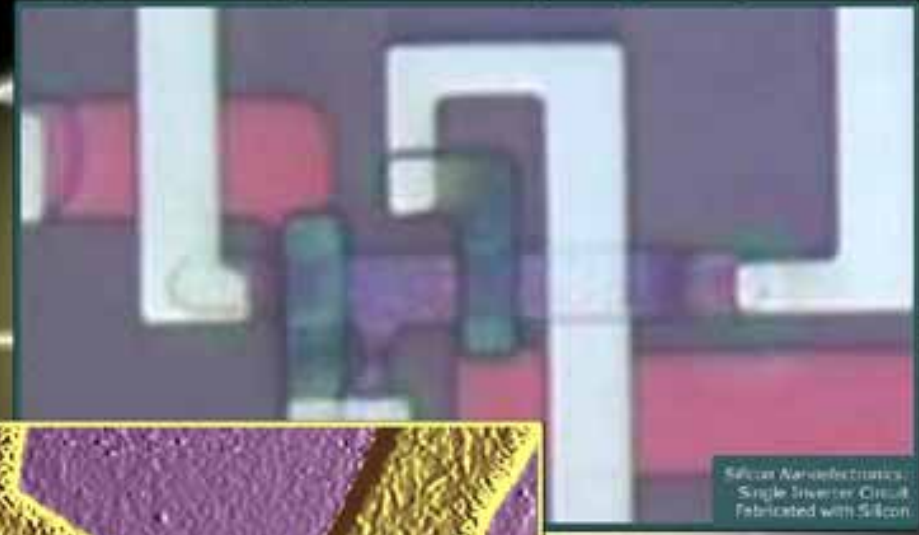
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## Nanoscale System Center (1998)

- Studies electronic, photonic, and magnetic nanoscale systems that can revolutionize information technology.
- Also funded by NSF for multiple disciplines.

# CNS

## Center for Nanoscale Systems



Innovative Systems Research at CNS  
Revolutionizes Information Technology



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The Kavli Institute at Cornell for Nanoscale Science is a new center (2004).

- KIC is privately endowed. The center sponsors studies of strategies for new science using nanotechnology.
- First conference was a meeting for science writers.
- Second conference was on molecular devices held jointly with Japanese Ministry of Education and Science.

# KIC

Kavli Institute at Cornell  
for Nanoscale Science



Fosters collaboration across interdisciplinary  
nanoscale science research centers.





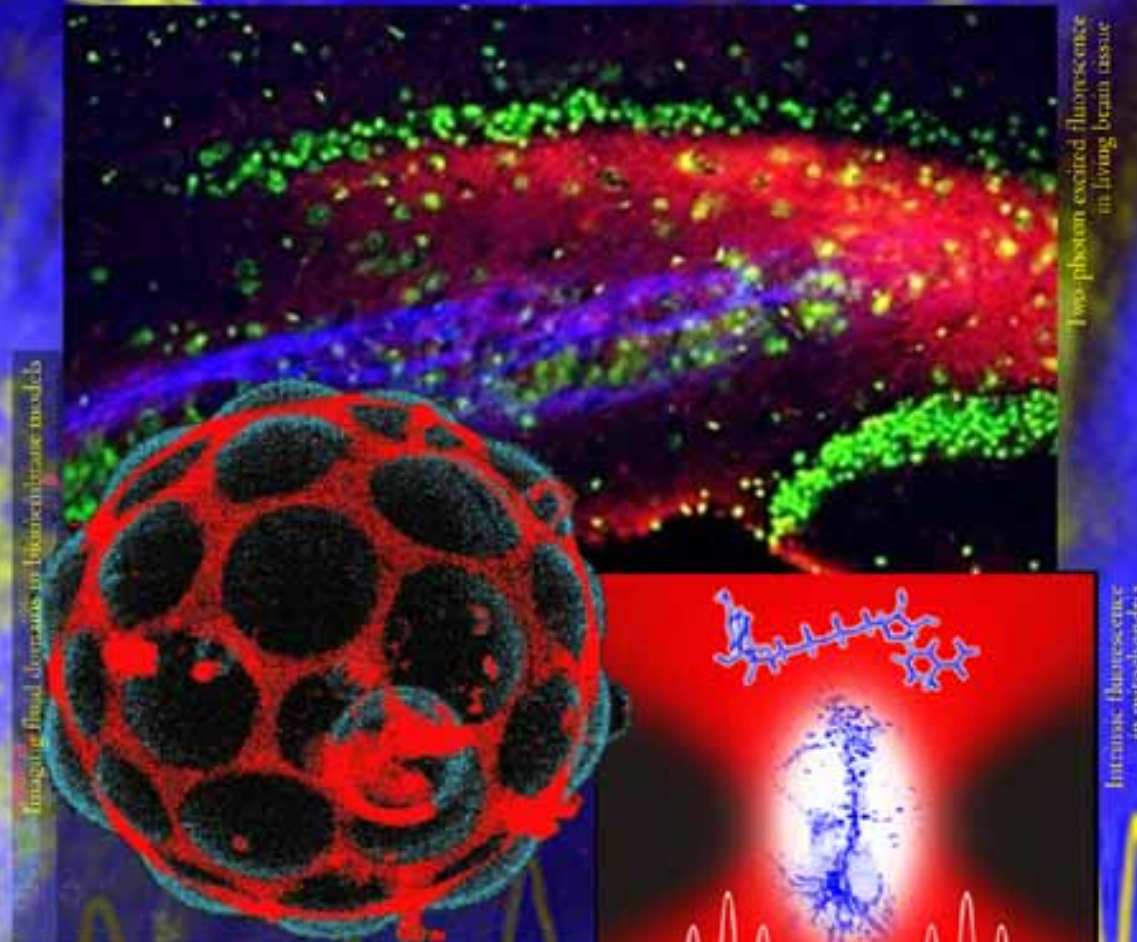


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- Transfer of new technology is an important responsibility of a Research University.
- Poster illustrates an invention of W.W.Webb, an engineering physics faculty member of all 5 of the Cornell nanoscience centers.

# CCTEC

Cornell Center for Technology,  
Enterprise & Commercialization



Multiphoton microscopy, from the  
Watt Webb group, produces  
high-resolution, three-dimensional  
images of living tissues.



# Effective Collaborations

- Use existing strength in disciplines.
- Grow out of discussions among young scientists as well as recognized leaders.
- Require a willingness to share resources among the disciplines.
- Share in educational and training activities.
- Welcome new scientific associations





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# Why Mixing Disciplines is Frequently Better

Stronger innovation: -- At Cornell physical scientists and engineers invent important new techniques to attack significant problems in biology of proteins, cells, neurobiology, and medicine. Both groups benefit.



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# Lessons Learned

- Start with small collaborations.
- Develop excellence in a few areas.
- Use growing reputation to develop other key specialties.
- Expand the breadth of fields in the collaborations.
- Communicate with the public.