Superfund Scoop

THE NEWSLETTER OF THE UNC-CH SUPERFUND BASIC RESEARCH PROGRAM

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‘Integrated research’ emphasized in new UNC-Chapel Hill SBRP

With its renewal grant from the NIEHS, the SBRP’s multidisplinary research team will focus on gaining knowledge about the impact and opportunities for remediation of two high-priority chemicals found at Superfund sites

In February, the Superfund Basic Research Program (SBRP) at the University of North Carolina-Chapel Hill received word that the National Institute of Environmental Health Sciences (NIEHS) has renewed our grant funding through a multi-year, multi-million dollar award.

While the SBRP will continue to focus on advancing the basic science required to understand and reduce risks to human health associated with several chemicals regulated under the Superfund program, under this grant we have specifically committed to apply our expertise to the study of two of the highest priority Superfund contaminants: polycyclic aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons, which include trichloroethylene (TCE).

“This competitive renewal process has given us an opportunity to fine-tune a very integrated approach to our projects, applying expertise across UNC’s interdisciplinary spectrum to achieve our mission,” says UNC-Chapel Hill SBRP Program Director James Swenberg.

The six SBRP projects under the new grant include interdisciplinary research that uses systems biology, biomarkers (physical traits used to measure or indicate the effect of exposure), and novel approaches to remediation. These projects are supported by cores that provide expertise in chemistry, mathematical and statistical analysis and modeling, training, research translation and administration. By sharing information across

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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.

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these projects, investigators will develop critical information to improve the accuracy of risk assessment at Superfund sites. We will also develop new remediation technologies — such as bioremediation and novel technology to remove dense nonaqueous-phase liquids (DNAPLs), the most important class of contaminants at Superfund sites — to reduce exposure to toxic chemicals and protect human health.

The new grant cycle brings a stronger focus on biomedical research, with four projects aimed at helping us evaluate and understand the human body's reaction to exposure to hazardous chemicals as well as the role of genetics in susceptibility to these chemicals. A new project, described in this newsletter, will use a systems biology approach to elucidate the relationships between exposure to trichloroethylene (TCE) and disease, as well as the genetic basis of health effects resulting from exposure to TCE.

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Several projects will also heighten our focus on PAHs, notes Swenberg, which "will lead to improved understanding of exposure from skin contact, ingestion and inhalation. The PAHs and their metabolites will be monitored in skin, blood and urine to understand similarities and differences between individuals. Furthermore, we will determine whether risks are confined to direct interactions of the PAH metabolites with DNA, or if other conditions contribute. Finally, SBRP researchers will develop advanced methods to remove PAHs from the environment, to protect the citizens of our state and our country."

WHAT ARE POLYCYCLIC AROMATIC HYDROCARBONS?

Found in over 600 Superfund sites, polycyclic aromatic hydrocarbons (PAHs) are a group of more than 100 different chemicals that are a result of the incomplete burning of organic substances such as oil, coal, wood and gas. Although they enter the environment primarily through volcanic eruptions, forest fires and exhaust from cars, they are also found in tobacco smoke and cooked foods, especially char-broiled foods. PAHs are found in the air, soil and water. They can also be encountered in some medicines, pesticides, dyes, asphalt and plastic. Certain PAHs may cause cancer of the lung, skin and bladder in humans.

WHAT ARE CHLORINATED HYDROCARBONS?

Chlorinated hydrocarbons are a category of toxins that includes trichloroethylene (TCE), a nonflammable, colorless liquid that has been discovered in over 850 Superfund sites and can remain in groundwater for long periods of time. TCE is primarily used as a solvent to remove grease from metal parts. It can be found in paint and spot removers, typewriter correction fluids and adhesives. Drinking or inhaling TCE can cause health problems ranging from lung irritation, headaches and poor coordination, to lung, liver or kidney damage, coma and impaired heart function.

Other chlorinated hydrocarbons include polychlorinated biphenyls (PCBs) and chlorinated dioxins, both found at Superfund sites. Dioxins may be formed during the chlorine bleaching process at pulp and paper mills, during chlorination by waste and drinking water treatment plants, or as contaminants in the manufacture of certain organic chemicals. They are also released into the air in emissions from municipal solid waste and industrial incinerators. PCBs were used as coolants and lubricants in transformers, capacitors and other electrical equipment until 1977, when their production was stopped in the U.S. due to evidence they build up in the environment and can cause harmful health effects. PCBs remain in the environment, causing health effects that include acne-like skin conditions in adults, neurobehavioral and immunological changes in children, and cancer.

Research Highlights

Exploring the impact of genetics on the body's reaction to toxins

THOUGH A NEW project in the UNC Superfund Basic Research Program, Ivan Rusyn and David Threadgill are studying the influence that genes have on liver and kidney toxicity from exposure to the chemical trichloroethylene (TCE).

"Genetics plays a huge role in the health effects of environmental exposures to potentially harmful chemicals," says Project Leader Rusyn, an assistant professor of environmental sciences and engineering and toxicology. "Some people, based on their genes, can metabolize certain chemicals faster and more efficiently than others. Traditionally, the laboratory investigation of the effects of toxic agents has been unable to capture this genetic diversity. That's why it is important to incorporate new knowledge of genome sequences and recent major advances in genetics into studies of toxicology."

Graduate student Amanda Burns and research technician Pam Ross (right); Dr. Rusyn and his research team (below).

The study uses mice as models. Mice and humans both metabolize TCE similarly, although different organs seem to be affected: when TCE is given chronically to mice, the major long-term effect of exposure is liver tumors; in humans, exposure to TCE may increase the risk of kidney cancer.

While most environmental toxicity studies use just one strain of an animal — mice or rats that were inbred over more than 20 generations, until every animal has virtually the exact same genetic makeup, to eliminate variability in responses to a toxin — for this study SBRP researchers are testing a panel of 16 different inbred mouse strains sequenced by the NIEHS.

Dr. Ivan Rusyn

"Studies using just one strain do not take into account the fact that, as humans, we are quite genetically diverse, so one person's body might react quite differently to exposure to a toxin than another's body," Rusyn notes. "Testing a potential toxin on one mouse strain is like testing on one person and generalizing the results for an entire population — while useful for understanding the major effects of toxic agents, it's just not realistic."

For this study, researchers will control environment and treatment regiments as much as possible and will analyze the biological responses to TCE, such as metabolism and health effects. Rusyn says they expect to find which strains are most susceptible to liver toxicity, and other strains that show greater kidney toxicity, thus finding appropriate models for potential harmful effects of TCE in humans. Next, the SBRP team will select these few susceptible strains for a more expensive, long-term cancer study. These strains will represent the extremes of the population, so the researchers argue they can measure the most susceptible and resistant individuals to determine differences in their development of cancer over several years.

Rusyn and Threadgill have already conducted a similar study on acetaminophen (Tylenol) — a well-known liver toxin in both rodents and humans — that demonstrated a tremendous variability in responses that may potentially be linked to genetic variability among mouse strains. They have also recently received an NIH grant to study this phenomenon as it relates to alcohol and its impact on the liver.

As a result of this study, Rusyn says the team hopes to develop a new strategy for testing chemical safety that incorporates information about the population's genetic diversity.

"For each chemical, we believe the susceptible or resistant strains will be different for different toxic agents. However, we plan to test a strategy that allows us to introduce a new dimension into the research by pre-selecting mouse strains for long-term studies that can capture the diversity in responses in the population. If, in mice, we can find regions in individual genes, variation in which is most connected to increased resistance or susceptibility to a chemical, we may be able to predict that people with similar genetic variations may be at greater risk from exposure to this chemical. Ultimately, it may become possible to analyze an individual person's genotype and predict their response to exposure to specific chemicals."

Research Highlights

Determining microorganisms' propensities for degrading PAHs

AS A MOLECULAR microbial ecologist, PhD candidate Sabrina Powell spends her days studying soil bacteria and determining the functions they perform. If she is successful, we may be one step closer to a new technique to remediate contaminated soil at Superfund sites.

Powell's research in Dr. Michael Aitken's laboratory focuses on soils contaminated with polycyclic aromatic hydrocarbons (PAHs), a group of toxic chemicals found at most Superfund sites. Over time, microorganisms that live in the soil will break down, or "degrade," PAHs in the contaminated soil. However, this process is slow and often results in incomplete removal of PAHs. Powell, a graduate student in UNC's Department of Environmental Sciences and Engineering, is trying to determine which microorganisms degrade which PAHs.

"The element carbon comes in slightly different forms, called isotopes. Our lab uses carbon-13, an isotope that is slightly heavier than the most common form of carbon, to label PAHs. If you take a PAH that contains C-13 atoms and feed it to a community of microorganisms, then the organisms that are able to break down that PAH will incorporate the labeled carbon into their DNA. We can then identify PAH degraders by extracting the DNA and looking for the label.

"Ideally, if we can identify the organisms that are actively degrading PAHs, we could modify our bioremediation efforts to favor the kind of microorganisms that are good at breaking down the PAHs."

Powell, who will complete her studies this spring, is focusing on a chemical called salicylate, which is known to activate PAH-degrading enzymes in certain microorganisms in pure cultures. Working on actual soil samples in the lab's bioreactor, she is trying to determine whether these results can translate to real-world situations. If salicylate proves useful in bioremediation efforts, it might be possible to introduce the chemical at Superfund sites to stimulate soil enzymes to attack the PAHs. ●

OUTREACH

Technical Assistance to Communities

WHEN THE AGRICULTURAL Resources Center, a North Carolina-based nonprofit working to minimize human and environmental exposure to toxic pesticides, got a call from citizens concerned about drift from aerial pesticide spray, the center asked the SBRP's Outreach Core for help. ARC taught the community members how to collect air samples so they could monitor the chemicals that drift beyond the cotton fields when the pesticides are sprayed, in particular to evaluate exposure to these drifts in homes and schools.

For the past six months, Brennan Bouma, a research associate with the Outreach Core, has helped conduct background research into demographics of the community, potential contacts for greater community involvement, and use of pesticides in other parts of the country. He has also helped spread the word about several less toxic alternatives to currently used pesticides, and is working with ARC as they explore new methods for reducing pesticide health risks for North Carolina communities.

"The Agricultural Resources Center is effectively advocating for the health of agricultural communities at the community level and with the government. I'm proud to help connect them and our other community partners to the resources of this university," says Bouma, a former Peace Corps volunteer in Paraguay, who also served as a translator during ARC's training sessions for Spanish-speaking participants. ●

Research Translation

Taking the SBRP's work from the lab into the real world

A VITAL ASPECT of the UNC Superfund Basic Research Program is translating our research findings for use by many different groups, including fellow researchers, government agencies, communities and technology developers. To ensure that our research is communicated in the varied ways that are most useful to each constituency, the SBRP has established a new Research Translation Core.

Research findings can have their greatest impact when they become commercial products available to the entire community of people dealing with contaminated sites. Therefore, one of the Research Translation Core's key objectives is to assist and prepare our researchers to commercialize their findings. Since most researchers have little background or experience turning research ideas into commercial enterprises, the Core, together with the SBRP's Training Core and the UNC Office of Technology Development, will launch a Technology Development Boot Camp for SBRP faculty, staff and students. The intensive, two-day training will introduce participants to everything from patenting and business plan development, to securing venture capital and the stages of business growth.

> **"Our goal is to get the clean-up technology that we develop at UNC out there so people can use it at Superfund and other contaminated sites."**

"Our goal is to get the clean-up technology that we develop at UNC out there so people can use it at Superfund and other contaminated sites," explains Core Director Fred Pfaender. "Once you have a brilliant idea, it takes a whole lot of expertise to transform it into a commercially viable technology. We want to familiarize our faculty and students with the steps it takes to carry their ideas forward."

In addition to the boot camp, Core leaders keep abreast of the research being developed within the UNC SBRP and help facilitate contact with business leaders in technology development and venture capital who might help in the commercialization of new technology.

The Research Translation Core also continues and extends the work previously done by the SBRP's Outreach Core to share the program's research results with local, state and national governmental agencies. The SBRP is working to develop closer relationships with several groups, in particular the Superfund Section of the Division of Waste Management in the NC Department of Environmental and Natural Resources (DENR). SBRP researchers regularly conduct seminars for DENR Superfund staff members, and new internships for UNC graduate students will provide assistance to the Superfund Section while giving students hands-on experience in the management and clean-up of Superfund sites. We also continue to work with DENR, the EPA and the US Army Corps of Engineers in the Formerly Used Defense Sites (FUDS) Program to provide outreach and community education support in addressing the potential hazards of unexploded ordnance in North Carolina.

In addition, the Research Translation Core provides information and assistance to community-based organizations and educators on Superfund-related topics, notes Core Co-Director Kathleen Gray. For example, we are providing research support to a nonprofit organization addressing the impact of drift from aerial pesticide spray and conducting educational workshops on water quality and Superfund-related topics in partnership with the NC Museum of Life and Science and North Carolina State University's The Science House. The Core will also conduct a needs assessment to determine the environmental information needs of local governments and community-based organizations in communities near North Carolina's 31 Superfund sites, so that we can help address these needs through focused outreach activities. This newsletter and the SBRP website are also produced by the Core. ●

SUPERFUND SCOOP
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JAMES A. SWENBERG, *Program Director*
919.966.6136
james_swenberg@unc.edu

KATHLEEN GRAY, *Outreach Director*
919.966.9799
kgray@unc.edu

DIANA DEGEN, *Research Associate*
BRENNAN BOUMA, *Research Associate*
ELISSA TOTIN, *Science Educator*

SUPERFUND SCOOP
LAURA ERTEL, *Writer*
REGINA MCCOY, *Design*

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Teacher Training

Water quality workshop held in Bertie County

IN MARCH 2006, the SBRP Outreach Core held a workshop for middle school science teachers in rural northeastern Bertie County. This workshop was modeled after last summer's Environmental Science Institute on water quality at Elizabeth City State University. Like the Institute, the Bertie County program was funded by a grant from the Z. Smith Reynolds Foundation and the SBRP. It featured classroom activities that encourage students to solve a problem of contaminated drinking water as well as an overview of relevant SBRP research. The workshop included many aspects of *What's in the Water?*, a teacher workshop developed by the UNC-Chapel Hill SBRP Outreach Core with funding from the National Institute of Environmental Health Sciences.

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SUPERFUND BASIC RESEARCH PROGRAM
The University of North Carolina at Chapel Hill
Campus Box #7431
Department of Environmental Sciences and Engineering
Chapel Hill, NC 27599-7431

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