



The UK
Superfund Research Center
Nutrition and Superfund Chemical Toxicity

Director: Bernhard Hennig, Ph.D., R.D.

Associate Director: Lindell Ormsbee, Ph.D., P.E.

Trainee Presenters:

Michael Petriello, Ph.D.

Angela Gutiérrez

NIEHS Grant: P42ES007380
www.uky.edu/Research/Superfund/

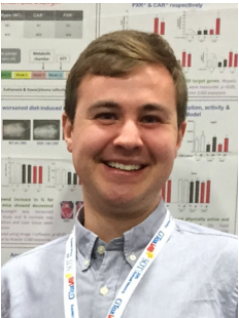
Center Director (bhennig@uky.edu)
Program Administrator (j.moore2@uky.edu)

Outline



Our Center's Approach to Mitigating Environmental Health Risks

Bernhard Hennig, Ph.D., R.D. (Director)



Quantifying Health Risk and Improving Health for Exposed Populations

Michael Petriello, Ph.D. (Trainee)



Reducing Exposures Through Sensing and Remediation; Translating Findings and Engaging Stakeholders

Angela Gutiérrez (Trainee)

Contaminants of Interest: PCBs and TCE



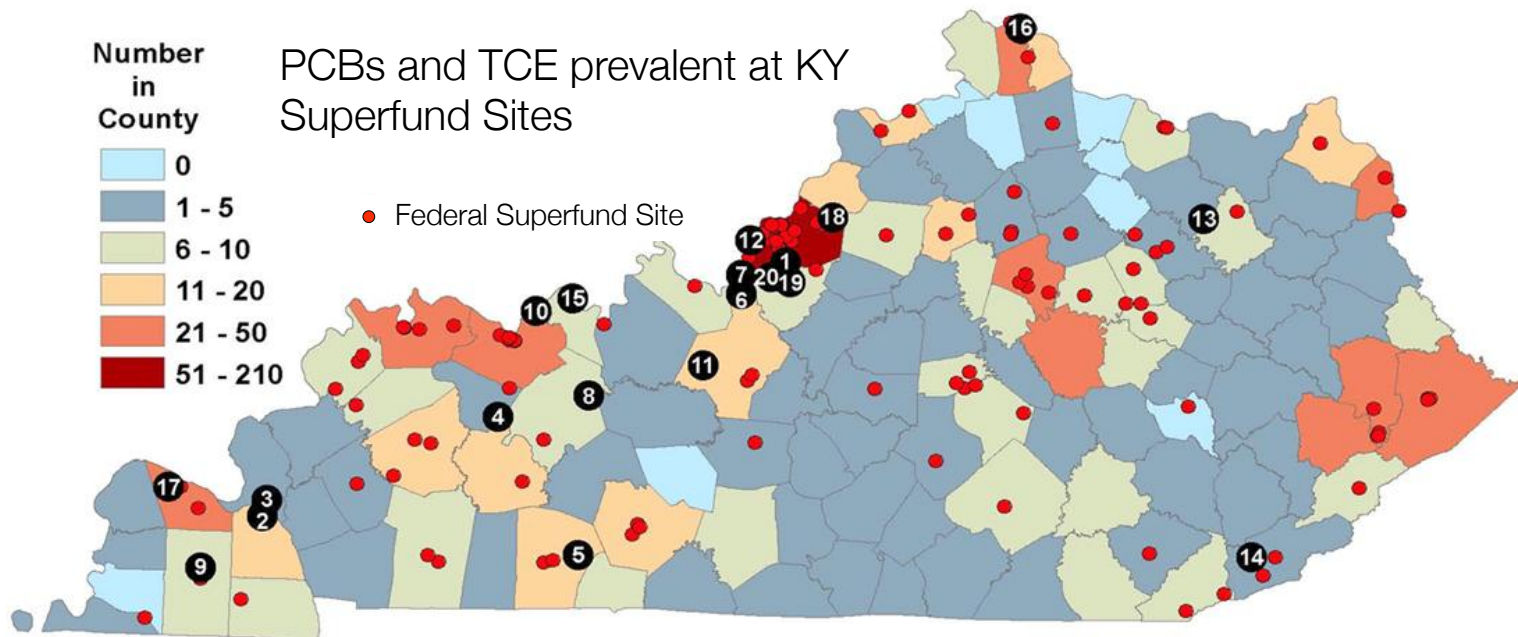
Polychlorinated biphenyls (PCBs)

- Inflammation and diabetes inducer, carcinogen, endocrine disruptor

Trichloroethylene (TCE)

- Central nervous system and endocrine disruptor, carcinogen

Kentucky Superfund Sites

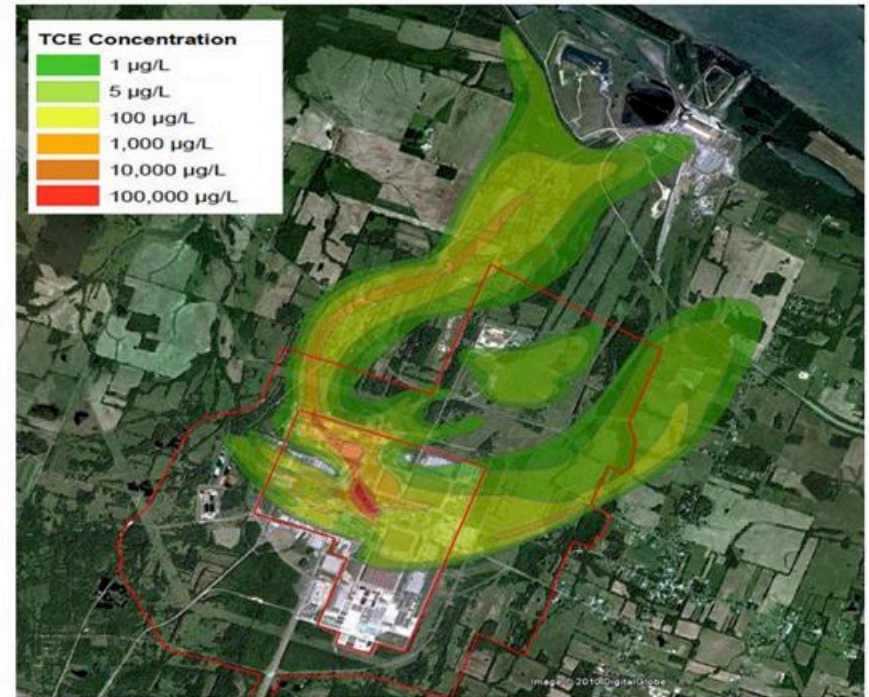


Federal National Priority List (NPL) Sites

- | | |
|---|---|
| 1 A.L. Taylor (Valley of the Drums) * | 11 Howe Valley Landfill * |
| 2 Airco | 12 Lee's Lane Landfill * |
| 3 B.F. Goodrich | 13 Maxey Flats Nuclear Disposal |
| 4 Brantley Landfill | 14 National Electric Coil/Cooper Industries |
| 5 Caldwell Lace Leather Co. | 15 National Southwire Aluminum Co. |
| 6 Distler Brickyard | 16 Newport Dump * |
| 7 Distler Farm | 17 U.S. DOE Gaseous Diffusion Plant |
| 8 Fort Hartford Coal Co. Stone Quarry | 18 Red Penn Sanitation Co. Landfill * |
| 9 General Tire and Rubber (Mayfield Landfill) * | 19 Smith's Farm |
| 10 Green River Disposal | 20 Tri-City Disposal Co. |

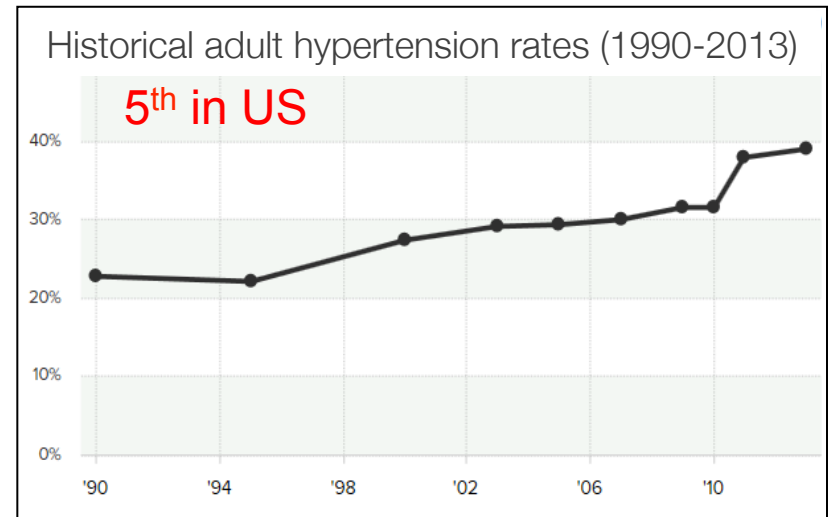
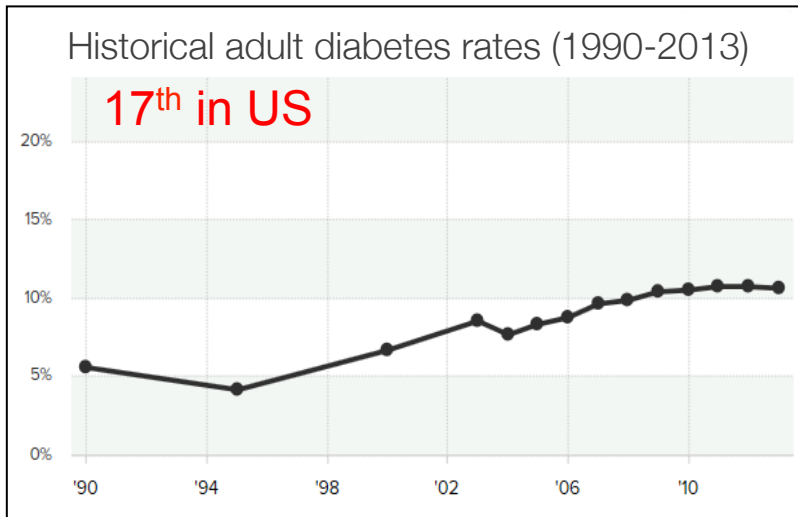
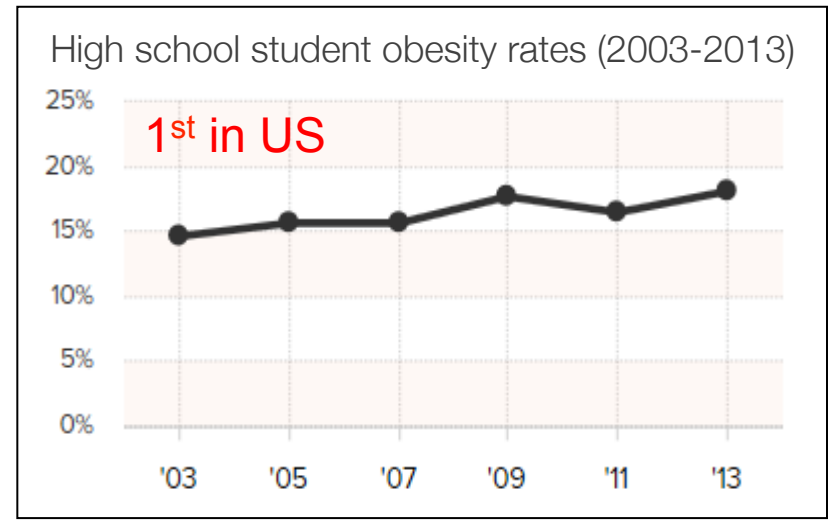
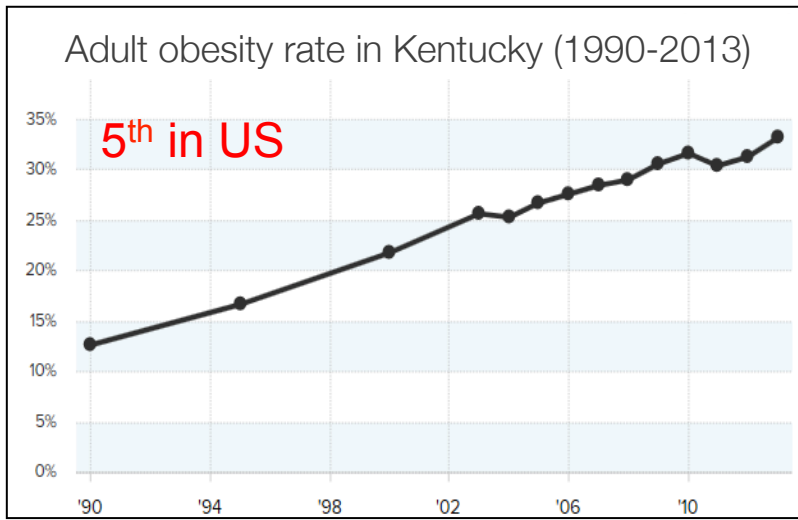
* Sites that are no longer active on the National Priority List

Paducah Gaseous Diffusion Plant



Kentucky's Largest Superfund Site: TCE, PCBs, Technetium, Heavy Metals, Uranium

Health Issues in Kentucky



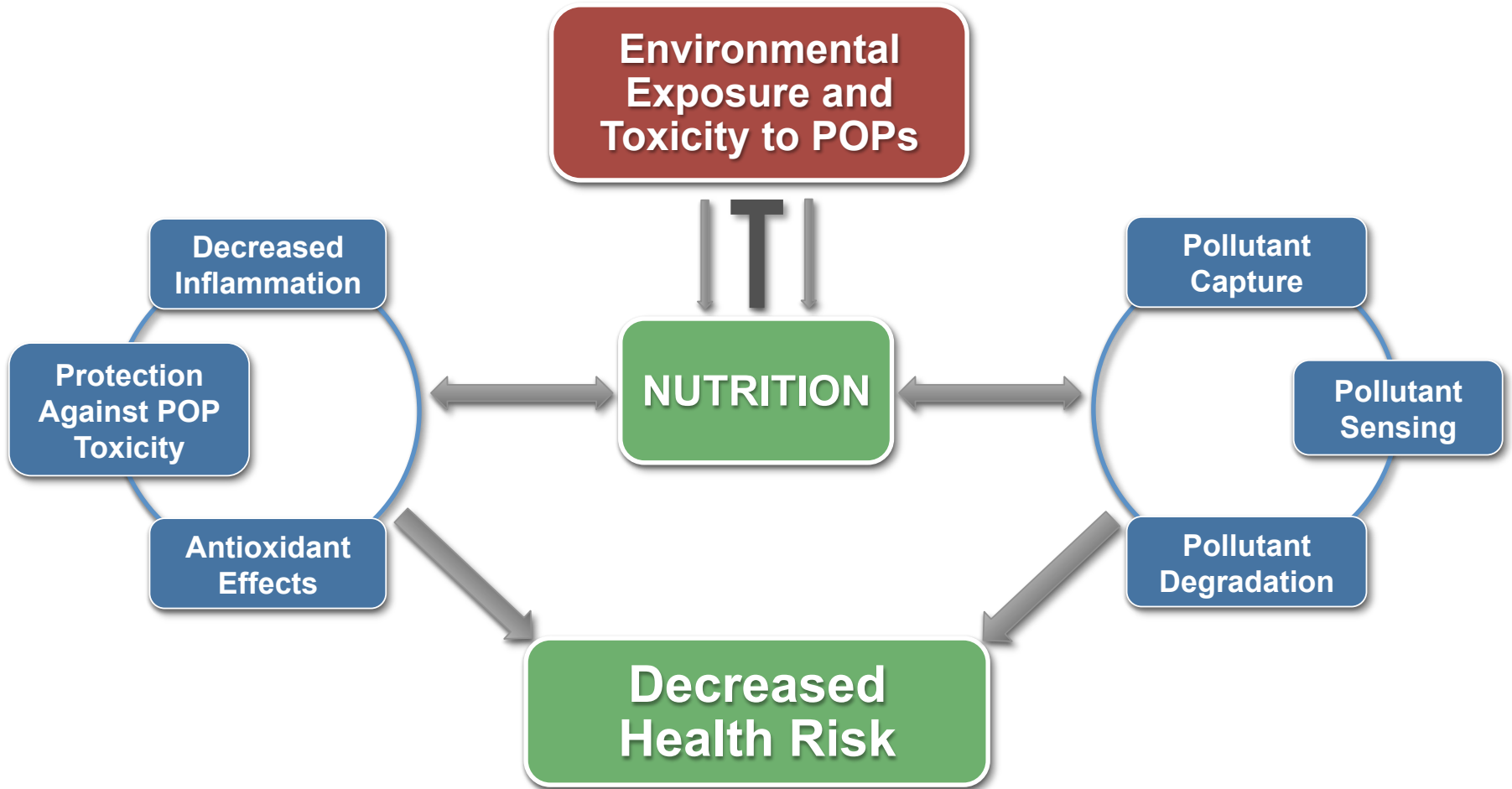
The state of obesity – RWJF (2014)

Possible Therapeutic Interventions

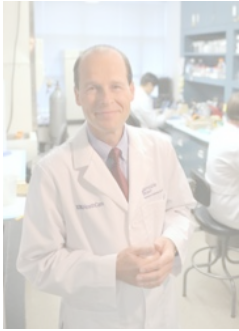
- 1) Prevent or reduce oxidative stress and inflammation
- 2) Decrease or prevent body burden (i.e., prevent obesity)
- 3) Choose a healthy lifestyle, including healthful nutrition, regular exercise, etc.



Chlorinated Organic Risk Reduction Using Nutrition and Green Chemistry

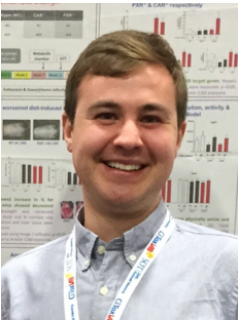


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Michael Petriello, Ph.D. (Trainee)



Reducing Exposures Through Sensing and Remediation; Translating Findings and Engaging Stakeholders

Angela Gutiérrez (Trainee)

Improving Health for Exposed Populations



Bernhard Hennig



Lisa Cassis



Kevin Pearson



Andrew Morris



Arnold Stromberg



Hollie Swanson

Quantifying Health Risk

Andrew Morris, Ph.D. (a.j.morris@uky.edu)

Arnold Stromberg, Ph.D. (astro11@uky.edu)

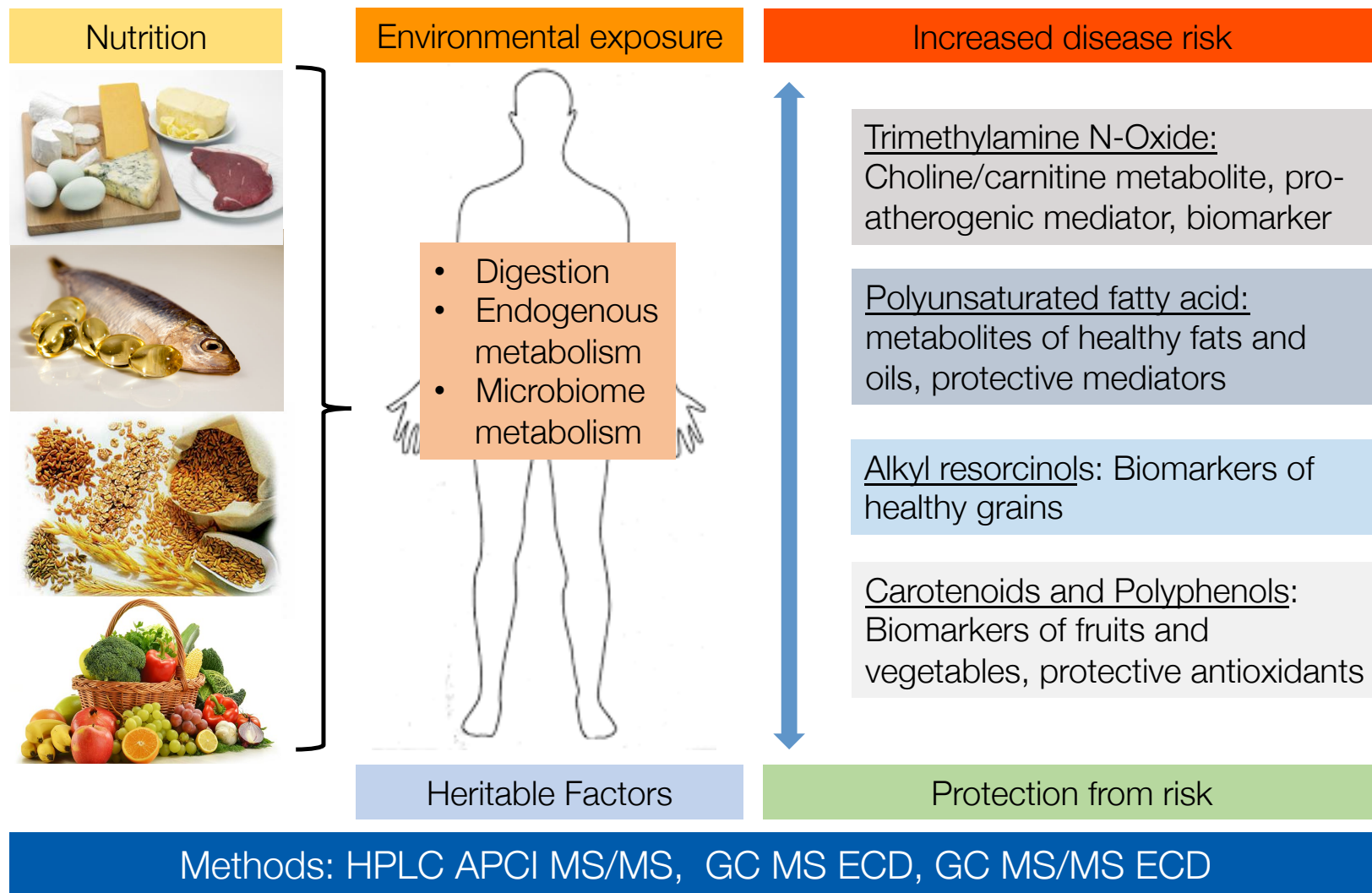
Analytical Staff: Sony Soman, Ph.D.; Manjula Sunkara, M.S.

Statistics Staff: Joshua Lambert, M.S.; Li Xu, M.S.



- Analytical support for biomedical and environmental science projects:
 - Targeted quantitation of PCBs, metabolites and remediation products
 - Quantitation of bioactive diet-derived mediators and metabolites
 - Profiling and quantitation of PCBs and related environmental pollutants in clinical and environmental samples
- Bio-statistical services provided:
 - Experimental design
 - Data analysis
 - Big data archiving and sharing

Quantifying Health Risk



Quantifying Health Risk

- Statistical analysis of microarray data and experimental design consultation
 - The importance of experimental design in mixture analysis
- “Big Data” Analysis (e.g., microarray data)
- Statistical modeling of PCB mixtures
- Analytical and bio-statistical trainee workshops



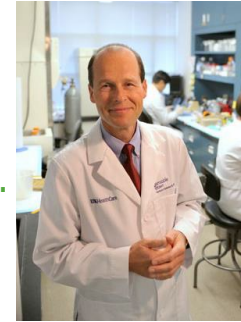
Nutrition and Cardiovascular Disease

Bernhard Hennig, Ph.D. (bhennig@uky.edu)

Andrew Morris, Ph.D. (a.j.morris@uky.edu)

Post Doc Trainees: Mike Petriello, Ph.D.; Banrida Wahlang, Ph.D.

Graduate Trainees: Jordan Perkins, Jessie Hoffman

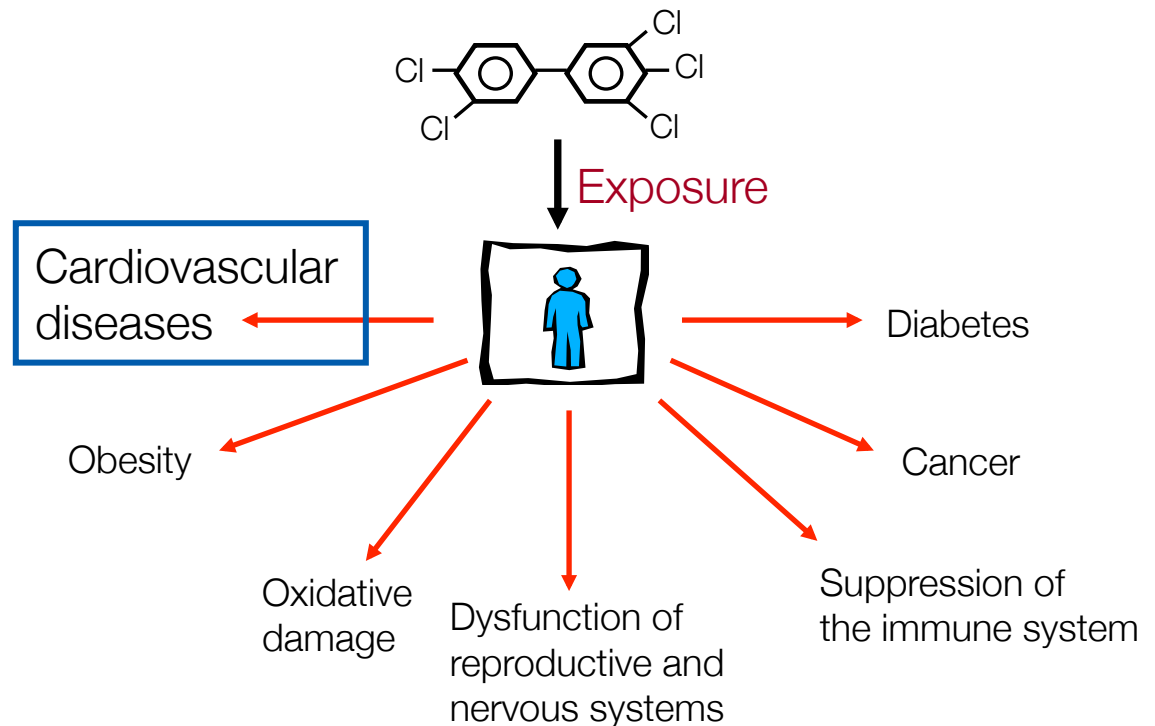


Overall goal: Utilize healthful nutrition as a sensible means of decreasing cardiovascular disease risks associated with environmental pollutants.

Background and Significance

A growing and convincing body of research indicates that nutrition may function as a modulator of vulnerability to environmental insults with nutrition serving to both better or worsen the health impacts associated with exposure to environmental toxins.

Kentucky has high incidence of obesity, diabetes, cardiovascular disease, poverty, and poor nutrition



<http://www.epa.gov/opptintr/pcb/>

Ongoing Research



Available online at www.sciencedirect.com

ScienceDirect

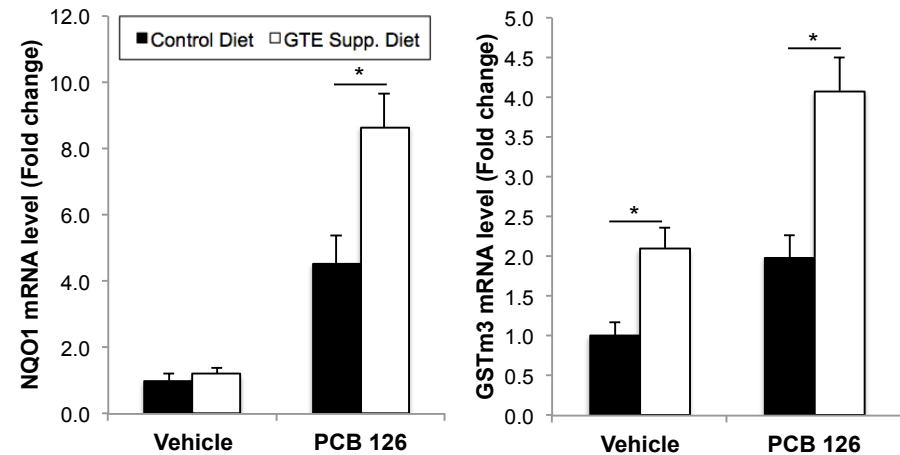
Journal of Nutritional Biochemistry 25 (2014) 126–135

**Journal of
Nutritional
Biochemistry**

Green tea diet decreases PCB 126-induced oxidative stress in mice by up-regulating antioxidant enzymes[☆]

Bradley J. Newsome^{a,b,1}, Michael C. Petriello^{a,c,1}, Sung Gu Han^{a,d,1}, Margaret O. Murphy^{a,e}, Katryn E. Eske^{a,e}, Manjula Sunkara^{a,f}, Andrew J. Morris^{a,f}, Bernhard Hennig^{a,g,*}

- Utilize *in vitro* and *in vivo* molecular biology techniques and knock-out animal models to determine signaling pathways critical to PCB-induced atherosclerosis and nutritional modulation.



Liver mRNA levels of multiple antioxidant enzymes were upregulated in mice fed GTE and exposed to PCB

Take Home Message

Exposure to PCBs and other pollutants may lead to **chronic inflammation** and **heart disease**, but eating diets high in antioxidant and anti-inflammatory bioactive nutrients such as those found in **fruits** and **vegetables** may buffer the body against toxic insult.

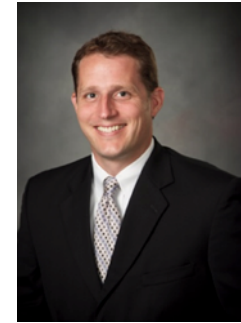


Postnatal Complications of Perinatal Exposures

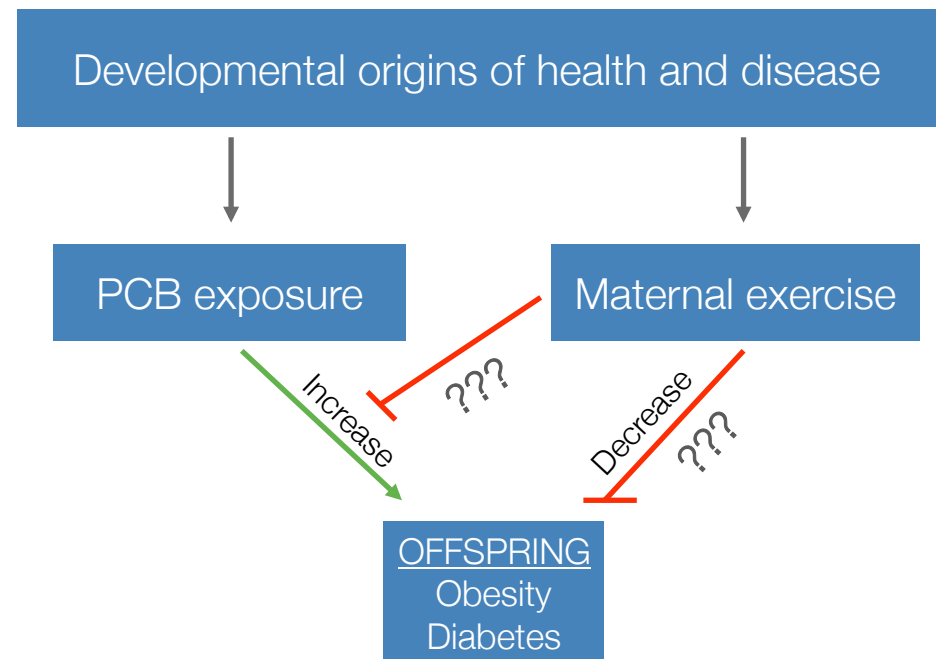
Kevin Pearson, Ph.D. (kevin.pearson@uky.edu)

Hollie Swanson, Ph.D. (hswan@email.uky.edu)

Post Doc Trainee: Leryn Reynolds, Ph.D.



Overall goal: Contribute new insights to understand the potential long-term health complications of PCB toxicity during critical periods of *in utero* and early postnatal life and explore the role of maternal exercise as a transgenerational intervention.

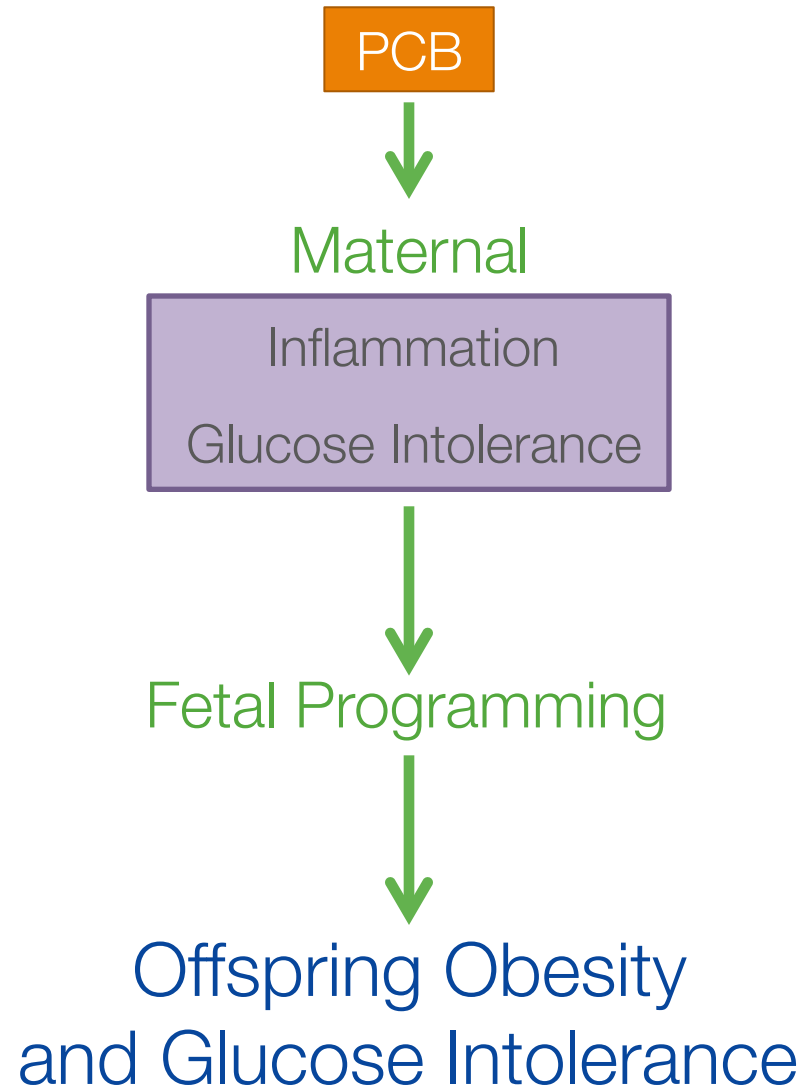


Background and Significance

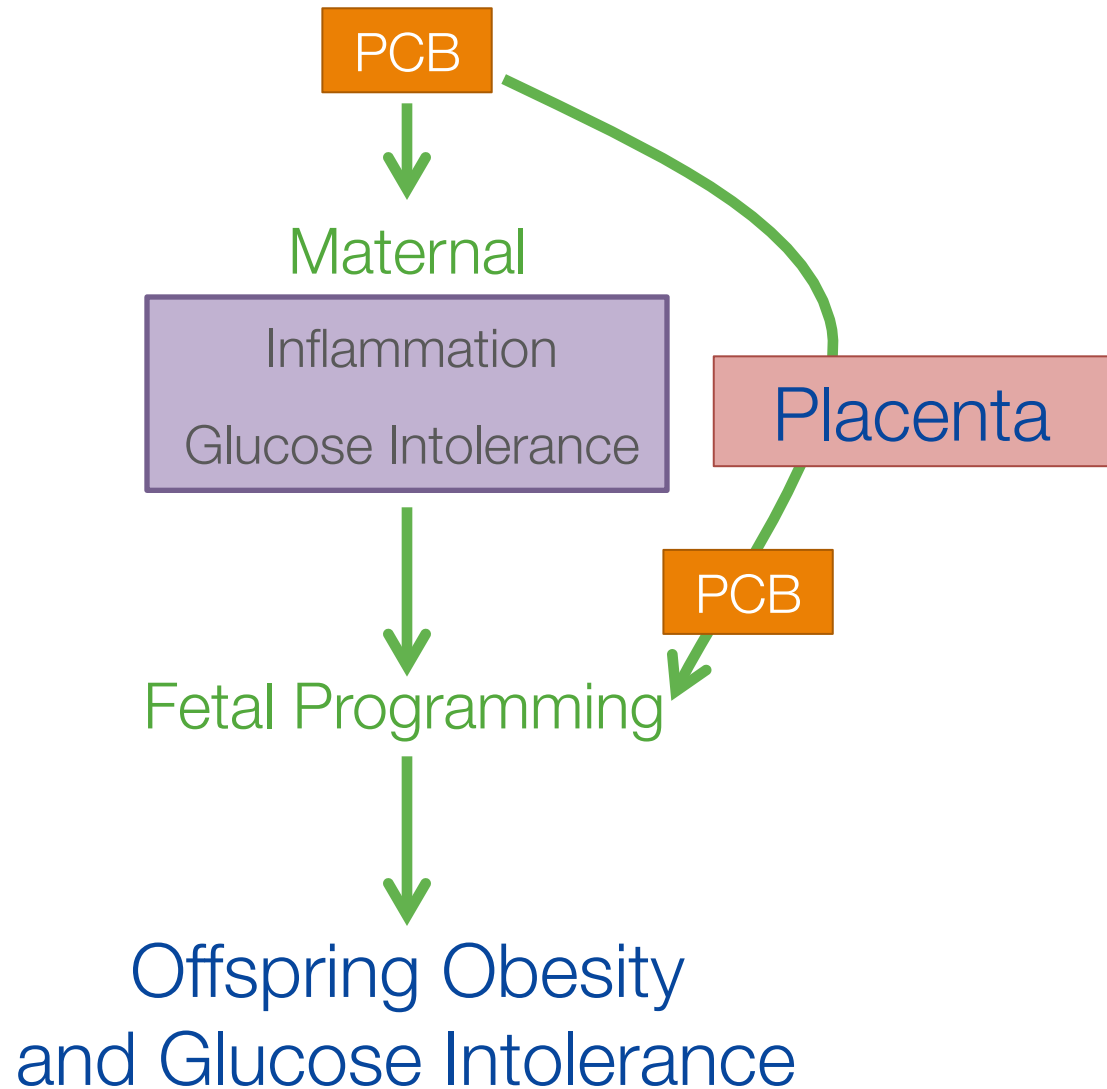


- PCBs can cross the placenta and enter into breast milk (levels of pollutants may be >5 times higher in milk than in maternal blood).
- Recent studies indicate that prenatal exposures to polychlorinated biphenyls (PCBs) contribute to gender-specific obesity development in children.

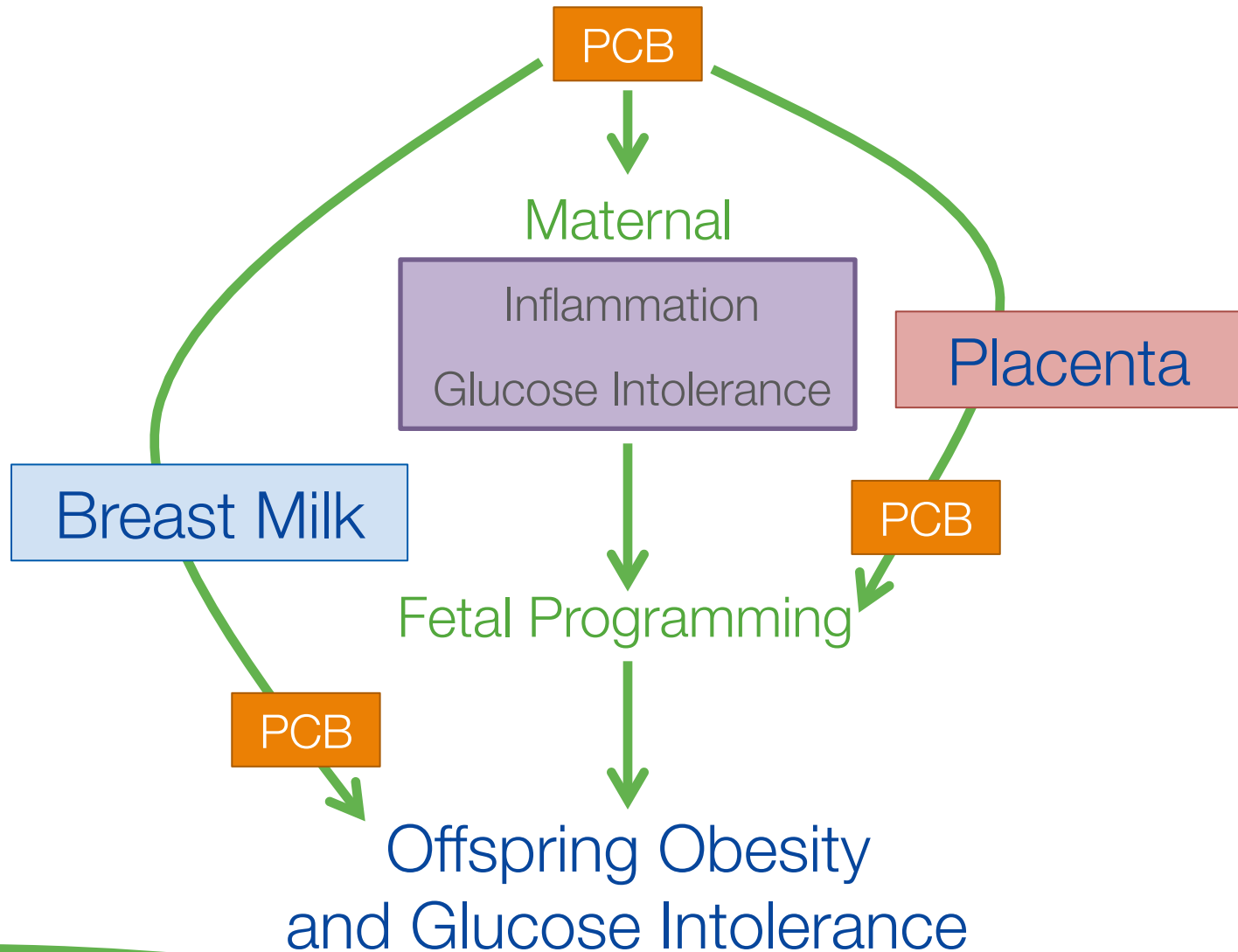
Ongoing Research



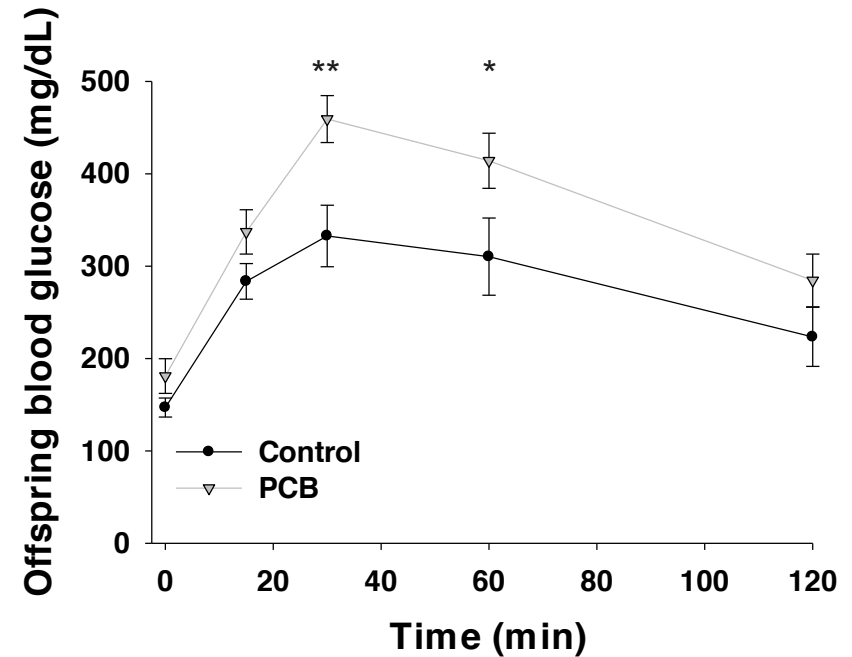
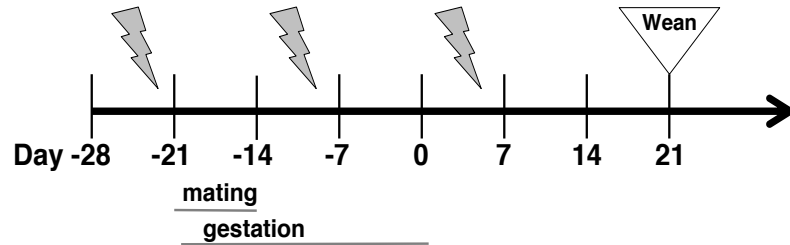
Ongoing Research



Ongoing Research



Maternal PCB 126 Exposure Alters Offspring Body Composition and Glucose Tolerance



Pups born to mothers treated with PCBs exhibit glucose intolerance and inflammation

Carter et. al. Am J Physiol Endocrinol Metab 2012

Rashid et. al. J Ped Biochem 2013

Take Home Message

Exposure of unborn children to pollutants may have detrimental implications long into adulthood, although maternal exercise may prevent toxicant-induced negative transgenerational effects.

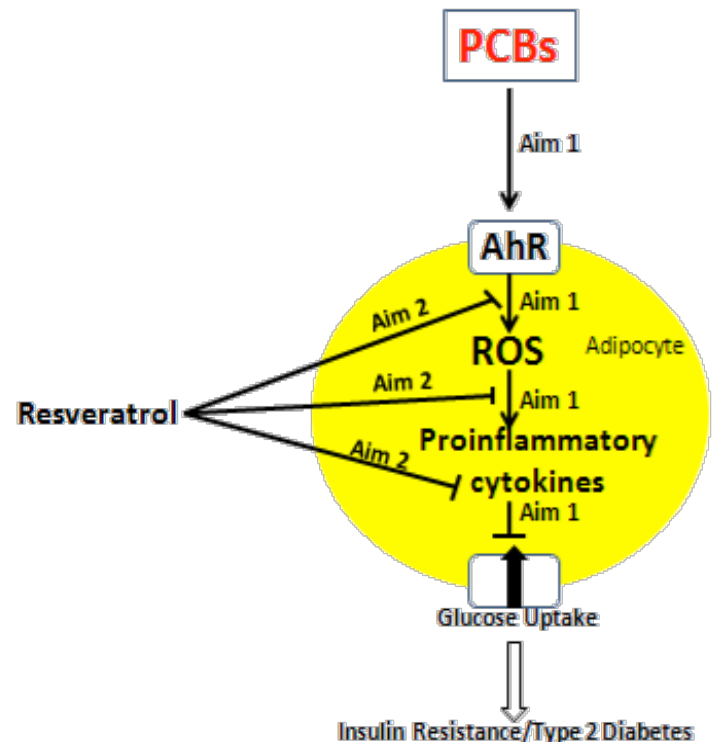


Nutrition and Diabetes

Lisa Cassis, Ph.D. (lcassis@uky.edu)
Research Associate: Sean Thatcher, Ph.D.
Graduate Trainee: Nika Larian



Overall goal: Identify mechanisms whereby PCBs promote the development of insulin resistance and type 2 diabetes. Examine resveratrol as a potential intervention to protect against harmful effects of PCBs on glucose homeostasis in lean subjects, and in obese subjects experiencing weight loss.

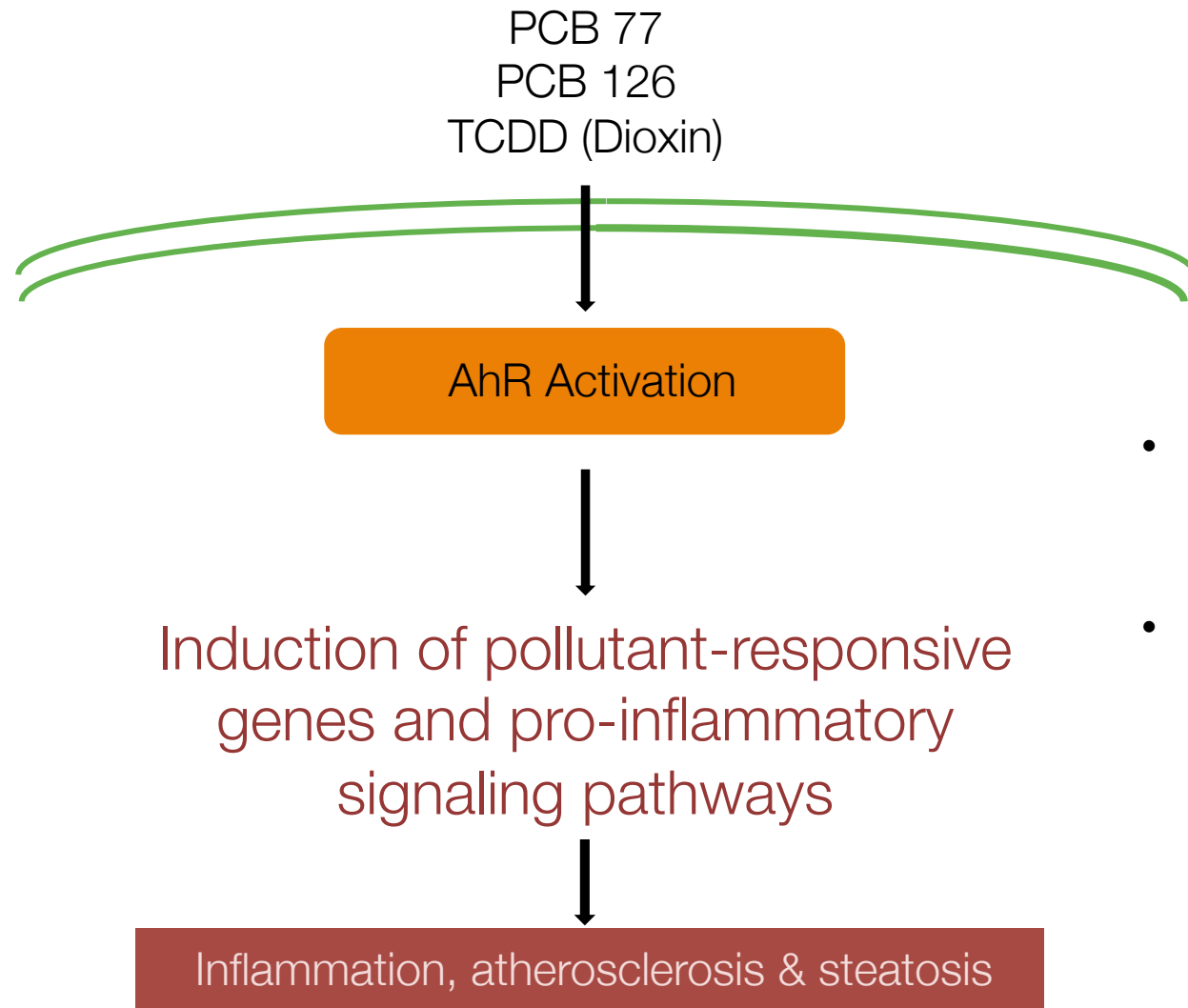


Background and Significance

- Over the past 32 years, the number of adults with diagnosed diabetes in the US has quadrupled (from 5.5 million to 21.3 million). If this trend continues, 1 out of 3 adults in the US will have diabetes by 2050.
- There is growing evidence that environmental toxins, including PCBs, contribute to the development of type 2 diabetes.



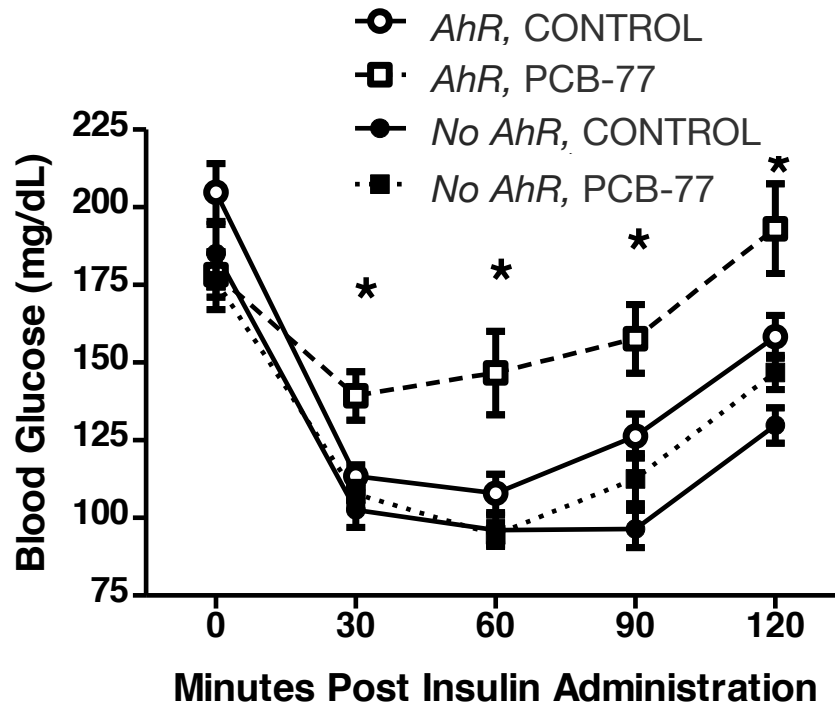
PCBs and the Aryl Hydrocarbon Receptor (AhR)



- AhR activation can lead to increased oxidative stress.
- Chronic oxidative stress can lead to **chronic inflammation**.

Ongoing Research

Overall approach: Delete AhR in adipocytes of lean and obese (with and without weight loss) mice administered coplanar PCBs.



Future Directions: Determine if the nutrient polyphenol [resveratrol](#) can protect against PCB-induced diabetes.

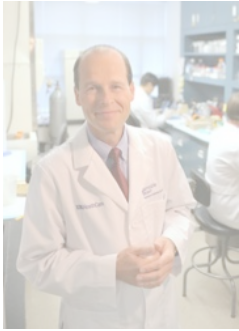
Take Home Message

Many environmental pollutants are stored in fat, and large amounts may be released during rapid weight loss. Eating diets high in antioxidant and anti-inflammatory bioactive nutrients may buffer the body against toxic insult during this susceptible time.

*Rapid
Weight
Loss*

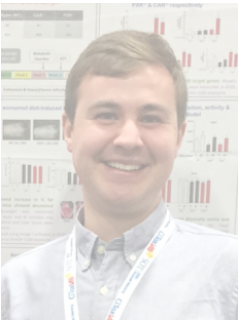


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Reducing Exposures through Sensing and Remediation



D.B. Bhattacharyya



J. Zach Hilt



Thomas Dziubla



Lindell Ormsbee



Andrew Morris



Arnold Stromberg

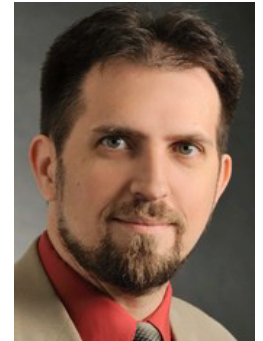
Nanomaterial-Based Pollutant Capture and Sensing

J. Zach Hilt, Ph.D. (zach.hilt@uky.edu)

Thomas Dziubla, Ph.D. (thomas.dziubla@uky.edu)

Post Doc Trainee: Rohit Bhandari, Ph.D.

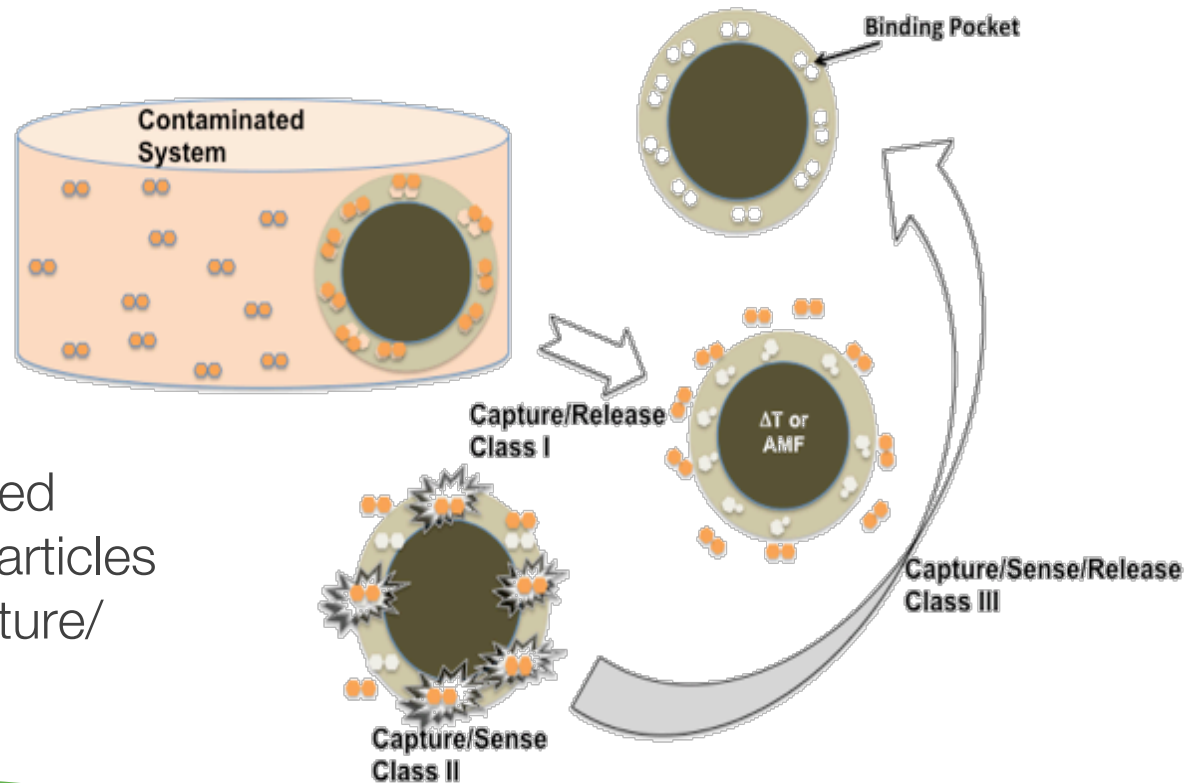
Graduate Trainees: Angela Gutiérrez, Prachi Gupta,
Irfan Ahmad, Shuo Tang



Overall Goal: Develop techniques that can easily and rapidly capture and detect PCB species at the ppb levels needed for useful screening. Determine if plant polyphenol-derived polymers can be coated onto magnetic nanoparticles for the creation of selective PCB binding domains with tunable affinity and selectivity.

Background and Significance

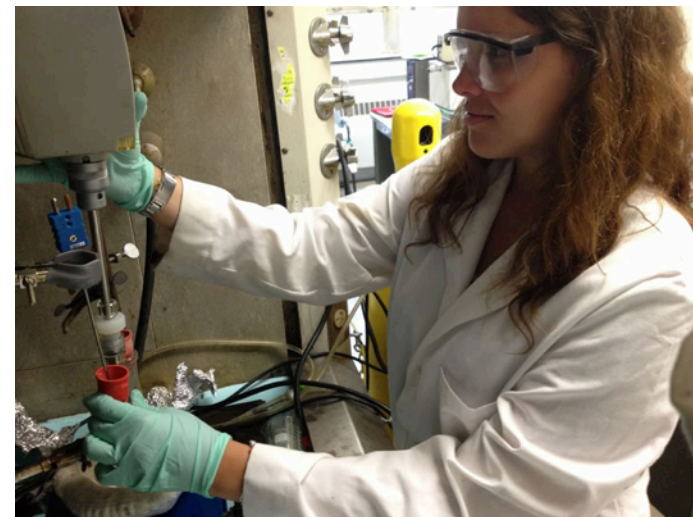
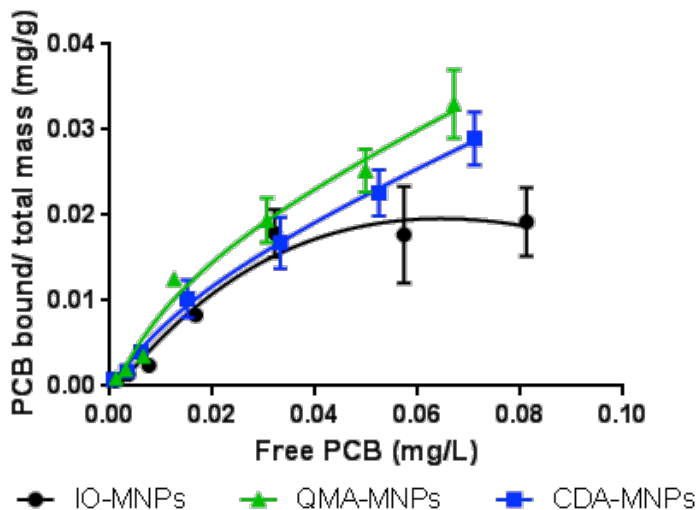
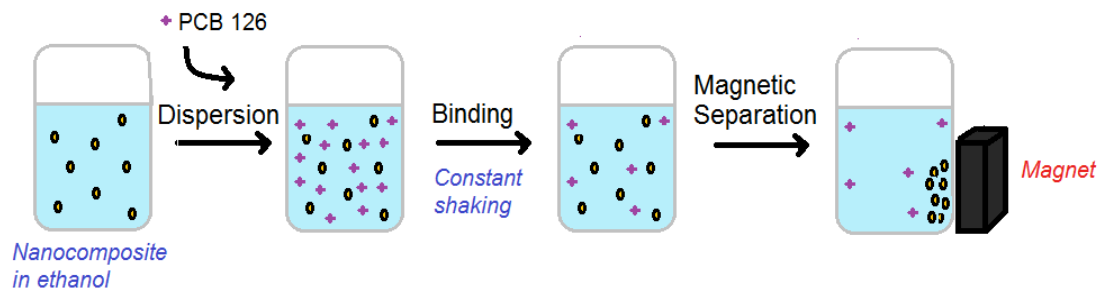
PCBs pose a health risk, and common remediation techniques are typically disruptive to the environment, costly, and unsustainable. Additionally, there are few techniques that can easily and rapidly detect PCB species at the ppb levels needed for useful screening.



Polyphenol-coated magnetic nanoparticles for pollutant capture/sense/release

Ongoing Research – Capture

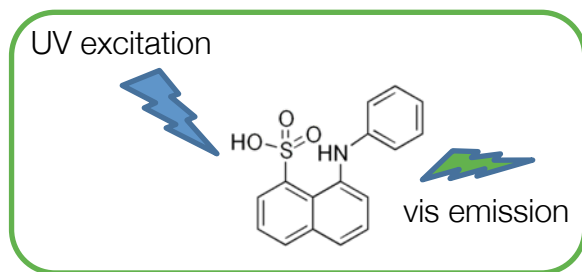
- Nanocomposite development for environmental remediation –
PCB capture: Binding Studies



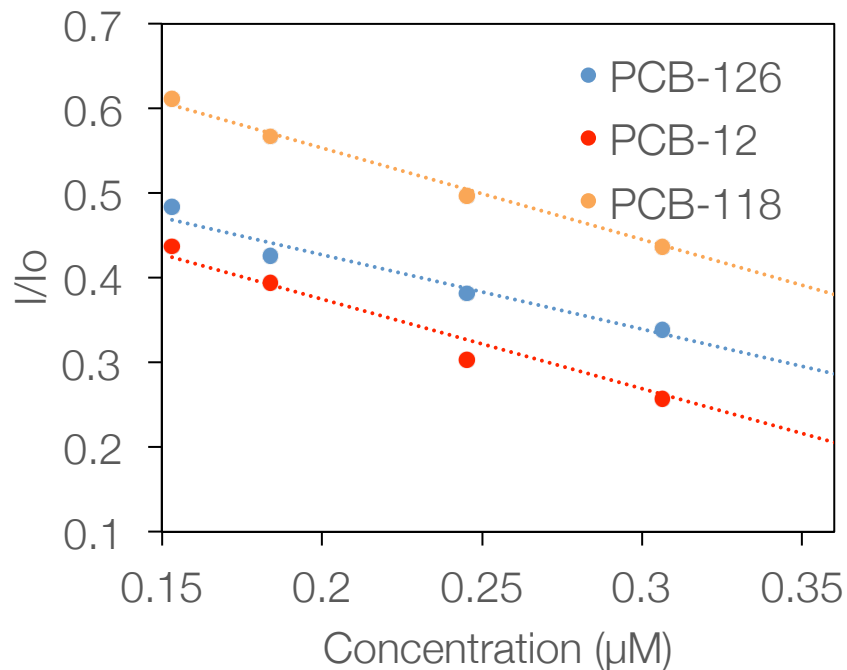
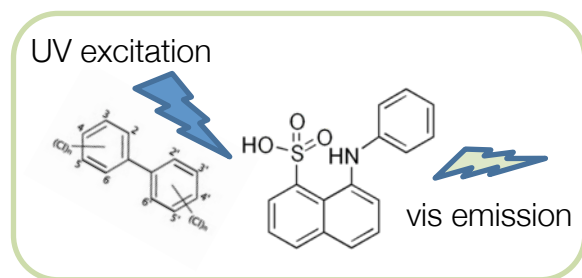
- We have developed nanocomposite materials with environmentally relevant adsorption coefficients.
- Presence of polyphenol (QMA or CDA) in the nanocomposite increases PCB binding

Ongoing Research – Sensing

PCB Sensing



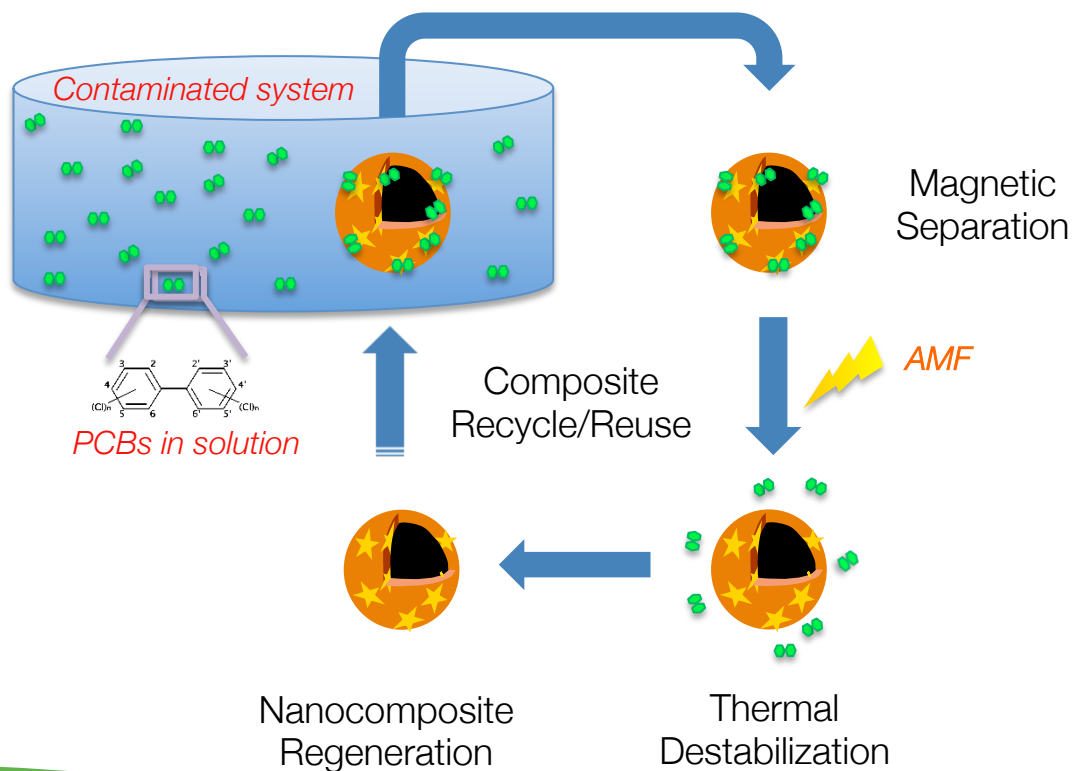
VS.



- PCB sensing is based on pollutant-induced signal attenuation
- Polyphenols and other fluorescent molecules evaluated for PCB interactions
- Data suggest viable platform for pollutant sensing

Take Home Message

Current pollutant remediation and sensing techniques are **inefficient** and may create **toxic byproducts**. This work seeks to create **Green and cost-effective methods** for capture, sensing, and remediation of pollutants.



Membrane-Based Pollutant Remediation

D.B. Bhattacharyya, Ph.D. (db@uky.edu)

Lindell Ormsbee, Ph.D. (lindell.ormsbee@uky.edu)

Faculty Collaborator: John Balk, Ph.D. (john.balk@uky.edu)

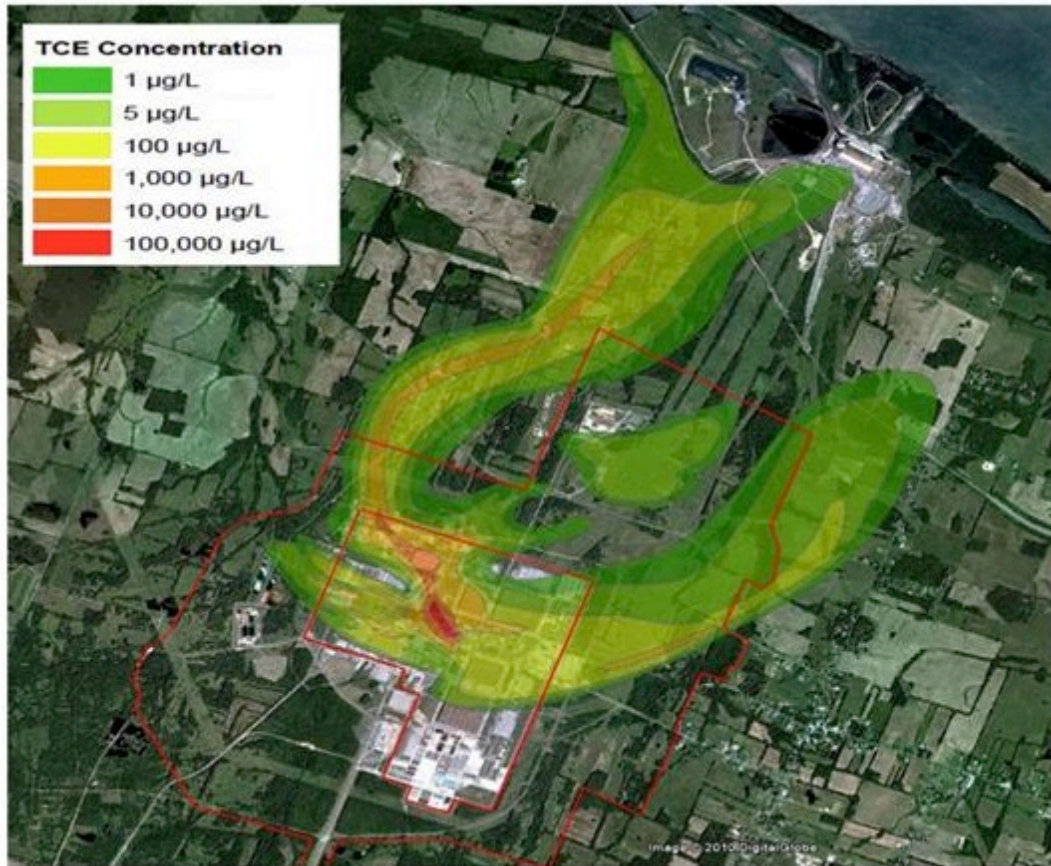
Post Doc Trainee: Minghui Gui, Ph.D.

Graduate Trainees: Sebastián Hernández, Anthony Saad,
Hongyi Wan, Michael Detisch



Overall Goal: To better understand chlororganic degradation processes and develop cost-effective sustainable technologies to remediate chlorinated organic compounds (i.e., PCBs and TCE) at Superfund sites.

Background and Significance



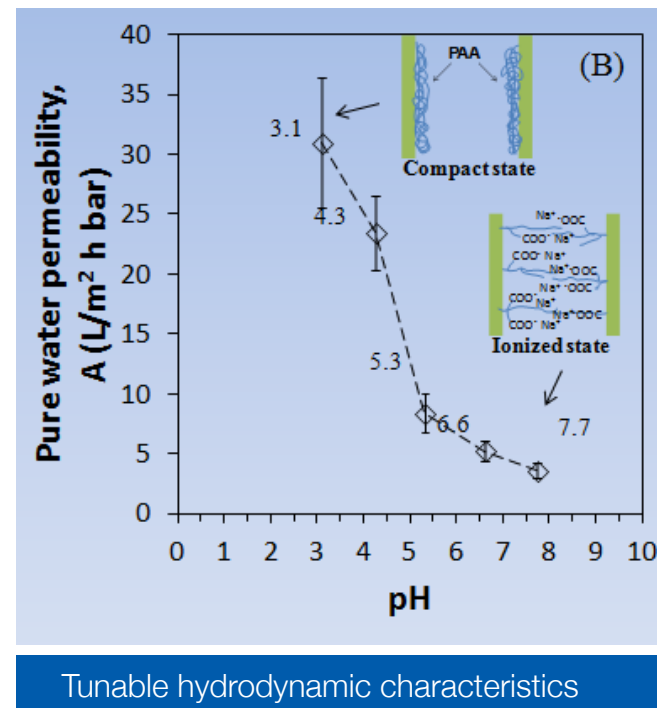
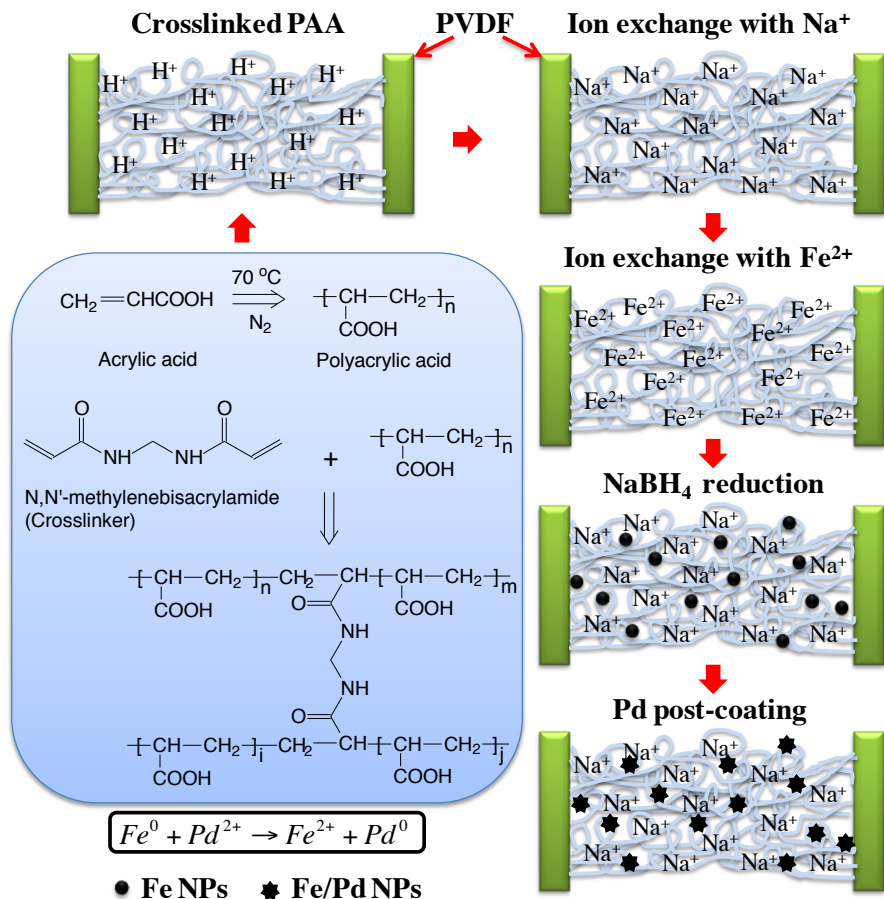
TCE plume at the Paducah Gaseous Diffusion Plant NPL site

Challenges with existing technologies:

- Cost
- Efficiency
- Worker safety
- Installation and performance
- Secondary environmental impacts

Ongoing Research

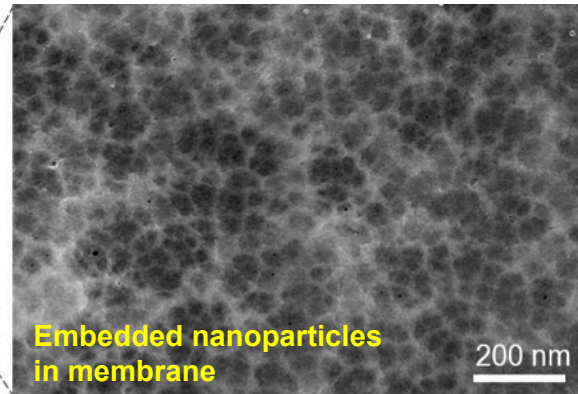
Develop process for creating functionalized membranes for remediation



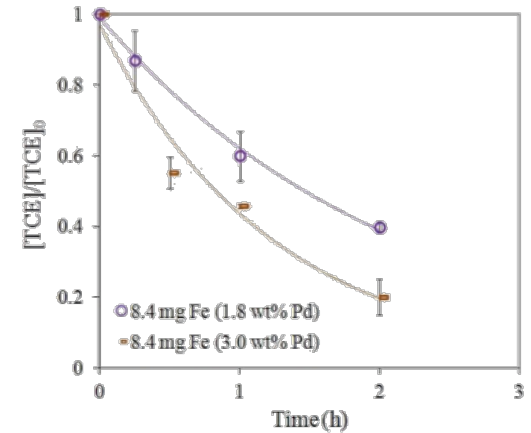
Xiao et. al. IEC RES 2012

Ongoing Research

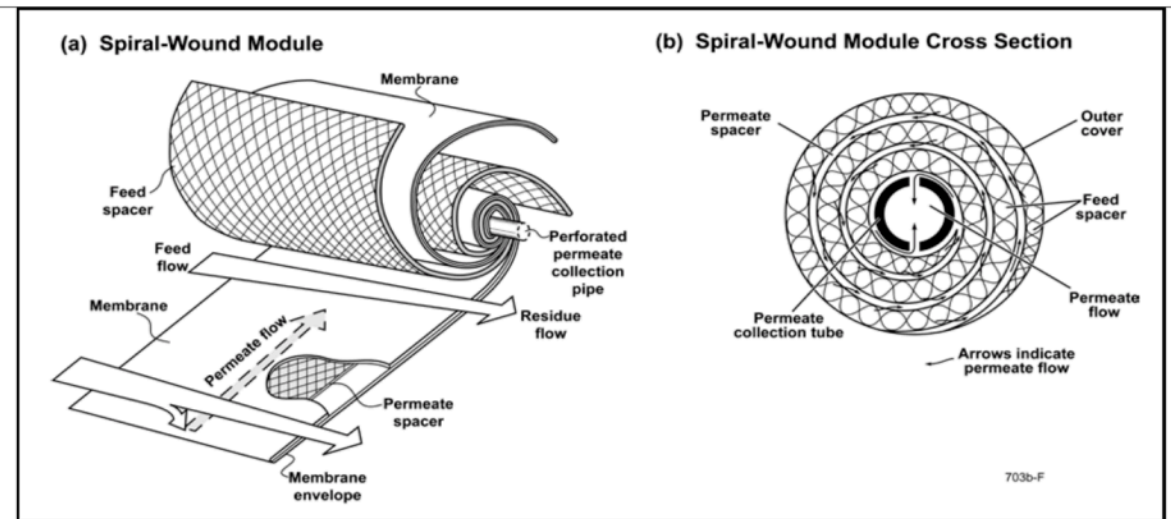
Work with manufacturer to scale up technology for field applications.



TCE dechlorination



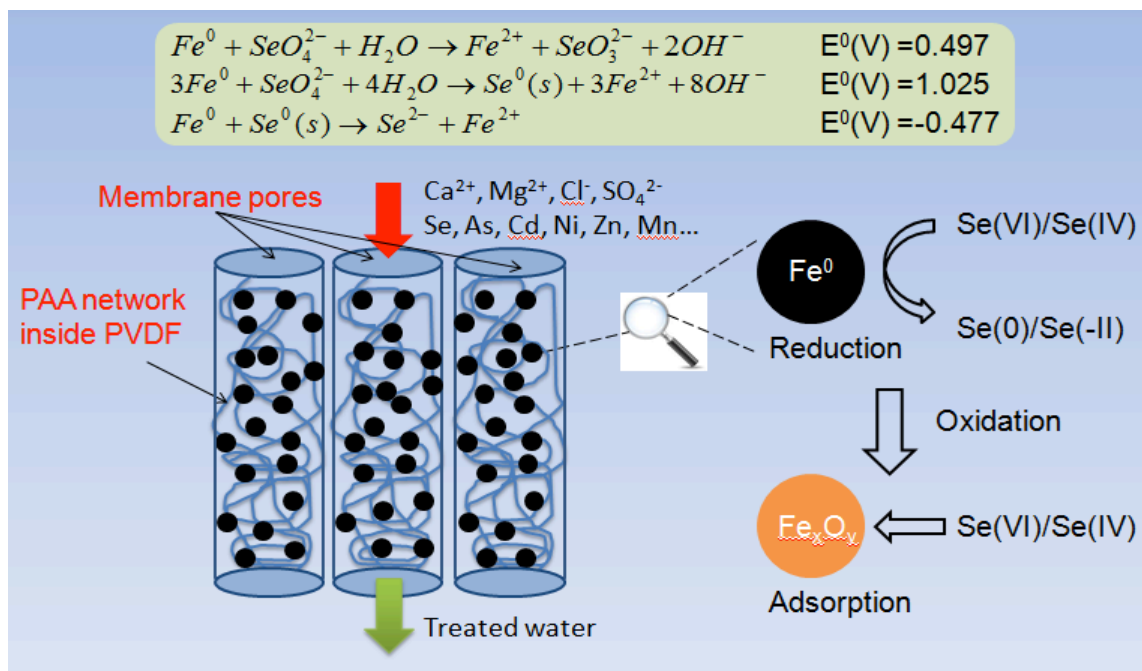
Full-Scale Synthesis:
40 inches wide and 300 feet long with fabric backing



Bhattacharyya et. al. J Membr Sci 2014

Leveraged Applications

Apply functionalized iron based membrane systems to remove potentially toxic compounds (e.g. selenium) from other industrial processes.



Joint work with industry: Gui, Meeks (Southern Co), Weaver (Nanostone Membrane Co)

Translating Findings and Engaging Stakeholders



Lindell Ormsbee



Anna Hoover



Lisa Gaetke



Kelly Pennell



Dawn Brewer



Bernhard Hennig

Translating Findings and Engaging Stakeholders



Overall Goal: To act as a multi-directional bridge between our researchers and our stakeholders.

- Multi-directional communication based on stakeholder needs
- Target populations **across the lifespan**
- Communication with SRP and collaborations with scientists
- Partnerships and tech transfer with government and industry

Responding to Impacted Communities

Curricula

*“Eat Good, Feel Good”
Nutrition Helps Your Body Be Its
Healthiest Even When Your
Environment Is Not*

“Color Your Plate”

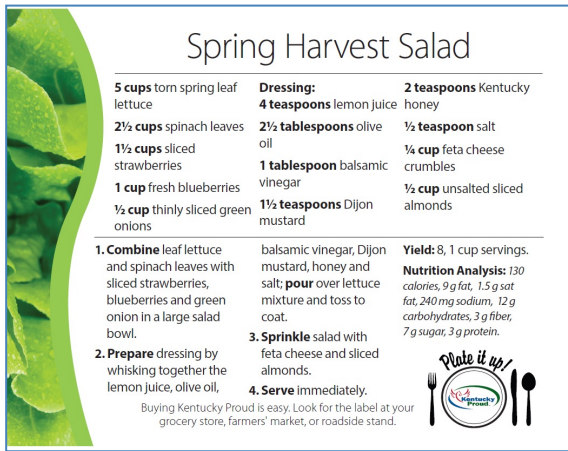
5 nutrition lessons, recipe cards, and
phytonutrient cards

Dayhoit, KY (Superfund Site)

Food demonstrations from a chef on
how to increase vegetables in meals

Healthful nutrition information to protect
against environmental exposures

Risk communication about PCBs, TCE,
and vinyl chloride exposure



Spring Harvest Salad

5 cups torn spring leaf lettuce
2½ cups spinach leaves
1½ cups sliced strawberries
1 cup fresh blueberries
½ cup thinly sliced green onions


Dressing:
4 teaspoons lemon juice
2½ tablespoons olive oil
1 tablespoon balsamic vinegar
1½ teaspoons Dijon mustard

2 teaspoons Kentucky honey
½ teaspoon salt
¼ cup feta cheese crumbles
½ cup unsalted sliced almonds

Yield: 8, 1 cup servings.
Nutrition Analysis: 130 calories, 9 g fat, 1.5 g sat fat, 240 mg sodium, 12 g carbohydrates, 3 g fiber, 7 g sugar, 3 g protein.

1. Combine leaf lettuce and spinach leaves with sliced strawberries, blueberries and green onion in a large salad bowl.
2. Prepare dressing by whisking together the lemon juice, olive oil, balsamic vinegar, Dijon mustard, honey and salt; **pour** over lettuce mixture and toss to coat.
3. Sprinkle salad with feta cheese and sliced almonds.
4. Serve immediately.

Buying Kentucky Proud is easy. Look for the label at your grocery store, farmers' market, or roadside stand.



Spinach and Leafy Greens

Contains lutein to **protect your eyes** from cataracts and macular degeneration.

Helps to keep **immune system healthy** to fight infections.

Helps **reduce the risk of cancer, high blood pressure, heart disease, and stroke.**



Engaging the Greater Community

Respond to the needs and interests of the greater public and engage in dialogs about environmental health topics

Dr. Hennig (Project 1 Leader and UK-SRC Director) prepared a policy brief for Senate and House Staffers to highlight the benefits of healthful lifestyles for reducing the effects of PCB exposures.

“Human studies suggest that 4 to 6 cups of green tea per day can protect against inflammatory diseases such as osteoporosis. Our research with animals suggest that a similar amount of green tea can protect against proinflammatory effects of PCBs by inducing antioxidant defenses within the body...”



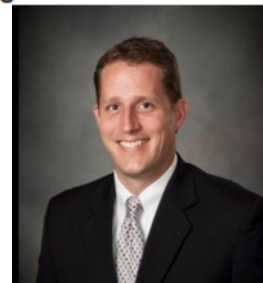
Dr. Dawn Brewer (CEC Co-Leader) and Dr. Brad Newsome (UK-SRC trainee) participated in the Mind Matters Health Fair that targeted the older adult population in May 2015. Approximately 400 older adults attended the health fair of which, we reached an estimated 215 participants or 54% of health fair participants with our handouts. In lieu of the UK-SRC's positive findings of phytochemicals, particularly those found in green tea, to decrease PCB-induced pro-inflammatory response in animal and cells models, strawberry green tea was served.

Dr. Pearson (Project 2 Leader and Leryn Reynolds (UK-SRC trainee) spoke at an event organized by the Lexington Chapter of Hadassah ("The power of Women who DO") in April 2015. They spoke about the importance of nutrition, lifestyle and environmental health. Dr. Pearson also summarized key points of his seminar in a column he authored for the Lexington Herald-Leader (readership: 200,000)

kentucky.com Lexington Herald-Leader
News, sports and entertainment

Lifelong health begins before birth

BY KEVIN J. PEARSON
contributing columnist April 10, 2015



We've long known that a pregnant mother's alcohol and tobacco use can harm a developing fetus, but we're now learning much more about how a baby's first nine months before birth can affect its health into adulthood.

The environment of the womb, which is determined by a mother's health, lifestyle and surroundings, can alter the development of a

Partnering with Government



Region 4
Region 9

Cincinnati Risk
Assessment Lab



Paducah Uranium
Gaseous Diffusion
Plant

Oak Ridge
Associated University



Atlanta Meeting



TCE Water
Distribution System
Contamination



Water Distribution
System Contamination
Recovery



Kentucky Energy and Environment Cabinet
Monthly Seminar Series



Transferring Technologies



Chevron



- PCB/TCE Remediation
- Paducah NPL site remediation
- Power plant selenium removal
- Organic acid degradation

Transferring Knowledge



Left to Right: Representative Chandler (former D-KY), Dr. Suk, Dr. Hennig, Dr. Birnbaum, Dr. Capilouto (UK President) at 2011 SRP Annual Meeting, Lexington, KY



Nicki Baker presenting her 2012 Wetterhahn Memorial award research on pollutant-induced diabetes



Trainees Mike Petriello and Maggie Murphy presented to high school teachers on environmental pollution and nutrition

The UK Superfund Research Center

Improving health by preventing exposure and promoting healthful lifestyles



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Thank You!



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