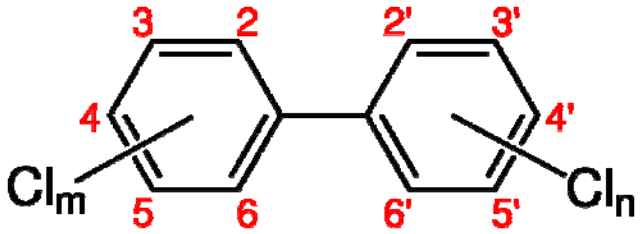
AIRBORNE PCBS: SOURCES, EXPOSURES, TOXICITIES, REMEDIATION

NIEHS/NIH Grant P42 ES013661

Mixtures of PCBs were produced as Aroclors until~1975 when the EPA banned their sale



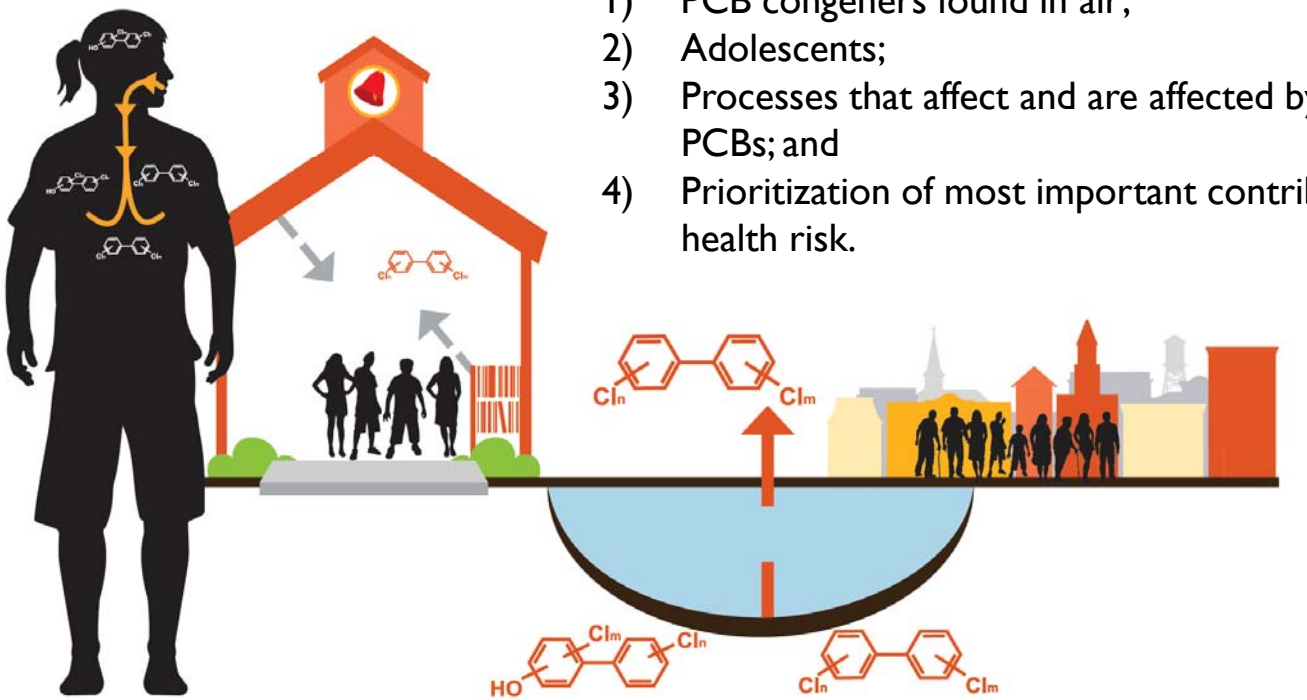
A typical pre-1979 PCB-containing fluorescent light ballast (FLB)

A typical Non-PCB containing fluorescent light ballast. The ballast has a "No PCBs" marking on the top of the ballast and the text "electronic ballast". Only magnetic fluorescent light ballasts contained PCBs.

The ISRP is the only SRP Center Focusing on Airborne PCBs. Since 2006, the ISRP has shown:

- PCBs are complete carcinogens
- PCBs disrupt the thyroid hormone system
- PCBs disrupt adipocytes and energy homeostasis
- PCB metabolites are often more toxic than the parent compounds
- Contaminated waters, including Superfund Sites are major sources of airborne PCB
- Modern paint, polymers, and legacy building materials are major sources of airborne PCBs indoors
- PCB levels are much higher in indoor air, especially in some schools
- Inhalation is a significant route for human exposure, particularly for children

IOWA SUPERFUND RESEARCH PROGRAM



1) PCB congeners found in air;
2) Adolescents;
3) Processes that affect and are affected by the metabolism of PCBs; and
4) Prioritization of most important contributors to human health risk.

Sources, Exposures, Toxicities, and Remediation of Airborne PCBs

Three Biomedical Projects

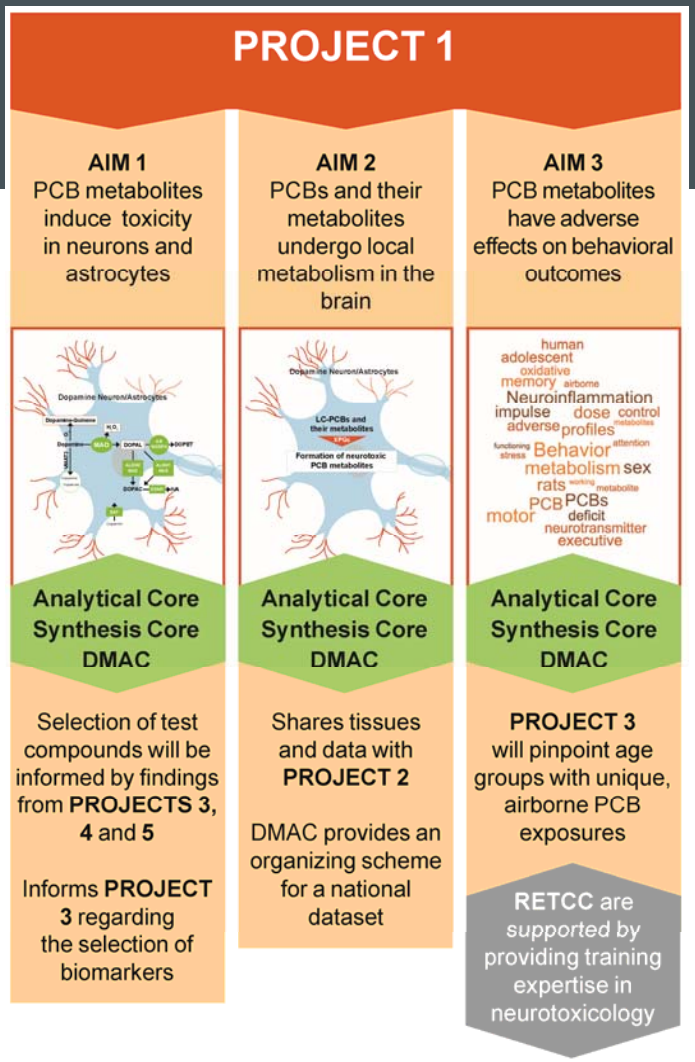
1. Airborne PCBs and their Metabolites: Risk Factors for Adverse Neurodevelopmental Outcomes in Adolescence
2. The role of Airborne PCBs in Adipogenesis, Adipose Function, and Metabolic syndrome
3. Airborne Exposures to Semi-volatile Organic Pollutants (The AESOP Study)

Two Environmental Engineering and Science Projects

4. Sources of Airborne PCB Congeners
5. Mitigating PCB emissions from sediments with black carbon materials and PCB-degrading biofilms

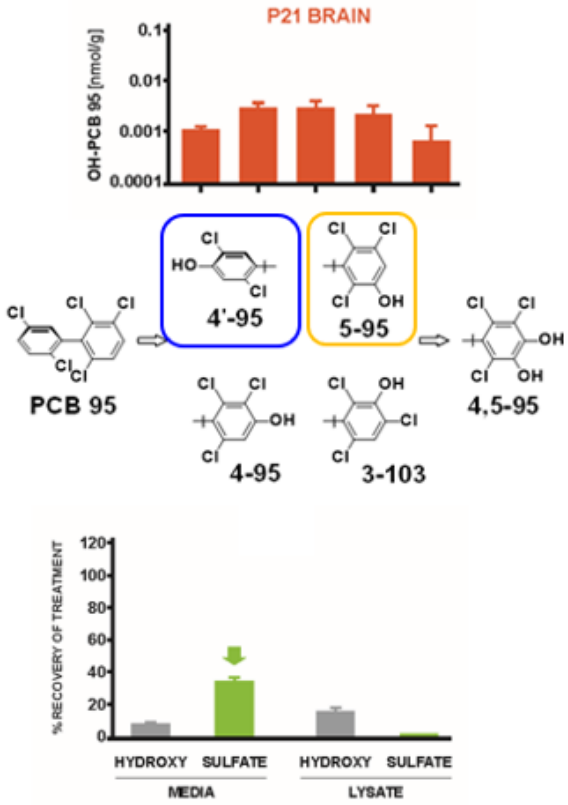
PROJECT 1:

Airborne PCBs and Their Metabolites: Risk Factors for Adverse Neurodevelopmental Outcomes in Adolescence



PROJECT 1: AIRBORNE PCBS AND THEIR METABOLITES: RISK FACTORS FOR ADVERSE NEURODEVELOPMENTAL OUTCOMES IN ADOLESCENCE

- PCBs and their metabolites are present in the brain (of mice)
- PCB metabolism differs between humans and rodents
- Inhalation of PCBs results in neurotoxic effects in rats
- PCBs alter dopamine metabolism *in vitro*
- Further local metabolism in the brain?



HYPOTHESIS: PCBS AND PCB METABOLITES FORMED IN HUMANS ARE PRESENT IN THE BRAIN AND SERVE AS RISK FACTORS FOR ALTERED NEURODEVELOPMENT DURING ADOLESCENCE

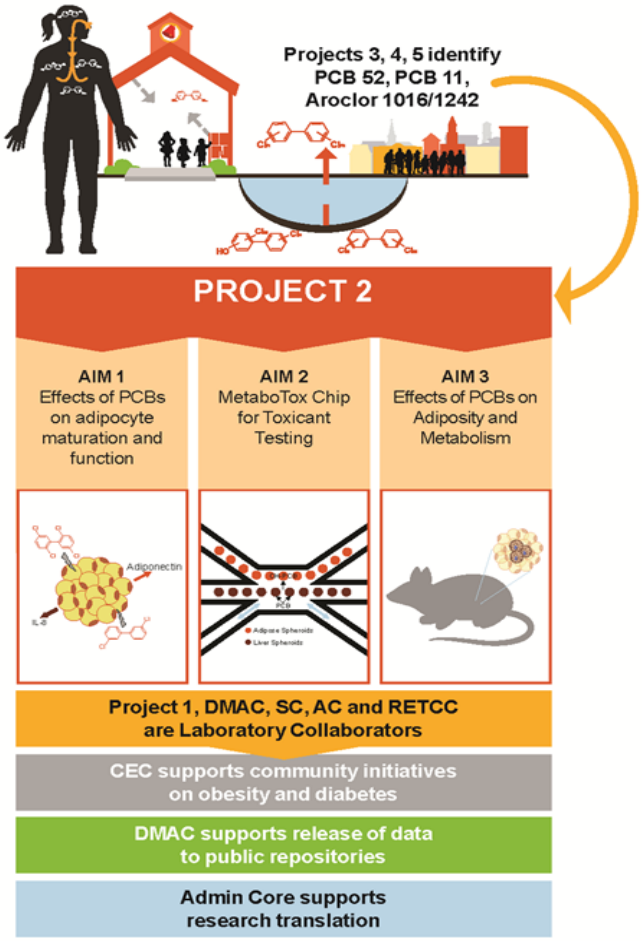
1. Identify cellular sites and mechanisms of toxicity of PCB metabolites vs. the parent PCBs in the brain *in vitro*
2. Characterize the region-specific biotransformation of PCB and PCB metabolites in the brain *in vitro* and *in vivo*
3. Determine the dose-dependent effects that metabolites of PCBs have on biochemical markers and behavioral outcomes in adolescent rats



- Hans-Joachim Lehmler (Occup & Env. Health)
- Jonathan Doorn (Pharmacy)
- Hanna Stevens (Psychiatry)
- Michael Duffel (Pharmacy)
- Donna Hammond (Pharmacology)


PROJECT 2: ROLE OF AIRBORNE PCBS IN ADIPOGENESIS, ADIPOSE FUNCTION, AND METABOLIC SYNDROME

- Certain PCB congeners, including those found in air, are associated with the development of type II diabetes
- Effects may be mediated through adipose tissue
- Metabolites of PCBs may be important in causing effects



HYPOTHESIS: PCBS AND THEIR METABOLITES CONTRIBUTE TO THE DEVELOPMENT OF METABOLIC SYNDROME THROUGH DISRUPTION OF ADIPOGENESIS AND ADIPOCYTE ENDOCRINE FUNCTION

1. Elucidate the functional consequences of airborne PCB exposure on adipogenesis and adipocyte function
2. Develop a human adipose-liver biomimetic on-chip that allows for facile and accurate testing of the effects of environmental toxicants on adipose function
3. Determine how airborne PCBs affect adiposity and metabolism in vivo

Alyosius Klingelhutz

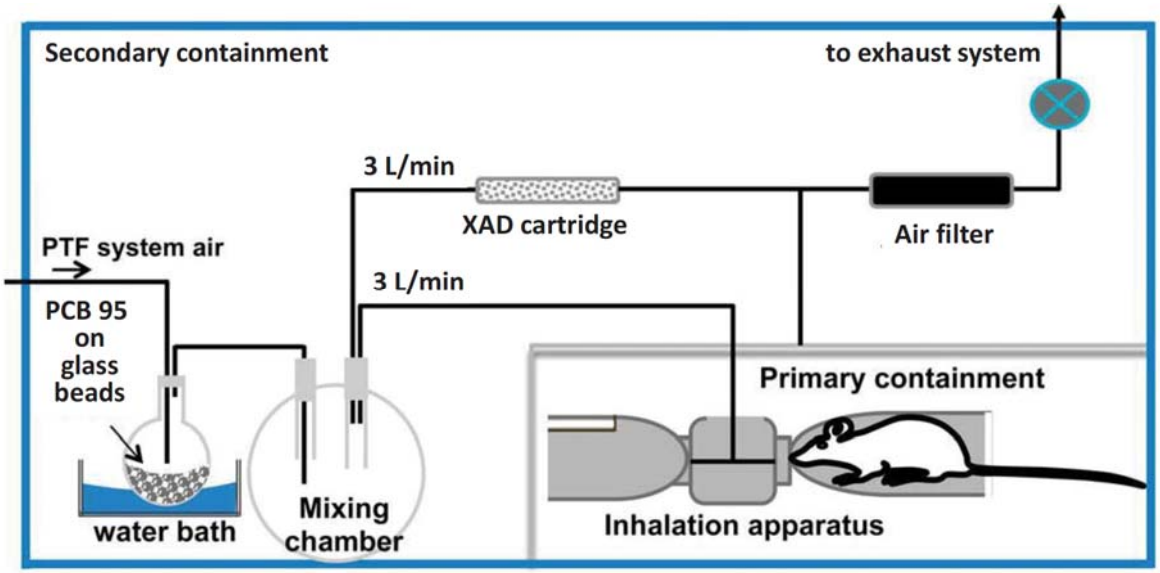
Microbiology and Immunology

James Ankrum

Biomedical Engineering

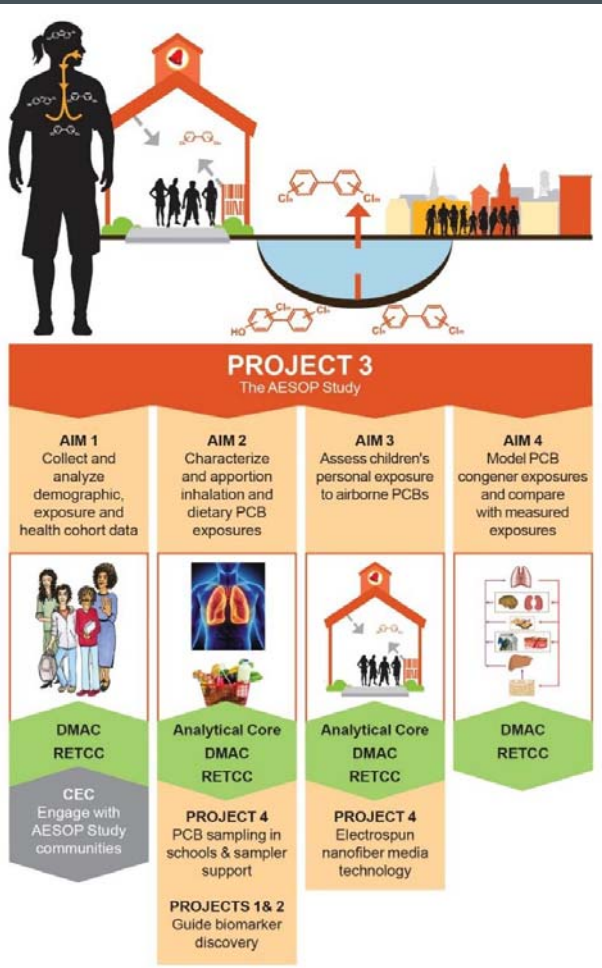
PROJECT 1 AND PROJECT 2 COLLABORATE ON ANIMAL STUDIES

The nose-only inhalation system to expose rodents to airborne PCBs developed previously by the the ISRP



PROJECT 3: AESOP STUDY (AIRBORNE EXPOSURES TO SEMI-VOLATILE ORGANIC POLLUTANTS)

- Human cohort study that assesses the PCB exposome for school children and their mothers
- Communities in rural Iowa and urban northwest Indiana
- Biobanked 10 years of samples (381 participants)
- Measured PCBs in the air of participant's' homes, schools, and outdoor environments, and in their serum
- Represents an unparalleled opportunity to characterize the importance of inhalation and dietary exposures to PCBs



HYPOTHESIS: BOTH INHALATION AND DIET CONTRIBUTE TO EXPOSURES TO SPECIFIC PCBS THAT ARE ASSOCIATED WITH ELEVATED RISKS FOR OXIDATIVE STRESS, INFLAMMATION, HORMONE DISRUPTION, AND METABOLIC SYNDROME

1. **Collect and analyze demographic, residential, occupational, activity, dietary and health, data from AESOP Study participants.**
2. **Characterize personal exposures to PCB congeners among children and their mothers through inhalation and diet**
3. **Assess adolescent children's time-integrated personal exposure**
4. **Model PCB congener exposures and body burdens**

Peter Thorne

Occupational and Environmental Health

Andres Martinez

Civil & Environmental Engineering, IIHR-Hydroscience and Engineering

Rachel Marek

IIHR-Hydroscience and Engineering

PROJECT 3 STUDIES:

Three cohorts:

- East Chicago Indiana
- Columbus Community in rural Iowa
- West Liberty in rural Iowa

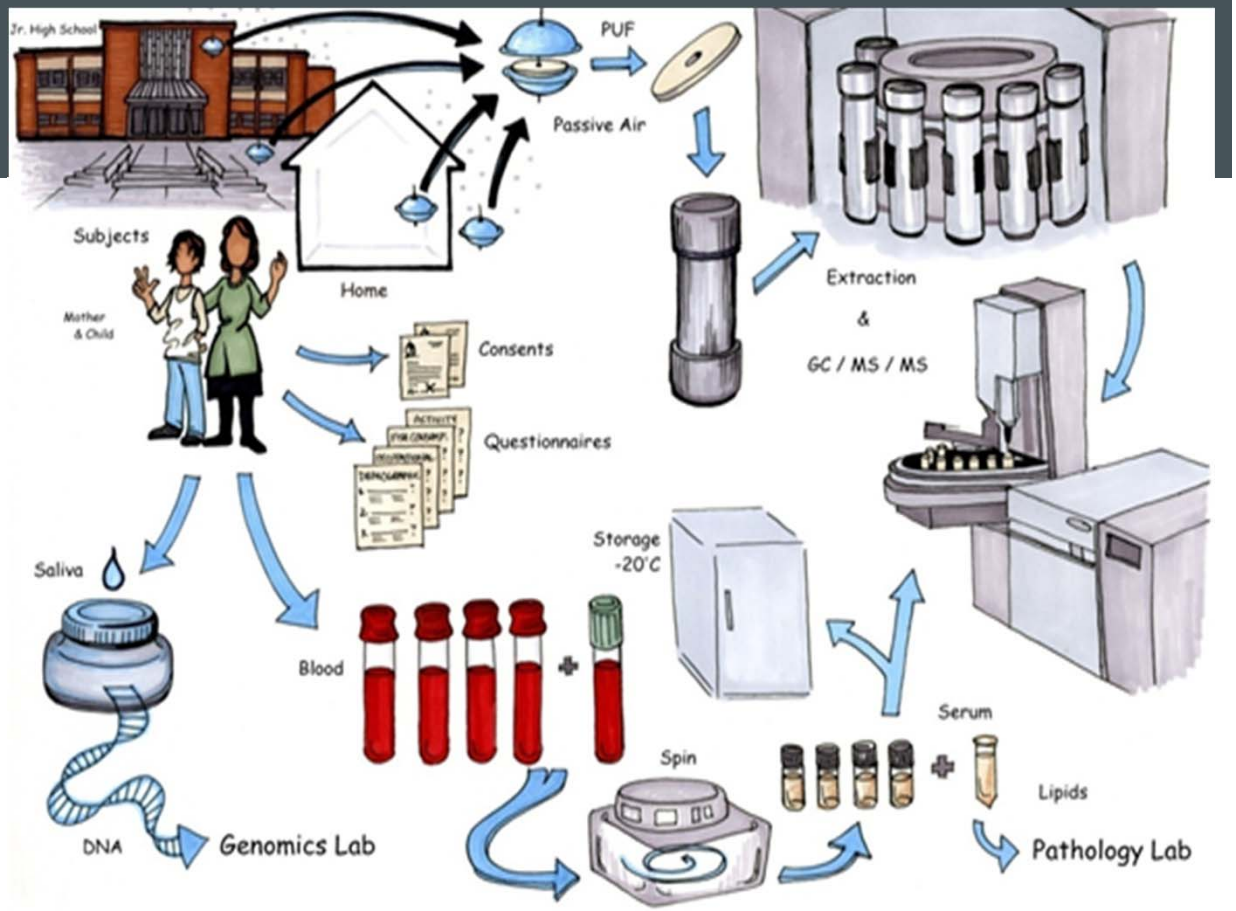


Fig. 3-2. General scheme for the AESOP Study. (Art: Jeanne DeWall)

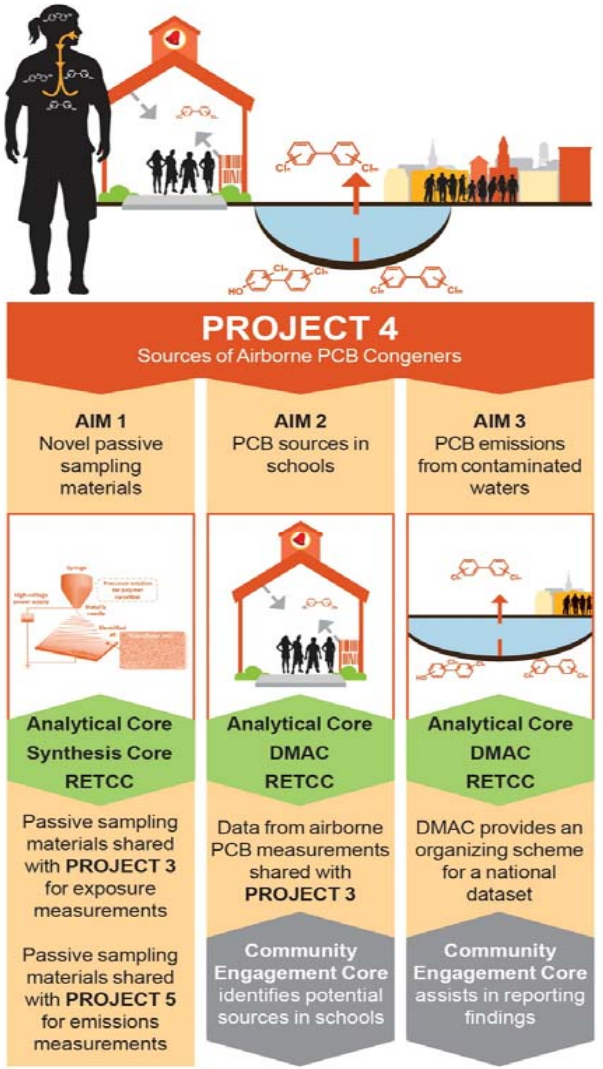
PROJECT 4: SOURCES OF AIRBORNE PCBS

Project 4 conducts field research using novel sampling and analysis methods.

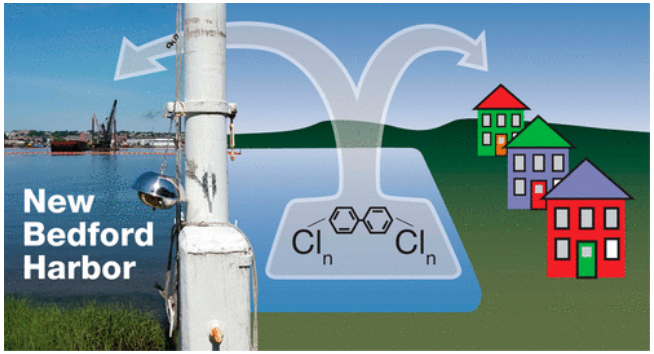
Project 4 addresses Aroclors and Non-Aroclors

Project 4 addresses two of the most important situations:

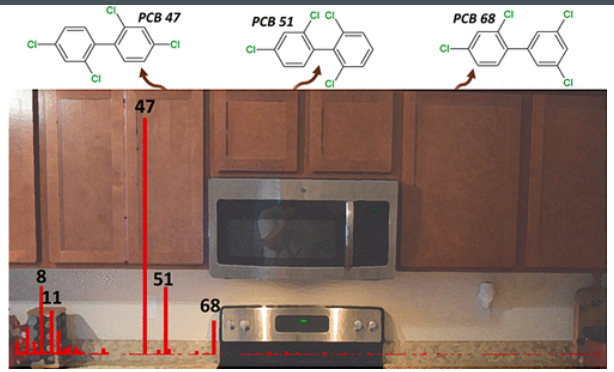
- Attending or working in a school containing PCBs in building materials and consumer products
- Living near PCB-contaminated surface water



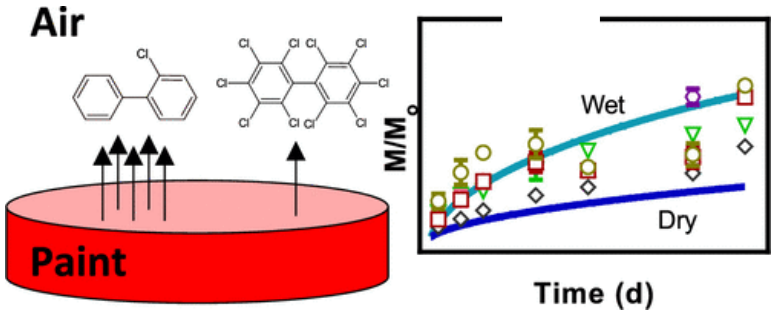
PROJECT 4 STUDIES: EMISSIONS OF PCBS FROM SURFACE WATER AND INDOORS



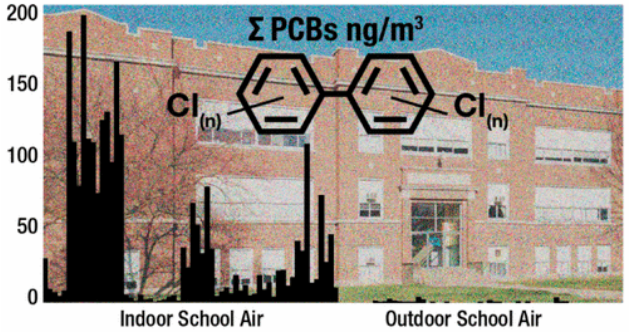
Martinez et al, *ES&TLetters* 2017



Herkert et al, *ES&T* 2018



Jahnke et al, *ES&T* 2019



Marek et al, *ES&T* 2017

HYPOTHESIS: PCB EMISSIONS ARE A FUNCTION OF THE PROPERTIES OF THE PCBS, ENVIRONMENTAL VARIABLES AND EMISSION SURFACES; AND MEASUREMENT OF EMISSIONS AND CONCENTRATIONS ENABLES COST-EFFECTIVE DECISIONS FOR THEIR REMOVAL

1. Develop novel passive sampling materials for fast measurement of airborne PCBs and PCB emissions
2. Identify specific sources of airborne PCBs in schools and homes.
3. Characterize emissions from contaminated waters nationwide

Keri Hornbuckle

Civil & Environmental Engineering,
IIHR-Hydroscience and Engineering

Andres Martinez

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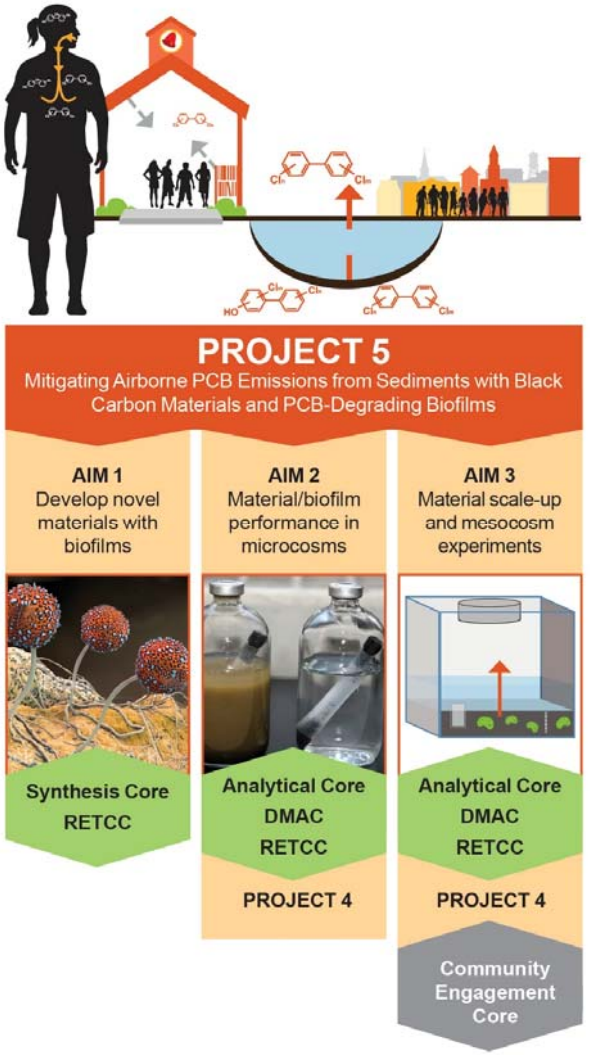
IIHR-Hydroscience and Engineering

PROJECT 5: MITIGATION OF AIRBORNE PCB EMISSIONS FROM SEDIMENTS

- Contaminated sediments are a major reservoir of PCBs and a pump for emissions of airborne PCBs from surface waters
- Project 5 leads research related to intervention, remediation, and reduction of exposure to airborne PCBs
- Project 5 will develop and test combinations of novel sorptive-reactive black carbon materials containing microbial PCB-degrading biofilms



HYPOTHESIS: NOVEL TAILORED BLACK CARBON MATERIALS CONTAINING PCB-DEGRADING BIOFILMS ENHANCE BIODEGRADATION OF PCBS IN CONTAMINATED SEDIMENTS, RESULTING IN LOWER PCB EMISSIONS FROM THESE SEDIMENTS

1. Optimize black carbon materials with sorptive and reactive properties toward PCBs and the ability to host PCB-degrading biofilms
2. Evaluate black carbon materials containing aerobic PCB-degrading biofilms to lower PCB concentrations in water and air under relevant environmental conditions
3. Scale up production and demonstrate the feasibility of decreasing airborne PCB flux from contaminated sediments at the mesocosm-scale

Tim Mattes, PI
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Jerry Schnoor
Civil & Environ. Engineering

Andres Martinez
IIHR-Hydroscience and Engineering

Greg Lefevre
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PROJECT 5 STUDIES: MATERIAL DEVELOPMENT AND TESTING

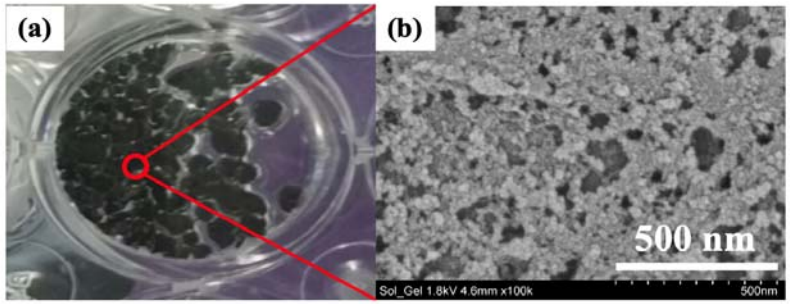


Fig. 5-5. a) Sol-gel encapsulated biochar materials we created; and b) SEM image of porous sol-gel.

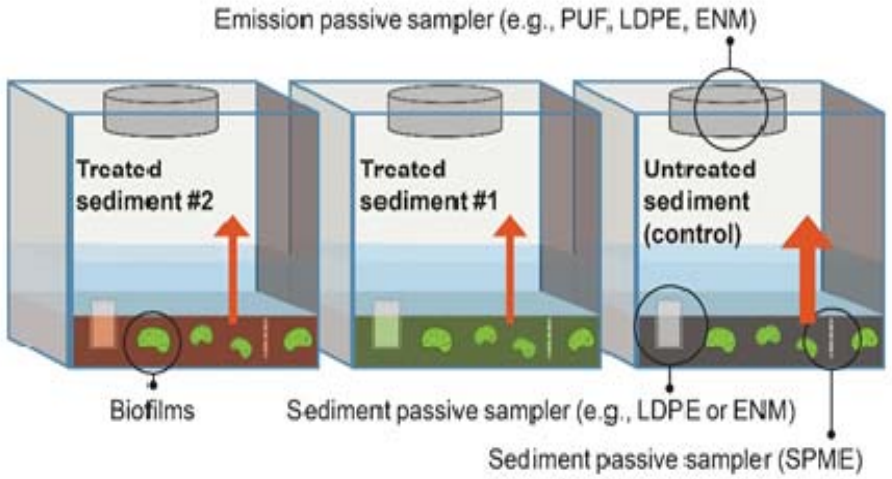
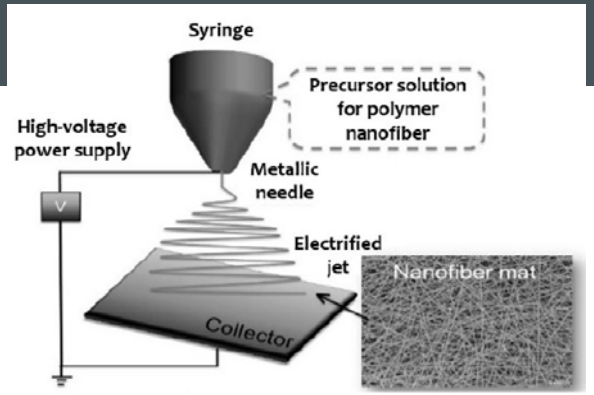
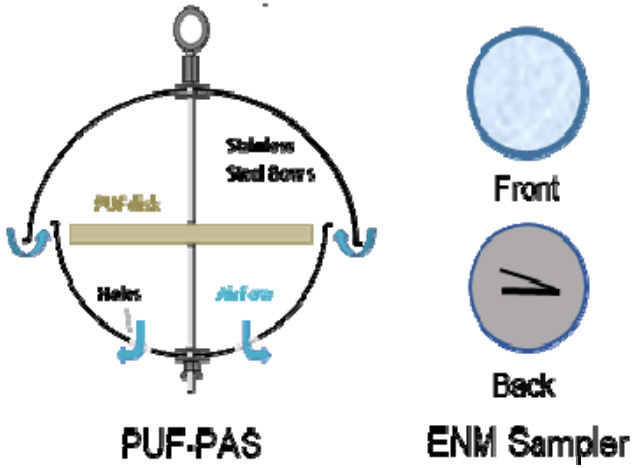


Fig. 5-11. Schematic of our proposed mesocosm experimental design. Arrows illustrate relative amounts of PCB emissions.

PROJECTS 3, 4, AND 5 COLLABORATE ON THE USE OF NOVEL SAMPLING MATERIALS

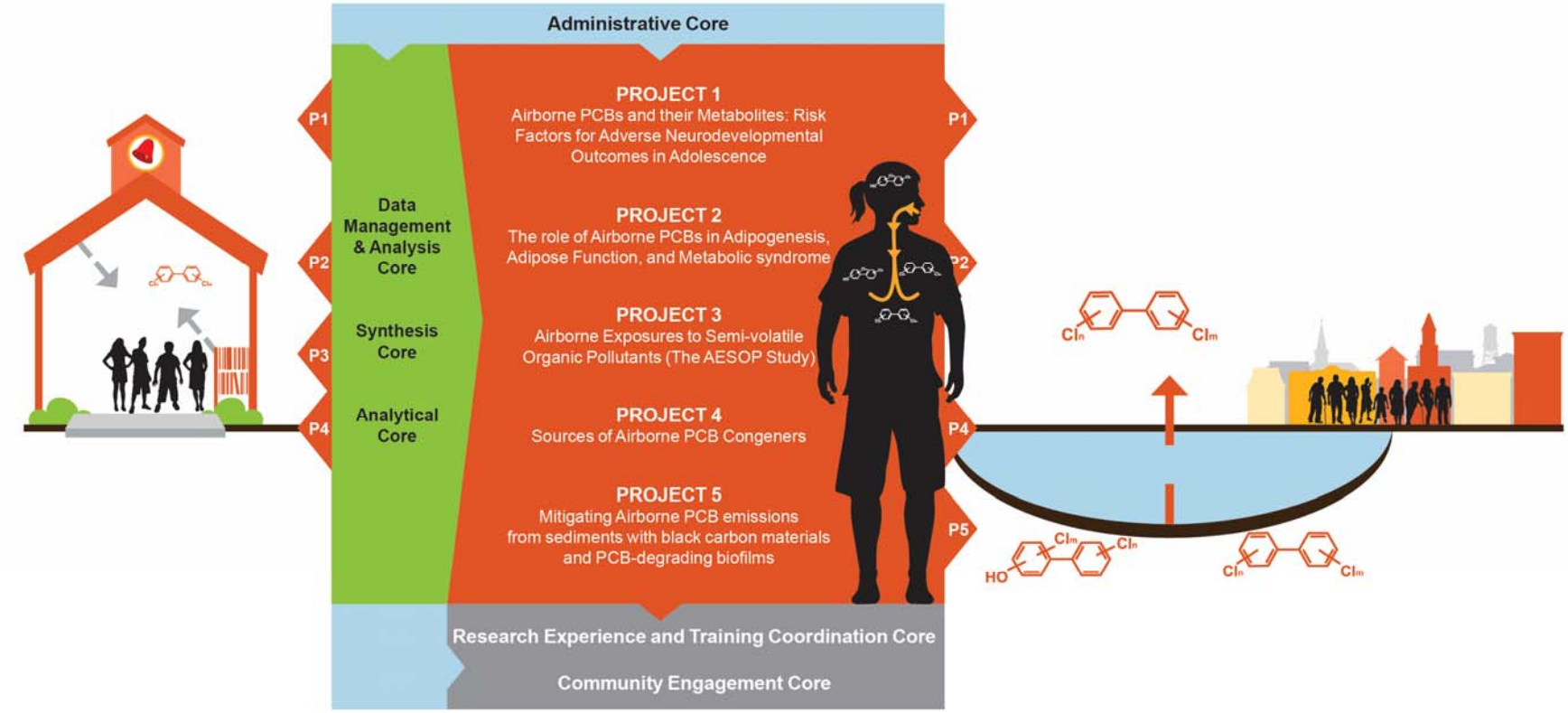
- **Electrospinning Nanofiber Materials** as a passive sampler to capture PCBs in air and water
- Project 3 will use the material to develop **personal integrative samplers** to measure children's exposures





- Project 4 will use the material to capture PCBs and emissions over high temporal and spatial **resolution**
- Project 5 will use the material to measure PCBs in sediment pore waters and **emissions from microcosms**

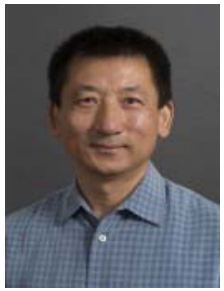
ISRP RESEARCH SUPPORT CORES: PROVIDE THE RESOURCES, MATERIALS, AND INFRASTRUCTURE TO TRANSLATE RESEARCH FROM BENCH TO COMMUNITY



DATA MANAGEMENT AND ANALYSIS: AN INTEGRATING CORE ACROSS ALL CENTER COMPONENTS

1. Data Management for full reproducibility, transparency, and rigor
2. Embedded biostatistical support
3. Develop novel methods
4. Training on data science and informatics to trainees and investigators
5. Provide the integrative data management and analytical foundations for research integration across the ISRP.

IN THIS RENEWAL CYCLE, DMAC WILL INTEGRATE CENTER-WIDE EFFORTS TO QUANTIFY AND COMMUNICATE UNCERTAINTIES IN THE ESTIMATION AND REDUCTION OF PCB EXPOSOMES OF THE U.S. SCHOOL-AGE POPULATION



Kai Wang

Biostatistics

Scott Spak

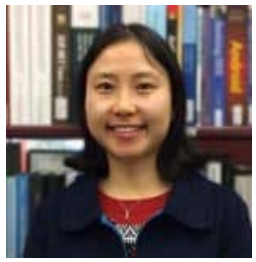
Planning and Public Affairs

Mike Jones

Biostatistics

Brian Westra

University Libraries

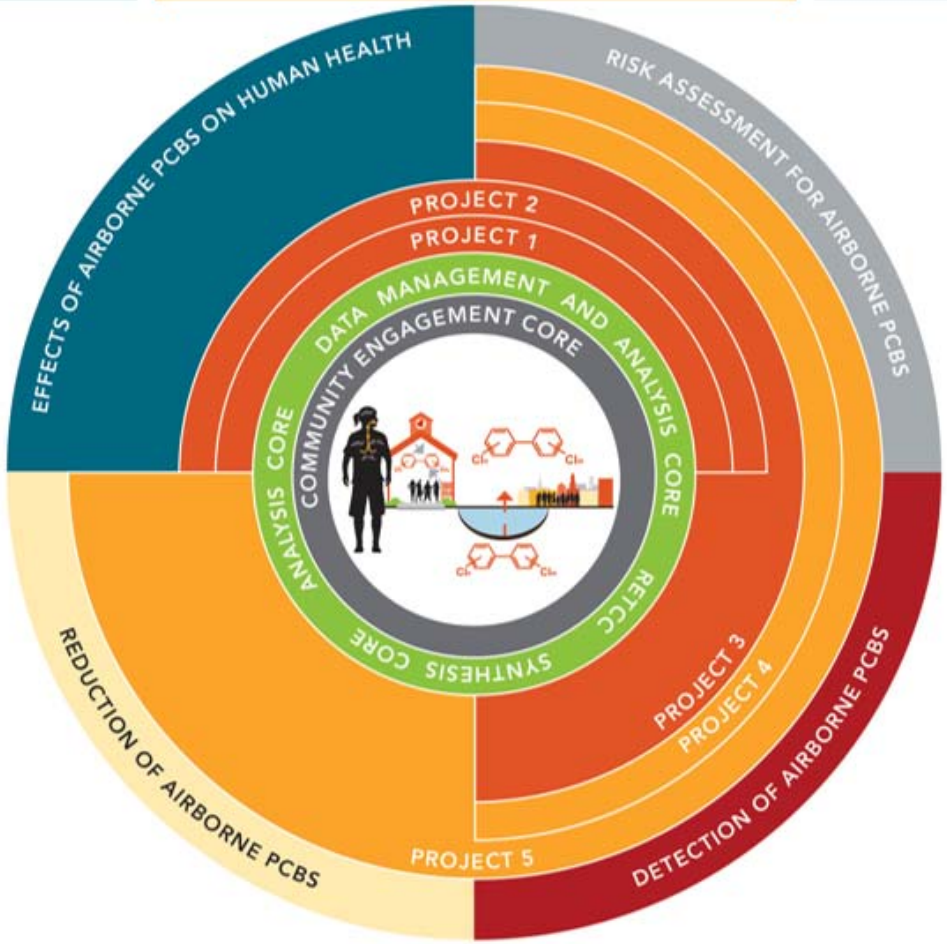


Marina Zhang

University Libraries

SRP Mandates Assessment of the Emerging Concern of Airborne PCBs

Effects
Risk Assessment
Detection
Reduction



Stakeholders and Collaborators

- Columbus Community School District
- East Chicago School District

USEPA Regions (7, 1, 2 & GLNPO)
USEPA ORD
USEPA NCEA/ IRIS
USEPA NERL

U.S. Army Corps of Engineers (USACE)

NIEHS/NIH Grant P42 ES013661

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National Institute of
Environmental Health Sciences
Superfund Research Program

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