

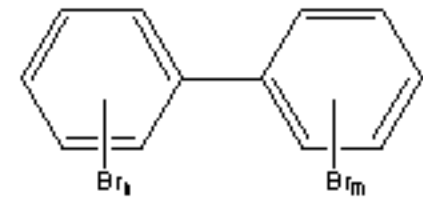
Introduction to Human Exposure and Epidemiology of Flame Retardants

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**Green Science Policy Institute
Fire Retardant Dilemma:
12 February 2010**

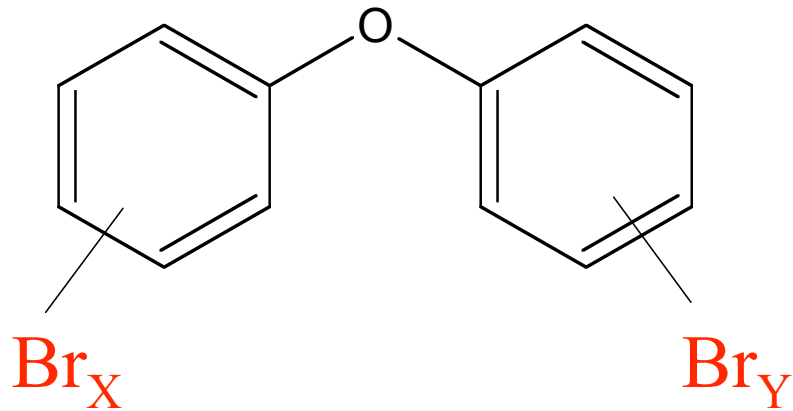
Michigan 1973-4



$$n+m = 5-7$$

**Polybrominated Biphenyls (PBBs)
Flame Retardant ("Firemaster")**

PBDEs: Polybrominated diphenyl ethers



- **209 possible congeners**
- **structurally related to PCBs & PBBs...**
- **persistent, bioaccumulative, toxic**

Use of PBDEs as fire retardants

penta **furniture (polyurethane foam)**



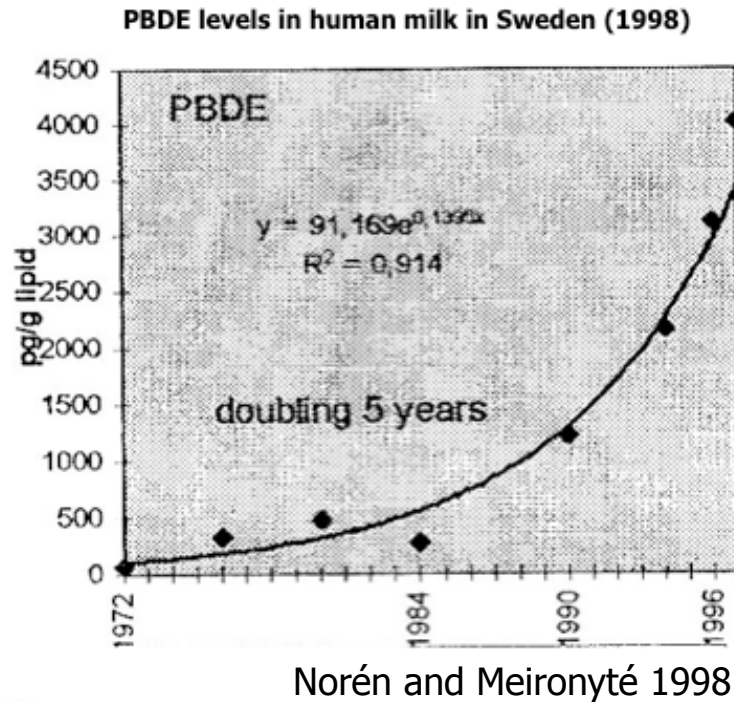
octa **electrical hard plastic**

deca **TV/computer plastic,
textiles (carpets, draperies)**

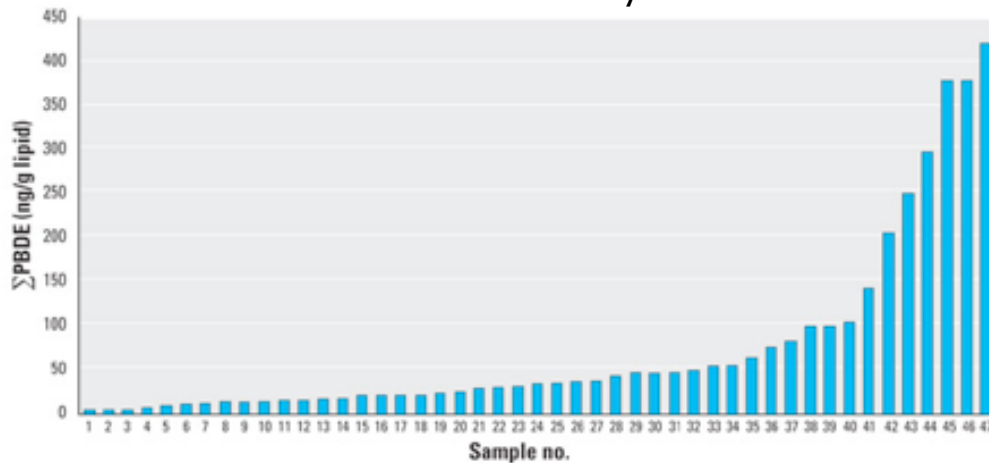


- **up to 10-20 % by weight**
- ***not* chemically bound to the plastic**
- **penta and octa added to Stockholm Convention 2009**
No longer manufactured but still present: lbs/home?
also recycled foam
- **agreement to phase-out deca manufacture**

Biomarker of exposure: PBDEs in breast milk & serum



Rising trend when first found

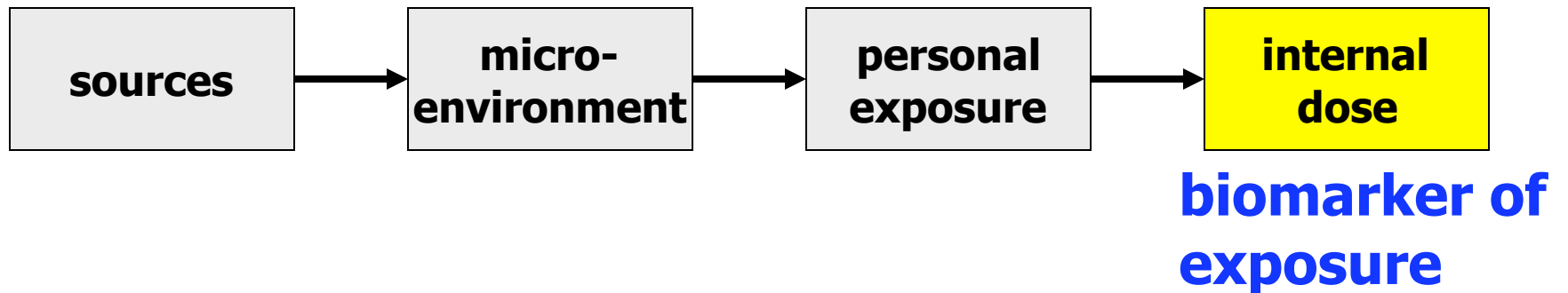


- * **Great variation between people**
- * **Highest in N. America, largest use of Penta**

Figure 2. PBDE concentrations in individual U.S. human milk samples from 2002 (ng/g lipid).

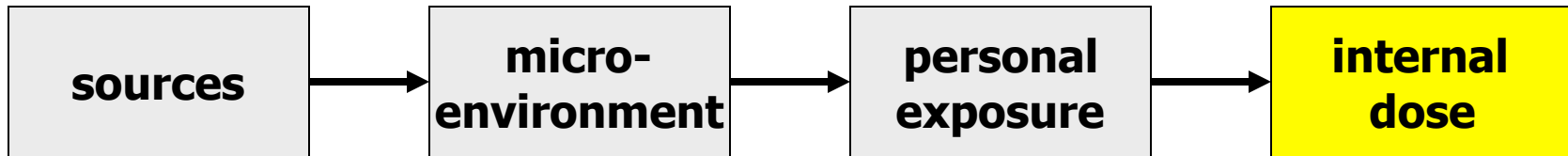
Schechter et al (2003)

How are people exposed?



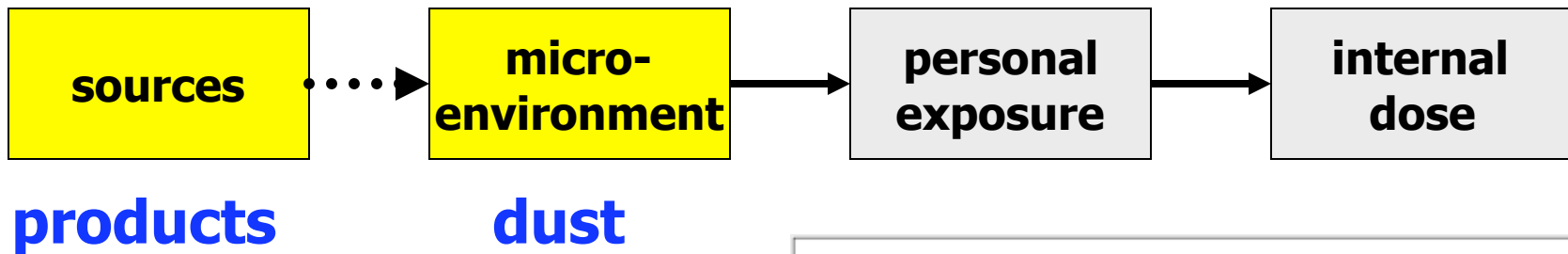
Goal: Understand how people are exposed to PBDEs along complete pathway *from product to person*

**focus on our research
North America, non-occupational**

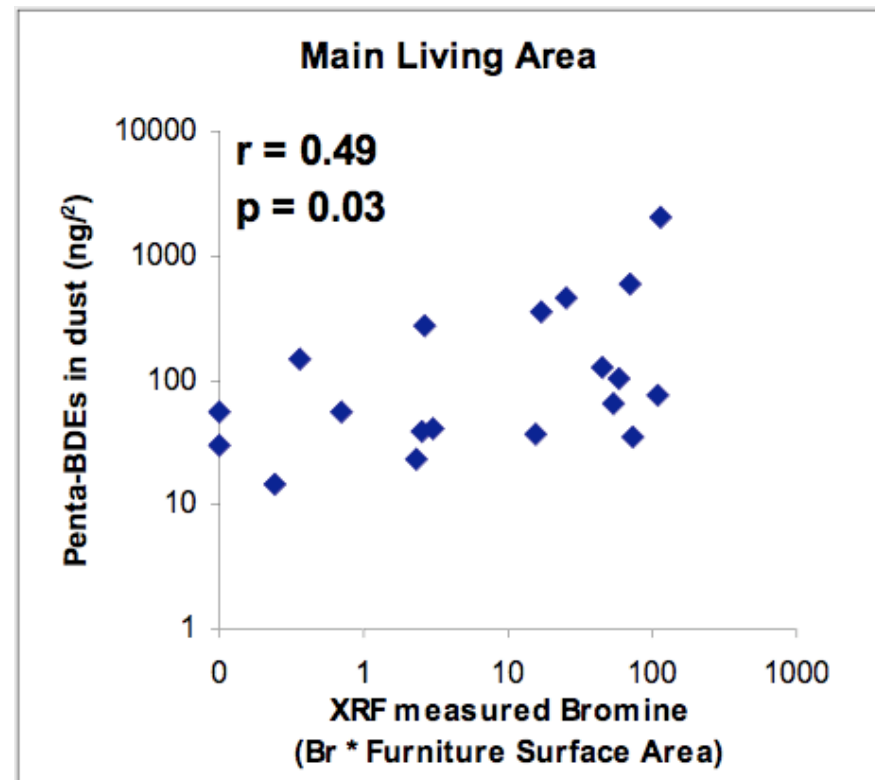


- **Exposure factor approach:**
e.g., **media concentration** X **exposure factor**
representative? **how well known?**
- **Empirical (epidemiologic) studies linking boxes:**
e.g., **association of dust concentrations & body burden**

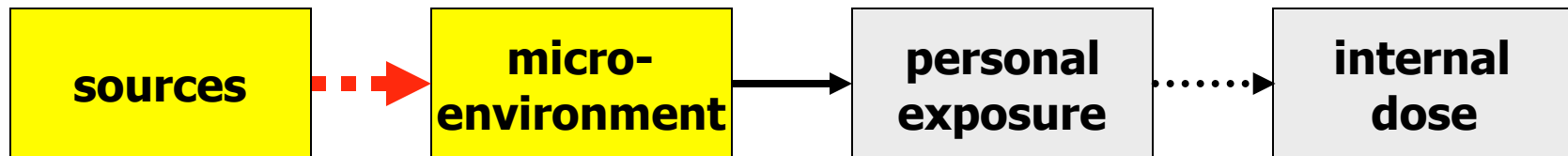
PBDEs in dust are associated with products



Dust concentrations don't correlate with # products, but with Br via XRF, a surrogate for PBDEs (BFRs) in products.

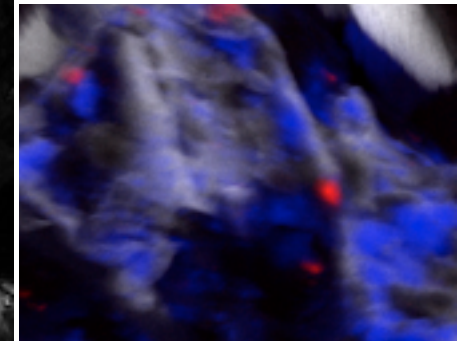
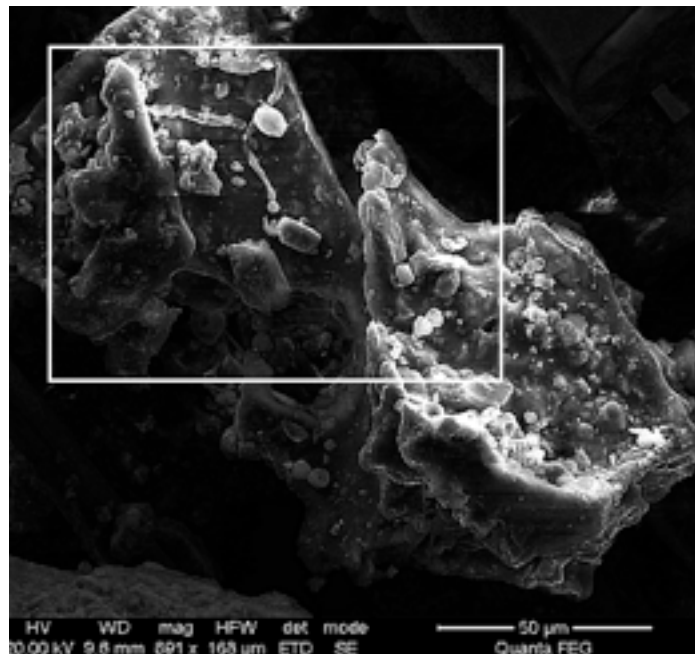


PBDEs are likely getting out of products via both volatilization & weathering of plastics



* penta via volatilization: limited chamber experiments

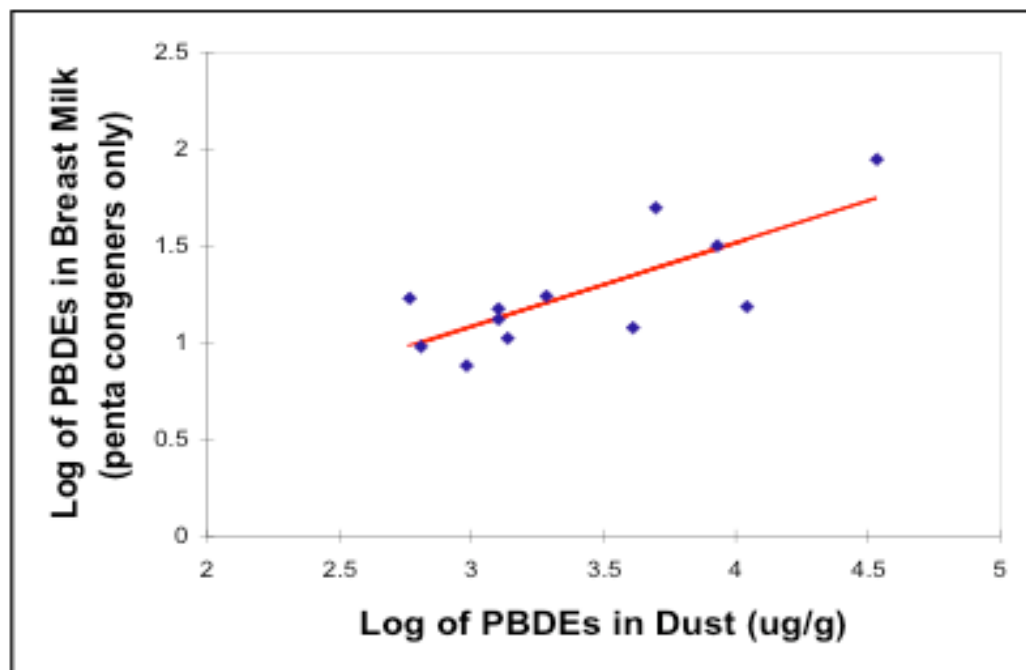
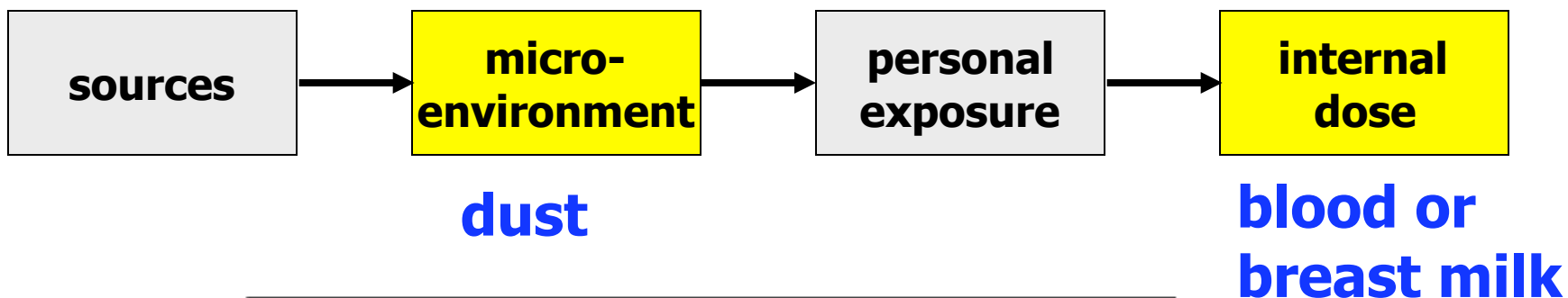
* deca via weathering:
initial work with
scanning electron
microscopy



C
Br
Ca

CaCO₃=plastic additive

Dust is an important source of exposure

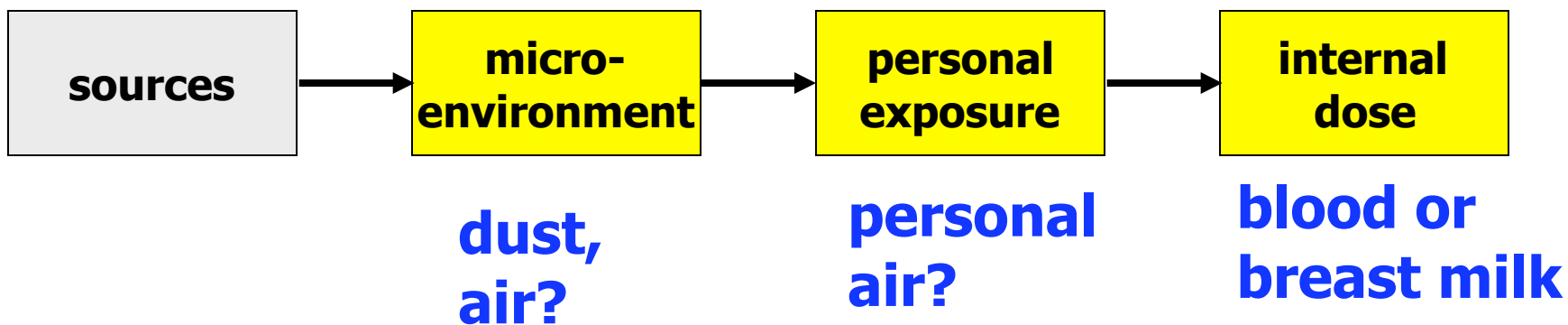


R = 0.76
p = 0.006

Wu et al *ES&T* 2007

Recently replicated in Denmark

Dust exposure > inhalation (in homes)

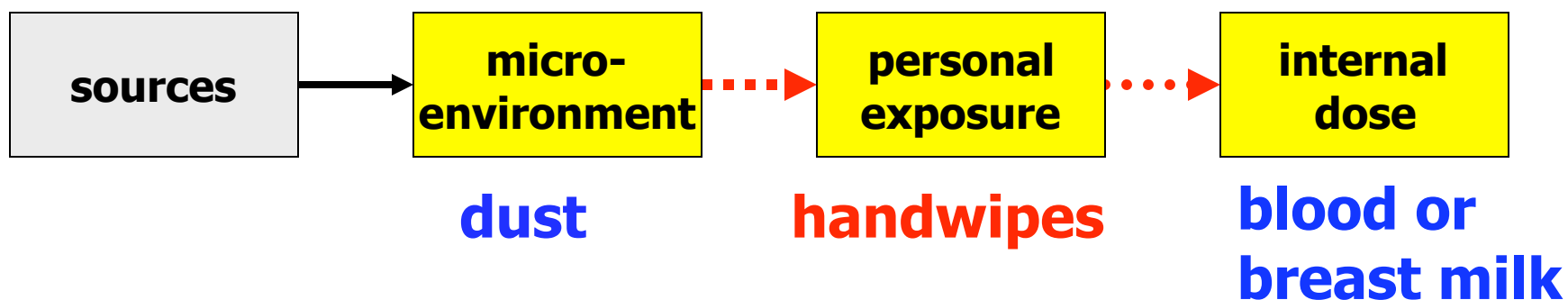


- Inhalation appears minor except occupational?
- Personal air > room air

"personal cloud"



Dust exposure: Hand-to-mouth, dermal?

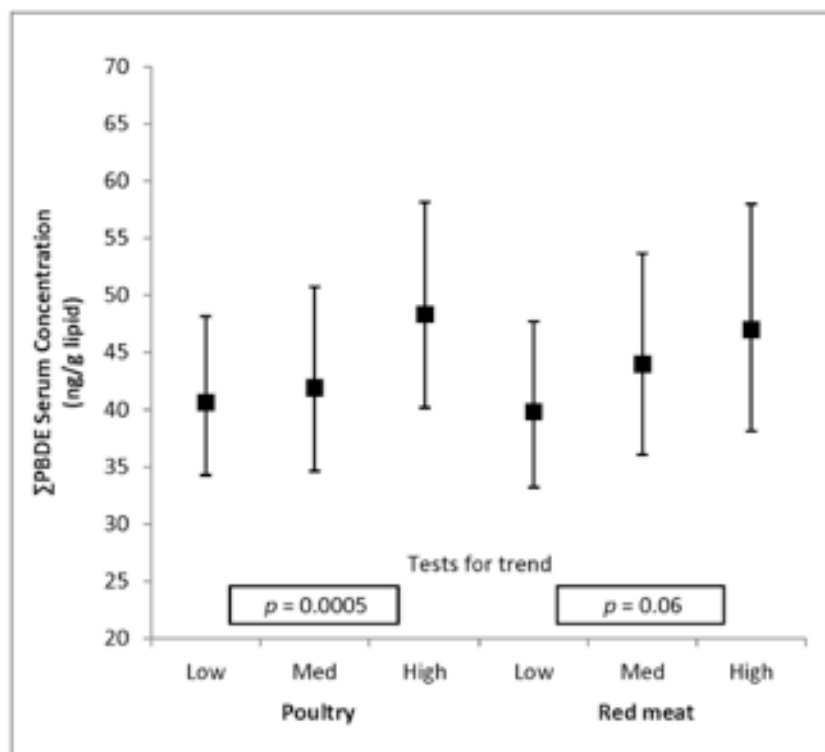
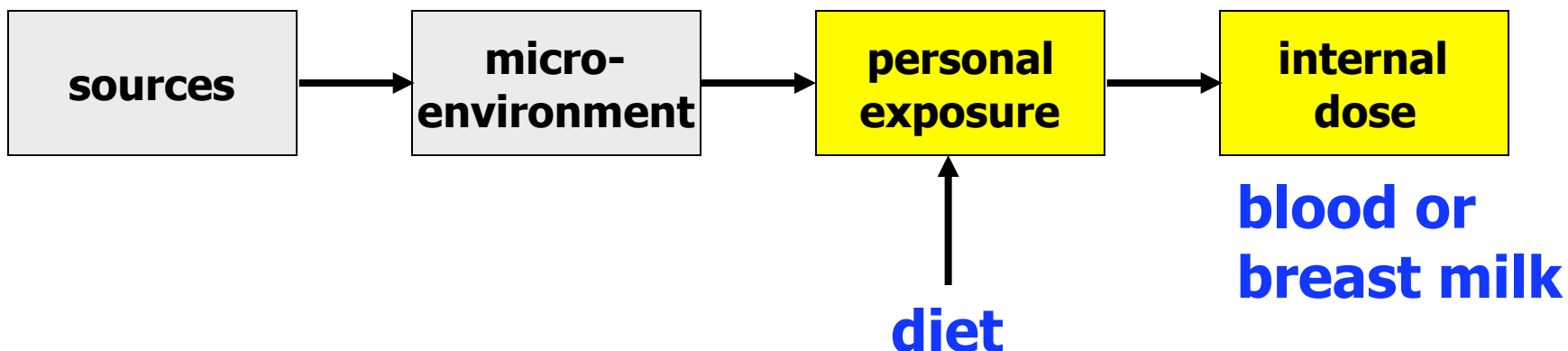


N=33	PBDE
detected	100%
median	129 ng
range	3-1982 ng

Stapleton et al *ES&T* 2008

- **Can measure PBDEs on hands**
- **Next steps: Link handwipes to dust & biomarker**
(see BFR 2010)

Diet is also an important route of exposure

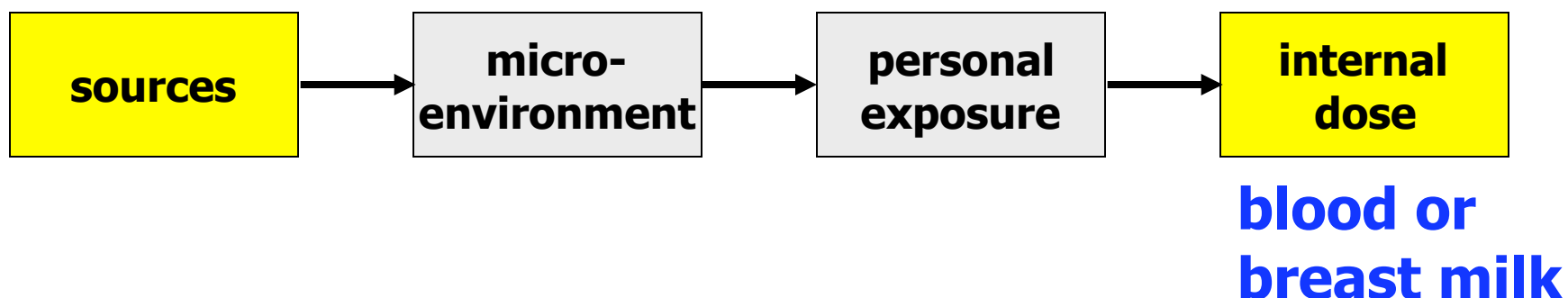


Penta in serum associated with meat consumption in general US population

Dairy, fish: weaker

Fraser et al *EHP* 2009;
Wu et al *ES&T* 2007

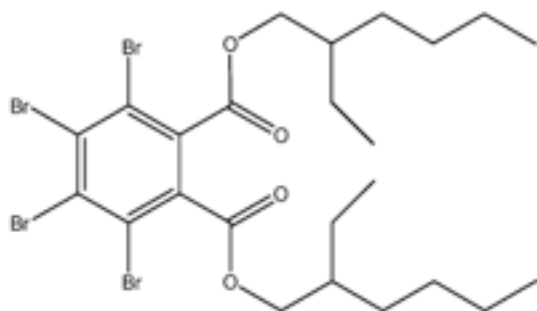
PBDE exposure and fire regulations



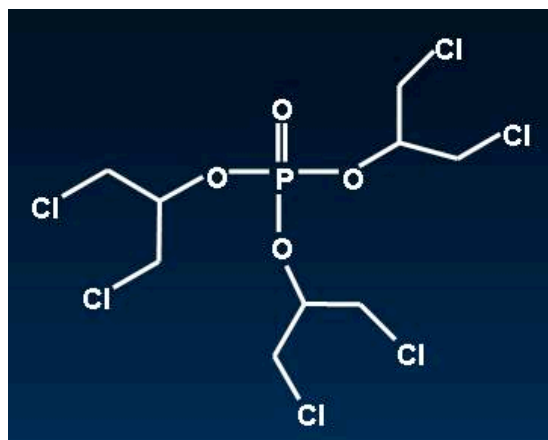
Penta exposure higher where furniture FR regs stricter?

- **Penta in serum higher in CA (Zota et al 2008)
not control for diet.**
- **Some evidence that CA house dust levels are elevated.**
- **Penta in breast milk higher in Northwest than MA, not explained by diet; spillover of CA market?**

Replacements for PentaBDE: now found in dust



Firemaster 550
found via unknown peaks on
chromatogram; "trade secret"
TBPH + other



Tris (1,3-dichloro-2-propyl) phosphate
"chlorinated tris", TDCPP
used in children's sleepware in 1970s

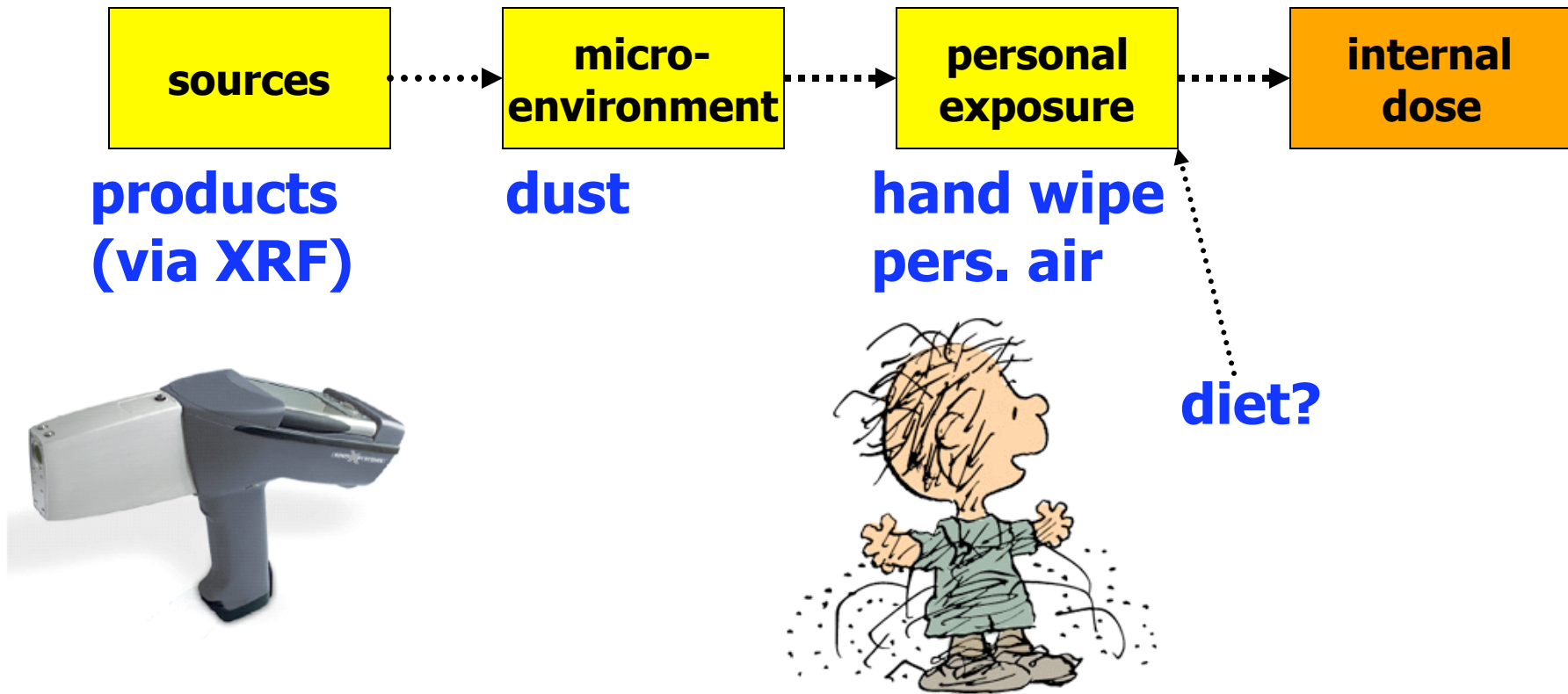
Replacements for decaBDE also found in dust

Penta: levels in dust related to products exposure via diet and indoor environment (dust)



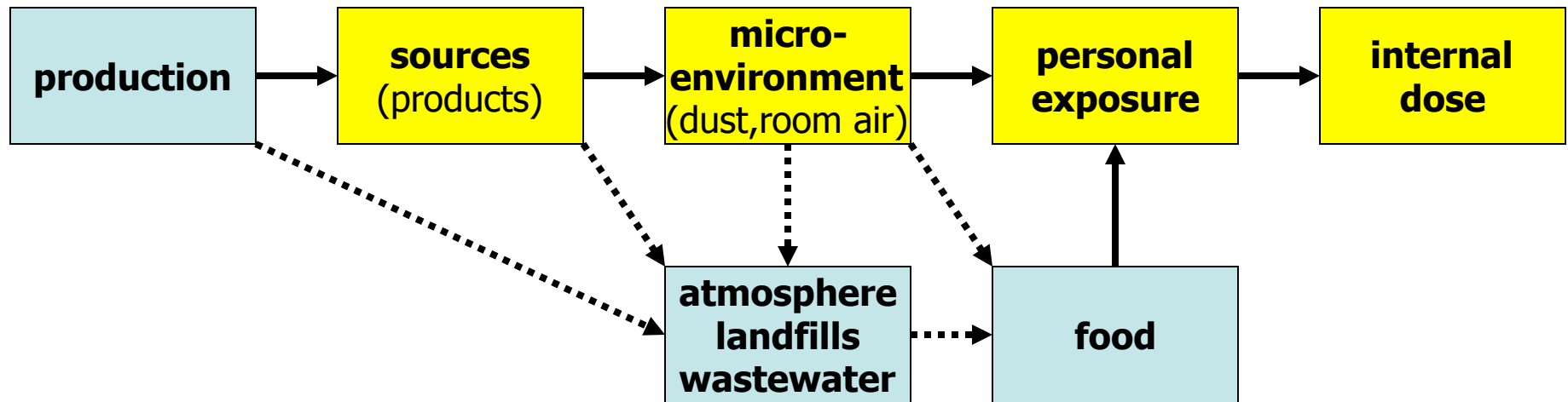
Need to better understand personal exposure to dust
Dust ingestion vs. dermal (& air to dermal)
Dust vs. diet: relative importance
Replicate in other groups
Geographical differences

Deca: less well understood

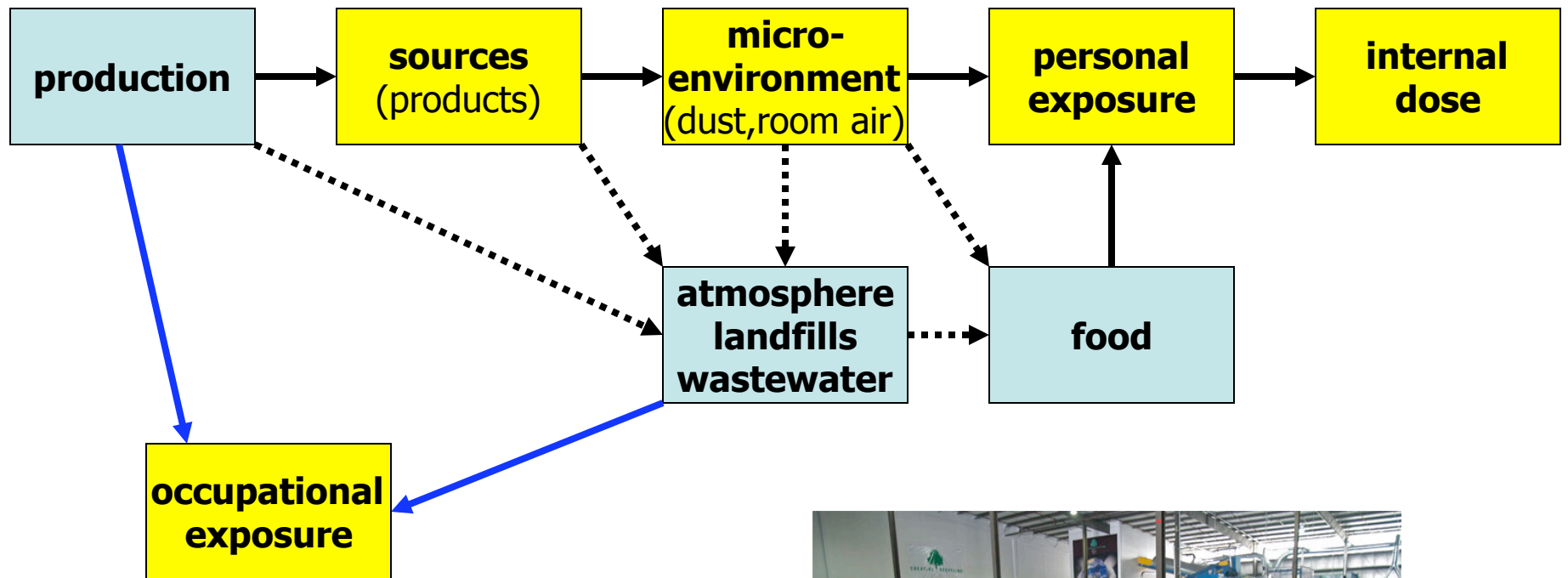


- Dust a likely route of exposure, not yet tied to body burden

Bigger picture



- **Main pathways of food contamination?**
- **Urban environment as source to wider environment**
- **Dietary exposure relatively more important as items containing PBDEs discarded?**



Occupational exposure!
 production
 disposal
 use (office, airlines)
 fire fighters



E-waste: Major problem



PBDD, PBDF

PBDE Toxicology

(selected, mostly rats & mice, by congener)

endocrine disruption

thyroid

anti-androgen (OH-metabolites?)

estrogen & anti-estrogen

developmental neurotoxicology

reproductive effects

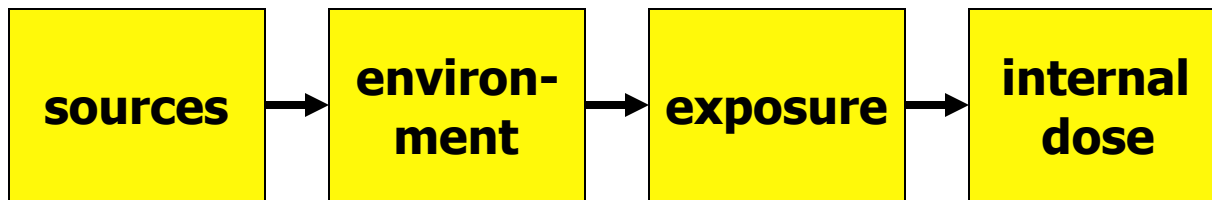
ovarian changes

decreased sperm, epididymis weight

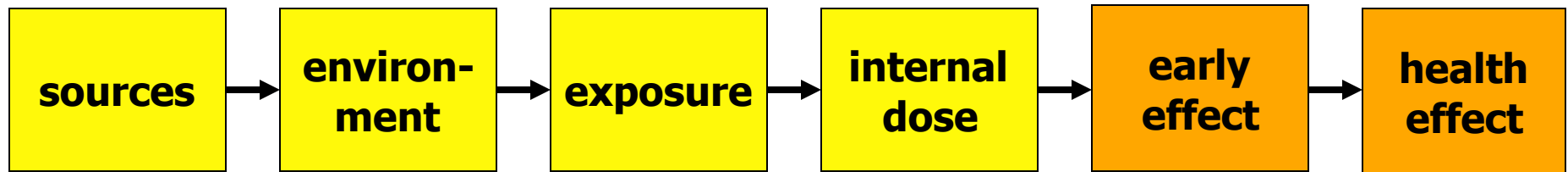
delayed puberty

Some effects seen at levels not that different from those found in some people.

“Source to Exposure”

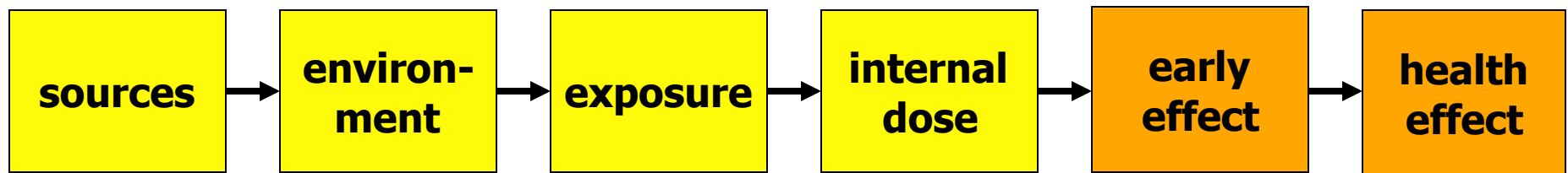


“Exposure Disease Continuum”



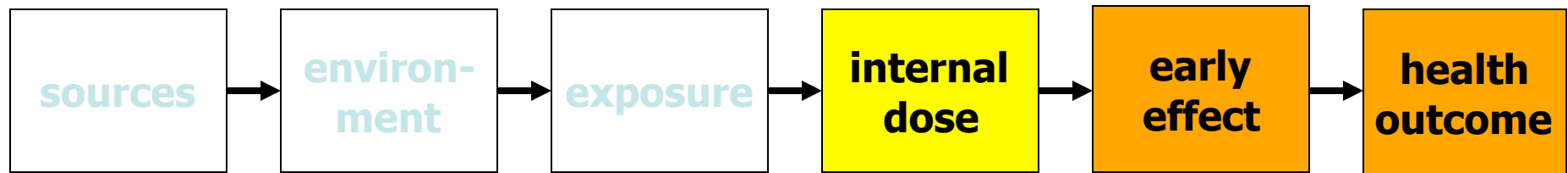
$$\text{Health effect} = f(\text{Exposure})$$

- **exposure assessment is often one of the most difficult aspects of environmental/ occupational epidemiology**
 - important to get the epidemiology right
 - important for intervention



Effect = f (Exposure)

Use of biomarker as exposure measure, e.g., serum PBDEs



Health outcome = f (biomarker of exposure)

**Often a superior measure of exposure, but
some caution needed, e.g. timing of exposure**

Growing health-related PBDE research on humans:

- **adult thyroid (Hagmar et al 2001)**
- **birth weight, thyroid (Mazdai et al 2003)**
- **testicular cancer (Hardell et al 2005)**
- **decreased birthweight (Chao et al 2007)**
- **cryptorchidism (Main et al 2007)**
- **sperm, adult males (Akutsu et al 2008)**
- **infant thyroid (Herbstmann et al 2008)**
- **thyroid, adult males (Turyk et al 2008)**
- **hormones, adult males (Meeker et al 2009)**
- **developmental neurotox, etc. (Roze et al 2009)**
- **birth outcomes (Wu et al 2009)**
- **developmental neurotox (Herbstman et al 2010)**
- **fecundity, menstrual cycles (Harley et al 2010)**

No time today to analyze/critique, only to give a flavor for what has been done.

None of these epi studies perfect yet (rarely are), but the field is rapidly maturing with larger, well-conducted studies.

(Partially) consistent with each other & animal toxicology

PBDEs appear to be associated with health effects in the general population of the USA and maybe other places.

Need to continue study, but need to reduce exposure.

Epidemiology of TDCPP (chlorinated tris)

Retrospective occupational cohort (TDCPP production) vs. US population

Lung cancer elevated, but...

Unpublished (Stauffer Chemicals, cited in NRC 2000, IPCD 1998)

Meeker & Stapleton (2009)

USA, n=50

TDCPP & TPP in dust

hormonal effects, sperm

What are we going to do with the huge reservoir of PBDEs that are in people's homes and offices?

Landfilling is probably not a good option & incineration is probably not good either.

Stockholm Convention & its loophole

What about the e-waste problem?

How safe are alternatives? How effective are they at reducing morbidity and mortality?

Acknowledgements:



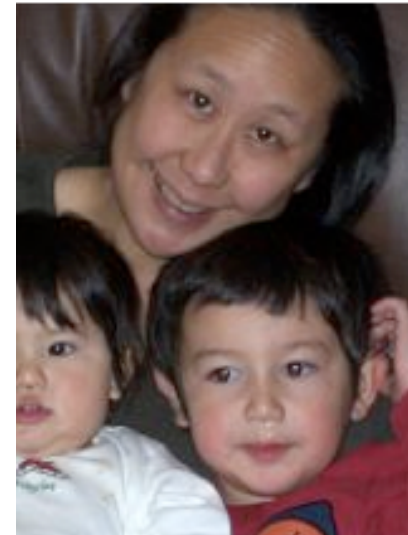
**Mike
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**Heather
Stapleton**



**Joe
Allen**



**Nerissa
Wu**



**Deb Watkins
Alicia Fraser**

**Courtney Walker
Stephanie Chan
Colleen Makey**

study participants

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U), Arlene Blum (GSPI), John Meeker (U. Michigan)**



<http://www.cireeh.org/pmwiki.php/Main/ExposureToPBDEs>

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