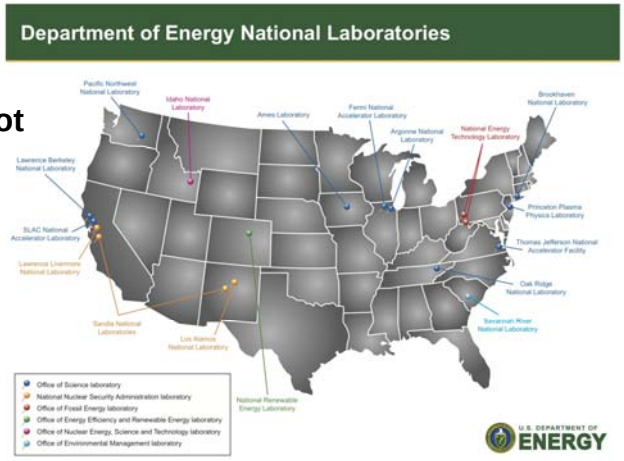
Outline

- **Biology at National Laboratories**
- **Biology and Energy**
- **Summary of BNL program**
- **Outlook**

Biology and Environmental Sciences at a DOE National Lab

- What?
- Why? and why not at a university?
- Why BNL?
- Partners?
- Who will fund it?



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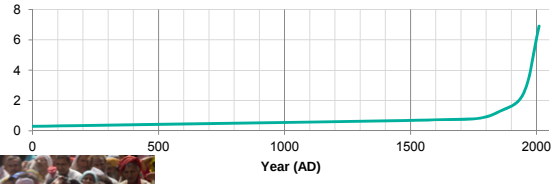
Biology and Environment

- In the final analysis, the drivers come from the need to produce energy and food for a growing world population.

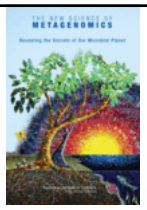
World Population (billions)



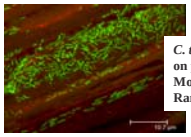
7 billion
October 2011

Source: World Population Database (http://esa.un.org/unpp/)

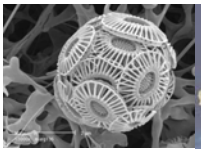
"Microbes run the world"*



- Environmental cycles



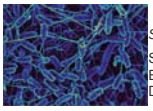
C. thermocellum on poplar, Morrell-Falvey and Raman, ORNL



Emiliana huxleyi

Blooms of *E. huxleyi*

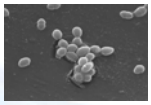
Source: J. Young, Natural History Museum, London



Shewanella oneidensis

Source: Rizlan Bencheikh and Bruce Arey, Environmental Molecular Sciences Laboratory, DOE Pacific Northwest National Laboratory

- Human health



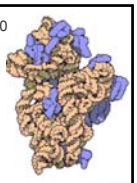
Enterococcus faecalis

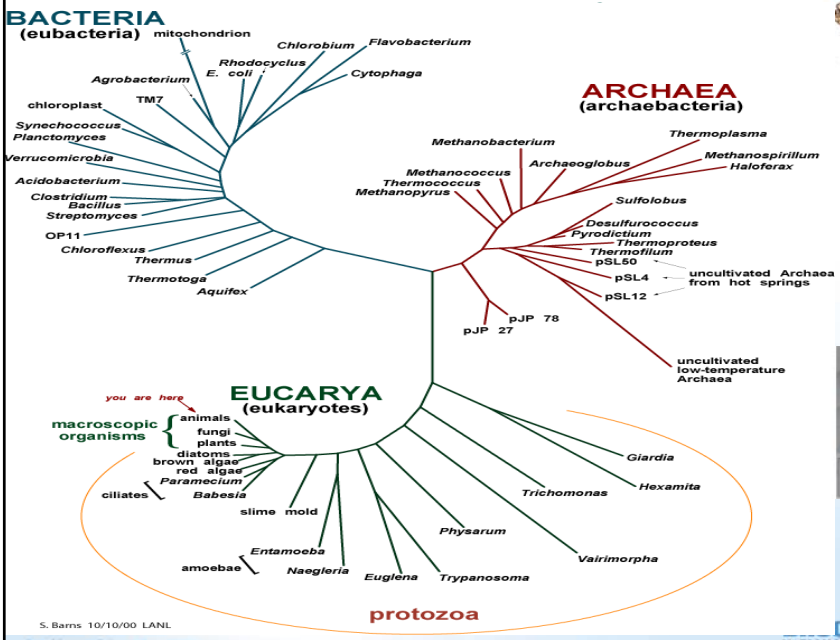
Bacteroides

*The New Science of Metagenomics: Revealing the Secrets of Our Microbial Planet
Committee on Metagenomics: Challenges and Functional Applications, National Research Council
ISBN: 0-309-10677-X, 170 pages, 6 x 9, (2007)

"Microbes run the world. It's that simple. Although we cannot usually see them, microbes are essential for every part of human life—indeed all life on Earth. Every process in the biosphere is touched by the seemingly endless capacity of microbes to transform the world around them. It is microbes that convert the key elements of life—carbon, nitrogen, oxygen, and sulfur—into forms accessible to all other living things. For example, although plants tend to get credit for photosynthesis, it is in fact microbes that contribute most of the photosynthetic capacity to the planet. All plants and animals have closely associated microbial communities that make necessary nutrients, metals, and vitamins available to their hosts."

http://en.wikipedia.org/wiki/16S_ribosomal_RNA#cite_note-Schluenzen-0





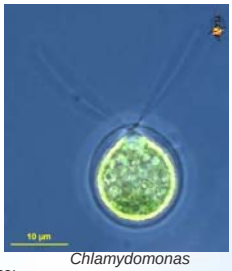
S. Barns 10/10/00 LANL

Biomass for fuel and other products

- Biofuel choices can have substantial environmental implications — positive and negative
- Baseline data and a set of indicators are essential to determine the direction of the effect
- Land-use change and associated carbon emission are complicated
- The opportunity exists to design biofuel choices to optimize socioeconomic and ecologic benefits

The use of biological processes to make cleaner fuels with high energy content

- Microbes carry out some chemical processes better than comparable engineered solutions.
- Thus, microbes or microbial products can be used to convert sunlight, hydrocarbons, or biomass to useful energy products.
- These types of biological conversions can operate under a wider range of conditions than traditional industrial approaches.



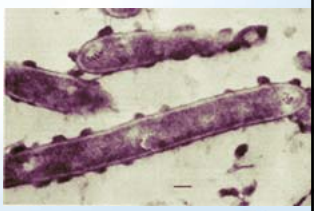
Chlamydomonas

Source: http://starcentral.mbl.edu/microscope/portal.php?pagetitle=assetfactsheet&imageid=1042

"I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable. I believe then that when the deposits of coal are exhausted, we shall heat and warm ourselves with water. Water will be the coal of the future."

Jules Vernes (1870) "L´île mystérieuse"

Source: John Houghton, DOE/BER



Clostridium thermocellum

Source: JGI

Department of Energy- biological and environmental research agenda

- Develop biofuels as a major secure national energy resource
- Understand relationships between climate change and Earth's ecosystems, and assess options for carbon sequestration
- Develop new tools to explore the interface of biological and physical sciences
- Understand complex processes that convert and store energy in biosystems

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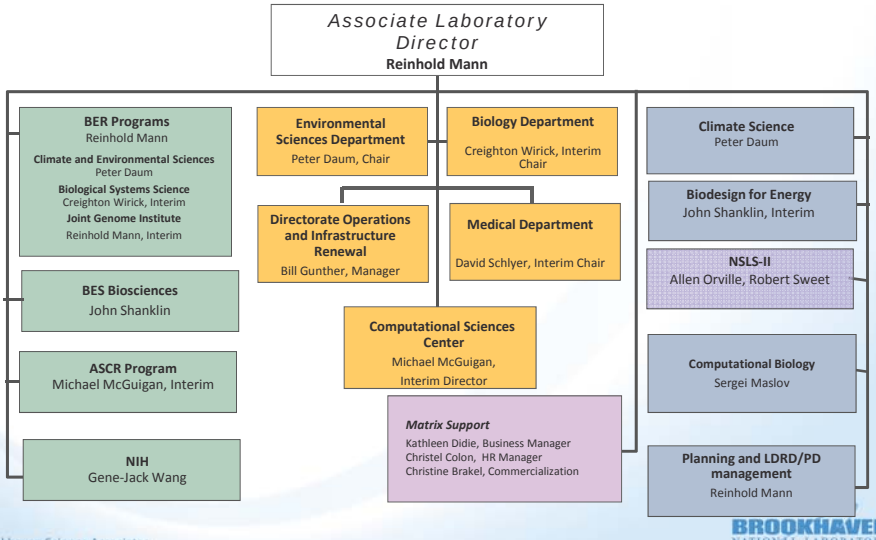
Environmental, Life and Computational Sciences Directorate



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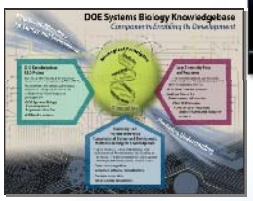
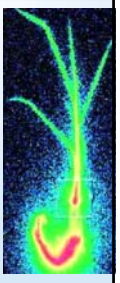
Environmental science

- Advanced targeted cloud science
  - Focus on role of clouds and aerosols in climate forcing
- Controlled ecosystem experiments
  - Innovate through coupling atmospheric process modeling expertise with ecosystem science at BNL to develop integrated atmosphere-ecosystem model, in collaboration with key partners in the climate community
- Tracer technologies
  - Further the application of non-radioactive perfluorocarbon tracers to study the movement of air and airborne contaminants in the parts/quadrillion range

Biology – Science and Facilities

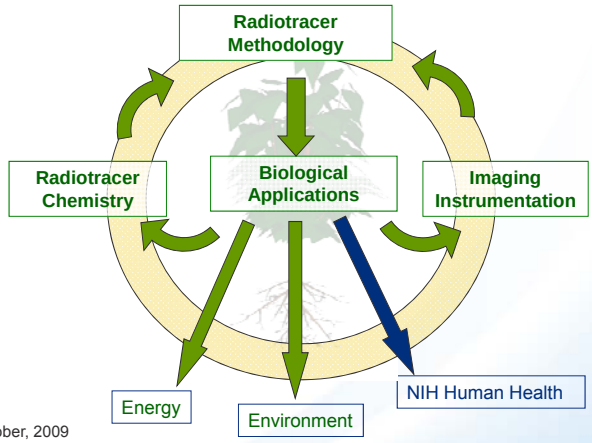
- **Science**
  - Plant physiology, biochemistry & metabolic engineering
  - Radiobiology
  - Bioinformatics and computational biology
  - Radiochemistry/instrumentation/plant imaging
  - Molecular biology and biophysics
  - Biomedical research
- **Facilities**
  - NASA Space Radiation Laboratory
  - Brookhaven Laboratory Animal Facility
  - Clinical Research Center and liaison to SBU Medical School





Bioimaging

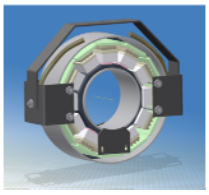
Radiotracer Chemistry, Instrumentation and Biological Imaging*



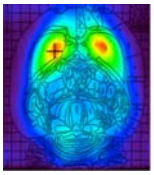
*funded in October, 2009

Goal: To develop new radiotracers and imaging instruments to study how plants use chemical signaling pathways to control carbon and nitrogen turnover in response to environmental stressors and other changes

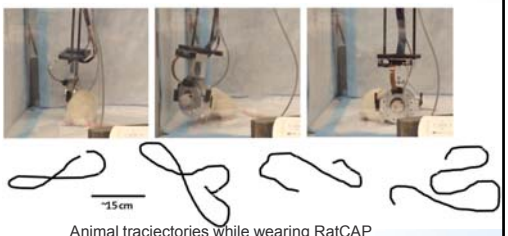
Integrating functional neuroimaging and the study of behavior with the RatCAP miniature PET tomograph



RatCAP scanner design

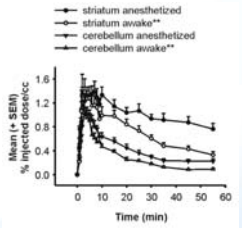


PET image of conscious rat brain overlaid with atlas

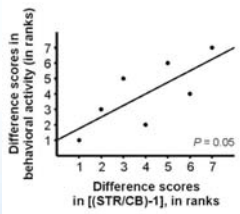


Animal tracjectories while wearing RatCAP

- New scientific tool: quantitative functional imaging of the whole brain in the behaving animal allows correlation with behavioral data
- Observed correlations challenge traditional paradigms of dopamine system function
- First peer-reviewed publication of full RatCAP system and scientific results
  - Accepted in Nature Methods (part of Nature Publishing Group, impact factor 17)
  - Reviewer comments:
    - "a monumental … truly remarkable and outstanding achievement"
    - "a breakthrough"
    - "tremendous potential"
- BNL Medical/Physics/Instrumentation, funded by DOE OBER, new NIH grant for animal studies (PI Schulz)



Large difference in tracer uptake between conscious and anesthetized rats



Behavioral activity correlates positively with tracer binding

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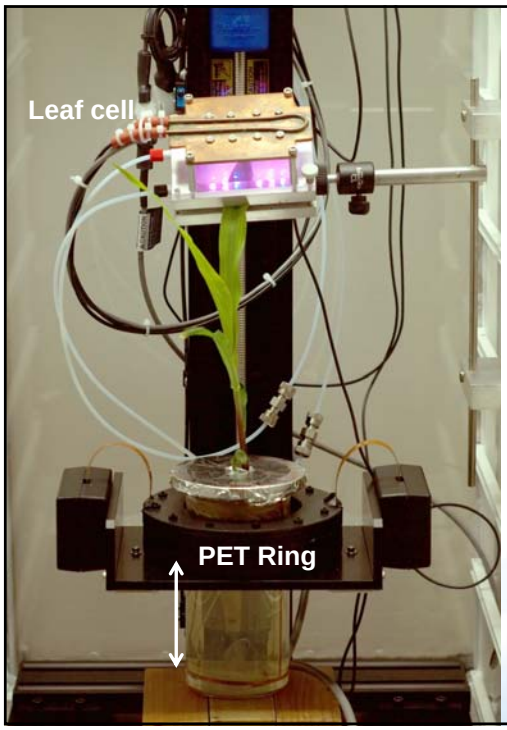

BNL Plant PET Imager

- A maize plant grown in agar gel is set up to receive a dose of $^{11}CO_2$ through the lighted leaf cell.
- Radiolabeled sugars produced through $^{11}CO_2$ fixation are transported to roots where the moveable PET imager can quantify allocation and transport speed--both metrics of our root phenotype screen.

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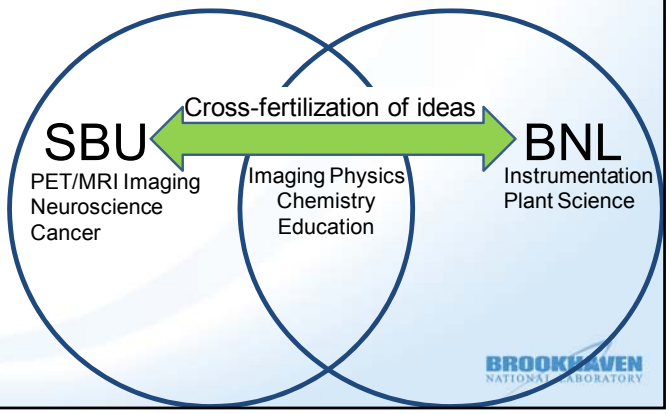
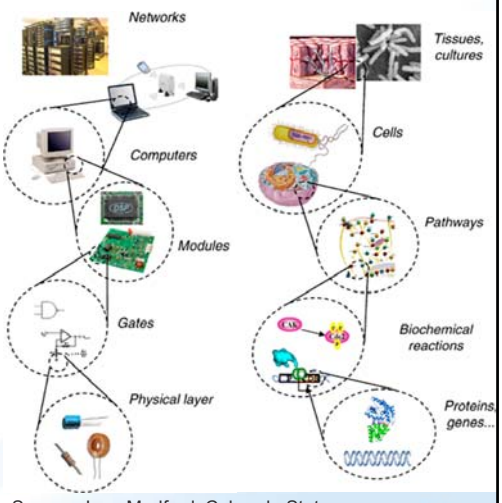
BNL Medical Research

- Extraordinary record of accomplishments
- Pioneered cross-disciplinary team research
- Many new opportunities
- Vision: SBU-BNL partnership, Joint Appointments for faculty, new PET facility at SBU



Synthetic biology - biodesign for energy

- A priority for DOE program
- Emerging activities in synthetic biology
- DOE Planning workshop held in July 2011
  a) **Microbial systems design for biofuels, from computer modeling to experimental validation**
  b) **Plant systems design for bioenergy**
- BNL to develop significant research effort



Source: June Medford, Colorado State

NSLS/NSLS-II are important for Biology

- Close to **50%** of **NSLS** use is in **biosciences**

- **NSLS-II Operations by 2015**
  - Energy: 3 GeV @ 500 mA
  - Flux density: ≥ 10^{15} ph/s/0.1% BW
  - Brightness: (2 keV - 10 keV) ≥ 10^{21}ph/mm^2/mrad^2/s/0.1%BW
  - Spatial resolution: 1 nm; Energy resolution: 0.1 meV
  - 10,000 times more powerful than NSLS

Summary and outlook

- The ELS Directorate is the steward for biology and environmental sciences at BNL
- In addition, we are developing the lab-wide high-performance computing strategy through the Computational Science Center
- The program is undergoing some changes to better align itself with the main thrust of the DOE program
- Strategic partnerships are essential to our future
- Stony Brook and our other core Universities, and Cold Spring Harbor Laboratory are key partners
- Leveraging the special facilities (NSLS-II, Nanoscience Center, Computing) and capabilities in the physical sciences are key to the future of biology at BNL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