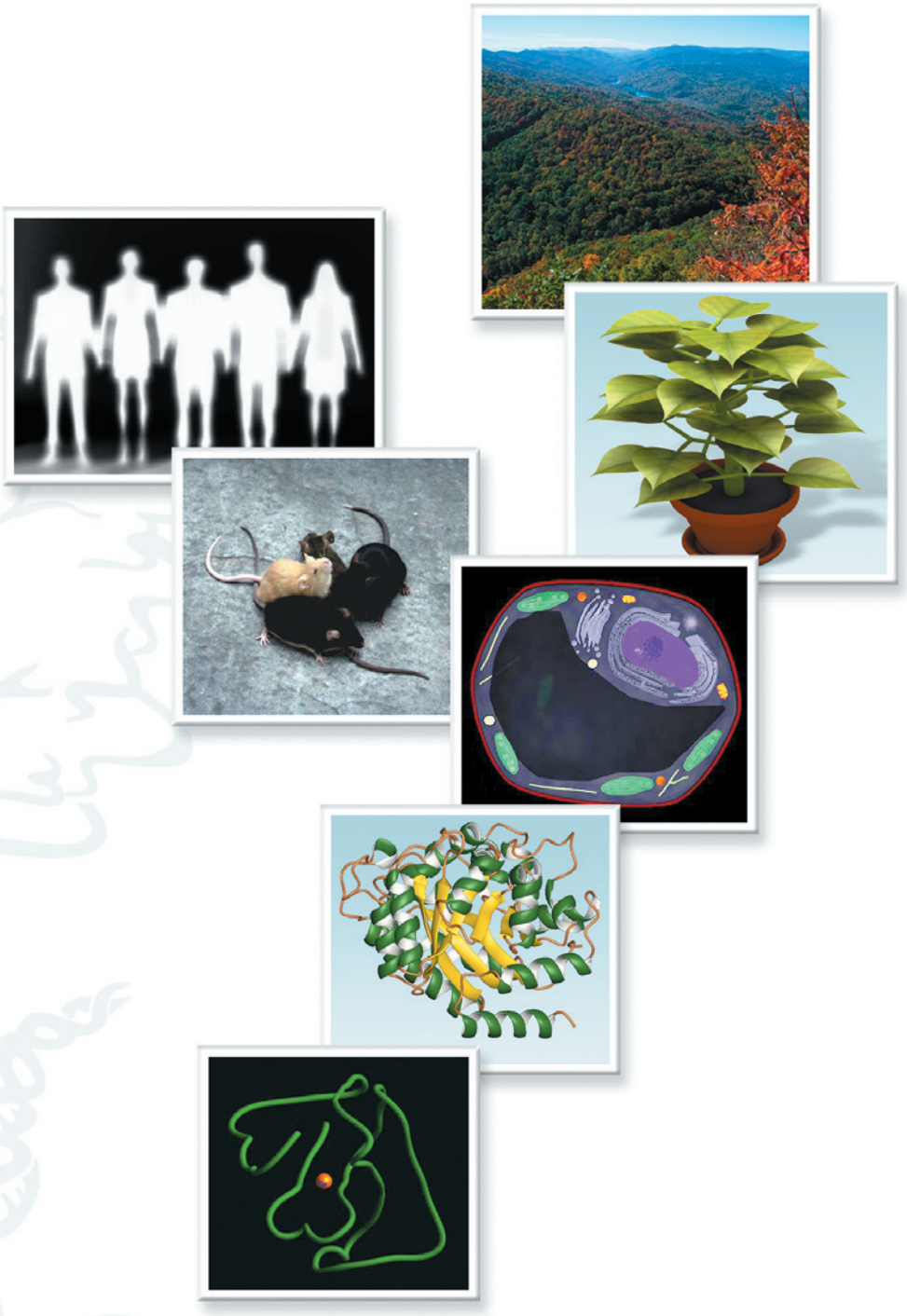
Annual Report

Biological and Environmental Research

BIOLOGICAL AND ENVIRONMENTAL RESEARCH • OAK RIDGE NATIONAL LABORATORY

FY 2004



December 2004

BIOLOGICAL AND ENVIRONMENTAL RESEARCH • OAK RIDGE NATIONAL LABORATORY

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Oak Ridge National Laboratory (ORNL) conducts basic and applied research and development to create scientific knowledge and technological solutions that strengthen the nation's leadership in key areas of science; increase the availability of clean, abundant energy; restore and protect the environment; and contribute to national security.

OAK RIDGE
NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Office of Science
U.S. DEPARTMENT OF ENERGY

Foreword

Reinhold C. Mann
ORNL Associate Laboratory Director
Biological and Environmental Sciences
Oak Ridge National Laboratory

Scientists and engineers in the Biological and Environmental Sciences Directorate at the Oak Ridge National Laboratory perform research that is supported primarily by the Department of Energy's Office of Science through the Office of Biological and Environmental Research. The Directorate consists of the Life Sciences Division and the Environmental Sciences Division. We manage a number of research facilities and data archives, including the Mouse Genetics User Facility, the Center for Structural Molecular Biology, the Natural Accelerated Bioremediation Research Field Research Center, one of the Free Air Carbon Dioxide Exchange facilities, the Atmospheric Radiation Measurement Program Data Archive, the Carbon Dioxide Information Analysis Center, and the Oak Ridge National Environmental Research Park.

Our research leads to new knowledge and technologies in areas of critical importance to the nation, such as energy security, environmental management, and homeland and national security. We perform research and development that leads to

- understanding biological systems and their relationships to the environment and to human health,
- understanding microbial communities and microbe–plant interactions in biogeochemical cycling,
- measuring and forecasting ecosystem change,
- understanding global climate change, and
- developing highly effective diagnostic and therapeutic techniques based on fusing nanotechnology with biology from the molecular to the systems level.

In addition to work supported by the Department of Energy, we perform research and development supported by other federal and state institutions and by the private sector as well.

This report features selected highlights of research by our scientist and engineers during the fiscal year 2004. It also summarizes the recognitions and awards received by these researchers. You can learn more about the Biological and Environmental Sciences Directorate by visiting our web site at (http://www.ornl.gov/sci/besd/).

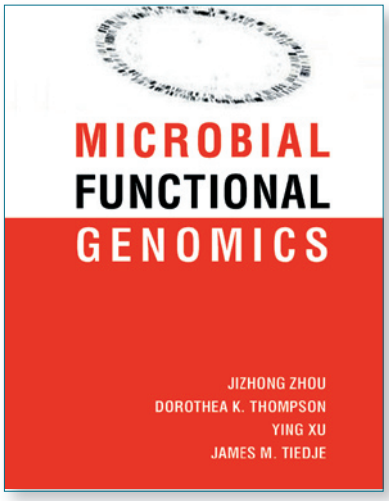
Genomics: GTL Program

DOE's Genomics: GTL (Genomes to Life) program is using new genomic data and high-throughput technologies for studying the proteins encoded by the genome to explore the amazingly diverse natural capabilities in microbes. During the first 18 months of this DOE-funded project at ORNL, the Center for Molecular and Cellular Systems (CMCS) team evaluated various technologies for performing protein complex pulldowns and analysis, assembled and validated capabilities, and initiated the "pipeline." To date, the pipeline has operated for 37 weeks with an average of 4 pulldowns per week, including replicates, controls, and blanks. The ORNL pipeline, which uses the endogenous pulldown method, is integrated with the Pacific Northwest National Laboratory (PNNL) pipeline that uses exogenous pulldowns. ORNL has lead responsibility for the integration of the entire CMCS project, which, in addition to ORNL and PNNL, includes researchers from Argonne National Laboratory, Sandia National Laboratories, the University of Utah, and the University of North Carolina.

M. B. Strader, N. C. VerBerkmoes, D. L. Tabb, H. M. Connelly, J. W. Barton, B. D. Bruce, D. A. Pelletier, B. H. Davison, R. L. Hettich, F. W. Larimer, and G. B. Hurst. "Characterization of the 70S ribosome from Rhodopseudomonas palustris using an integrated 'top-down' and 'bottom-up' mass spectrometric approach," **Journal of Proteome Research** 3(5): 965-978, American Chemical Society (2004).

First text on microbial functional genomics

Microbial Functional Genomics, the first book with a focus on microbial functional genomics, was published this year. As the first comprehensive treatment of its subject, the 624-page book provides a timely synthesis and summary of the principles, approaches, and applications of microbial functional genomics. It also identifies research gaps, challenges, and experimental directions in the field and points out the advantages and limitations of recently developed high-throughput genomic technologies, notably DNA microarrays and proteomic tools.



Microbial Functional Genomics begins with a chapter that attempts to codify and distinguish various aspects of functional genomics by defining the purpose and the scope of genomics; and it ends with a chapter that speculates on genomics beyond single-cell boundaries, focusing on studies of microbial genomics within the context of microbial populations, communities, and ecosystems. Chapter topics range from a discussion of computational and genomic-scale tools for gene expression analysis to the impact of functional genomics on such established research areas as microbial evolution, bacterial pathogenesis, antimicrobial drug discovery, and microbial detection.

J. Zhou, D. K. Thompson, Y. Xu, J. M. Tiedje,. A. S. Beliaev, T. Palzkill, and R. Hettich. **Microbial Functional Genomics**, John Wiley and Sons (www.wiley.com), 2004.

Nature Biotechnology *features R. pal work*

An article by Frank Larimer and his colleagues on their work with Rhodopseudomonas palustris (R. pal) was published in **Nature Biotechnology**, and the cover featured their work. The publication is a major step toward understanding how this bacterium coordinates and expresses its many metabolic capabilities in response to changing environmental conditions.

The article describes the genome sequence of R. pal, which consists of a 5,459,213-base-pair (bp) circular chromosome with 4836 predicted genes and a plasmid of 8427 bp. This work represents one of the first genomes of anoxygenic photobacteria to be finished. The sequence reveals genes that confer a remarkably large number of options within a given type of metabolism, including three nitrogenases, five benzene ring cleavage pathways, and four light harvesting 2 systems. R. pal encodes 63 signal transduction histidine kinases and 79 response regulator receiver domains. Almost 15% of the genome is devoted to transport. This genome sequence is a starting point to use R. pal as a model to explore how organisms integrate metabolic modules in response to environmental perturbations.

F. W. Larimer, P. Chain, L. Hauser, J. Lamerdin, S. Malfatti, L. Do, M. L. Land, D. A. Pelletier, J. T. Beatty, A. S. Lang, F. R. Tabita, J. L. Gibson, T. E. Hanson, C. Bobst, J. L. T. Y. Torres, C. Peres, F. H. Harrison, J. Gibson, and C. S. Harwood. "Complete genome sequence of the metabolically versatile photosynthetic bacterim Rhodopseudomonas palustris," **Nature Biotechnology** 22(1): 55–61 (2004).

ISI "new hot paper"

A scientific study of carbon turnover in fine roots conducted at the ORNL and Duke University Free Air CO_2 Enrichment sites was listed as an ISI Essential Science Indicators "new hot paper" in the field of Environment and Ecology for November 2004. The ESI Special Topics Web Site recognizes selected papers that are of special current interest.

ORNL's Richard Norby was among the authors of the paper.

The paper shows that differences between tree species in carbon allocation to roots and root dynamics help determine soil carbon sequestration potential. The study found that fine roots of some forest tree species live years longer than the 1-year lifespan estimates often used to calculate the carbon-storing capability of forests. Trees that regenerate fine roots more often deposit more atmospheric carbon into the soil than trees with longer-lived fine roots, the findings suggest. By using a uniform, 1-year turnover time for fine roots, past studies may have overestimated the amount of CO_2 that the forests of the world can sequester each year.

R. Matamala, M. A. Gonzalez-Meler, J. D. Jastrow, R. J. Norby, and W. H. Schlesinger. "Impacts of fine root turnover on forest NPP and soil C sequestration potential," **Science** 302: 1385–1387, November 21 (2003).

CSiTE evaluates CO_2 sequestration potential

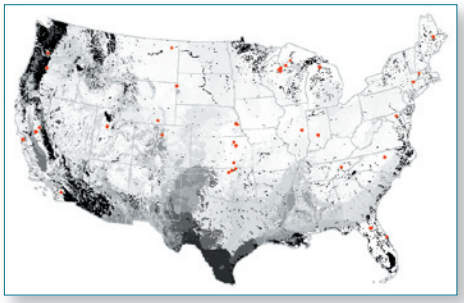
The Consortium for Research to Enhance Carbon Sequestration in Terrestrial Ecosystems, or CSiTE, has described an approach to assessing promising techniques for removing CO_2 from the atmosphere through management of terrestrial ecosystems. CSiTE is a group of researchers led by Wilfred Post of ORNL, Cesar Izaurralde of the Pacific Northwest National Laboratory, and Julie Jastrow of the Argonne National Laboratory. According to CSiTE, agriculturally-based options for reducing net greenhouse gas emissions by increasing carbon sequestration in soils should be evaluated for competitiveness with other options such as renewable energy and CO_2 capture with geologic storage.

Various land-use practices have potential for increasing CO_2 uptake, including intensifying cropping, adding organic material to soil, conservation tillage, and establishing forests and grasslands. Initial cost estimates of some of these practices appear low, but other considerations must be weighed before the techniques are likely to see widespread use, including the likely permanence of soil carbon sequestration using different methods. Assessing potential ancillary environmental effects is necessary, as are sensitivity analyses to determine likely consequences over the range of applicable conditions.

W. M. Post, R. C. Izaurralde, J. D. Jastrow, B. A. McCarl, J. E. Amonette, V. L. Bailey, P. M. Jardine, T. O. West, and J. Zhou. "Carbon sequestration enhancement in U.S. soils," **Bioscience** 54(10): 895–908 (2004).

AmeriFlux ecoregion-scale analysis

The AmeriFlux network, established in 1996, consists of a network of instrumented towers across the country that provide continuous observations of ecosystem-level exchanges of CO_2, water, energy, and momentum. Its purpose is to quantify variation in CO_2 and water vapor exchange between terrestrial ecosystems and the atmosphere and to clarify underlying mechanisms responsible for observed fluxes and carbon pools.



A new ecoregion-scale analysis of the AmeriFlux network reveals that although central continental environments are well represented, additional flux towers are needed to represent environmental conditions in south Texas, the Sonoran Desert, and the Pacific Northwest.

The new analysis is based on a set of statistically derived ecoregions produced for the lower 48 states, using a multivariate clustering process. Because of the small cell size and the large number of cells, the cluster analysis was performed in parallel on a supercomputer.

DOE is currently selecting additional tower sites in the upper Midwest region. In terms of representing conditions within the lower 48 states, however, the regional analysis suggests adding sites in the Pacific Northwest or south Texas would improve representation more.

W. E. Hargrove, F. M. Hoffman, and B. E. Law. "New analysis reveals representativeness of the AmeriFlux network," **EOS** 84(48) (December 2, 2003).

Atp 10c gene controls obesity, metabolic problems

Research has shown that deleting a specific gene in mice leads to obesity and associated metabolic problems. Mice lacking the Atp10c gene are heavier and fatter and develop non-alcoholic fatty liver disease over time.

Atp10c is believed to function in the transport of lipids in fat cells. It is a novel type IV P-type ATPase and a putative phospholipid transporter. The study assessed the overall effect of the heterozygous deletion of Atp10c on obesity-related phenotypes and metabolic abnormalities in mice fed a high-fat diet. Heterozygous mice with maternal inheritance of Atp10c were compared

	10% fat diet	10% fat diet	45% fat diet	45% fat diet
	Controls	Atp10c mutants	Controls	Atp10c mutants
Body weight	28.2+2.75 g	36.28+5.99 g	32.3+3.85 g	37.4+4.86 g
Inguinal fat pad	0.22+0.08 g	0.39+0.02 g	0.41+0.14 g	0.67+0.27 g
Epididymal fat pad	0.35+0.09 g	0.65+0.16 g	0.66+0.16 g	0.66+0.13 g
Mesenteric fat pad	0.27+0.11 g	0.52+0.15 g	0.42+0.12 g	0.58+0.21 g
Retroperitoneal fat pad	0.11+0.04 g	0.21+0.07 g	0.16+0.05 g	0.26+0.16 g
Visceral fat	0.74+0.21 g	1.38+0.26 g	1.23+0.25 g	1.51+0.33 g
Adiposity index	4.6+1.20	6.9+1.32	7.1+1.51	8.2+1.0

with heterozygous mice with paternal inheritance of Atp10c and wild-type controls.

Mutants inheriting the deletion from their mothers had significantly higher body weight; adiposity index; and plasma insulin, leptin, and triglyceride concentrations than sex- and age-matched male control mice fed a 10% fat diet and female mice fed a 45% fat diet. Glucose and insulin tolerance tests after 4 and 8 weeks on the diets showed mutants had altered glucose tolerance and insulin response compared with the controls, suggesting insulin resistance in both sexes.

Mice were killed at 12 weeks, and routine gross and histological evaluations of the liver, pancreas, adipose tissue, and heart were performed. Histological evaluation showed more severe micro- and macrovesicular lipid deposition within the hepatocytes in the mutant mice. Although gender differences were observed, our data suggest that heterozygous deletion, along with an unusual pattern of maternal inheritance of the chromosomal region containing the single gene Atp10c, causes obesity, type 2 diabetes, and nonalcoholic fatty liver disease in these mice.

M. S. Dhar, C. S. Sommardahl, T. Kirkland, S. Nelson, R. Donnell, D. K. Johnson, and L. W. Castellani. "Mice heterozygous for Atp10c, a putative amphipath, represent a novel model of obesity and type 2 diabetes," **Journal of Nutrition** 134(4): 799–805 (April 2004).

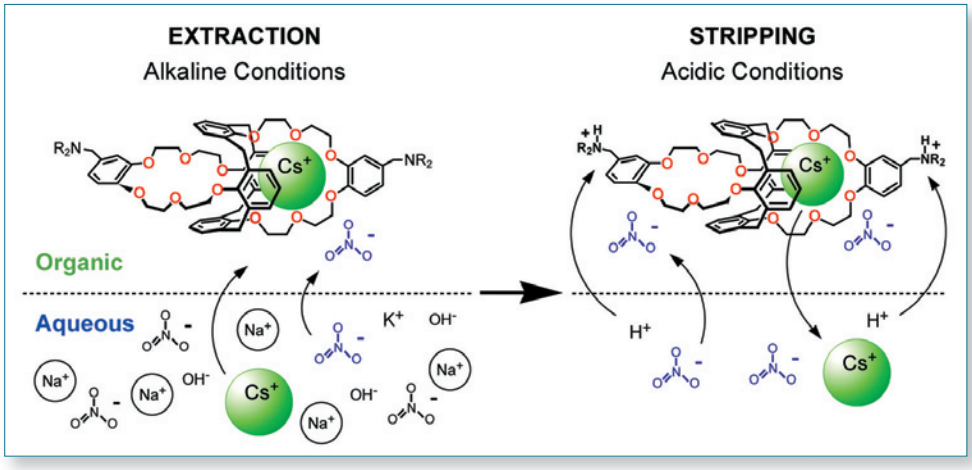
New cesium extractants promising for cleanup

A proof-of-principle experiment has shown that a prototype generation of new pH-switchable cesium extractants offers up to three-fold greater stripping efficiency. In principle, if this single-stage improvement is propagated in a multistage flowsheet, a smaller, more efficient, and less expensive plant for cleanup of high-level waste could be designed.

The results were recently published in a journal article describing extraction experiments using new calixarene-crown ether extractants bearing amino substituents. Except for the amino substituents, the new extractants closely resemble BOBCalixC6, the calixarene-crown targeted for use in the Salt Waste Processing Facility being designed for cleanup of high-level waste at the Savannah River Site starting in 2010.

Under acidic stripping conditions, the amino groups in the new extractants become protonated, and it is thought that the resulting charged ammonium groups repel the bound cesium, resulting in its release. Experiments will aim at testing this hypothesis, improving the pH-switching efficiency, and increasing the solubility and robustness of this exciting new family of extractants.

E. Bazelaire, M. G. Gorbunova, P. V. Bonnesen, B. A. Moyer, and L. H. Delmau. "pH-switchable cesium nitrate extraction with calix[4]arene mono- and bis(benzocrown-6) ethers bearing amino functionalities," **Solvent Extr. Ion Exch**. 22(4): 637–661 (2004).



Under alkaline conditions extant in tank waste, the calixcrown extractant binds the cesium, drawing it and a nitrate counterion into the solvent phase. On stripping, protonation of the amine sites in the calixcrown causes release of the cesium ion by charge repulsion.

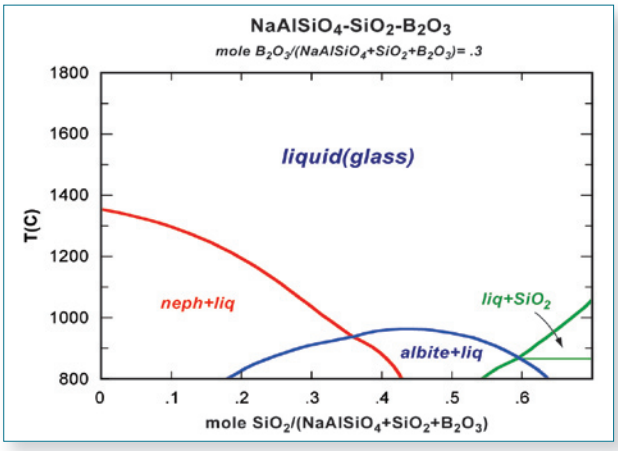
HLW glass model reproduces key chemical behaviors

A model of high-level-waste (HLW) base glass has been developed that reproduces key melting points and chemical behavior, information critical for predicting the behavior of glass in melters and for dealing with problems such as the precipitation of crystals that clog melters. The glass models will also be important as source terms for predicting leaching and stability in waste repositories, and they can provide the initial point for models of radionuclide transport within geologic media. The modeling results have already found commercial utility, in particular in projects with the glass companies Visteon and PPG.

For this work, Dr. Theodore Besmann was honored with the Spriggs Phase Equilibria Award.

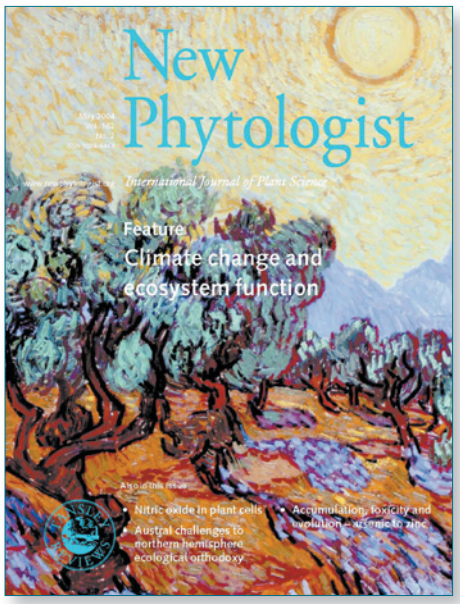
Models of HLW glass composition, processing schemes, limits on waste loading, and corrosion/dissolution release depend on an accurate knowledge of liquidus (melting point) temperatures and thermochemical values. Unfortunately, existing models for liquidus temperatures are empirically based, depending on extrapolation of experimental information. In addition, present models of the leaching behavior of different glass waste forms use simplistic assumptions of the thermochemistry, or experimentally measured values obtained under nonrealistic conditions. There is thus a critical need for more accurate and more widely applicable models for HLW glass behavior. These models were developed based on the associate species approach.

T. Besmann. "Thermochemical modeling of oxide glasses," **J. Am. Ceram. Soc.** 85(12): 2887–94 (2002).



Calculations of liquidus boundaries in nepheline ($NaAlSiO_4$)–SiO_2 system when 30 mol% B2O3 is added, showing significant lowering of maximum possible precipitation temperatures.

New Phytologist *highlights biological, environmental research*



Work sponsored by the Office of Biological and Environmental Research was prominent in the May 2004 issue of the international plant sciences journal New Phytologist, which featured the theme "ecosystem function in response to elevated CO_2 and temperature in terrestrial ecosystems."

The special issue developed from an April 2003 workshop on interactions between increasing CO_2 and temperature in terrestrial ecosystems, organized and chaired by ORNL's Richard Norby. Norby also serves as environment editor of **New Phytologist**. The workshop and the journal issue were strongly influenced by research sponsored by BER's Program for Ecosystem Research and Terrestrial Carbon Processes.

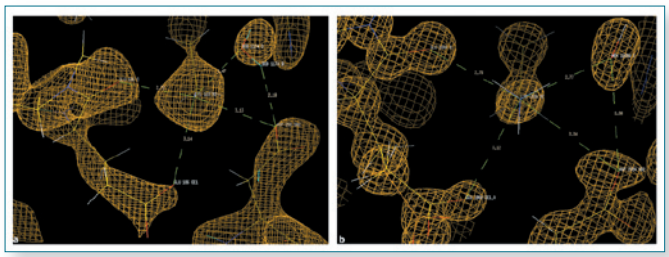
A prestigious Tansley review by Robert Nowak, David Ellsworth, and Stanley Smith focuses on responses observed in DOE's network of Free Air CO_2 Enrichment (FACE) experiments. A review by Norby and Yiqi Luo addresses the issues of multi-factor interactions and data-model fusion that are foci of the Program for Ecosystem Research. Research articles describe results from the FACE experiments at ORNL, Duke University, and the Nevada Test Site, as well as ORNL research on CO_2 and temperature interactions and research sponsored by the National Institute for Global Environmental Change in Colorado.

The special issue is available online at http://www.blackwell-synergy.com/links/toc/nph/162/2, and the workshop is described at http://gcte-focus1.org/activities/activity_11/teracc/tahoe2003summary.html.

Bio-based synthesis of silica nanostructures

Natural systems excel in directing the synthesis of inorganic material for various functional purposes. One of the best-studied systems is silica synthesis, such as occurs in diatoms and marine sponges. ORNL has successfully used poly-L-lysine to promote the synthesis of silica in neutral, aqueous solution and then immobilize it onto a silicon support structure. The resulting structures show silica particles on the order of 30 nm across that eventually fuse to form an interconnected coating. The surface patterning technique offers a route to integrate conventional silicon-patterning technologies with biologically-based material synthesis. This combined fabrication enables controlled assembly over multiple length scales and an understanding of silica synthesis in natural systems.

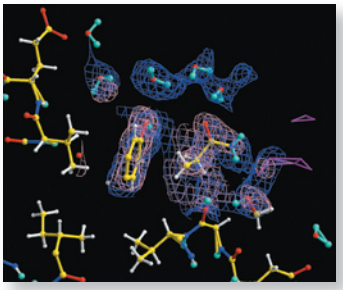
E. A. Coffman, A. V. Melechko, D. P. Allison, M. L. Simpson, and M. J. Doktycz. "Surface patterning of silica nanostructures using bio-inspired templates and directed synthesis," **Langmuir** 20(20): 8431–8436 (2004).



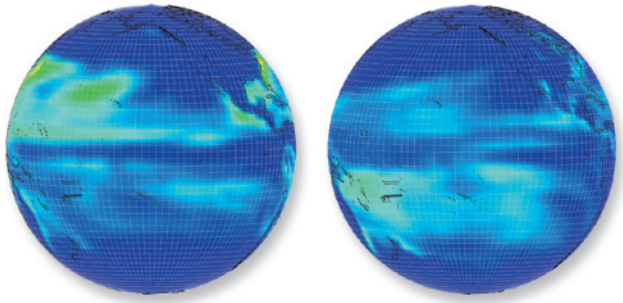
Protonation states of D-xylose-isomerase revealed

Research on the protonation states of D-xylose isomerase (XI) conducted by Dr. Gerry Bunick and his colleagues has been published in the open literature and presented at the 2004 American Crystallographic Association.

To demonstrate the effectiveness of time-of-flight (TOF) neutron diffraction in biology, crystallographers used spallation neutrons at the Los Alamos Neutron Science Center Protein Crystallography Station (PCS) to reveal the protonation states of XI, an important industrial enzyme. These publications are a major step toward validating the PCS and TOF macromolecular neutron diffraction. In addition, XI is one of the largest biological macromolecules ever studied at high resolution using neutron TOF techniques. Most important, this research provides strong justification for funding a macromolecular diffractometer (MaNDi) at the Spallation Neutron Source at Oak Ridge National Laboratory.



B. L. Hanson, P. Langan, A. Katz, X. Li, J. M. Harp, J. P. Glusker, B. Schoenborn, and G. J. Bunick. "A preliminary time-of-flight neutron diffraction study of Streptomyces rubiginosus D-xylose isomerase," **Acta Crystallographica** D60: 241–249, 2004.



Climate modeling for IPCC

ORNL supports climate change studies for the Intergovernmental Panel on Climate Change (IPCC), an organization established by the United Nations Environment Program and the World Meteorological Organization. IPCC climate simulations will document the state of the scientific understanding of climate change due to anthropogenic greenhouse gas emissions. As part of this assessment, the computer models that countries use to make future projections are subjected to detailed comparison and critique. Collections of studies of future emissions scenarios have recently been completed using the computing resources of DOE, the National Science Foundation, and the Japanese Earth Simulator. This collection will form the basis for many of the U.S. research communities' contributions to the IPCC.

Over the last year, ORNL's Center for Computational Sciences dedicated 1.5 million CPU-hours of the IBM p690 computer Cheetah toward this completion of the project. Over 1100 years were simulated using the ORNL computers. The simulation model used is jointly developed by the National Center for Atmospheric Research and a consortium of DOE labs. (The SciDAC program of the Office of Science directed this work.) A new release of the Community Climate System Model in June 2004 was specifically designed to provide simulation results addressing the chief scientific questions asked by the IPCC study.

W. Washington, H. Teng, G. Meehl, J. Arblaster, J. Hu, L. Buja. "Future polar climate change simulations with the CCSM3," to appear in ams.confex.com/ams/pdfpapers/84955.pdf. Data set available at www-pcmdi.llnl.gov/ipcc/ipcc_data_status.php.

Making the artificial retina safe

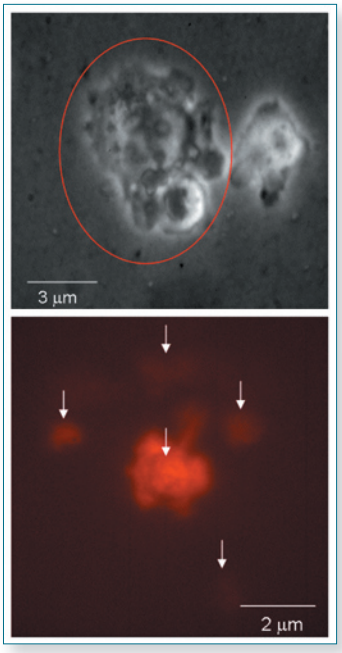
DOE is sponsoring research on development of an artificial retina to restore vision to victims of retinal disorders. As part of that effort, the DOE national laboratories are designing a micro-electronic device that would be implanted on the surface of the retina. A critical issue associated with multielectrode implants for artificial sight is operating the electrodes within safe limits of charge injection and avoiding formation of harmful electrochemical by-products. One of the most harmful of these by-products is gaseous hydrogen formed by electrolysis of water. Multielectrode implants are operated in constant current mode. The compliance voltages can easily exceed the thermodynamic limits of water electrolysis.

To address this problem, ORNL has developed an original diagnostic analysis system to detect the formation of hydrogen under real-world operating conditions. We have constructed a model "glass eye" that contains synthetic vitreous humor and is operated at 37°C. The system can accommodate virtually any electrode size and geometry. The test "eye" cell is part of a flow system that employs a tin oxide gas-sensitive sensor for hydrogen detection. When hydrogen chemisorbs on the surface of the semiconductor sensor, it causes a change in electrical conductivity. The sensor's great sensitivity and ability to operate in steady-state mode for many hours has been recognized as a valuable contribution to the repertoire of diagnostic tools needed for the successful development of retinal implants.

Surface-enhanced Raman scattering on any surface

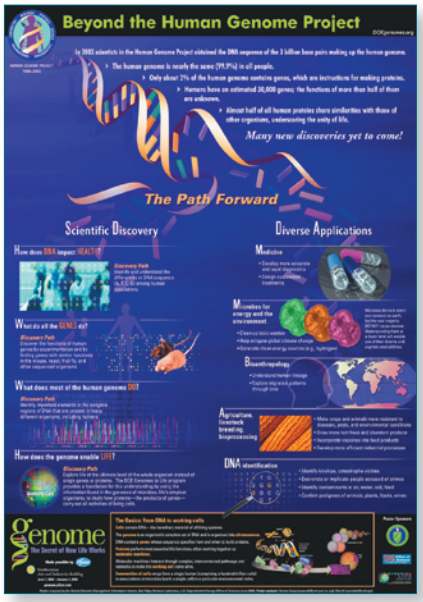
Tuan Vo-Dinh and his colleagues at ORNL have created a nanoprobe that induces surface-enhanced Raman scattering (SERS) on any surface. The SERS-inducing probe was fabricated from an optical fiber tapered to a tip 100 nm in diameter. A thin layer of silver islands was applied to the tip of the tapered fiber via thermal evaporation to induce the SERS effect. The small scale of the tip may be amenable to localized, nondestructive SERS-based analyses of surfaces with high spatial selectivity. Because the contact probe itself induces the SERS effect, no modification of the sample is required. Direct analysis at submicrometer spatial selectivity is therefore possible for analyte compounds on any type of surface.

The small-scale probe allows SERS detection in nanoscale environments, on localized surfaces, and inside cells. Direct analysis of dry surfaces also is now possible. This could spur renewed interest in SERS as a diagnostic tool.



D. L. Stolzes, Z. H. Chi, and T. Vo-Dinh. "Surface-enhanced-Raman-scattering-including nanoprobe for spectrochemical analysis, **Applied Spectrometry** 58: 292–298 (March 2004).

Awards for Genome Management Information System



The Genome Management Information System (GMIS) received eight publication, art, and online awards from the East Tennessee and Pittsburgh chapters of the Society for Technical Communication (STC). The poster "Beyond the Genome" won a Distinguished (first place) award and was entered in STC's international competition, where it received an Award of Excellence.

GMIS also received Excellence awards in the Online Books category, in informational materials, and in technical reports. Merit awards were received in cover design, technical art, and informational materials.

Receiving honors were Anne Adamson, Jennifer Bownas, Denise Casey, Betty Mansfield, Sheryl Martin, Marissa Mills, Kim Nylander, and Judy Wyrick of GMIS and Shirley Andrews of Y-12 Graphic Design Services.

Vo-Dinh is AIMBE Fellow

Tuan Vo-Dinh was elected a Fellow of the American Institute for Medical and Biological Engineering (AIMBE) in 2004. This election is a recognition of his many distinguished contributions to the field, as well as his demonstrated interest, concern, and involvement with critical issues affecting medical and biological engineering.

Membership in AIMBE's College of Fellows is a distinct honor. Total membership in the College is not to exceed 2% of the total number of individuals active in medical and biological engineering.

BER wins R&D 100 Awards

The highly specific, regenerable perchlorate treatment system: Baohua Gu, Gilbert Brown, Bruce Moyer, Peter Bonnesen, and Paul Schiff. This remediation system consists of a unique, highly specific resin that uses selective ion exchange to trap and break down perchlorate—a chlorineoxygen compound found in solid rocket propellant that is increasingly being found in soil and water. The chemical disrupts function of the human thyroid gland, which regulates metabolism in adults and physical development in children. The reaction in the ORNL treatment system that destroys the perchlorate also produces a chemical that regenerates the resin, breaking the perchlorate down into harmless chloride and water.

The explosives vapor sensor: Thomas Thundat, Lal Pinnaduwage, Tony Gehl, Vassil Boiadjiev, and Eric Hawk (with David Hadden of the University of Tennessee, and others). This instrument is a compact, low-cost explosive vapor sensor for detecting and locating a variety of explosives, including plastic-based ones. A micromechanical transducer, no wider than a human hair and with a mass of only a few nanograms, allows only explosive molecules to chemically adsorb to a sensor that can identify the molecule. The explosives vapor sensor is an improvement over other explosive detection products because of its high sensitivity and selectivity, direct vapor sensing, low power consumption, less than one-second response time, stability, compact size, and low cost. It will have applications in counterterrorism, law enforcement, airport safety, and humanitarian efforts such as land mine removal.

FLC Award for tech transfer

The microcantilever-based biosensors technology was chosen by the Federal Laboratory Consortium for an Excellence in Technology Transfer award. The technology can be used in the diagnosis of disease, cancer, and cardiac markers; high-throughput drug screening; and exposure to chemical and bio-warfare agents.

Commercial startups

A new company, Femtogen, LLC, was created to license and commercialize the high-throughput screening microcantilever technology.

Intellectual property

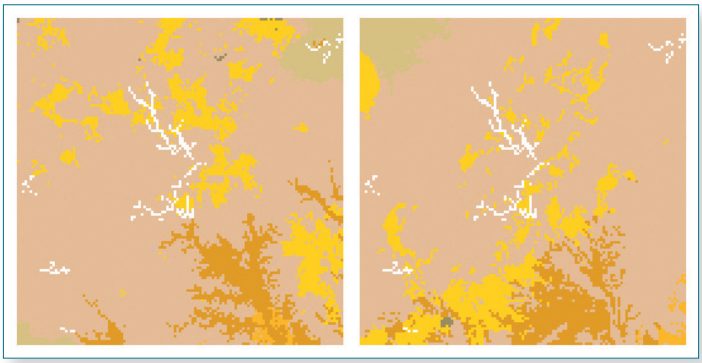
- 14 U.S. and foreign patents awarded
- 18 U.S. patents filed
- 25 invention disclosures filed
- 26 nondisclosure agreements entered

Patent licenses were issued for Protiveris VeriScan™ 3000, Dynamax and Diversified Biotech. An inter-institutional agreement was filed with Marshfield Medical Clinic. Royalty income from licenses in 2004 was $300,000, and UT-Battelle acquired equity as a result of BES licenses with Apocom Genetics, Protein Discovery, HealthSpex, Sense Holdings, Femtogen, and Protiveris.

Comprehensive reviews of the technology and intellectual property portfolios were conducted in 2004, and 17 market analysis studies were completed for BES technologies.

Outstanding Paper in landscape ecology

W. W. Hargrove, F. M. Hoffman, and P. M. Schwartz of ORNL were presented the award for Outstanding Paper in Landscape Ecology in 2004 by the International Association of Landscape Ecology (IALE). The three researchers developed and published a new statistical tool, the Fractal Landscape Realizer, that can generate synthetic multiple-category landscape maps to users' specifications.



The alternative landscape realizations produced are not identical to the actual maps after which they are patterned, but the areas and fractal character of each map category (e.g., vegetation type, water body) are preserved. The Fractal Realizer uses a "recipe" of statistical specifications to produce synthetic landscapes. Because the technique is stochastic, each time the program is executed, it produces a different realization of a landscape map that obeys the statistical recipe.

Since human experts can recognize even subtle differences in pattern, the authors adopted a modified form of a Turing test to evaluate the performance of the Fractal Realizer. Interested persons may take the test at http://research.esd.ornl.gov/realizer. Their results will be added to the summary statistics.

The paper received three nominations for the IALE award. The paper and the test are now part of the standard laboratory curriculum in many introductory classes on landscape ecology, so a new generation of students is also familiar with the Fractal Realizer.

W. W. Hargrove, F. M. Hoffman, and P. M. Schwartz. "A fractal landscape realizer for generating synthetic maps," Conservation Ecology 6(1): article 2, 2002. Available at http://consecol.org/vol6/iss1/art2/index.html

Honors for Thundat

Thomas Thundat received five recognitions from professional and academic groups during 2004:

- The Pioneer Award from the Nanotechnology Institute of the American Society of Mechanical Engineers for pioneering the field of molecular recognition with micro- and nanocantilevers. He published his first paper on microcantilever sensors in May 1994.
- The Jesse W. Beams award for research excellence from the Southeastern Section of the American Physical Society for especially significant research in physics.
- A "Scientific American 50" Award, based on his work with microcantilevers for TNT detection.
- A Distinguished Alumnus Award 2004 from the Indian Institute of Technology in Madras, India for pioneering work in nanomechanical sensor development.
- An invitation to serve as an editor for **Microscale Thermophysical Engineering**, a peer-reviewed journal focusing on microscale thermophysical engineering fundamentals and advanced applications.

Ferrell elected APS Fellow

Thomas Lee Ferrell was elected a fellow of the American Physical Society (APS) in 2004. Ferrell was selected for his invention of the photon scanning tunneling microscope. The microscope can obtain images of single atoms by scanning a tapered optical fiber probe with a nanometer-size tip within a few hundred nanometers of a sample surface.

APS Fellowship recognizes those who have made advances in knowledge through original research or have made significant and innovative contributions in the application of physics to science and technology. Each year, no more than half of one percent of the current APS membership are recognized by their peers by election as Fellows.

Watson receives Commander's Medallion

Annetta Watson was awarded a commendation and the Commander's Medallion for her membership in and extended support for more than a decade to the Toxicology Review Board of the U.S. Army Center for Health Promotion and Preventive Medicine.

Watson was further commended for contributions and commitment to ensuring that quality toxicology is sustained at the Center, mentoring its young scientists, and encouraging its more seasoned professionals to state-of-the-art excellence.

The commendation was signed by William T. Bester, Brigadier General, U.S. Army, Commanding General, U.S. Army Center for Health Promotion and Preventive Medicine.

Russell Laboratory for Comparative and Functional Genomics

The new William L. and Liane B. Russell Laboratory for Comparative and Functional Genomics opened in September 2003 and began rebuilding its population of research mice. Several litters of mouse pups have been re-derived. Nine pups born in March 2004 were the first litter to be re-derived from eight-cell frozen embryos. They marked the beginning of rebuilding a pathogen-free mouse colony in the new Russell Lab.

The mouse population was allowed to dwindle to zero in 2003 as biologists prepared to move their research quarters to a new home on the west campus of ORNL. The old Mouse House was infested with parasites that reduced the quality of research and threatened the facility's accredita-

tion for animal care. Elaborate measures have been taken to ensure the cleanliness of the new Russell Lab and allow high-quality research. ORNL biologists will be implanting female mice with embryos about three times a week for the foreseeable future to rebuild the population. This will result in seven to ten litters a week. The Russell Lab mouse population was expected to reach about 6000 by the end of FY 2004.

As a result of outstanding management of the Russell Laboratory project by ORNL, DOE presented the project managers an Acquisition Improvement Award as part of the 2004 Secretary's Project Management Award.

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