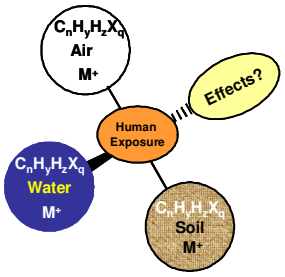


Superfund Research Program
University of California Davis

Dr. Bruce D. Hammock, Director

Research Update No. 7 **September 2014**

Introduction

The primary purpose of this Research Update is to inform staff in State and Federal government involved in legislation and regulation of toxic substances in the environment about research results emanating from the UC Davis Superfund Program. Additionally, others involved in the mitigation and assessment of toxic substances in the environment may find some value in these updates. The goal of these updates is to provide information about the National Institutes Environmental Health Sciences (NIEHS) funded Superfund Research Program (SRP)[1] that has been at UC Davis for the past 27 years. This national program was initiated to address human and environmental problems such as Love Canal, NY where improper disposal of chemical wastes occurred at Times Beach where oil containing chlorinated dioxins was sprayed as a dust suppressant. The mission of the SRP is stated below[2]

> "*Since its inception in 1987, the SRP has applied a multidisciplinary approach to basic research focused to provide a solid foundation which environmental managers and risk assessors can draw upon to make sound decisions related to Superfund and other hazardous waste sites. We believe that basic research plays a crucial role in addressing challenges posed by environmental contamination such as health risks, toxicity, exposure predictions, fate and transport, and the need for cost-effective treatments for hazardous waste sites found throughout the United States"*

The Superfund Research Program at UC Davis[3] (UCD SRP) has provided basic research information to address these needs. We continue to develop innovative, novel technology to investigate human exposures, environmental fate and transport of toxic substances, as well as cost-effective methods for the treatment and remediation of these chemicals. The success of our program is due to the breadth of the multidisciplinary approach to these complex scientific issues of chemical exposure that continue to pose hazards to human and environmental health.

This program exports its findings beyond academic journals and publications to other venues and audiences. As required by the NIEHS, we have concerted efforts to effectively partner with government, transfer technology to commercial ventures, or communicate with broader public audiences for the purpose of improving human and environmental health. Research Translation of scientific results is important for society to understand the goals of the SRP in the mitigation of toxic substances in the environment.

This newsletter highlights three relevant areas of research from the program:

1) Researchers identify chemicals of concern in many consumer plastic, rubber, and paper products
2) Studying the whole organism, not just genes, helps researchers learn about disease, adaptation, and aging
3) Academic research used to detect unwanted microbes in cheese production

[1] Name changed from Superfund Basic Research Program to Superfund Research Program in 2008
[2] www.niehs.nih.gov/research/supported/srp/about/index.cfm
[3] www-sf.ucdavis.edu/

1) Researchers identify chemicals of concern in many consumer plastic, rubber, and paper products

Background

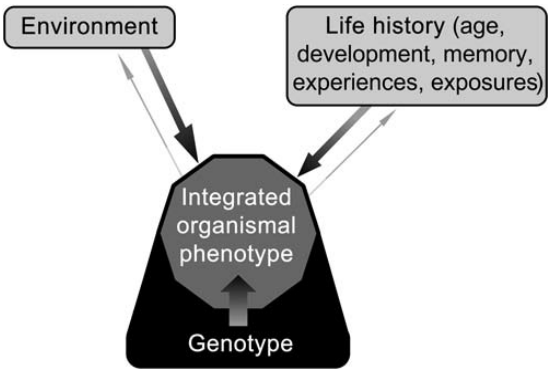
Since 2013, California law has prohibited manufacturers of baby bottles and sippy cups from using Bisphenol A (BPA) in their products. BPA is commonly used to coat receipts handed out from cash registers, the inside of soda cans, and to strengthen plastic water bottles. Concerns over BPA's ability to activate estrogen receptors prompted the ban. BPA is just one of a large assortment of chemicals that can mimic the hormone estrogen in the body. These "xenoestrogens" or estrogenic chemicals can cause early puberty and hormonal disorders.

Another group of chemicals called dioxins can also affect estrogen pathways and have negative effects on the immune, nervous, endocrine, and reproductive systems. The public has known about the dangers of dioxin and dioxin-like chemicals (DLCs) since the 1970s. Although dioxin production has vastly declined since then, Denison has also been using his specialized cell-based assays to measure the amounts of chemicals that mimic the actions of dioxin and DLCs in the body.

Impact

Dr. Denison's laboratory, with support from the UC Davis SRP, investigates how environmental exposure and chemicals in consumer products may activate the dioxin- and estrogen-responsive signaling pathways. Denison uses a specific kind of cell-based assay to measure how much of these harmful substances are present in our everyday products. By analyzing various rubber and paper products with cell-based assays his group found that these products contain chemicals that can activate the dioxin and estrogen signaling pathways in human cells.

One of his more disturbing findings concerns children's sippy cups. After the US EPA banned the use of BPA, manufacturers had to find a combination of chemicals to replace it. In 2013, Denison's laboratory collaborated with the Center for Environmental Health (CEH), a non-profit consumer safety group based in Oakland, to study "BPA-free" children's sippy cups. Denison and the CEH not only reported that a number of these BPA-free plastic sippy cups could activate the estrogen signaling pathway, but that extracts of some products were more active than BPA-containing products. The color-changing sippy cups appeared to be the worst offenders. This means that BPA-free does not mean estrogen-free. These sippy cups with "BPA-free" labels may appear safer to consumers, but in reality they might be able to produce the same hormonal problems as BPA does at an equal or even greater level. As the target consumers in this case are children, the threat of early puberty is particularly salient.



2) Studying the whole organism, not just genes, helps researchers learn about disease, adaptation, and aging

Background

The impact of genetics on modern society can hardly be overstated. Many people learn about evolution in the context of Darwin's discovery, and about the genetic processes driving evolution from Gregor Mendel's work. The recent ability to sequence all of an organism's genetic information has greatly expanded our ability to treat disease and our knowledge of how genes affect the behavior and health of all organisms, including humans. More recently, many scientists, including UC SRP researcher, Dietmar Kueltz, have called for greater attention to the interaction between genes and the environment instead of focusing on genetic information alone.

An organism's genome contains all genes that could produce the full range of phenotypes possible for that organism. A phenotype refers to detectable aspects of an organism, including appearance, behavior, and biochemical properties. A genome is like an owner's manual for a car: it is a repository of instructions for possible future scenarios, like how to fix problems or install upgrades. At any one time you are following only a few of the instructions like changing the oil or driving on cruise control.

Kueltz and his colleagues in the discipline of organismal biology argue that recent research has focused too closely on the contribution of genome to phenotype. By maintaining a narrow focus on genetics, researchers neglect the impact of environmental factors that act on organisms at different times throughout their lives.

Impact

This interaction between environment and phenotype allows us to gain new insights into human health, the ability of organisms to adapt to climate change, and the effects of toxic chemicals on human development. What are next steps for advancing the study of environment-phenotype interactions? One of the most important tasks is to promote collaboration between researchers who study different aspects of phenotypes and to combine the results of many studies in a meaningful way to see patterns. Research efforts should explore more methods like proteomics, which show the end-result of genes and regulatory mechanisms that can alter their expression. To facilitate and encourage more wide-spread use of systems level approaches for studying environmental effects on organismal phenotypes, Dr. Kueltz developed a Proteomic Molecular Phenotyping workflow and an associated database. The format in which data are made available via this database permits rapid grasping of emerging biological patterns while also providing the necessary technical detail for judging technical soundness of the experiments. This database and the associated label-free quantitative proteomics workflow are available to any interested investigator at https://kueltzlab.ucdavis.edu/EPP/promophe.cfm.

3) Academic research used to detect unwanted microbes in cheese production

Background

Immunoassays, or antibody-based tests, have been used in widely used in medicine to help determine someone's health. Some common examples include the home pregnancy test or testing for diabetes. While these are sensitive enough for their purposes, researchers are always looking for ways in detect fewer and fewer molecules of something. Researchers in the UC Davis SRP have discovered a technique that can do just that.

Founders of SonanuTech, Sudheendra Lakshmana (L) and Ian Kennedy (R).

Led by Dr. Kennedy, the UCD SRP's Biosensors team has changed the format of the common immunoassay so that the assay is conducted on the surface of a photonic crystal. Photonic crystals are unique structures that are able to greatly amplify light; in their assay, light from a fluorescent reporter molecule is used to indicate the results of the test. By combining immunoassay technology with photonic crystals, they are pushing the limits in ultrasensitive assays to improve detection ability to nearly a single molecule.

Ultrasensitive detection methodologies can vastly improve other real-world applications beyond the clinical setting. Dr. Kennedy and his colleagues have created a company called SonanuTech and are now testing out their patent-pending technology with food producers. They are working with a cheese-making company, which needs fast, cheap methods to determine if pathogens – unwanted microbes – have infected their cheese batches.

Impact

University-industry partnerships are an excellent way to apply research to a real-world problem. While many academic-born technologies are developed with the intent of being used to solve a great social need, few are transferred to the public sector. SonanuTech has obtained a grant called a Small Business Innovative Research grant, which helps to launch university innovations into business ventures while creating new jobs in the Sacramento area.

This newsletter continues to evolve to improve its intended purpose. Therefore, we value critique so that in the future it will improve and therefore better meet the needs of the recipients. Some areas on which we would like comment are content, effectiveness of communication, and how it can build interactions and relationships with others outside the UC Davis Superfund Research Program. Please share this Research Update with your colleagues who may have an interest in the results of our research.

For more information about the UC Davis SRP, please contact:
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