



## Superfund Research Program

The Superfund Research Program (SRP) supports practical research that creates benefits, such as lower environmental cleanup costs and reduced risk of exposure to hazardous substances, to improve human health. SRP funds colleges, universities, and small businesses, including the University of California, Berkeley Superfund Research Center (UC Berkeley SRC), to advance this work across the nation.

### Research Highlights

#### Identifying biomarkers of benzene and arsenic exposure



UC Berkeley SRC scientist Tom Burton analyzes samples to improve methods to clean up groundwater. (Photo courtesy of UC Berkeley SRC)

Martyn Smith, Ph.D., and his team identified changes in specific genes that may be biomarkers of benzene exposure.<sup>1</sup> Benzene is an industrial chemical that has been shown to cause leukemia.<sup>2</sup> Using sophisticated mathematical methods, the researchers revealed a relationship between benzene dose and response of the genes, which is present even at very low levels. These biomarkers hold great promise for helping to better measure benzene exposure and assess health risks.

Allan Smith, M.D., Ph.D., and Craig Steinmaus, M.D., identified biomarkers in urine that may provide clues about why some individuals are more sensitive to arsenic's toxic effects.<sup>3</sup> Arsenic exposure is associated with cancer and other health effects.<sup>4</sup> In this study, the UC Berkeley SRC team found that people who have more

of a certain type of arsenic breakdown product in their urine were more likely to have lung or bladder cancer.<sup>3</sup> Researchers are now working to determine why individuals metabolize arsenic differently to help better understand sensitivities to arsenic. UC Berkeley SRC researchers were among the first to document that early life exposures result in health effects during adulthood.<sup>5</sup>

#### New device for convenient on-site well water treatment

David Sedlak, Ph.D., and colleagues obtained a provisional patent in 2015 for a new compact and inexpensive system to remove a wide variety of environmental contaminants at well heads.<sup>6</sup> The system is energy-efficient, convenient to use, and removes contaminants from water without creating toxic byproducts. Research is now focused on testing the long-term performance of the system, improving the technology, and reducing the cost of manufacturing the parts.



The patented device developed by Sedlak and his team uses a combination of electrical current and ultraviolet light treatments to remove contaminants from groundwater and other water sources. (Photo courtesy of UC Berkeley SRC)



Researchers at UC Berkeley SRC are working to improve their understanding of the relationship between exposures and disease. Chemicals being studied include arsenic, benzene, mercury, and polycyclic aromatic hydrocarbons. Their research aims to provide better risk assessments, reduce cleanup costs, and develop prevention strategies to improve and protect public health, ecosystems, and the environment.

#### Center Contact:

**Martyn Smith, Ph.D.**

University of California,  
Berkeley

Division of Environmental  
Health Sciences

[martynts@berkeley.edu](mailto:martynts@berkeley.edu)

510-642-8770

## Sensors for detecting mercury in the environment

UC Berkeley SRC researchers led by Catherine Koshland, Ph.D., developed a new portable sensor that uses a film of gold nanoparticles to detect extremely low amounts of mercury in water.<sup>7</sup> Mercury exposure is associated with neurological problems, such as poor memory and attention, particularly when one is exposed during early development.<sup>8</sup> The technology replaces current methods requiring costly laboratory instruments to measure mercury.

Former UC Berkeley SRC trainees Jay James, Ph.D., and Jeffrey Crosby, Ph.D., worked on this project with Koshland and moved the technology out of the lab after completing their doctoral degrees. James and Crosby patented the technology and founded the company Picoyune to provide cost-effective and reliable mercury monitoring for industrial and environmental applications.<sup>9</sup>

## The importance of studying biomarkers of arsenic and benzene

- Arsenic and benzene are known to cause cancer, and exposure is associated with lung, liver, and other health problems.<sup>2,4,10</sup>
- Some people, including children, have higher risk for health problems after exposure to hazardous chemicals. Understanding why will help find ways to protect their health.<sup>11</sup>

## Research overview

- Identifying biomarkers of arsenic exposure, susceptibility, and disease over the lifespan, and how arsenic causes disease. (Allan Smith, M.D., Ph.D., [ahsmith@berkeley.edu](mailto:ahsmith@berkeley.edu))
- Improving efficiency of environmental contaminant cleanup by using bacteria that can break down chemicals. (Lisa Alvarez-Cohen, Ph.D., [alvarez@ce.berkeley.edu](mailto:alvarez@ce.berkeley.edu))
- Identifying biological markers and pathways that link benzene exposure to diseases, including leukemia. (Martyn Smith, Ph.D., [martynts@berkeley.edu](mailto:martynts@berkeley.edu))
- Developing cost-effective technologies and approaches to clean up hazardous chemicals in groundwater. (David Sedlak, Ph.D., [sedlak@ce.berkeley.edu](mailto:sedlak@ce.berkeley.edu))
- Identifying genetic factors that make some individuals more susceptible to health problems after exposure to pollutants. (Luoping Zhang, Ph.D., [luoping@berkeley.edu](mailto:luoping@berkeley.edu))

## Sharing results

UC Berkeley SRC shares research findings and scientific knowledge with communities, government agencies, business leaders, and others involved in the cleanup of Superfund sites. Researchers have also obtained patents for new technologies for chemical testing and cleanup that can be put to use to solve real problems. (Amy Kyle, Ph.D., [adkyle@berkeley.edu](mailto:adkyle@berkeley.edu))

## Other contributions to advance science

The UC Berkeley SRC research support facility provides vital access to expertise, research resources, and state-of-the-art instrumentation for its research projects. (Daniel Nomura, Ph.D., [nomura@berkeley.edu](mailto:nomura@berkeley.edu); Mark van der Laan, Ph.D., [laan@stat.berkeley.edu](mailto:laan@stat.berkeley.edu))

## NIEHS Grant Number:

**P42ES004705**

## Grant Period: 1987-2016

## NIEHS Contacts:

### William Suk, Ph.D.

Director  
Superfund Research Program  
[suk@niehs.nih.gov](mailto:suk@niehs.nih.gov)  
919-541-0797

### Michelle Heacock, Ph.D.

Program Administrator  
Superfund Research Program  
[heacockm@niehs.nih.gov](mailto:heacockm@niehs.nih.gov)  
919-541-7824

## Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

For more information on the National Institute of Environmental Health Sciences, visit [www.niehs.nih.gov](http://www.niehs.nih.gov).

For more information on the Superfund Research Program, visit [www.niehs.nih.gov/srp](http://www.niehs.nih.gov/srp).

For more information on the University of California, Berkeley Superfund Research Center, visit <http://superfund.berkeley.edu>.

<sup>1</sup> Thomas R, Hubbard AE, McHale CM, Zhang L, Rappaport SM, Lan Q, Rothman N, Vermeulen N, Guyton KZ, Jinot J, Sonawane BR, Smith, MT. 2014. Characterization of changes in gene expression and biochemical pathways at low levels of benzene exposure. *PLoS One* 9(5):e91828.

<sup>2</sup> Khalade A, Jaakkola MS, Pukkala E, Jaakkola JJ. 2010. Exposure to benzene at work and the risk of leukemia: a systematic review and meta-analysis. *Environ Health* 9:31.

<sup>3</sup> Melak D, Ferreccio C, Kalman D, Parra R, Acevedo J, Perez L, Cortes S, Smith AH, Yuan Y, Liaw J, Steinmaus C. 2014. Arsenic methylation and lung and bladder cancer in a case-control study in northern Chile. *Toxicol Appl Pharmacol* 274(2):225-231.

<sup>4</sup> Naujokas MF, Anderson B, Ahsan H, Aposhian, HV, Graziano JH, Thompson C, Suk WA. 2013. The broad scope of health effects from chronic arsenic exposure: update on a worldwide public health problem. *Environ Health Perspect* 121(3):295-302.

<sup>5</sup> Smith AH, Marshall G, Yuan Y, Ferreccio C, Liaw J, von Ehrenstein O, Steinmaus C, Bates MC, Selvin S. 2006. Increased mortality from lung cancer and bronchiectasis in young adults after exposure to arsenic in utero and in early childhood. *Environ Health Persp* 114(8):1293-1296.

<sup>6</sup> University of California, Berkeley Office of Intellectual Property and Industry Research Alliances. 2015. System for Efficient, Environmentally Friendly Water Treatment. Available: <http://techtransfer.universityofcalifornia.edu/NCD/NCDPDF.aspx?ncid=24449> [accessed 1 June 2015].

<sup>7</sup> Crosby JS, James JZ, Lucas D, Koshland CP. 2014. Determination of total mercury concentration in aqueous samples with gold nanoparticles. *Anal Methods* 6(4):1254-1260.

<sup>8</sup> EPA (U.S. Environmental Protection Agency). 2014. Mercury: Health Effects. Available: <http://www.epa.gov/mercury/effects.htm> [accessed 1 June 2015].

<sup>9</sup> NIEHS (National Institute of Environmental Health Sciences). 2014. Translating research into products to improve public health. Available: <http://www.niehs.nih.gov/news/newsletter/2014/6/science-translating> [accessed 1 June 2015].

<sup>10</sup> EPA (U.S. Environmental Protection Agency). 2008. Polycyclic Aromatic Hydrocarbons (PAHs). Available: <http://www.epa.gov/wastes/hazard/wastemin/minimize/factshts/pahs.pdf> [accessed 1 June 2015].

<sup>11</sup> Environmental Health Perspectives. 2013. Children's Health Collection 2013. Available: <http://ehp.niehs.nih.gov/chc-2013> [accessed 1 June 2015].