Superfund Scoop

THE NEWSLETTER OF THE UNC-CH SUPERFUND BASIC RESEARCH PROGRAM

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UNC-Chapel Hill SBRP celebrates progress, plans for future

By Program Director James Swenberg

UNC is one of 19 basic science research programs funded by the National Institute of Environmental Health Sciences

In April, the Superfund Basic Research Program (SBRP) at the University of North Carolina-Chapel Hill enters its 14th year. As we apply to renew our grant funding from the National Institute of Environmental Health Sciences (NIEHS), we have an opportunity to celebrate our accomplishments.

The UNC SBRP has been built around seven major research projects, several of which are highlighted in this newsletter. Cutting-edge basic science research at UNC runs the gamut from developing new methods to measure DNA damage caused by exposure to chemicals, to understanding how certain contaminants biodegrade in the soil and exploring ways to use microorganisms and organic processes to clean up contaminated soil, to investigating how skin exposure to toxic chemicals affects human health. Researchers on these projects are supported by experts in our Chemistry and Analytical, Mathematical and Statistical Analysis, and Molecular Epidemiology Cores, who help ensure that researchers optimize how they collect and interpret data. In addition, our Training, Outreach and Administrative Cores help fulfill our missions of education, research and public service.

Some highlights of our recent work include the following:

- By bringing together a team with a strong biomedical focus, we are developing better ways to measure what people are exposed to and the effects of these exposures on tissues and cells. Dr. Steve Rappaport's work on benzene, highlighted in this newsletter, is a great example of this effort. UNC is one of the only SBRPs focused on finding quantitative measures of exposure (or biomarkers) that we can use to study whether there are related toxic effects. Our goal is to understand how chemicals cause disease; biomarkers allow us to quantify the exposure to certain chemicals so that we can more accurately evaluate risk.

- The most common toxins found at Superfund sites in North Carolina and across the nation — dense non-aqueous phase liquids (DNAPLs) — are also the hardest to corral and clean up. If Dr. Cass Miller's field test of his innovative technology using a brine solution to remediate these contaminants (see Research Highlights) is successful, it will change the way the

see **cover story**, next page

The UNC SBRP brings together a diverse group of more than 70 biomedical researchers, engineers, chemists, statisticians, experts in conventional remediation and bioremediation, environmental modelers and students. Together, we are achieving the program's goal to advance society's understanding of the human health and environmental risks associated with hazardous waste and to develop new environmental strategies and technologies for the cleanup of Superfund sites, thereby minimizing human and environmental risk.

major Superfund sites around the country are cleaned up.

- In an exciting example of interdisciplinary teamwork, a group of SBRP researchers recently identified a new genetic polymorphism that may enhance susceptibility to breast cancer in women who smoke.

- Our Outreach Core has effectively taken what our scientists are learning in the laboratories and shared this information with North Carolina citizens, policymakers and environmental advocates and, recently, has strengthened its ties to the N.C. Department of Environment and Natural Resources (DENR). UNC researchers regularly brief DENR staff on our latest findings, and our outreach staff is helping a DENR working group focused on Formerly Used Defense Sites to educate the public about the potential dangers of unexploded ordnance. DENR leaders tell us that this connection has been greatly beneficial to their staff.

For most people living near Superfund sites, the exposures to potentially toxic chemicals are relatively low. Still, quite reasonably, these people are concerned about the impact of this exposure on their health and the health of their families. They want to know: Is it safe to live here? Is it safe to drink the water? Is it okay for my kids to play in the grass or soil? And how much clean-up is needed to eliminate the risks?

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At the UNC SBRP, we believe these are vital questions that deserve answers, and we're doing our best to help.

Through the scientific research that we are conducting across the Carolina campus — and through our efforts to disseminate our findings to the public and to policymakers, local officials and advocates across North Carolina and the country — we are helping to increase understanding of the environmental and health impacts of exposure at Superfund sites and of better ways to clean up these sites.

With the NIEHS' renewed support, the UNC SBRP plans to enhance the interdisciplinary focus of our program, interweaving our major research projects to an even greater extent so that our scientists can learn from, and build upon, what their colleagues have done, and so that our trainees will learn the value of such teamwork. By integrating our research to a higher degree, we are confident that the scientific discoveries taking place at Carolina can have an even greater impact on our state's and our country's ability to minimize the health and environmental risks associated with Superfund sites. ●

Dr. Jun Nakamura is using a microplate spectrophotometer to measure real-time single-strand breaks in DNA of cells treated with carcinogens.

Brian Pachkowski, PhD candidate, is culturing human cells for future testing.

Research Highlights

From New York to China: UNC scientist studies impact of exposure to two airborne toxins

BENZENE IS AN INDUSTRIAL chemical that is present in petroleum and products of incomplete combustion. All of us are routinely exposed to low levels of benzene via second-hand cigarette smoke, automobile emissions and gasoline vapors; however, workers in fuel refining and transportation and those who use certain solvents or glues can be exposed to much higher levels.

"We have known for years that benzene causes blood diseases and leukemia in workers who are exposed to very high levels, but we don't know how toxic benzene can be at the lower exposures we all experience," said Rappaport, a professor of environmental health and member of the UNC-Chapel Hill SBRP. He collaborated with researchers at the University of California-Berkeley SBRP, the National Cancer Institute, and the Chinese Center for Disease Control to study the impacts of exposure to benzene at low to moderate levels.

The study followed 250 shoe workers in China who used benzene-containing glues and compared them to control workers. For 16 months, they took blood and urine samples and measured air quality in factories and homes. Rappaport's laboratory analyzed the blood and urine samples to determine the levels of benzene and its toxic products in the body.

The findings were published in the journal *Science* in December. Even workers exposed to less than 1 ppm of benzene had significantly decreased white blood cells and platelets compared to unexposed workers. Researchers also found that benzene was toxic to progenitor cells — the unspecialized "parent" cells from which all other blood cells develop — and that subjects with genetic variations in certain enzymes were especially susceptible to reduced white blood cell counts.

"The big news is, benzene seems to be toxic at levels at least ten times lower than thought before," Rappaport notes. "It looks like there are effects even in the range you and I are exposed to when we fill up our cars with gasoline. Our findings highlight the importance of additional investigations into long-term health effects in people exposed to low levels of benzene."

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Rappaport also led a study, published in the *Proceedings of the National Academy of Sciences* in August, that evaluated the long-term cancer risks for New Yorkers exposed to smoke and soot following the World Trade Center (WTC) disaster on September 11, 2001. More than a million tons of dust and smoke were emitted into the air from the collapse of the towers and ensuing fires. The soot from the smoldering fires and the diesel equipment used in clean-up efforts contained numerous carcinogens, notably polycyclic aromatic hydrocarbons (PAHs), which have been associated with skin, lung and bladder cancers and reproductive effects.

For six months following the WTC disaster, the U.S. Environmental Protection Agency collected daily air samples at or near Ground Zero to monitor fine particulate matter. Rappaport, working with EPA scientists, developed a method to measure PAHs in the EPA's samples.

"We found that the levels of PAHs were very high immediately after 9/11, but dropped off quite rapidly over the first 100 days," he explained. "The highest levels were from the fires. After the fires were extinguished, PAH levels were still elevated due to the emissions from the diesel equipment used in the clean-up effort. As the diesel equipment was phased out, we saw a slow decline in PAH levels. After 200 days, PAH levels approached background values observed in cities due to exhaust from trucks, buses, taxis, etc."

Given the rapid decline of PAH levels after 9/11, Rappaport and his colleagues consider it unlikely that the long-term cancer risks from PAHs would be significantly elevated. "Everyone in New York City is at some risk from exposure to these chemicals over their lives. After 9/11, the PAH levels went up, but returned to normal in about six months. We estimate that the increased risk from PAH exposure during these months was so small that, over a lifetime of 70 years, it would hardly be noticeable."

Note: This study only addressed cancer risks specifically from PAH exposure — not from other chemicals released during the disaster. Other investigators are exploring whether certain high-risk populations might face other health concerns. ●

Research Highlights

Taking promising remediation technology from the lab to the field

SOME OF THE MOST COMMON contaminants found at Superfund sites are DNAPLs (dense non-aqueous phase liquids) a class of chemicals that are difficult to clean up, or "remediate." Many DNAPLS are chlorinated solvents used as degreasers, in the dry cleaning industry and in large manufacturing facilities. When DNAPLs seep into the ground due to a spill, they sink below the water table. Then, because they don't dissolve easily in water, they stick around for a long time — and even low concentrations of DNAPLs make water undrinkable for decades or longer.

Dr. Cass Miller, chair of the UNC Department of Environmental Sciences and Engineering, and his team are developing new ways to remediate subsurface systems contaminated with DNAPLs.

"This is an extraordinarily difficult problem," Miller admits. "The scientific community has been working on this for the last quarter century, and billions of dollars have been spent trying different technologies, yet we have not been effective at remediating sites contaminated with DNAPLs."

Miller's team has developed a complex technology that shows great promise. "We inject a dense brine (salt) solution into the ground and it forms a fluid layer at the bottom of the aquifer, which acts as a barrier. Because the brine solution is denser than the DNAPL, the DNAPL floats on top of the brine layer. Then we use a surfactant solution to mobilize the DNAPL and collect it off the top of the brine layer, removing it from the subsurface."

Dr. Miller's group is currently conducting laboratory experiments in preparation for the field demonstration. Shown here is a small scale laboratory experiment looking at strategies for injecting and recovery of the dense brine.

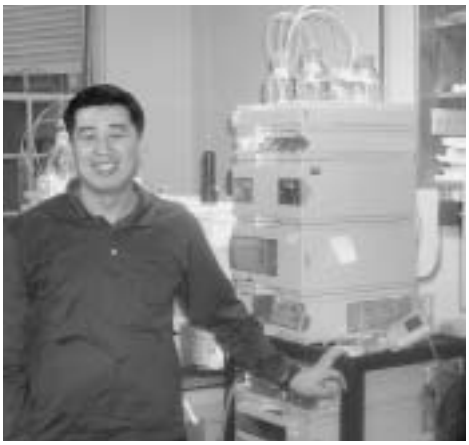
Miller and his colleagues have already tested this procedure in his UNC laboratory; this spring, he will begin a field study at the Dover National Test Site in Delaware. The site is specially constructed with thick metal barriers and state-of-the-art measurement devices to allow chemicals to be released into the ground for research purposes, while keeping them contained so they do not contaminate the environment.

"This is a great opportunity to take the technology we have developed, and have excellent results for in the laboratory, to a well characterized yet complex field setting to further our development efforts toward the resolution of this difficult problem." ●

Finding better ways to measure DNA damage caused by chemicals

SIMPLY THROUGH THE ROUTINE acts of breathing and metabolizing oxygen, our DNA regularly gets damaged. But beyond this, some chemicals — including many found at Superfund sites — and their metabolites cause additional damage to DNA, proteins and lipids. Specifically, substances called reactive oxygen species (ROS) may be produced. The ROS then attack DNA, causing three major forms of DNA damage: changing the chemical nature of DNA bases, attacking the sugars that hold the DNA together, and forming lipid peroxides that themselves damage the DNA. All three types of damage can lead to mutations and potentially to cancer and other diseases such as aging and neurodegeneration.

Dr. James Swenberg, program director for UNC's SBRP, and his team are developing new, highly sensitive and accurate methods for measuring such ROS-induced DNA damage in both research animals and in humans.



YoChan Jeong, PhD candidate, is pictured with the capillary liquid chromatograph electrospray mass spectrometer used to measure DNA adducts.

"We have developed some neat systems using mass spectrometry, and we're applying these to understand genetic effects of known Superfund chemicals," Swenberg explains. Novel "assays," or methods, developed at UNC are highly accurate and sensitive, requiring only tiny amounts of DNA, so that they can be applied to everything from cell cultures and tissues to human blood samples. ●

Community Outreach

Eastern NC teachers learn about water quality issues

IN JULY, 17 MIDDLE and high school teachers from four counties in northeastern North Carolina gathered at Elizabeth City State University (ECSU) for a three-day Environmental Science Institute on water quality. The program featured a field experience where teachers sampled water from Bennett's Millpond, plus activities using a classroom science kit that encourages students to solve a problem of contaminated drinking water. The institute included many aspects of *What's in the Water?*, a teacher workshop developed by the UNC-Chapel Hill SBRP Outreach Core. Two follow-up workshops were also held.

Middle and high school science teachers from northeastern NC experiment with the permeability of various earth materials.

The Environmental Science Institute was developed and presented through a partnership between the UNC-Chapel Hill SBRP, NC State University's The Science House and ECSU's NC-MSEN PreCollege Program. It was funded by the SBRP and a $40,000 grant from the Z. Smith Reynolds Foundation. In addition to gaining knowledge, participants trained fellow teachers back at their schools.

Participants gave the institute a thumbs-up. Said one: "This workshop was inspirational. I have science materials to work with, and I know how to use them! I love hands-on learning, and my kids will love these activities too."

"We're working with an outstanding group of teachers whose resources are limited due to their rural location," says Outreach Core K–12 Program Coordinator Michele Kloda. "This institute partners environmental science resources from three major universities and shares them with these dedicated teachers in their own community."

Contact Michele Kloda at **mkloda@email.unc.edu** or **919.843.5735** for more information.

SBRP helps educate about dangers of unexploded ordnance

MORE THAN 180 SITES around North Carolina hold the remnants from their previous lives as defense training sites: unexploded grenades, ammunition, mines and other ordnance lying on or just below the surface. Because unexploded ordnance (UXO) presents a public health and safety risk — for everyone from playing children, to farmers or builders digging in the ground, to people fishing in the waters — the North Carolina Department of Environment and Natural Resources (DENR) is working with federal agencies to coordinate the efforts to clean up these Formerly Used Defense Sites (FUDS).

The Outreach Core of the UNC SBRP participates in the FUDS Working Group, which is jointly convened by DENR, the U.S. Army Corps of Engineers, and the EPA. The SBRP staff has provided outreach and education assistance to the group, such as creating brochures to educate the public on the dangers of UXOs. A brochure for the Albemarle and Currituck Sound areas of northeastern North Carolina, where there may be high concentrations of UXOs, is currently being developed; brochures for other coastal regions are in the works.

Additionally, at Camp Butner, one of the state's most active FUDS, the SBRP Outreach staff helped recruit community representatives from diverse backgrounds to serve on the Restoration Advisory Board, which helps coordinate the clean-up.

For more infomation on SBRP outreach activities, contact Kathleen Gray at **kgray@unc.edu** or **919.966.9799**.

SUPERFUND SCOOP
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In Memoriam

WE NOTE WITH GREAT sadness the passing of two dear friends and colleagues.

Dr. Frances Lynn passed away on January 18th after a valiant battle with cancer. A pioneer in academia and environmental advocacy and outreach, Dr. Lynn was the driving force behind the creation of UNC's Environmental Resource Program, which she directed since its inception in 1985. A faculty member in the UNC School of Public Health, she also co-directed the Outreach Core of the SBRP and directed the Community Outreach and Education Program of the UNC Center for Environmental Health and Susceptibility. Most recently, she served as associate director for outreach and public service of the Carolina Environmental Program. Dr. Lynn will be greatly missed by her friends, colleagues, students and the many people she worked with around the state to help her fellow North Carolinians understand and address pressing environmental issues.

Dr. Ramiah Sangaiah passed away February 18th due to a stroke. Dr. Sangaiah had been with the Department of Environmental Sciences and Engineering in the UNC School of Public Health since 1983 and was an integral part of the SBRP Chemistry and Analytical Core. His expertise in the synthesis of DNA-adducts and other molecules of toxicological importance is underscored by numerous publications in international journals. Not only will Dr. Sangaiah be greatly missed by his colleagues and students for his knowledge of chemistry, but also for his endless patience and genuine kindheartedness. ●

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