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PCBs in School Buildings

Sensible Steps to Healthier School Environments
Webinar Series, February 18, 2014

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Office of Research and Development
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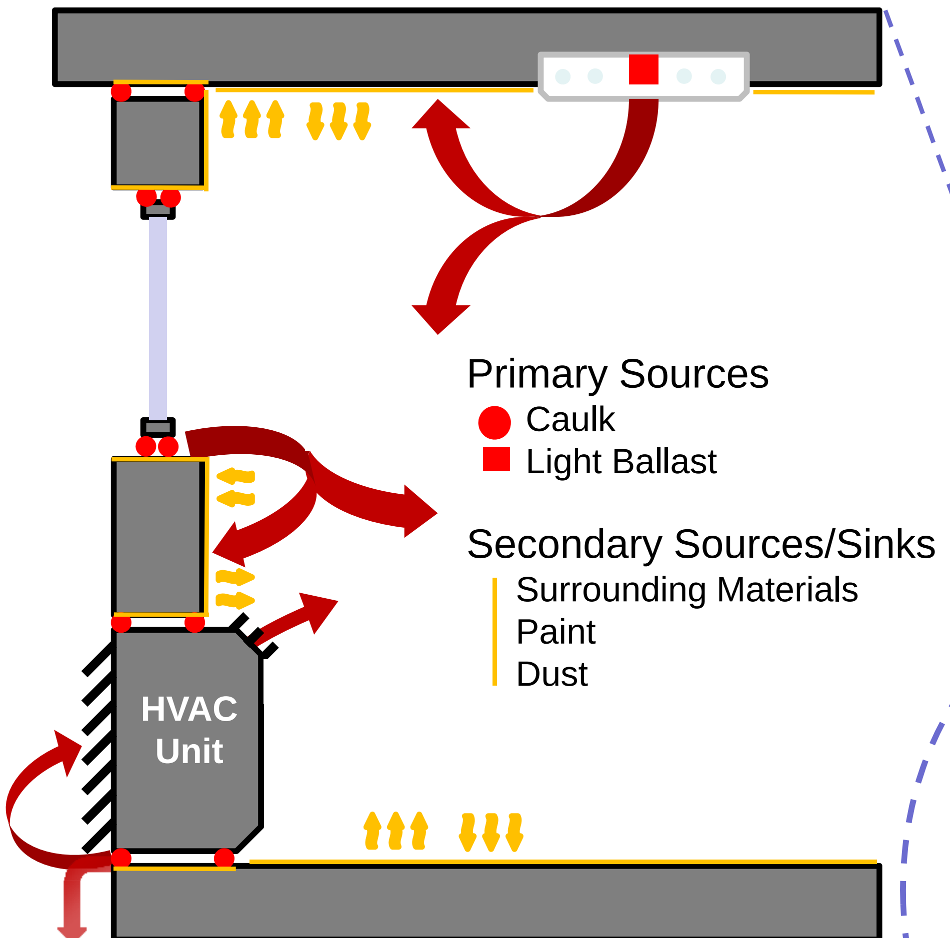
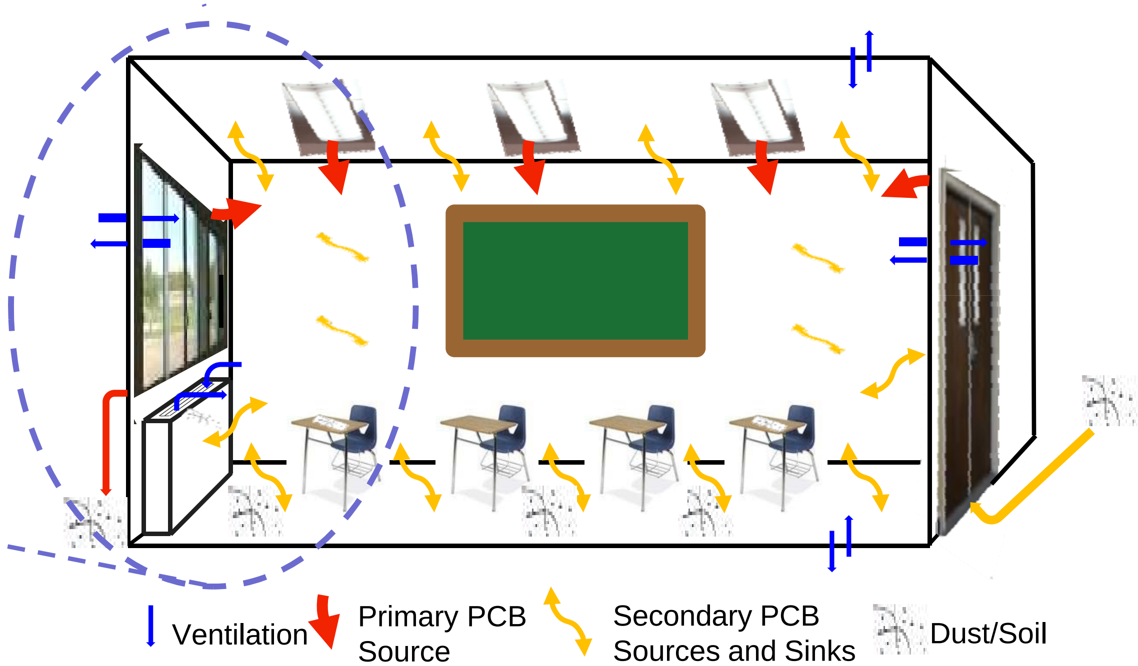
PCBs - A Complex Problem in Buildings

Example Scenario



- Over 100 PCB chemicals
- Multiple primary sources possible
- Transport from sources to air, surfaces, dust, soil
- Secondary sources created
- Exposures through multiple pathways
- Ventilation and temperature effects

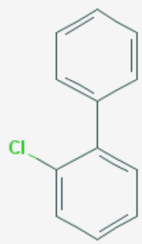


Presentation Topics

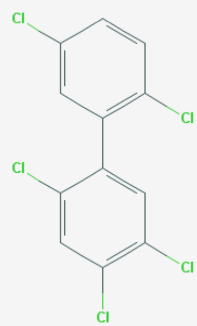
1. About PCBs
2. Sources of PCBs in school buildings
3. Environmental levels of PCBs in schools
4. Potential exposures to PCBs in schools
5. Some outstanding questions

Polychlorinated Biphenyls (PCBs)

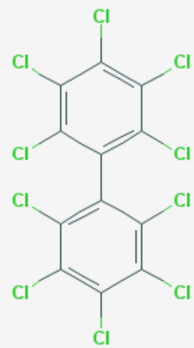
209 possible PCB congeners



PCB 1



PCB 101



PCB 209

Common Aroclors	Chlorine Weight %	Number of Congeners
Aroclor 1221	21%	60+
Aroclor 1232	32%	90+
Aroclor 1016	41%	70+
Aroclor 1242	42%	90+
Aroclor 1248	48%	95+
Aroclor 1254	54%	95+
Aroclor 1260	60%	90+
Aroclor 1262	62%	90+

- PCBs are comprised of many similar semi-volatile organic chemicals called "**congeners**"
- PCBs were manufactured in the U.S. as mixtures of congeners from approx.1929 to 1977
- **"Aroclor"** mixtures had the highest U.S. production

PCB Properties

- Electrical insulation
- Flame-resistance
- Plasticizer
- Chemical stability
- Durability

Useful for many applications

- Persistent in the environment
- Can vaporize and migrate
- Persistent in people
- Toxic effects

Implications for human exposure

PCBs in School Buildings
Possible Uses/Sources

For schools built or renovated from about 1950 to 1978
(potentially >50% of U.S. public school buildings)

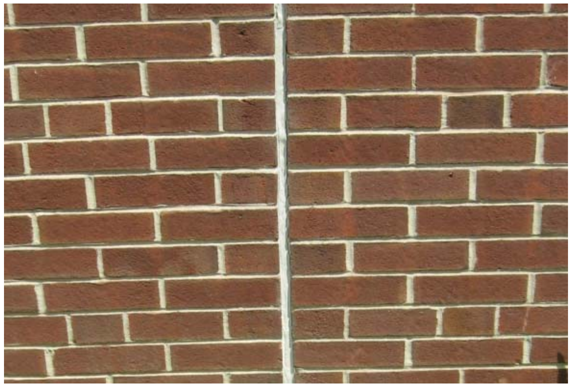
Could be or have been in buildings

- Motor and hydraulic oil
- Electrical device capacitors
- Adhesives and tapes
- Carbonless copy paper
- Paints, coatings and inks
- Floor finish
- Microscope oil

Have been found in schools

- Fluorescent light ballasts
- Caulk
- Window glazing
- Joint sealant
- Ceiling tile coatings
- Spray-on fireproofing material
- Paints *(??)*

PCB Sources – Caulk and Other Sealants



- U.S. Production of Aroclors as a plasticizer ingredient
  - 1958 - 4 million lbs.
  - 1969 - 19 million lbs.
  - 1971 – 0 lbs.
- PCBs were sometimes added to caulk during construction
- Used for
  - Exterior and interior windows and doors
  - Exterior and interior joints
  - Window glazing
  - Other locations/seams (plumbing, casework, etc.)
- Caulk with PCBs > 50 parts per million (ppm) is not an allowed use

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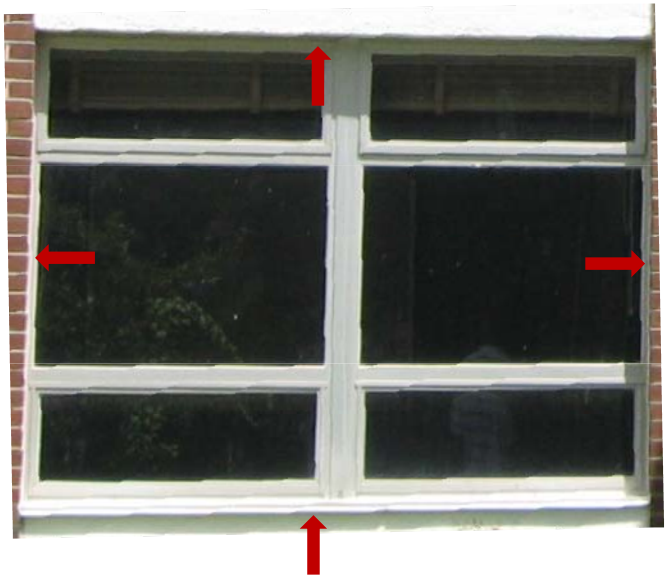
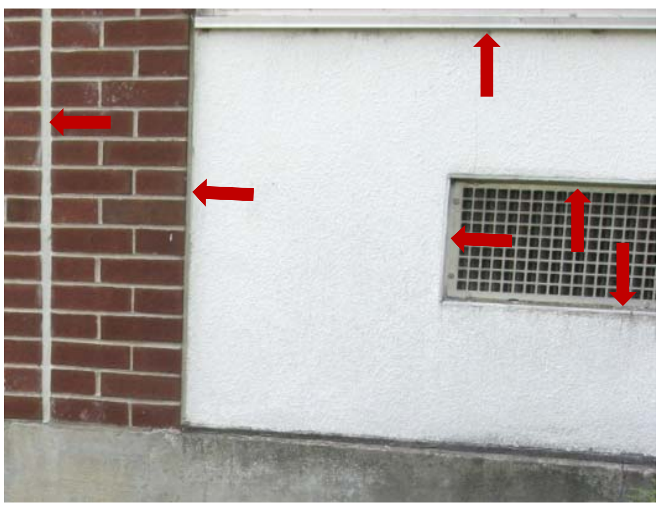
PCB Sources – Caulk and Other Sealants

- In several northeastern schools:
  - 18% of 427 interior caulk/sealant samples >50 ppm PCBs
  - 6% of interior samples >100,000 ppm (10% by weight)
  - 63% of 73 exterior caulk/sealant samples >50 ppm PCBs
  - 34% of exterior samples >100,000 ppm
  - Highest level was 440,000 ppm PCBs (44% by weight)
- We have found that caulk with high PCB levels is usually still flexible and often largely intact
- Visual identification of caulk with PCBs is not reliable

PCB Sources – Caulk and Other Sealants





- PCBs in caulk/sealants move over time into:
  - Adjoining wood, cement, brick
  - Air and dust inside schools
  - Soil near school buildings
  - Other materials/furnishings
- Emissions of PCBs into the air can be quite substantial
  - Emissions can create indoor air levels above recommended concentrations
  - As the temperature increases, emissions increase
  - Ventilation is an important factor
- Although installed 40 – 60 years ago, high PCB levels remain and emissions will continue far into the future
- Other PCB sources, like coatings and paints, will act much like caulk in releasing PCBs into the environment

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PCB Sources – Fluorescent Light Ballasts

- Fluorescent and high intensity light ballast capacitors
  - Prior to 1977 - Many (most?) contained PCBs
  - 1977 – 1978 - Some new ballasts contained PCBs
  - After 1978 - No new ballasts manufactured w PCBs
- Some PCB-containing ballasts remain in place
  - In several northeastern schools, 24% - 95% of the light ballasts likely contained PCBs
- Most PCB-containing ballasts have exceeded their expected lifetimes
- Failure and release of PCBs will continue and may increase

PCB Sources – Fluorescent Light Ballasts

- PCBs are continuously released into the air from intact, functioning light ballasts
  - When lights are off, emissions are low
  - When lights are on, the ballast heats up, and emissions increase several-fold

- PCB ballasts can fail, releasing PCB vapors into the air and liquid PCBs onto surfaces
  - Air levels of PCBs can become quite large
  - Surfaces can be contaminated
  - Significant impact/costs to remediate

- Residues from previously failed ballasts can remain in light fixtures even if the ballast is replaced
  - The impact on PCBs in the school environment has not been determined

PCB Sources – Secondary Sources/Sinks

- PCBs released from primary sources are absorbed into other materials in the school environment over time
- Following removal of primary sources, PCBs in secondary sources may be released into the school environment and result in continuing exposures
- In some cases, secondary sources may need to be considered for additional remedial actions following removal/remediation of primary sources

PCB Sources – Secondary Sources/Sinks

- In several northeastern schools with caulk and fluorescent light ballast PCB sources, 93% of 411 building material samples had measurable levels of PCBs

- Examples of some median and maximum PCB levels in different materials:
  - Paint 39 ppm (max. 720 ppm)
  - Fiberboard 31 ppm (max. 55 ppm)
  - Dust 22 ppm (max. 87 ppm)
  - Varnish 11 ppm (max. 62 ppm)
  - Ceiling tile 7.6 ppm (max. 14 ppm)
  - Laminate 5.4 ppm (max. 200 ppm)
  - Floor tile 4.4 ppm (max. 57 ppm)

- Paint may be an important secondary source due to its high surface area

- Dust is important as a source of ingestion and inhalation exposures

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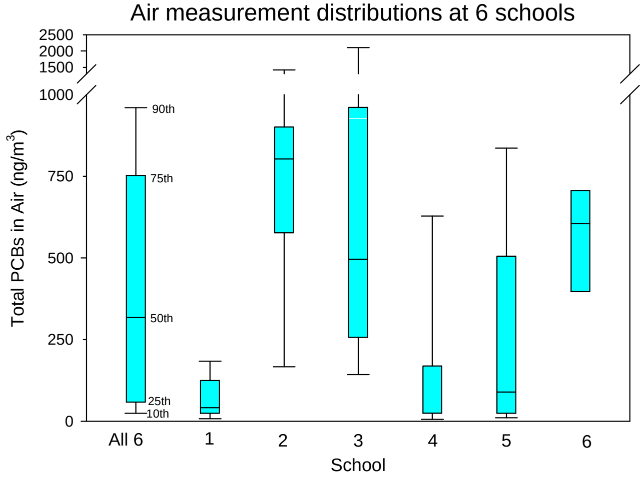
PCB Levels in the School Environment

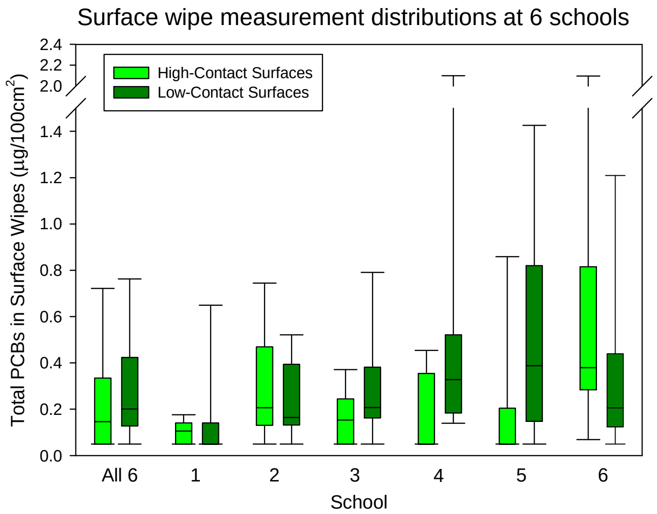
Summary of measurements from six northeastern schools

	Total PCB Levels		
Environmental Medium (units)	Median	75th Percentile	Maximum
Indoor Air (ng/m^3)	**318**	730	**2920**
Indoor Surface Wipes (µg/100cm^2)			
High-contact surfaces (tables/desks)	**0.15**	0.33	**2.8**
Low-contact surfaces (floors/walls)	**0.20**	0.42	**2.3**
Indoor dust at one school (ppm)	**22**	53	**87**
Outdoor Soil (ppm)			
0.5' from building; 0 – 2" soil depth	**<QL**	2.1	**210**
3' from building; 0 – 2" soil depth	**<QL**	0.55	**21**
8' from building; 0 – 2" soil depth	**<QL**	<QL	**5.3**
Outdoor Air (ng/m^3)	**<QL**	<QL	<QL

QL = Quantifiable Limit

PCB Levels in the School Environment





- Indoor Air
  - PCB concentrations in air exceeded EPA-recommended levels in many school rooms
  - There was considerable within- and between-school variability in indoor air concentrations
  - Indoor air levels were much higher than outdoor levels
- Surface Wipes
  - Most surface wipes were less than 1 µg/100cm^2
  - There was considerable within- and between school variability in surface wipe levels
  - There was a significant correlation between air concentrations and high-contact surface wipe levels
- Soil
  - Soil concentrations varied greatly between schools
  - In general, decreasing levels with increasing distance from buildings
  - Some levels were greater than 1 ppm

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Exposures to PCBs in the School Environment

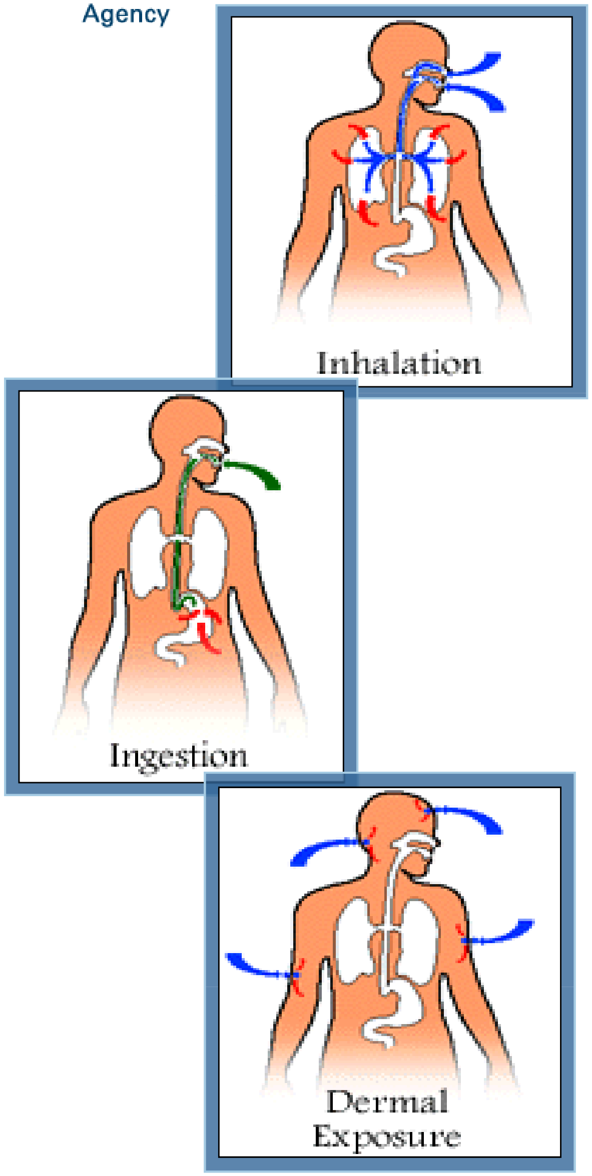


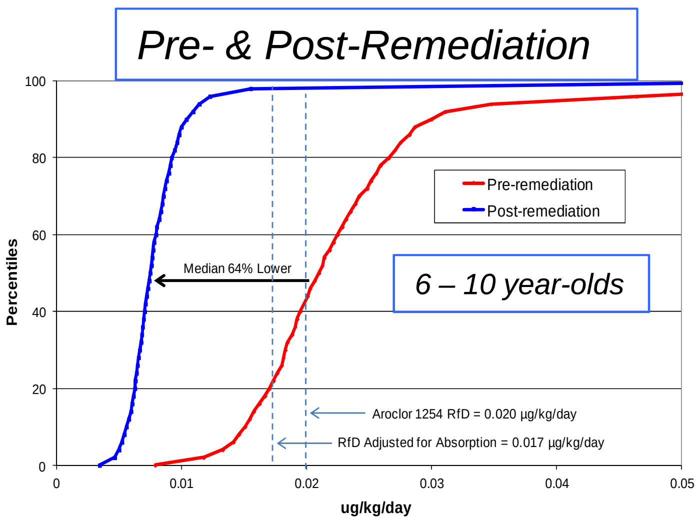
Figure from 2009 NIEHS L. Birnbaum presentation

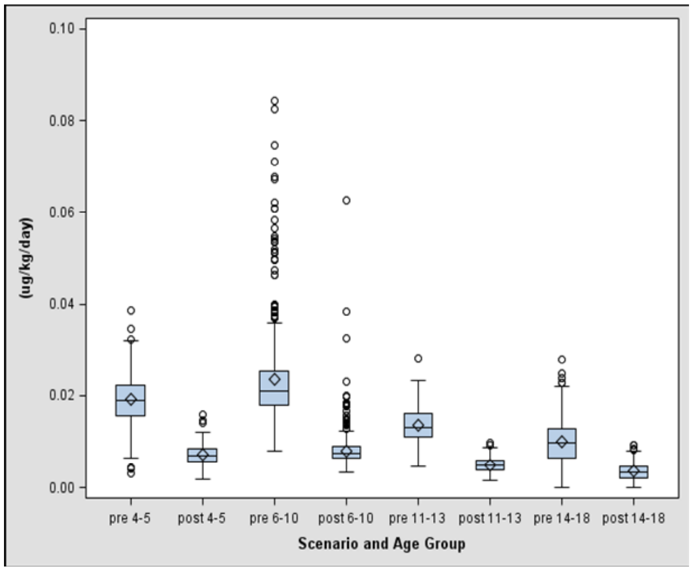
- Occupants in schools with interior PCB sources will be exposed to PCBs in the indoor air, dust, and on surfaces through their normal activities

- In school buildings with exterior PCB sources, exposures may occur through contact with contaminated soil

- Exposures will occur through inhalation, ingestion, and dermal contact

Exposures to PCBs in the School Environment





- An exposure model was used to estimate what exposures children might experience, using levels measured across several northeastern schools.
  - Many children would be predicted to receive exposures above the EPA IRIS Reference Dose for Aroclor 1254
  - With PCB levels measured following remediation efforts at several schools, most children would be predicted to receive exposures below the RfD
  - For the environmental levels found in these schools, >70% of the exposure would be predicted to result from inhalation of PCBs in the school air
  - Dust ingestion may also be an important route of exposure in some situations
  - *These exposure estimates do not include PCB exposures from diet or other sources away from school*
  - *There is considerable uncertainty in these modeled estimates of exposure*

Figures from 2009 NIEHS L. Birnbaum presentation

Outstanding Questions

- Do schools nationwide, built or renovated from about 1950 through 1978, have similar sources and environmental levels of PCBs?
- Are there other types of PCB sources that have not been identified?
- Do fluorescent light ballasts lead to higher levels of PCBs in schools than PCB-containing caulk ?
- Are exposure models accurately predicting occupant exposures to PCBs in school buildings?
- What is the best approach for determining if PCBs present a problem in school buildings?

Figures from 2009 NIEHS L. Birnbaum presentation