UT-BATTELLE

Oak Ridge National Laboratory
An overview

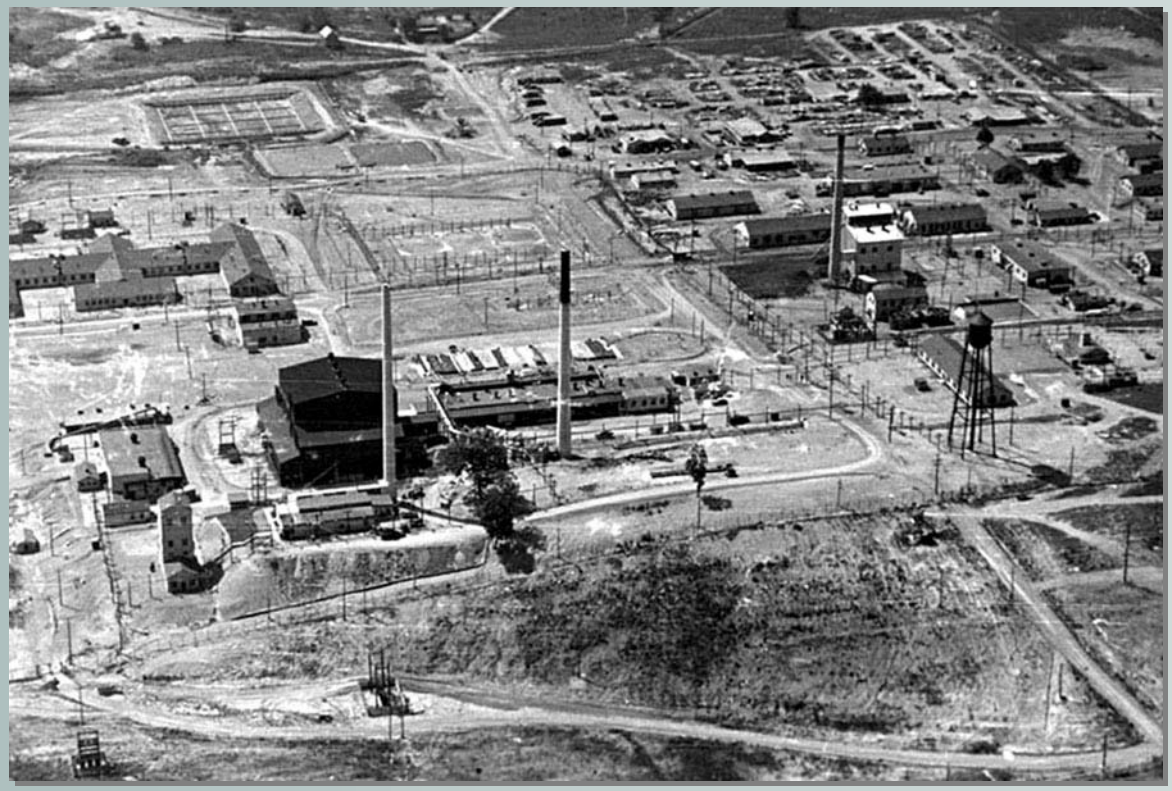
Presented to summer students

Lee Riedinger
Deputy Director for Science and Technology

June 6, 2003

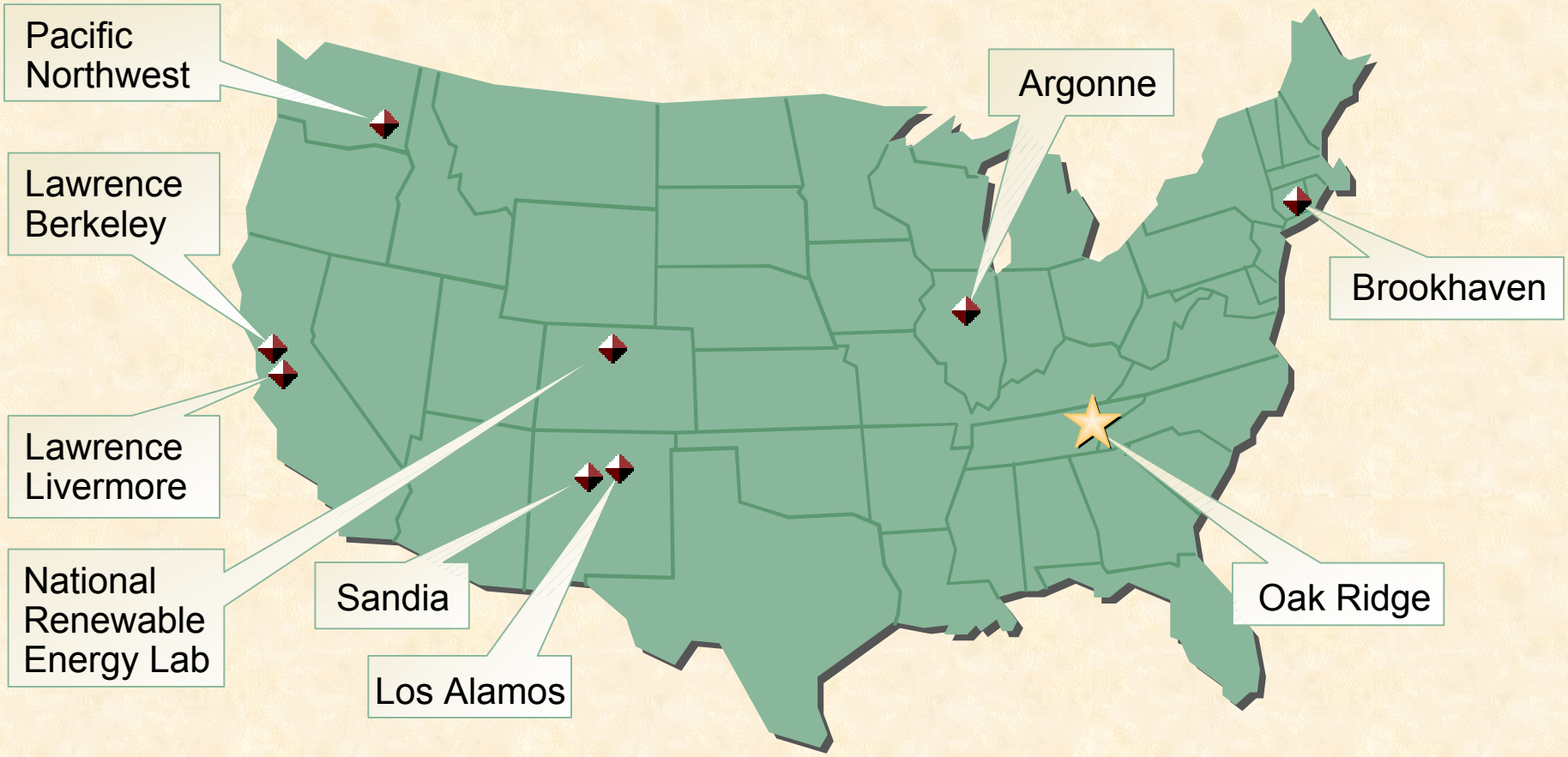
Oak Ridge National Laboratory was established during World War II

Senator
Kenneth D. McKellar



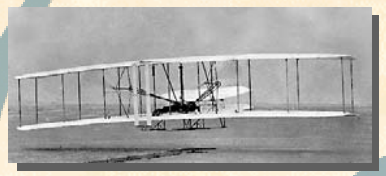
The Graphite Reactor was the world's first continuously operated nuclear reactor

The Department of Energy maintains a system of multipurpose national laboratories to execute its missions

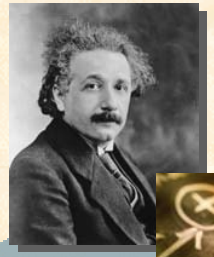


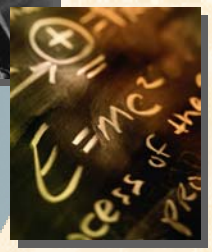
Science and technology flourished in the first half of the 20th century

1901: Radio



1903:
Air travel





1905:
Theory of relativity

1911:
Atomic structure

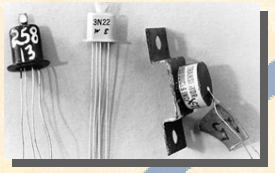
1933:
Electron Microscope

1934:
Television

1945:
Digital computer

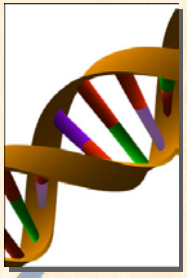
1937: Radar

1947:
Transistors

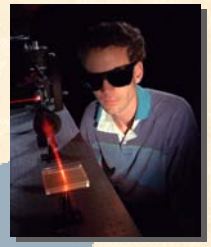


1945:
Nuclear weapons

The past 50 years have brought even more innovations



1953: DNA structure

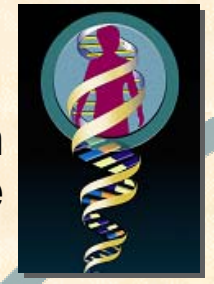


1960: Laser

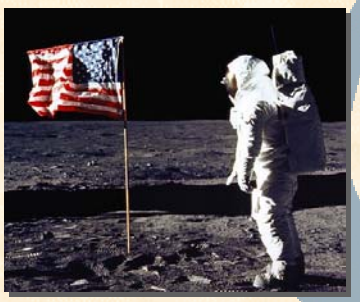
1957: Commercial nuclear power

1967: Microwave oven

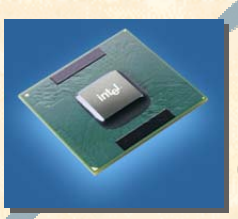
1975: Apple computer



2000: Human Genome



1968: Men on the moon



1970: Intel chip

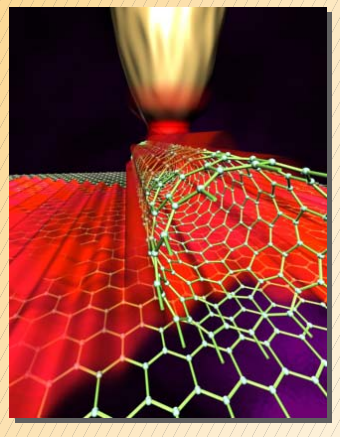
1979: Cell phone

1989: World Wide Web

1982: Compact Disk

Where is science leading us?

Materials



Manipulating materials at the atomic level

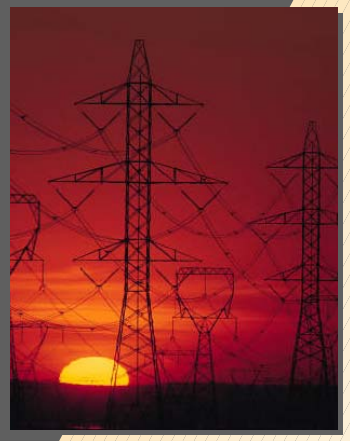
Genomics

DNA to living organisms

Computing

PCs to petaflops

Energy technologies



Sustainable future

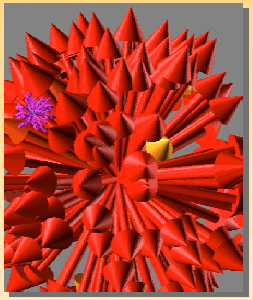
Oak Ridge National Laboratory today

- $1 billion budget
- DOE's largest multiprogram science laboratory
- Nation's largest energy R&D laboratory
- Nation's largest concentration of open source materials research
- Building the $1.4 billion Spallation Neutron Source
- 3700 employees
- 3000 research guests annually
- 18 user facilities
- $300 million modernization program in progress

Our Science and Technology Agenda

Energy

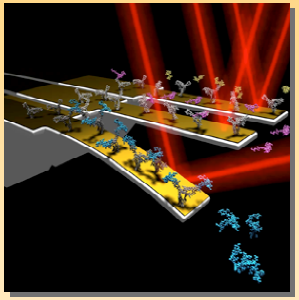
Homeland/ National Security



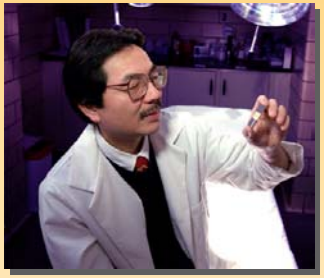
Neutron Science

Computing

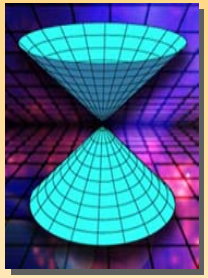
Biology



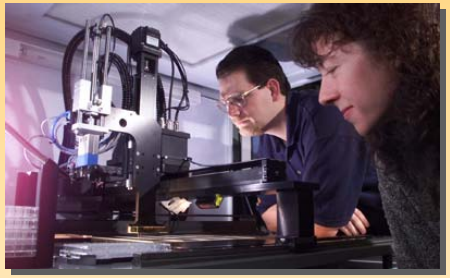
Materials



Human Capital



Future R&D Directions



University Partnerships

18 user facilities at Oak Ridge

Buildings Technology Center

High Flux Isotope Reactor

High Temperature Materials Laboratory

Holifield Radioactive Ion Beam Facility

National Environmental Research Park

ORNL will become the world's foremost center for neutron sciences

Spallation Neutron Source

- World's most powerful pulsed spallation source
- World's leading facility for neutron scattering
- Best-in-class instruments (10-100x better than current instruments)
- On schedule for 2006 completion
- $1.4B project cost

High Flux Isotope Reactor

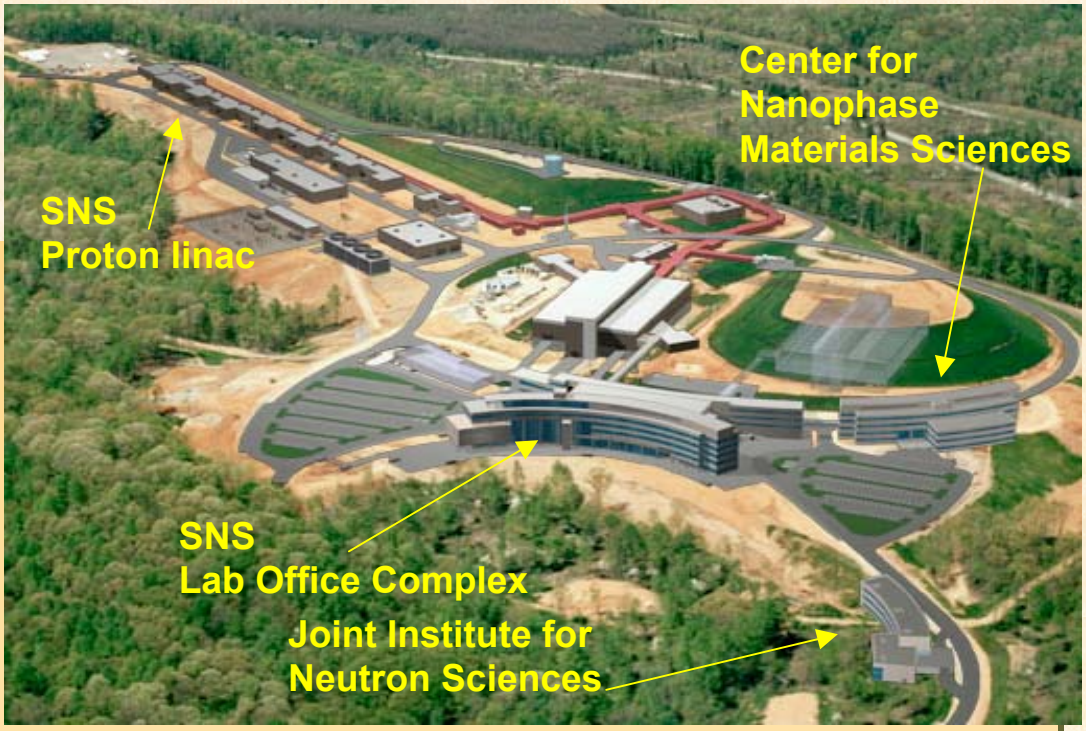
- World's highest steady-state thermal neutron flux
- World-class cold source
- World-class instruments for neutron scattering
- National resource for isotope production, materials irradiation, and neutron activation analysis
- $800M replacement value

Joint Institute for Neutron Sciences

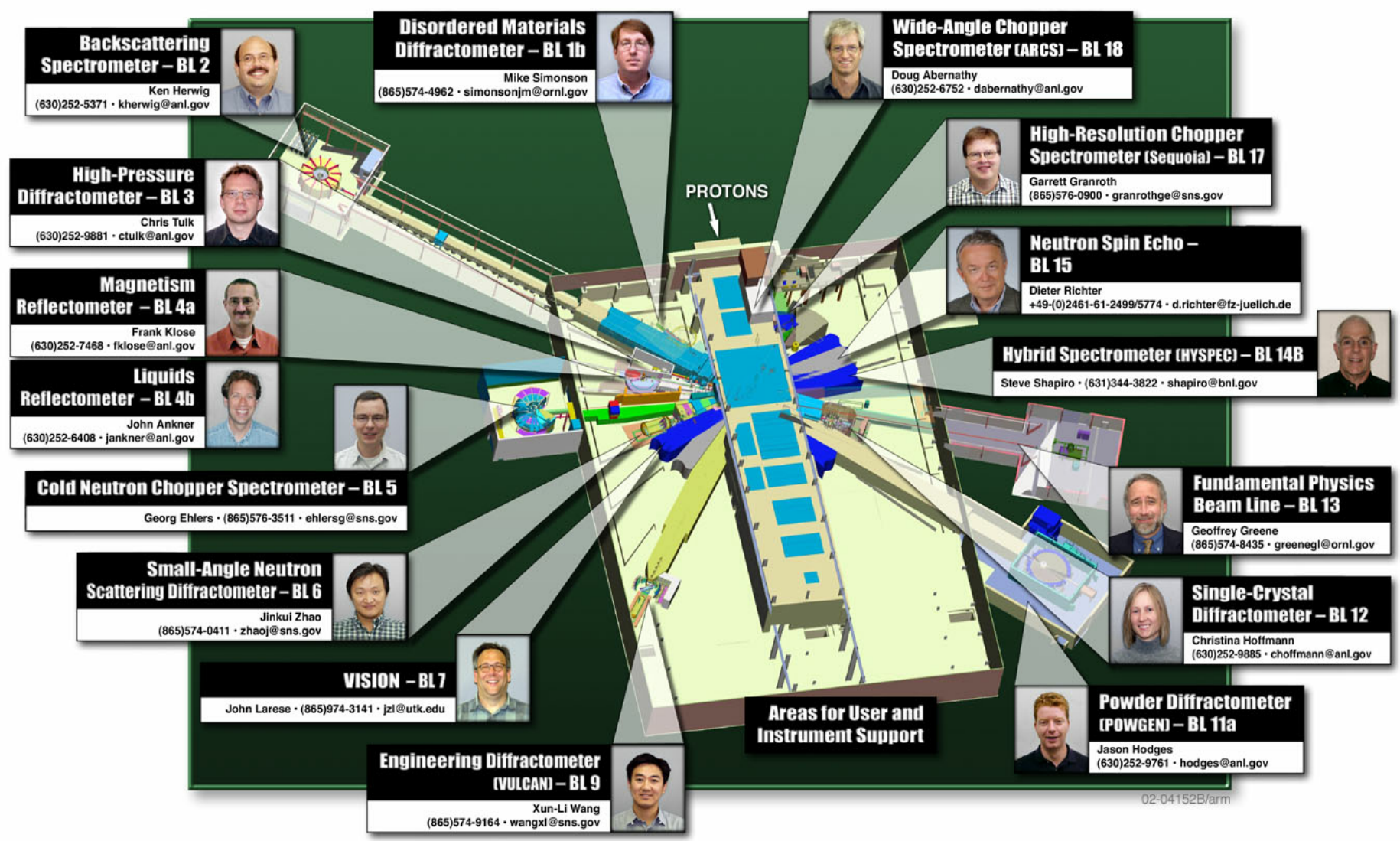
- $8M facility to be funded by the State of Tennessee
- Intellectual center (workshops, outreach, collaborations)
- User support center (housing)

SNS continues on schedule and on budget

- Project design is 86% complete
- Project is 61% complete
- Front end has been installed and commissioned



16 Instruments now formally approved

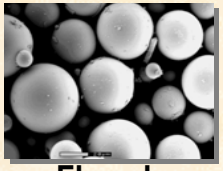


Nanoscale science and technology presents extraordinary opportunities

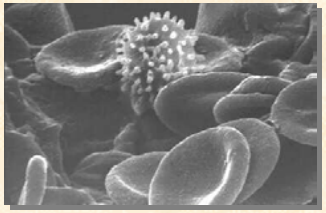
Ant

Human hair

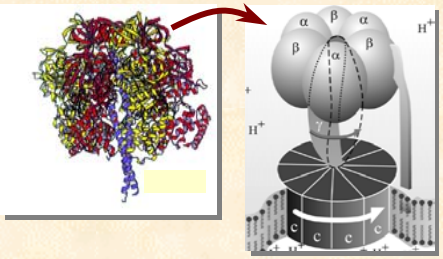
Dust mite



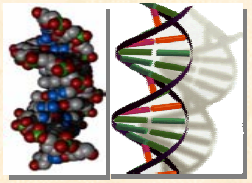
Fly ash



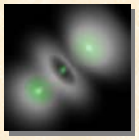
Red blood cells



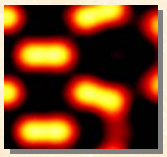
ATP synthase



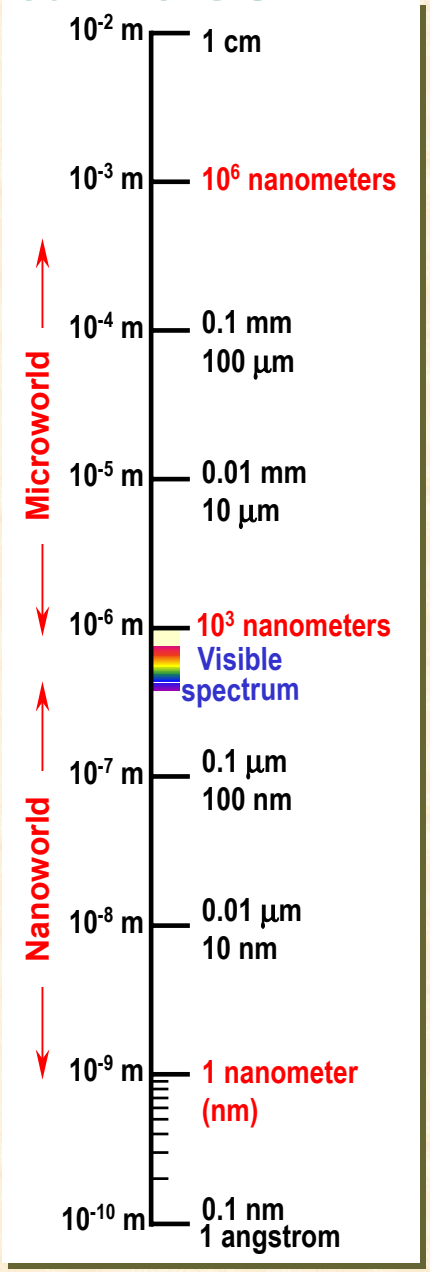
DNA

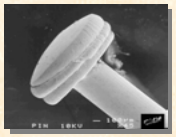


Hydrogen atom



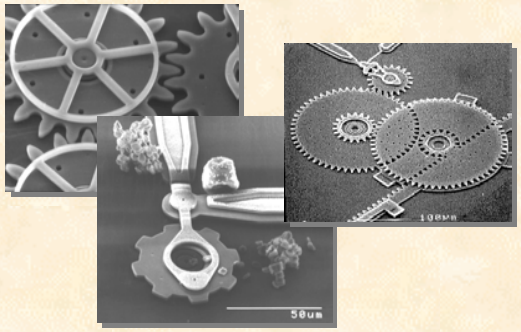
Silicon atoms

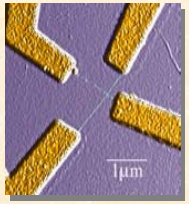




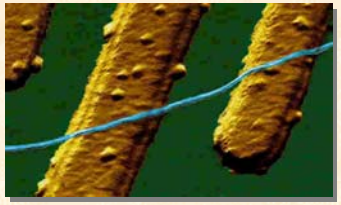
Head of a pin

Microelectromechanical devices

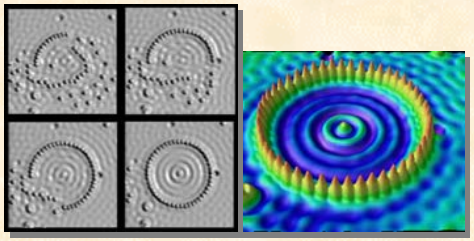




Nanotube electrode



Nanotube transistor



Quantum corral of 48 iron atoms (14 nm diam)

Center for Nanophase Materials Sciences

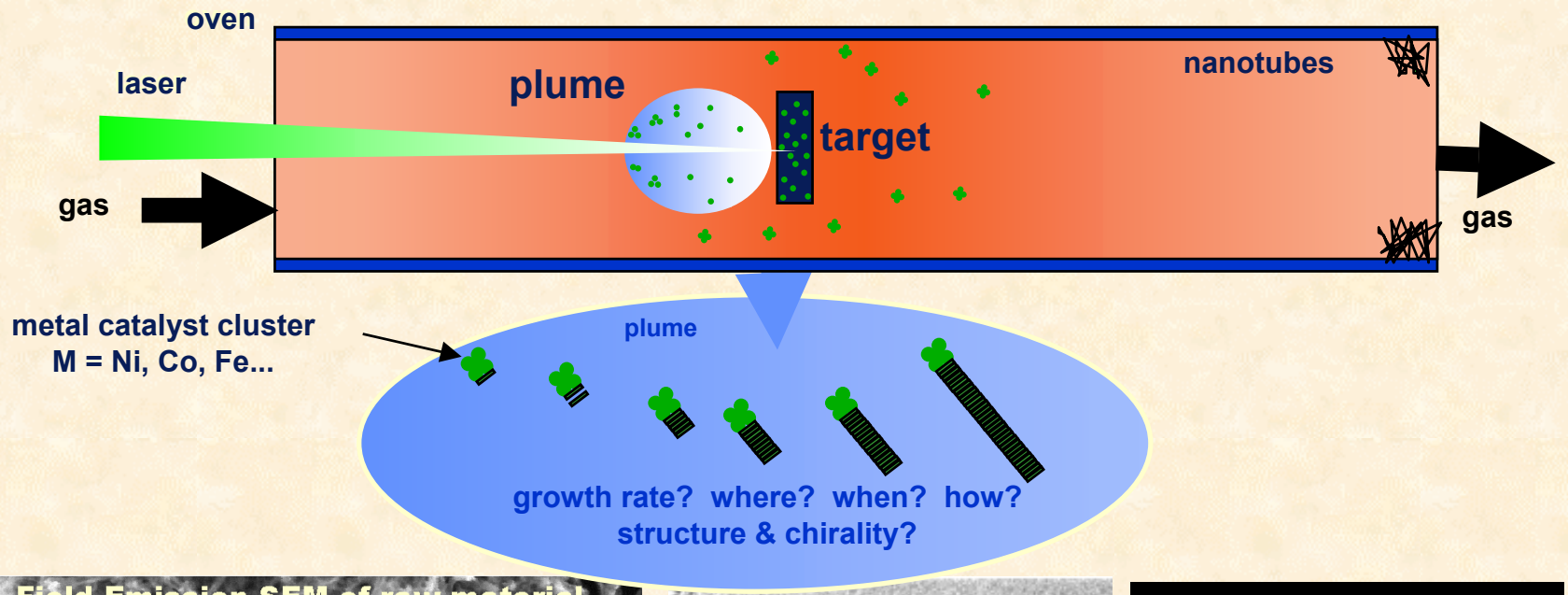
- Integrates materials, chemical, biological, neutron, and computational sciences in a state-of-the-art facility
  - Complex nanophase materials
  - Macromolecular systems
  - Synthesis and nanofabrication
  - Theory, modeling, and simulation
- Strong partnerships with universities
  - 61 universities represented at second planning workshop
- On schedule for FY 03 construction start
- Jumpstart user program in FY 03

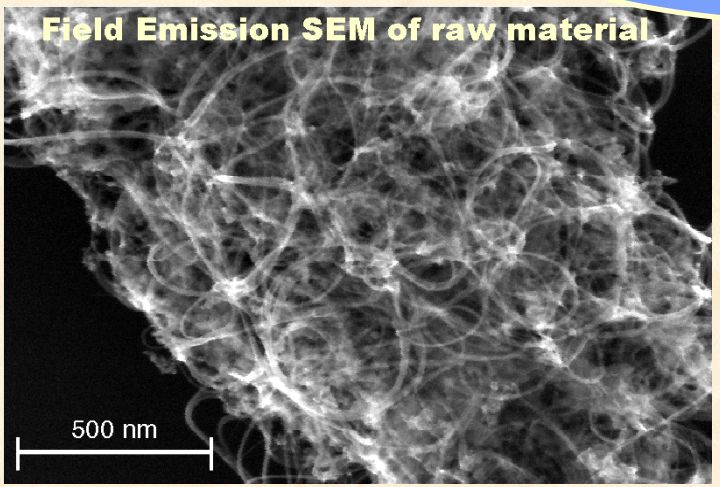
Center for Nanophase Materials Sciences

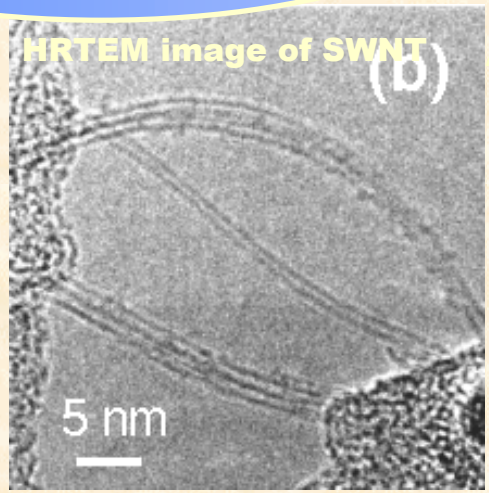
New research initiatives

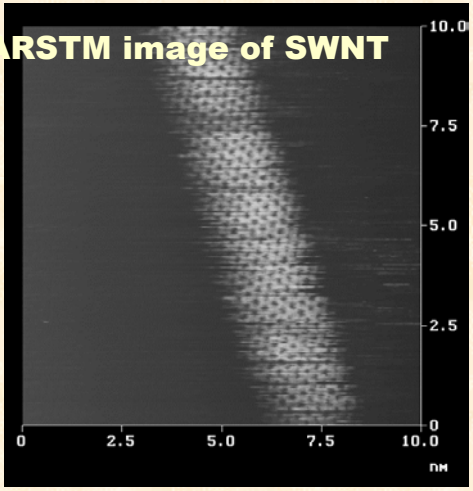
- *Nanoscale cooperative phenomena*
- *Nanocatalysis*
- *Self-assembled nanotube crystals*
- *Nanoscale solid/liquid interfaces*

We are learning how to grow Carbon Nanotubes by laser vaporization





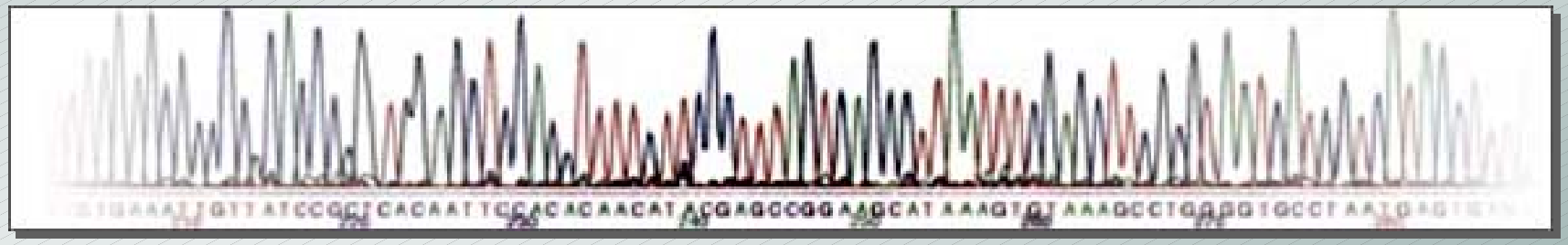




The human genome is life's "instruction manual"

Human genome → Protein → Protein complex → Genetic and metabolic pathways → Cell functions

"If written in 10-point type, your human genome would stretch from Los Angeles to New York"



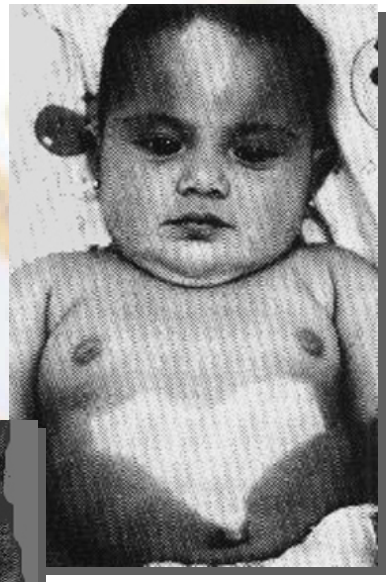
We know where the genes are, but what do they do?

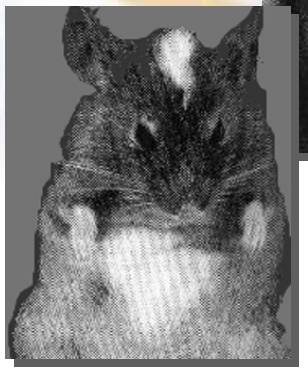
Next-generation biology will have huge impacts

Mouse models for human disease

Albinism

Piebald trait





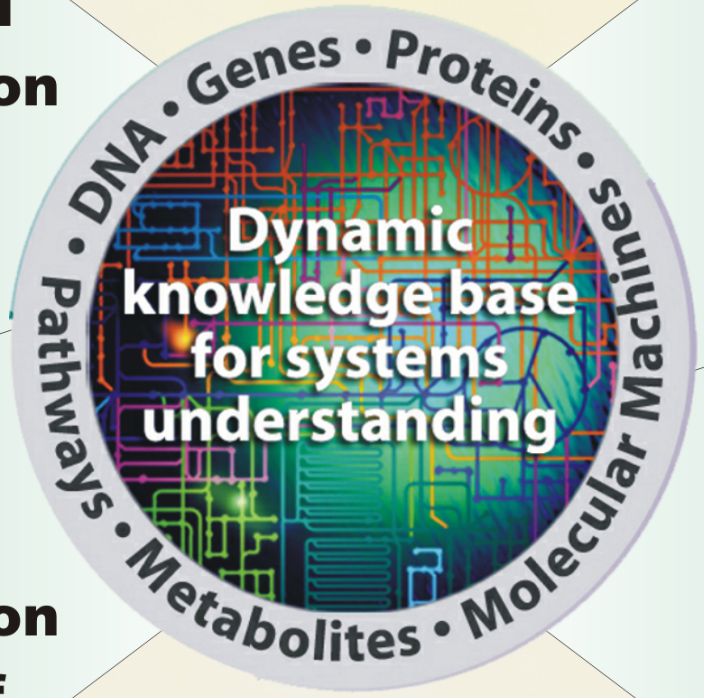
We have a specialized mouse colony for genomics research

- A new mouse vivarium is under construction
- This will allow a new generation of pathogen-free mouse genomics research
- *Populus* genomics research has been initiated

User Facilities for 21st Century Biology

Facility I
Production and Characterization of Proteins

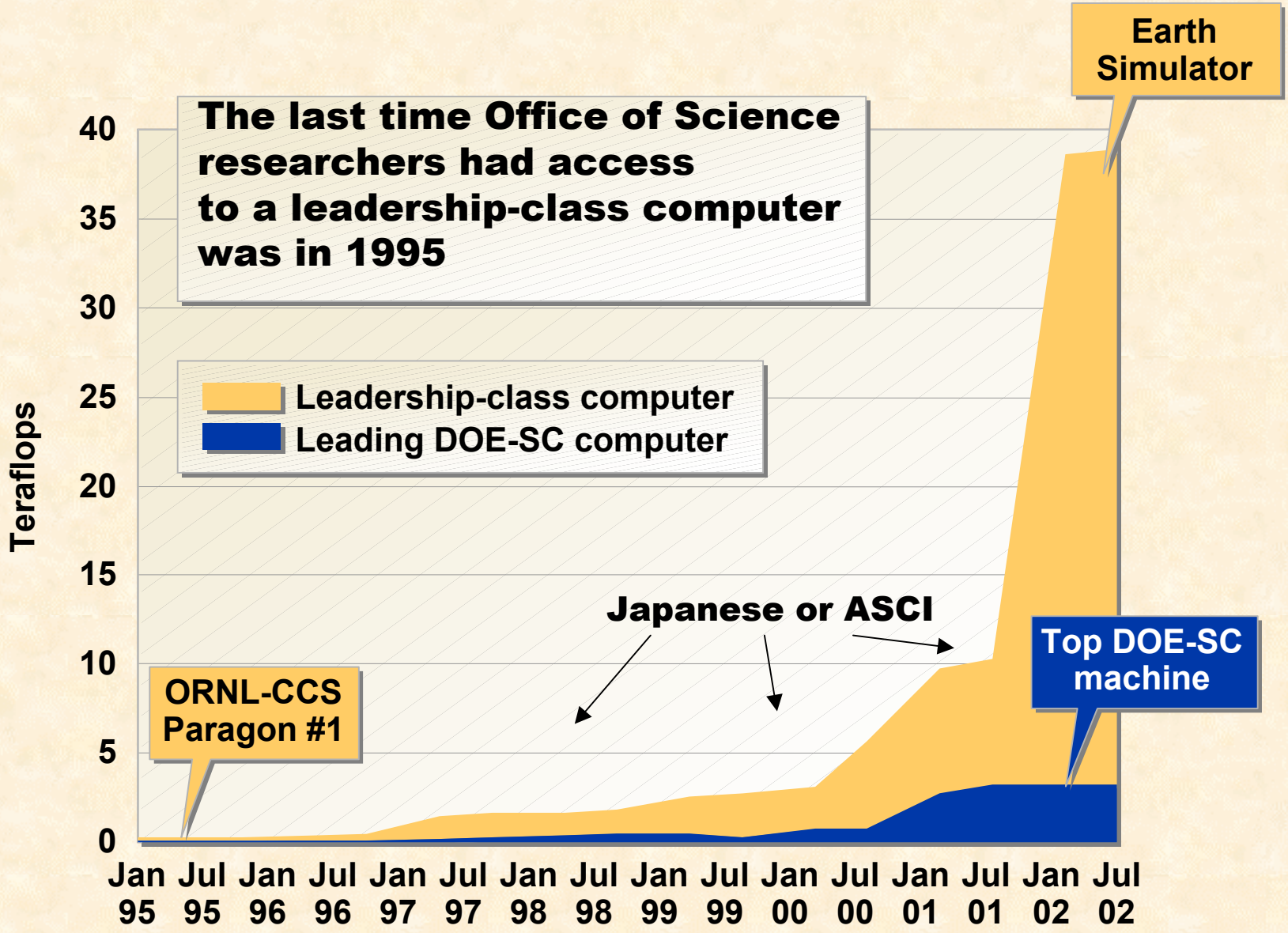
Facility II
Whole Proteome Analysis



Facility III
Characterization and Imaging of Molecular Machines

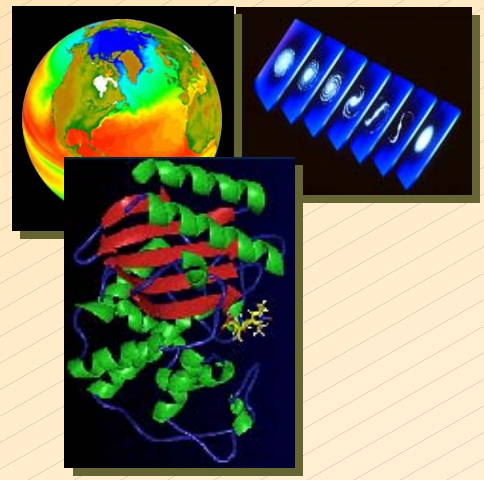
Facility IV
Analysis and Modeling of Cellular Systems

Office of Science computing capability is significantly behind leadership class

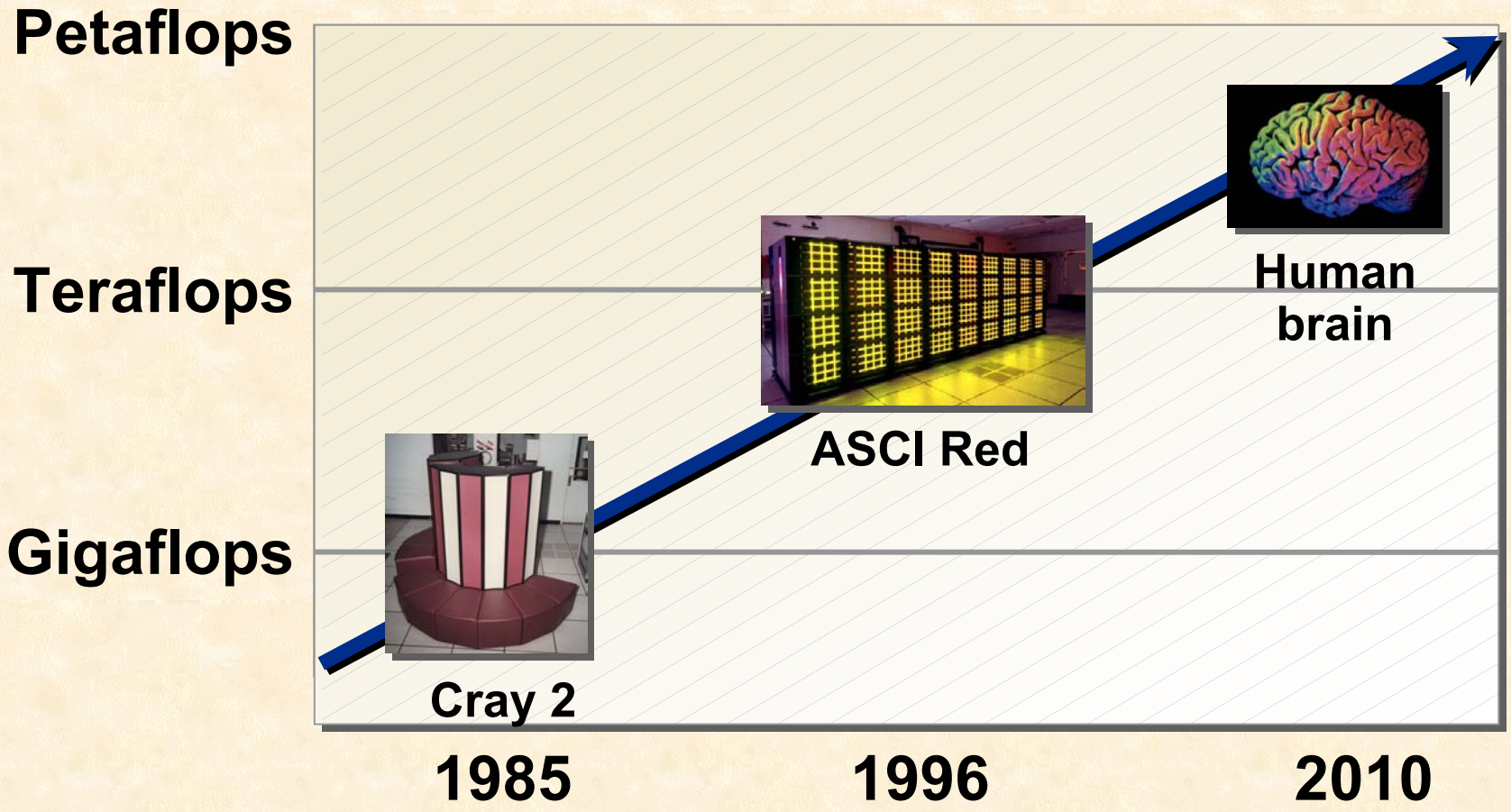


ORNL will provide leadership in high-performance computing

- Developing the Cray X1 "Phoenix"
  - First of eight cabinets delivered in March
  - Performance comparable to the Japanese Earth Simulator
  - We anticipate 150 teraflop capability
- OC192 connection to Internet2
- Supporting key science initiatives
  - Computational biology
  - Global climate change
  - Computational materials science
- Building a coalition to pursue opportunities in NSF's Advanced Cyberinfrastructure Program



Computing power is approaching human proportions



We support DOE's energy mission

Generation

- Distributed energy resources
- Hydrogen
- Fusion
- Nuclear

Distribution

- High-temperature superconductors
- Transmission technology

Consumption

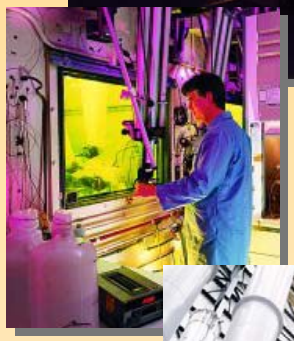
- Buildings
- Transportation
- Industry

ORNL's science base

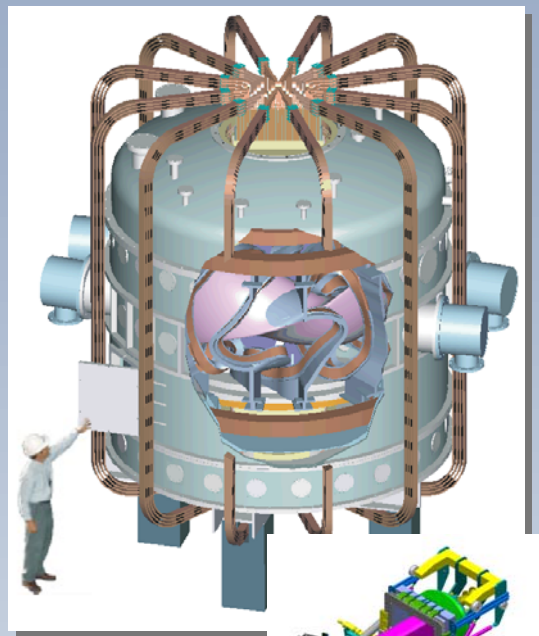
Developing new generating capacity is essential

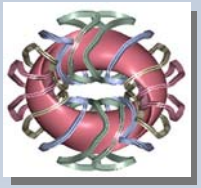
Renewable energy

Nuclear power



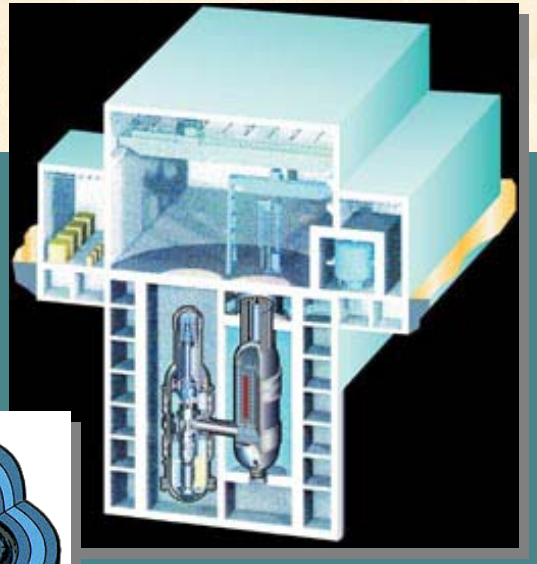
Fusion energy

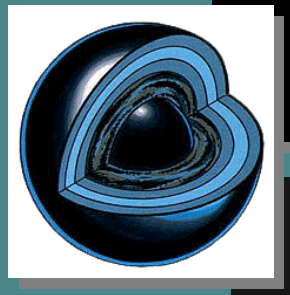




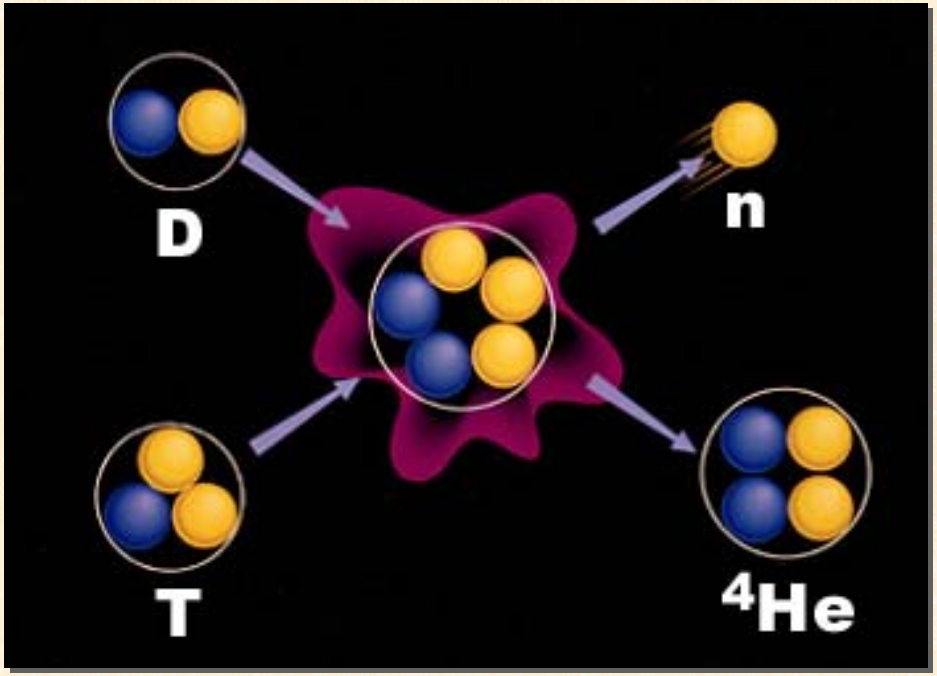
Nuclear energy is an area of increasing programs

- Coated-particle fuel fabrication R&D
- Part of international collaboration to develop Generation IV nuclear energy systems
- Seeking new research roles in fuel recycling technologies
- Key role in DOE's program supporting NASA's space fission systems



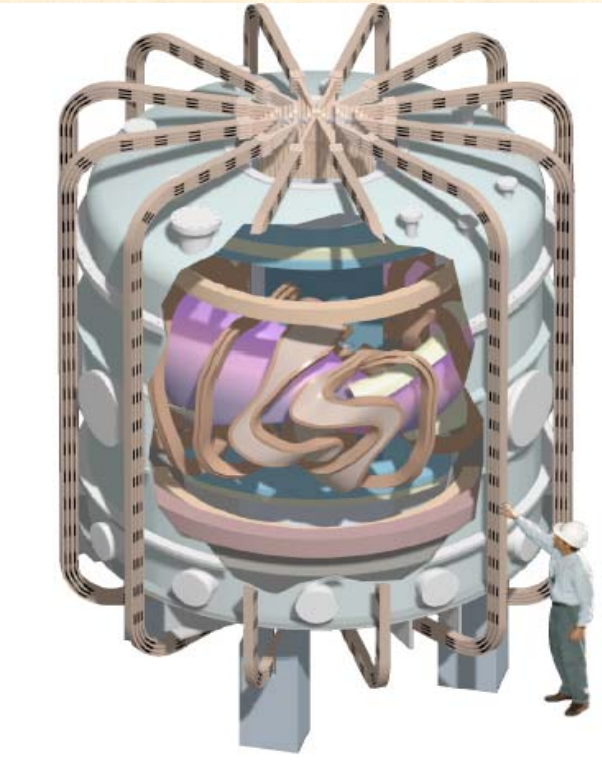


Fusion: a long-term energy solution



- Limitless fuel (1 cup seawater = 1/2 ton coal)
- Very low nuclear waste

U.S. program aims at a compact stellarator design



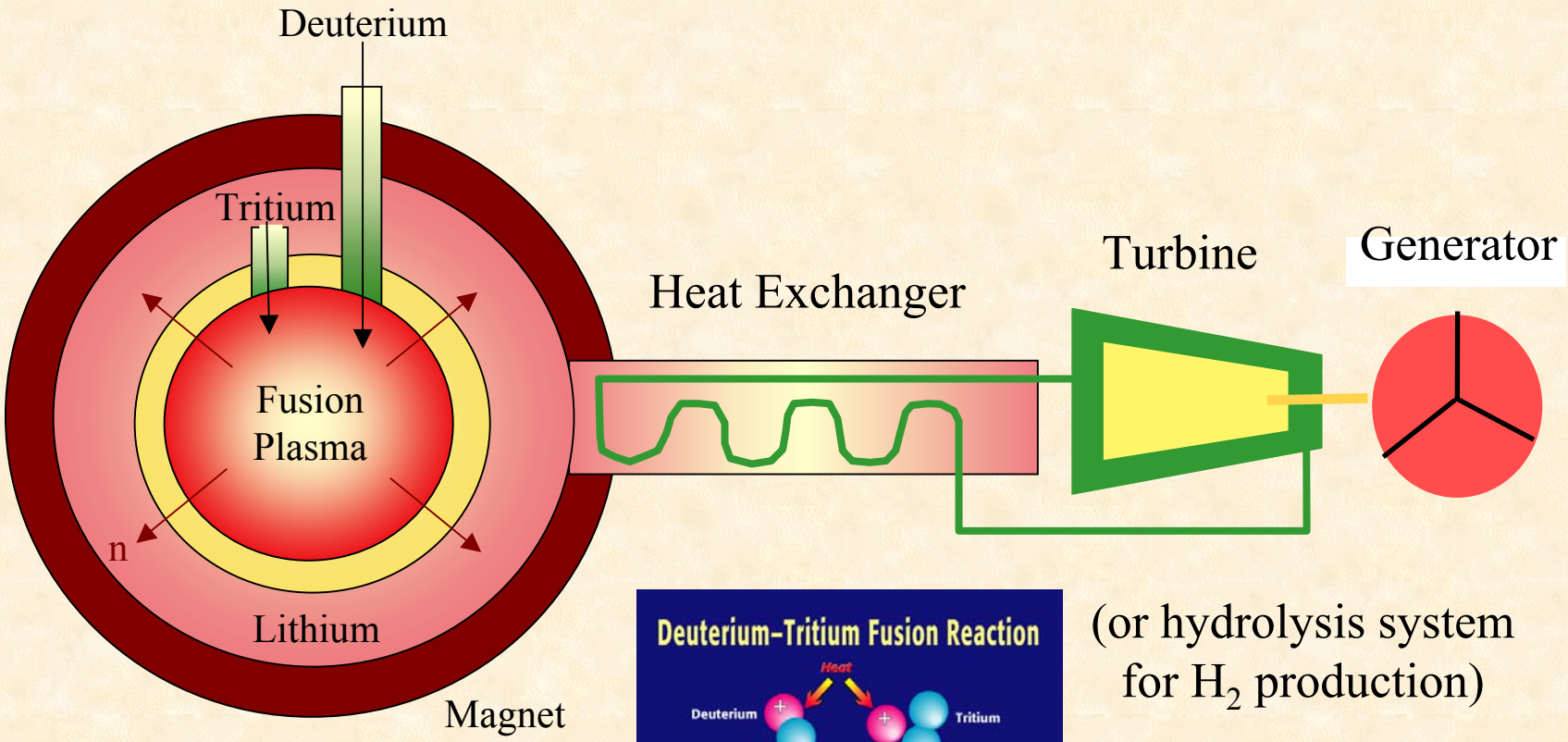
Quasi Poloidal Stellarator
ORNL - in design
Compactness limits

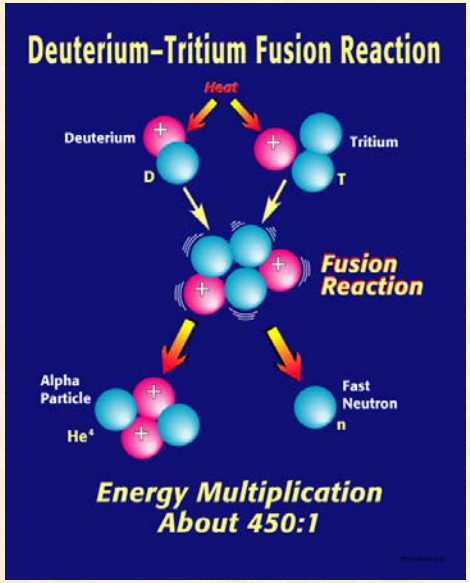
Questions to be addressed:

- How high can the plasma pressure be?
- What is the optimum 3D shape?
- How compact can we make it?

What is the best design for a fusion reactor?

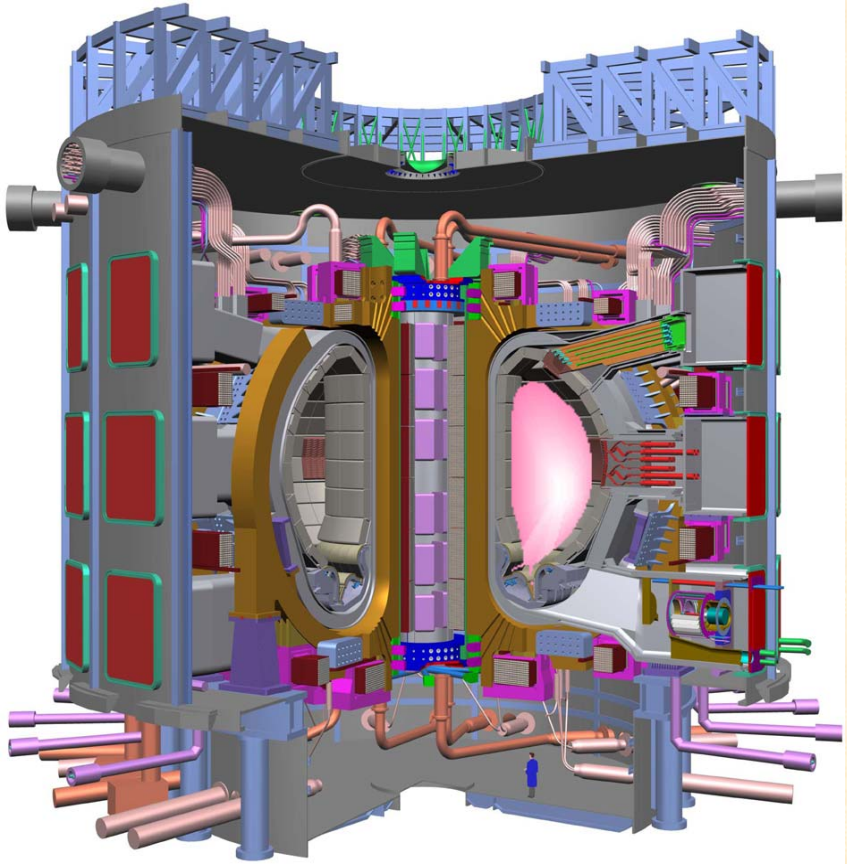
A goal is to design and build a magnetic fusion power system





(or hydrolysis system for H_2 production)

ITER provides a cooperative opportunity to make a sun on earth



500 – 700 MW thermal fusion power
400 sec – 1 hr pulse length

Science Benefits:
Extends fusion science to larger size, burning (self-heated) plasmas

Technology Benefits:
Fusion-relevant technologies
High duty-factor operation

Goal:
To demonstrate the scientific and technological feasibility of fusion energy

Bioenergy and plant genomics: Expanding renewable energy resources

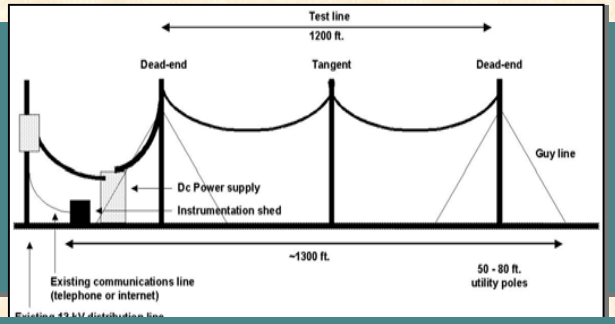
Poplar trees

- New energy source biomass → thermal → energy
- 40 million acres would replace all projected oil from the Persian Gulf

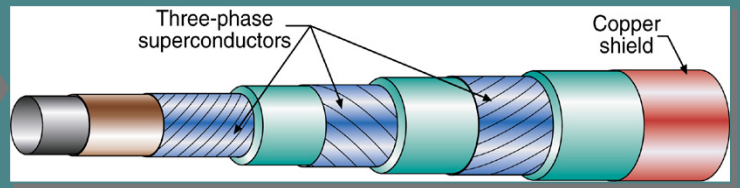
Energy Efficiency and Renewable Energy Program

Recent Accomplishments

- Initiated new program on electric transmission technology research, development, and testing



- Developed a compact tri-axial high temperature superconducting cable

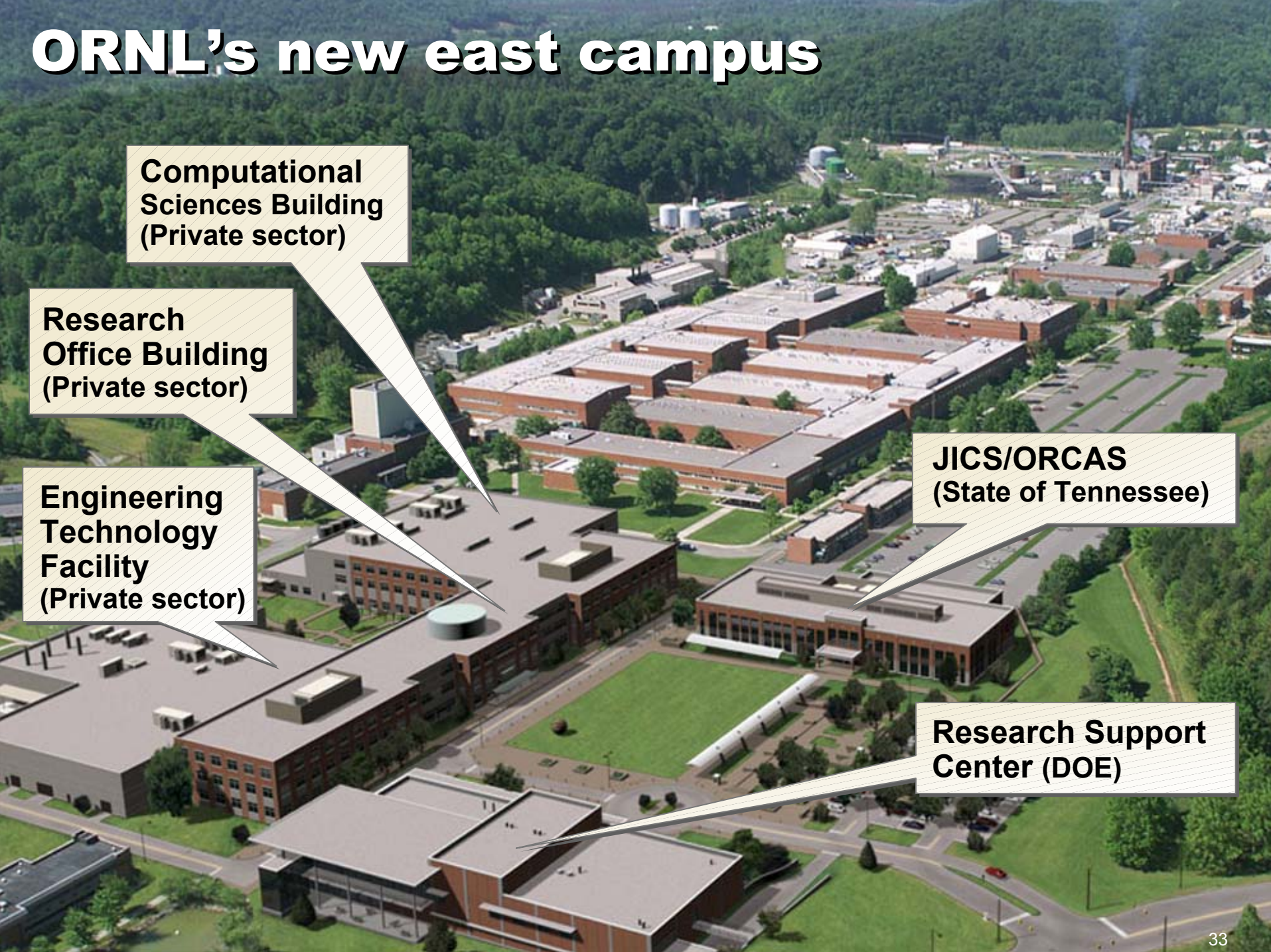


- Starting a hydrogen program aimed at eventual H energy economy

National/Homeland Security

- SensorNet is being tested in D.C. and at Watt Road on I-40
  - Y-12 site possible
- CBMS Block II is in commercial production
- Aqua Sentinel is moving from the lab to the field
- Weigh stations on Tennessee interstate highways are equipped with ORNL radiation detectors
- ORNL technologies were featured on ABC's "World News Tonight" in December

ORNL's new east campus

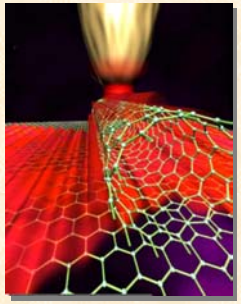
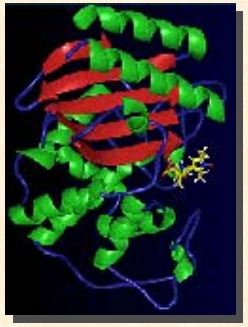
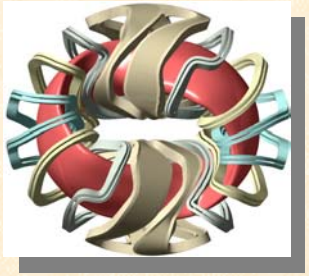


Private-sector facilities

We collaborate extensively with our university partners

Oak Ridge Center for Advanced Studies	• 21st century think tank • Focused on complex interdisciplinary problems
Collaborative research	• Tennessee Mouse Genome Consortium • Georgia Tech/Virginia Tech topical center • Homeland security workshops
Joint hiring	• Distinguished scientists • Joint faculty
Joint institutes	• Heavy ion research • Neutron sciences • Biological sciences • Computational sciences
User facilities	• 18 at ORNL • Many at our university partner sites
UT-Battelle Board	• Science and technology committee

Science is a great career



- Materials - R&D is affecting our lives
- Physics and chemistry - fundamental research drives many fields
- Biology - a revolution in knowledge
- Computing - large scale computing is changing the nature of science
- Energy - huge problems for the world to solve