The Fate of PBDEs in the (Indoor) Environment

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SCHOOL OF PUBLIC HEALTH

Fire Retardants & their Potential Impact on Fire Fighter Health

NIST

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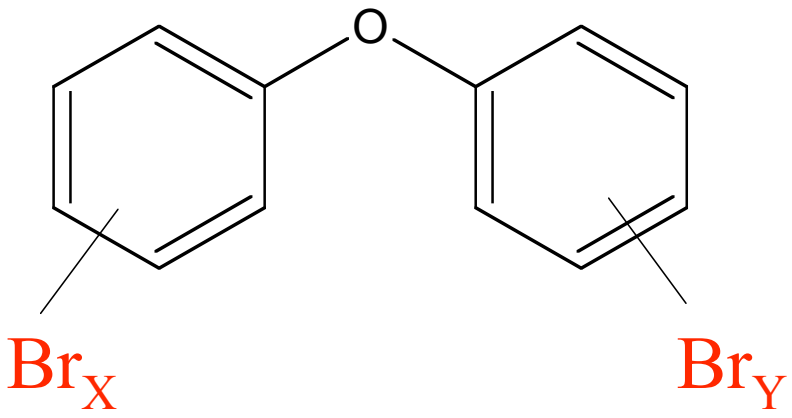
PBDEs: Polybrominated diphenyl ethers



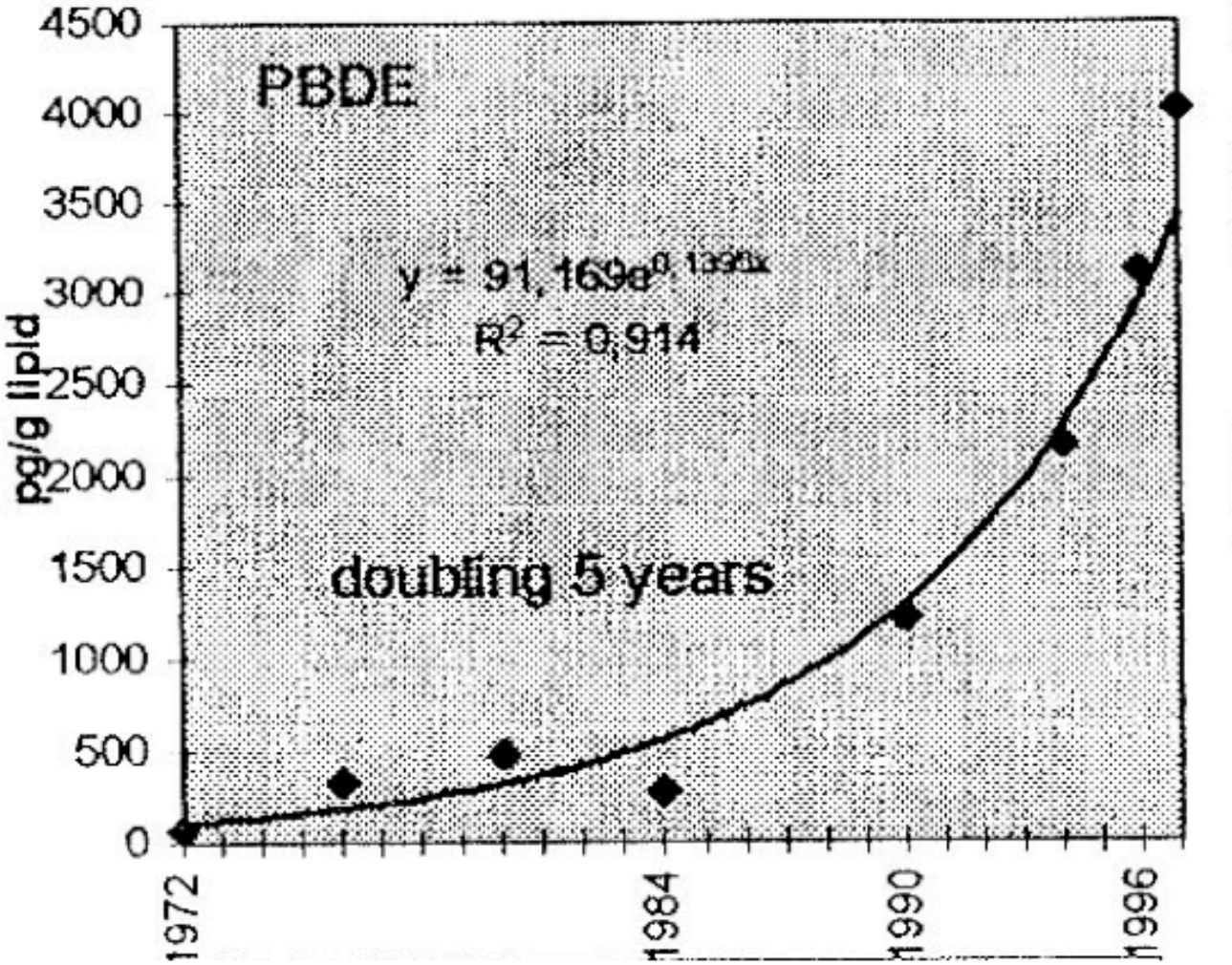
- **209 possible congeners**
- **structurally related to PCBs & PBBs…**
- **persistent, bioaccumulative, toxic**

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?**

PBDE levels in human milk in Sweden (1998)



Norén and Meironyté 1998

U.S./Canadian human levels > 10 times higher than Europe & increased since 1970s

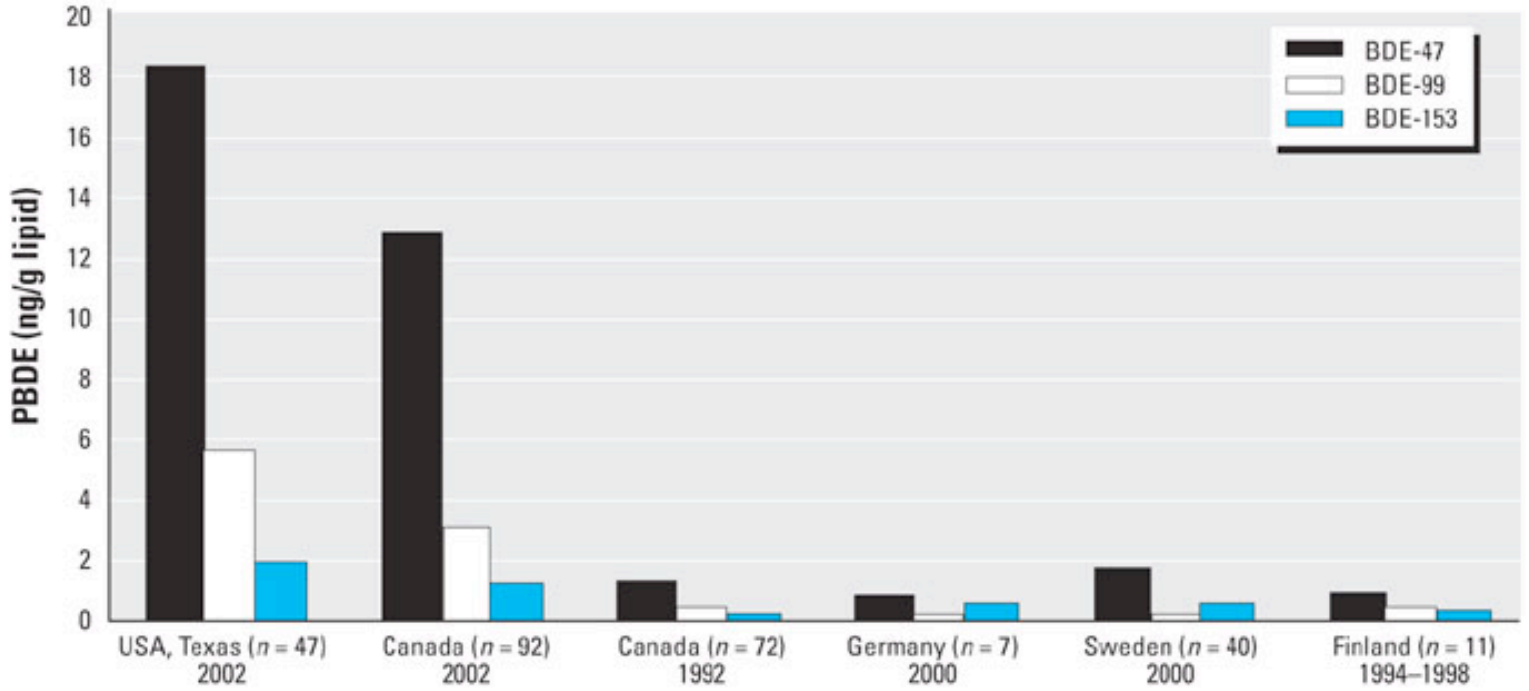


Figure 3. Median concentrations (ng/g lipid) of BDE-47, BDE-99, and BDE-153 in human milk from different countries. Data from Ryan et al. (2002) and Ryan and Patry (2001) for Canada, from Schroeter-Kermani et al. (2000) for Germany, from Noren and Merionyte (2000) for Sweden, and from Strandman et al. (2000) for Finland.

Schecter et al (2003)

Much higher North American use of penta

PBDE levels vary considerably in populations

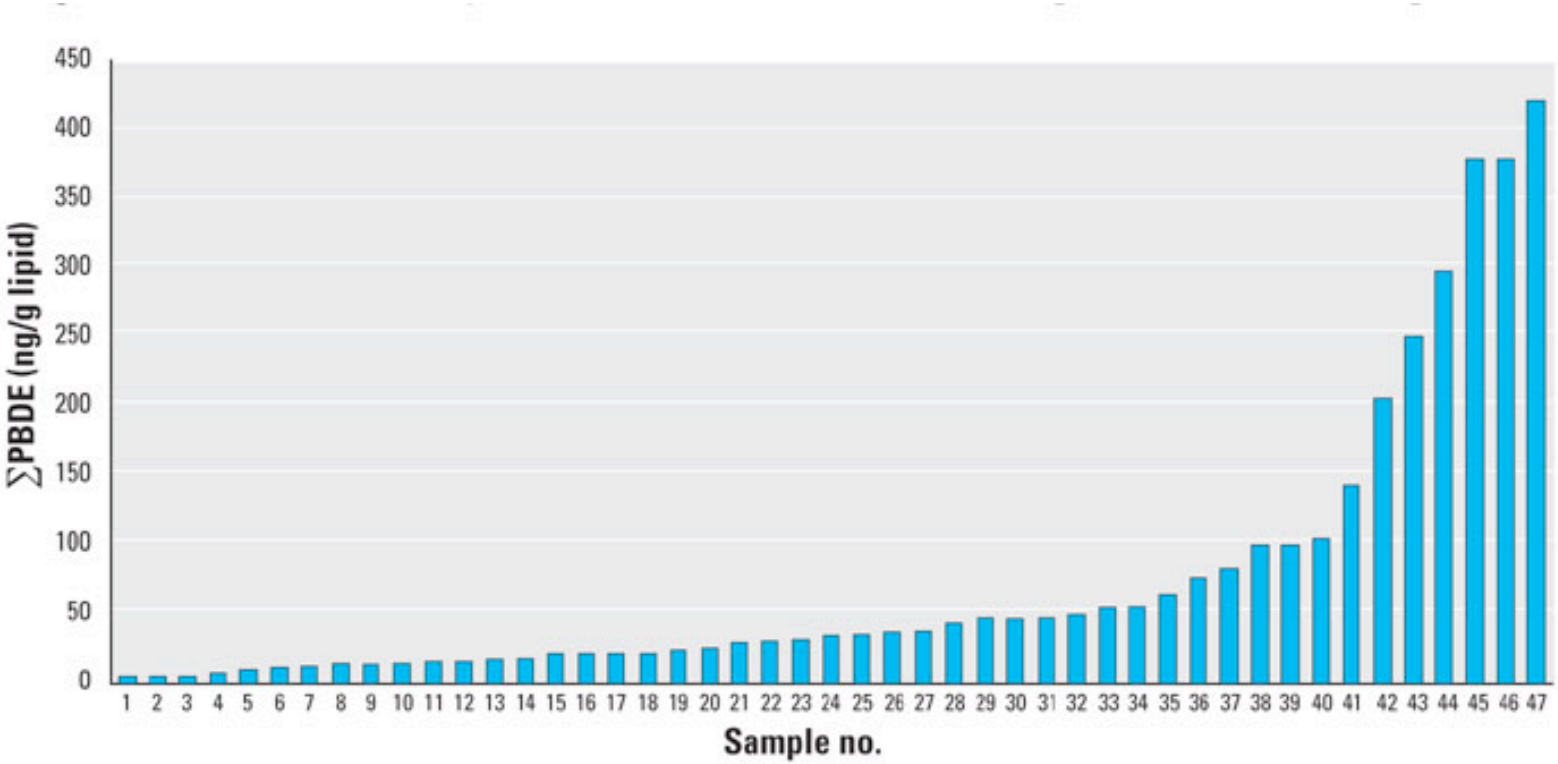
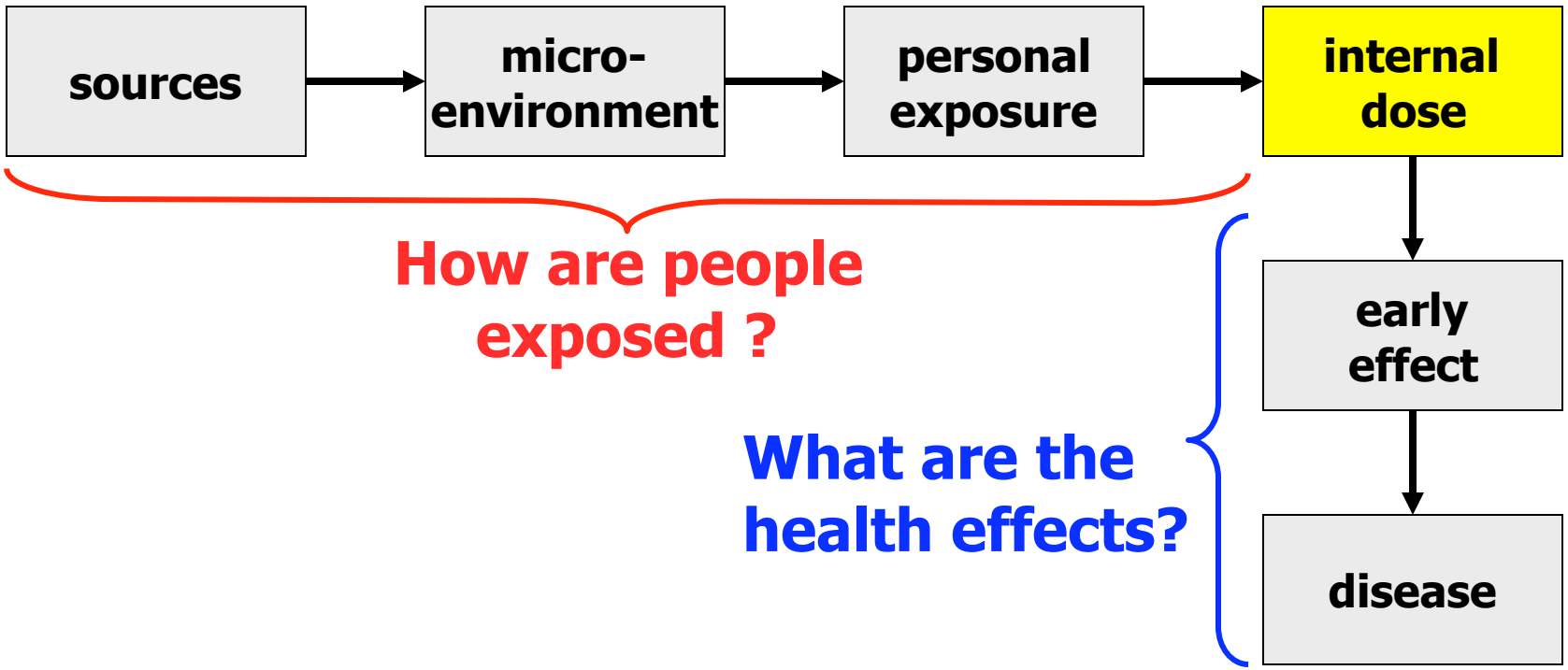


Figure 2. PBDE concentrations in individual U.S. human milk samples from 2002 (ng/g lipid).

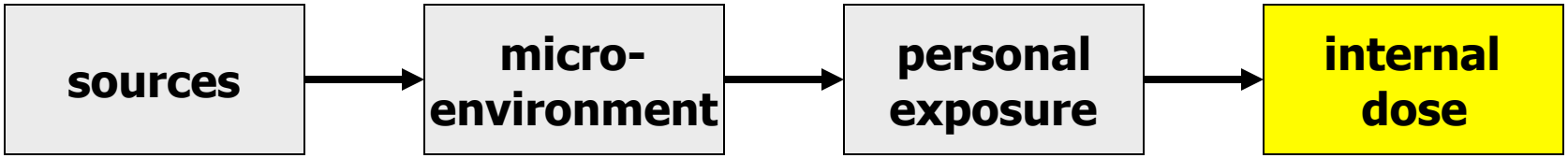
Schecter et al (2003)

In everybody, but large variation.
Small number of people have very high levels—why?

Exposure Assessment Paradigm: Source to Disease



How are people exposed?

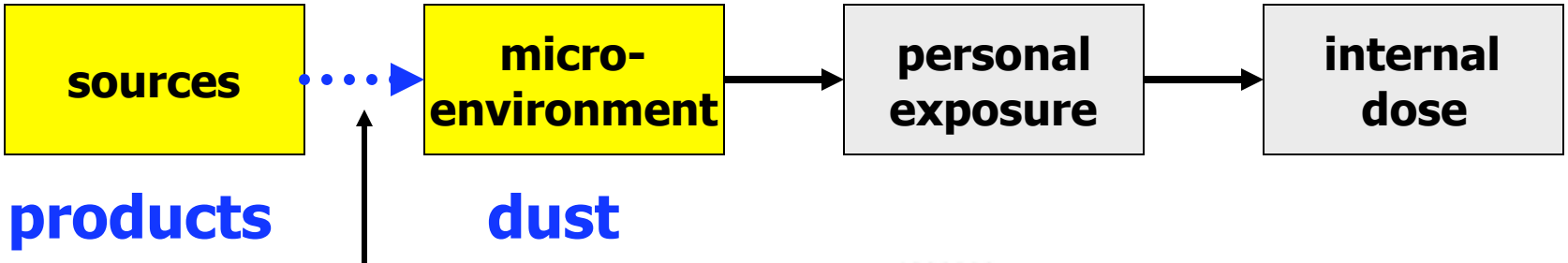


biomarker of exposure

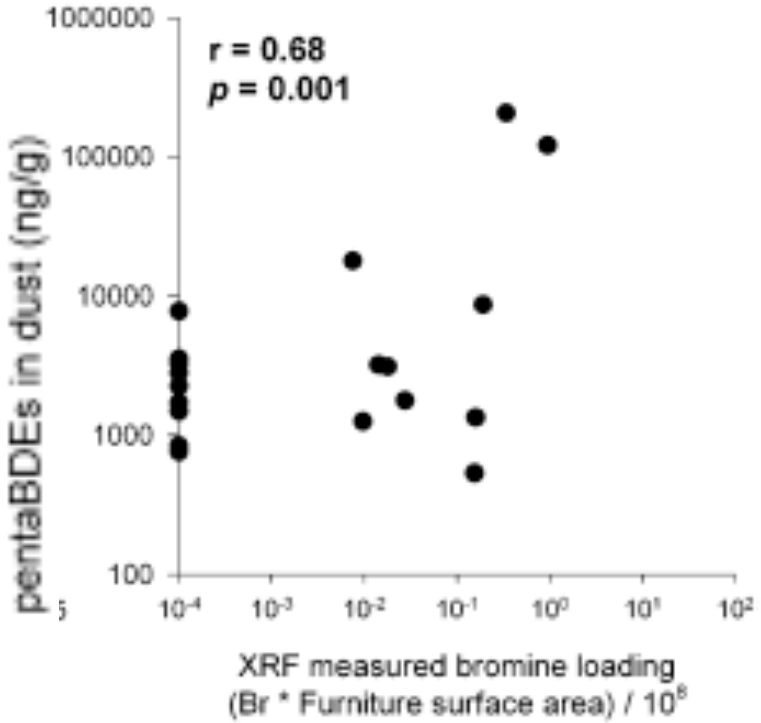
Goal: Understand how people are exposed to PBDEs along complete pathway from product to person

focus on our research:
North America, non-occupational

1. PBDEs in dust are associated with products

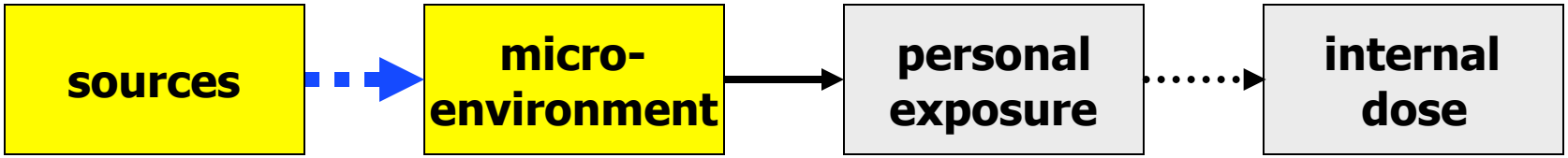


Dust concentrations doesn't correlate with product counts, but with Br via XRF (X-ray fluorescence), a surrogate for PBDEs (BFRs) in products.

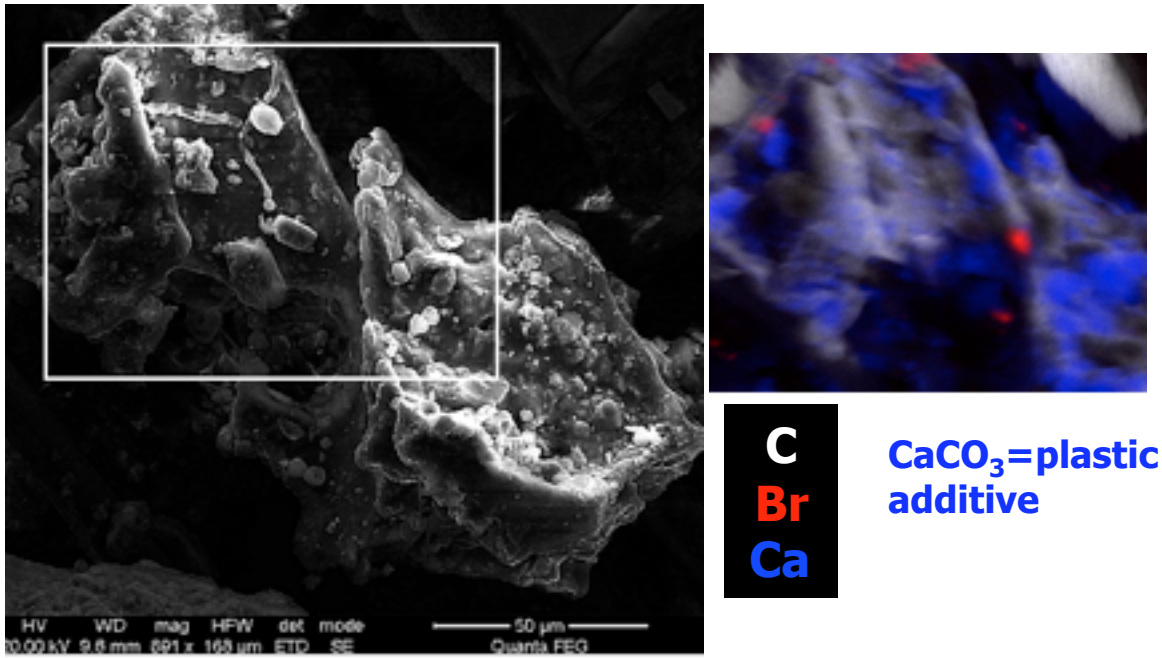


Allen et al 2008

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

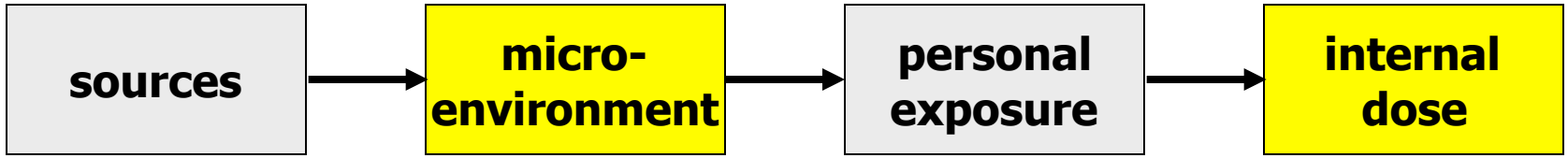


- penta via volatilization: limited chamber experiments
- deca via weathering: initial work with scanning electron microscopy



Webster et al 2009

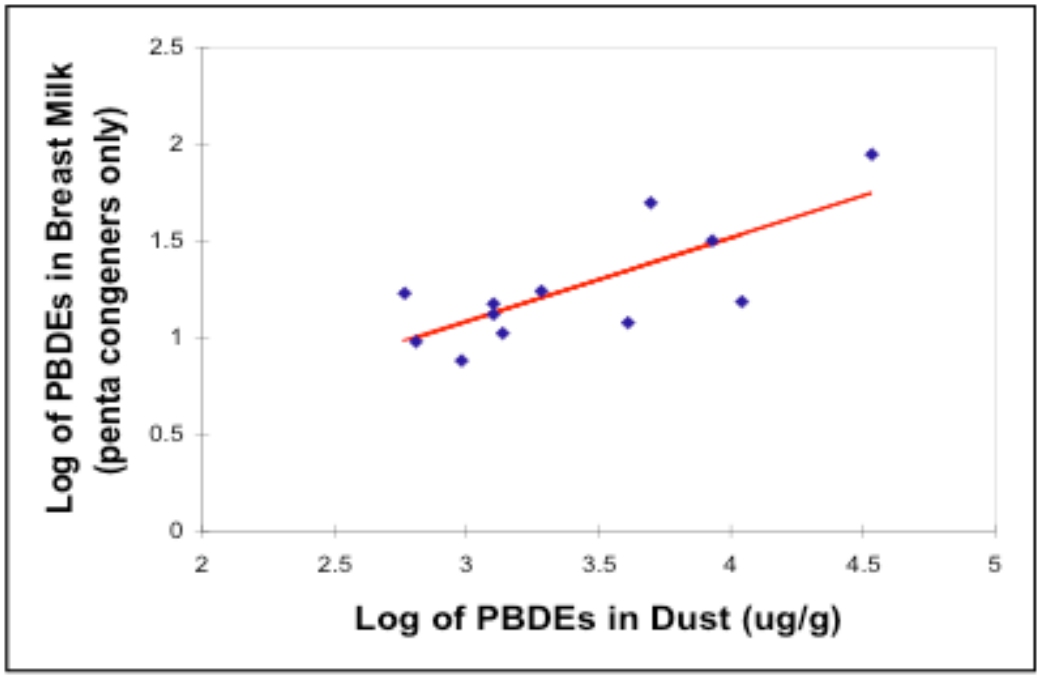
3. Dust is an important route of exposure



dust

blood or breast milk

Penta

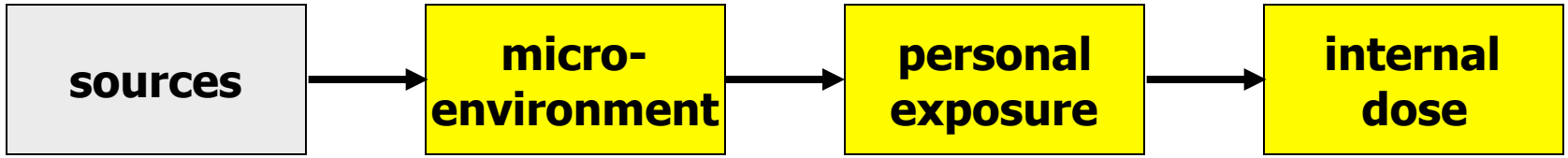


R= 0.76
p = 0.006

Consistent with exposure factor approach

Wu et al 2007

4. Dust exposure > air (in homes)



dust, air?

personal air?

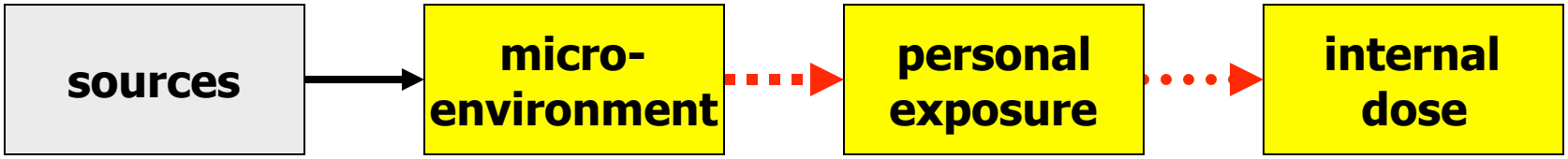
blood or breast milk

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

"personal cloud"

Allen et al 2007

5. Dust exposure: Hand-to-mouth, dermal?



dust

handwipes

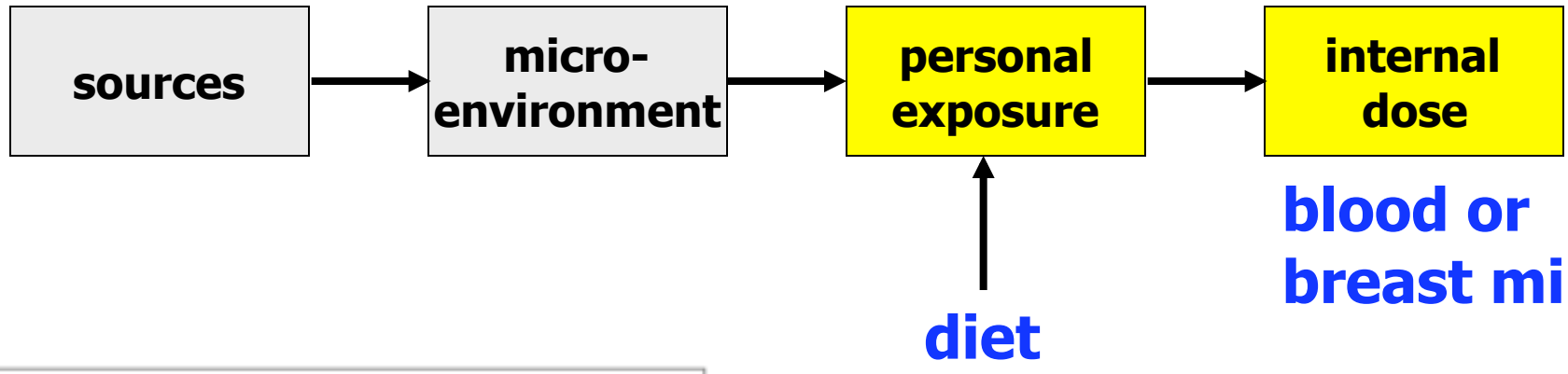
blood or breast milk

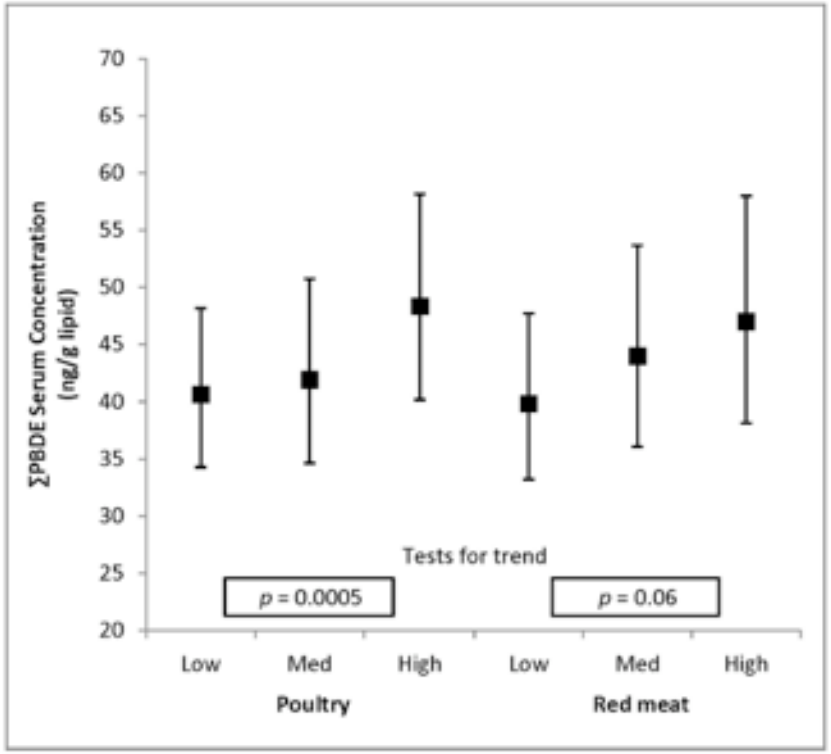
N=33	PBDE
detected	100%
median	129 ng
range	3-1982 ng

- Can measure PBDEs on hands
- Next steps: Link handwipes to dust & biomarker

Stapleton et al 2008

6. Diet is also an important route of exposure



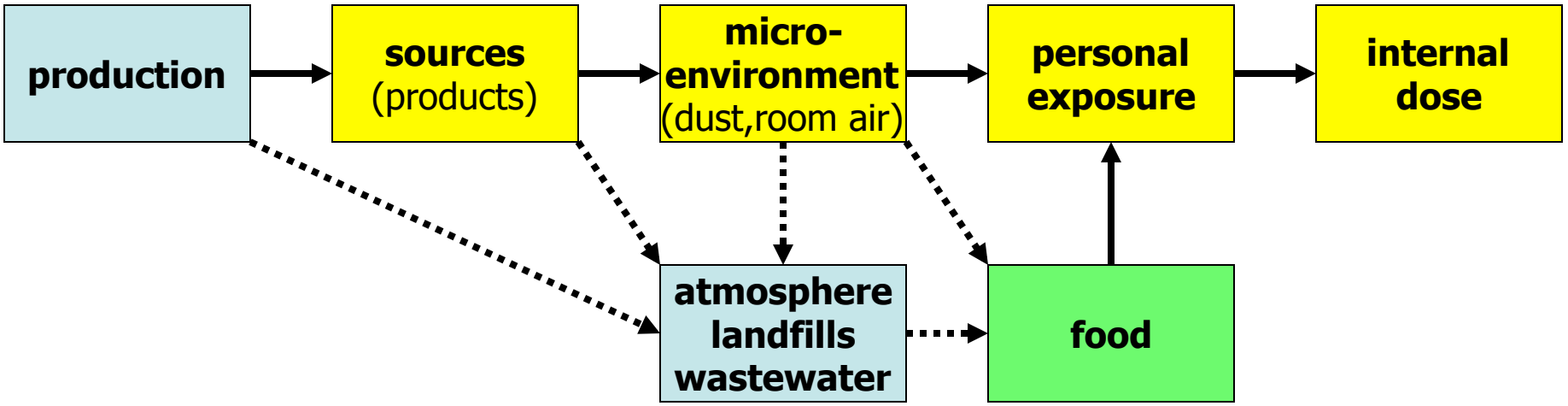


Penta in serum associated with meat consumption in general US population

Dairy, fish: weaker

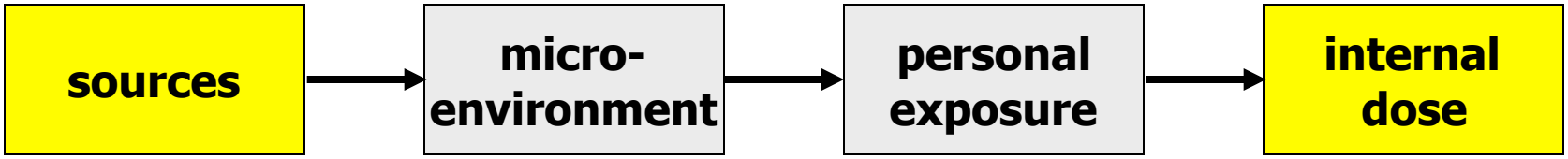
Fraser et al 2009

Bigger picture & food contamination



- **Main pathways of food contamination?**
- **Urban environment as source to wider environment?**

7. PBDE exposure and fire regulations



blood or breast milk

Penta exposure higher where furniture FR regs stricter?

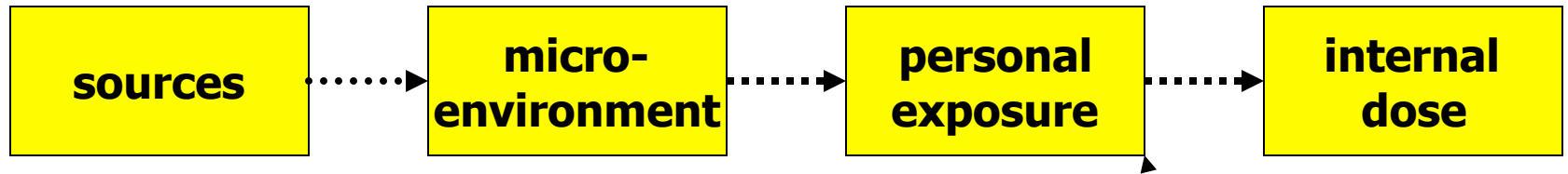
Penta in serum higher in CA (Zota et al 2008)

- **not control for diet**
- **some evidence that CA dust levels are elevated**

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

Need to better understand personal exposure to dust
Dust vs. diet: relative importance
Replicate in other groups

Deca: less well understood



products (via XRF)

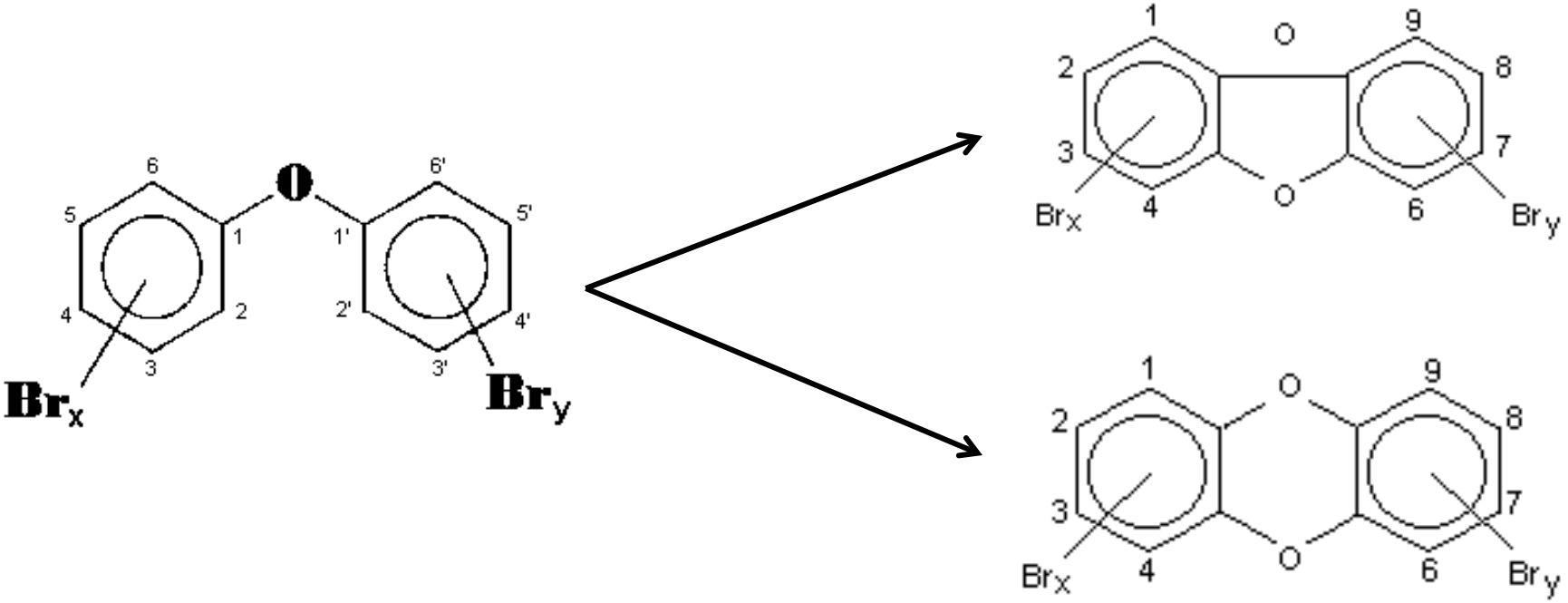
dust

hand wipe
pers. air

diet?

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

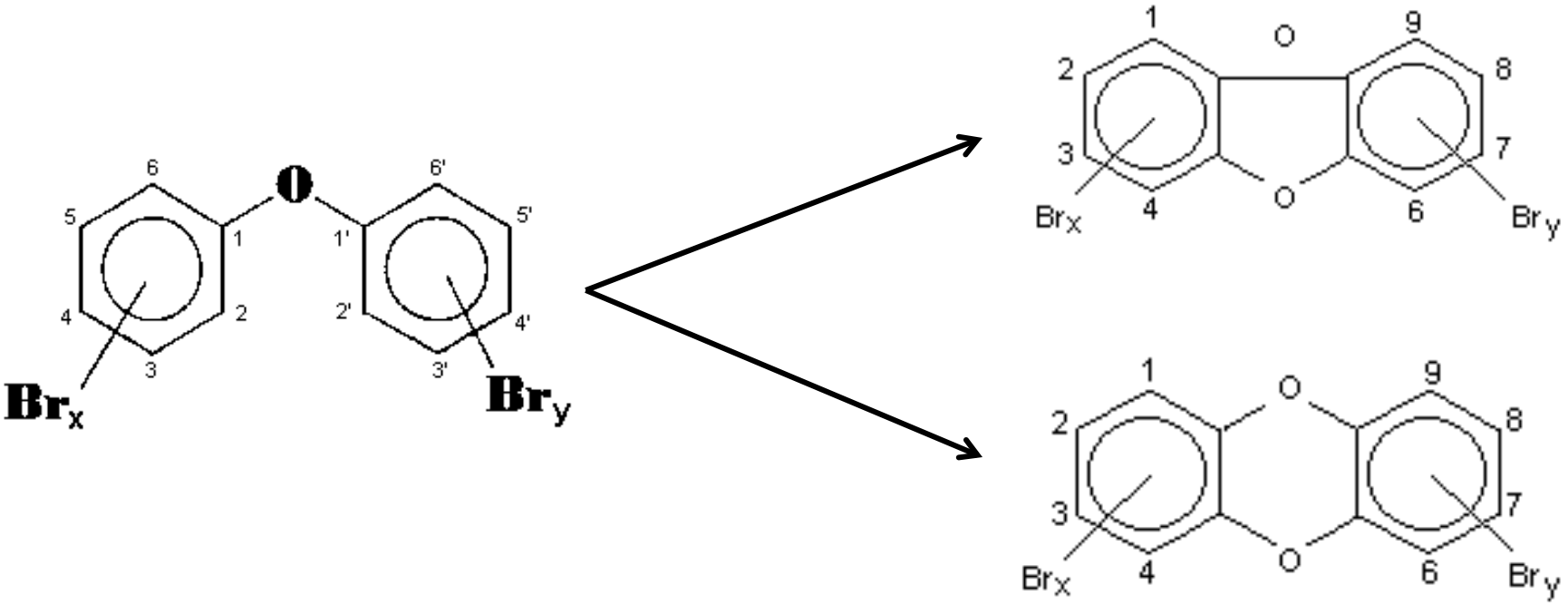
Combustion of PBDEs (& other BFRs) produces brominated dioxins and dibenzofurans



- **Also bromo-chloro mixed versions**
- **Extremely high levels at ewaste sites in China**

e.g., Weber 2003, 2009

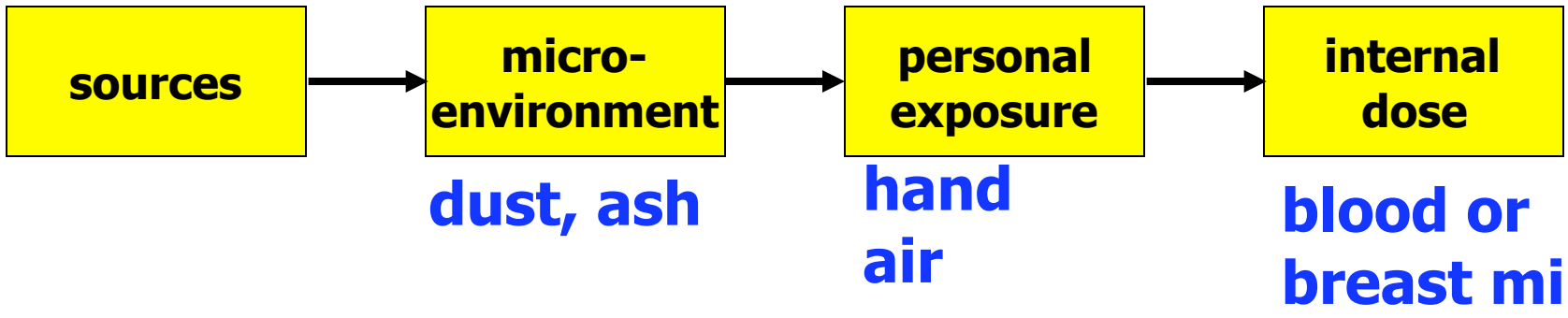
Fires: PBDEs (& other BFRs) produce brominated dioxins and dibenzofurans



- **House fires**
- **Found on fire fighters clothing**

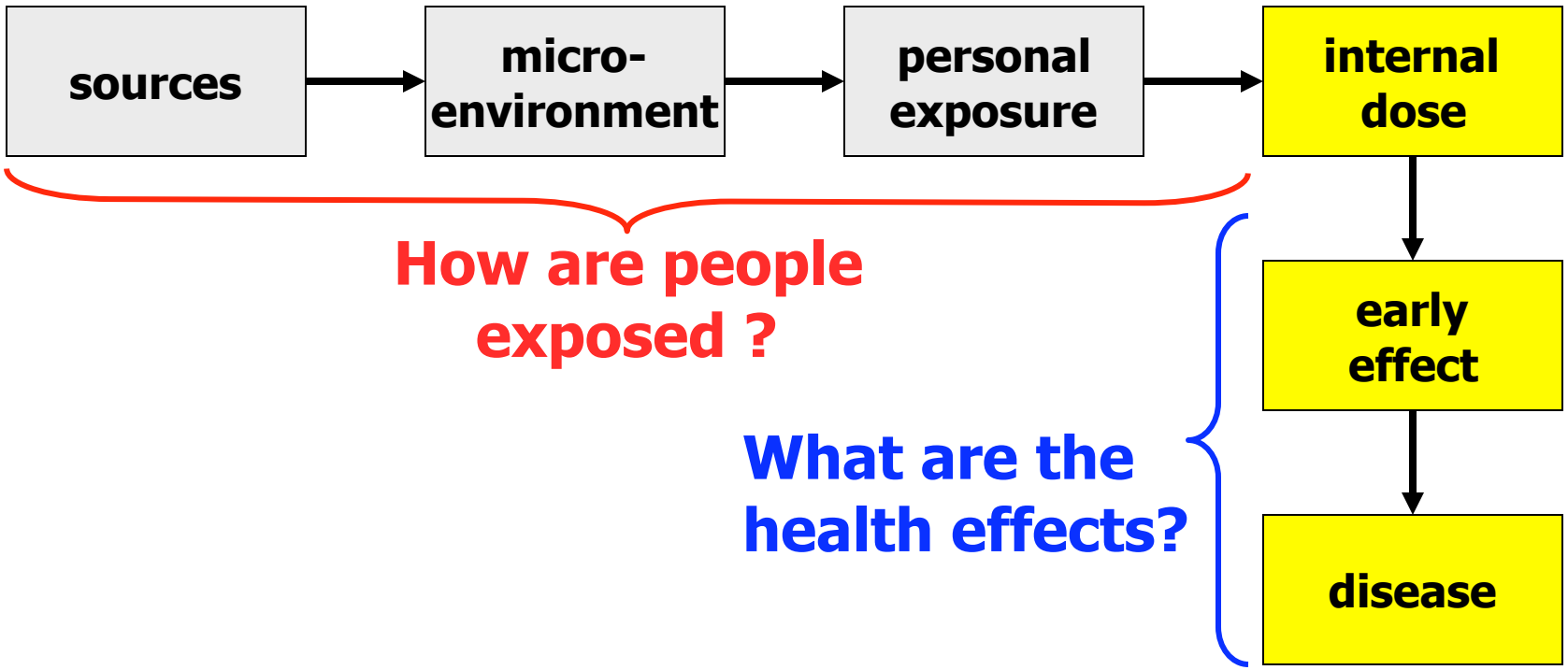
e.g., Weber 2003, Ebert 2003, Litten 2003, Takechi 2009

Exposure of Fire Fighters to PBDEs, brominated dioxins and dibenzofurans



- Exposure likely via dust/ash, air
- Studies of fire fighter body burdens?

Exposure Assessment Paradigm: Source to Disease



PBDE Toxicology
(selected, mostly rats & mice, depends on congener)

endocrine disruption
- **thyroid**
- **anti-androgen (OH-metabolites?)**

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.

e.g., Birnbaum & Staskal 2004, McDonald 2005

Health-related PBDE research on humans

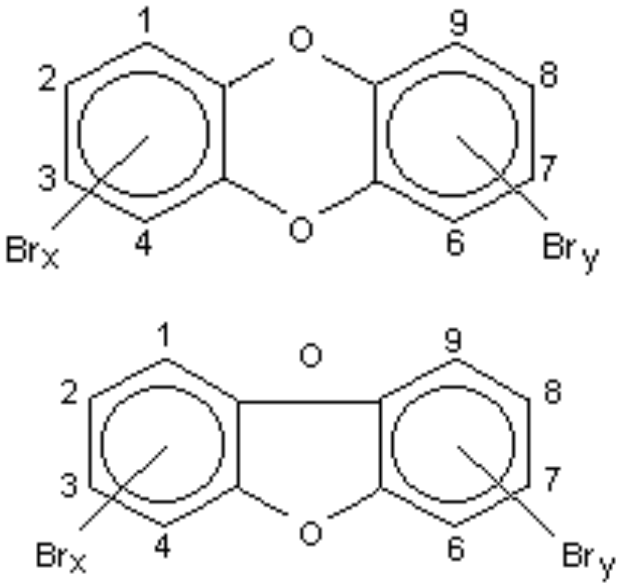
- testicular cancer (Sweden, Hardell et al 2005)
- decreased birthweight (Taiwan, Chao et al 2007)
- cryptorchidism (Scandinavia, Main et al 2007)
- infant thyroid (USA, Herbstmann et al 2008)
- developmental neurotoxicity (Netherlands, Roze 2009)

- adult thyroid (Sweden, Hagmar et al 2001)
- sperm, adult males (Japan, Akutsu et al 2008)
- thyroid, adult males (USA, Turyk et al 2008)
- hormones, adult males (USA, Meeker et al 2009)

Growing evidence for Penta effects in general population
More under way

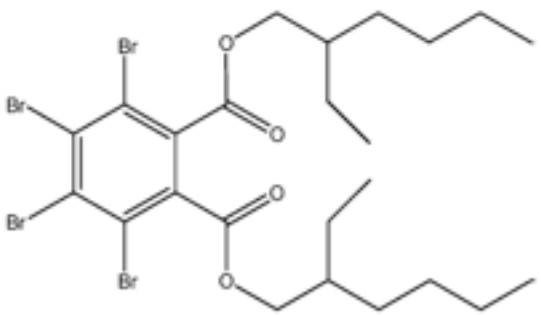
Brominated dioxins and dibenzofurans

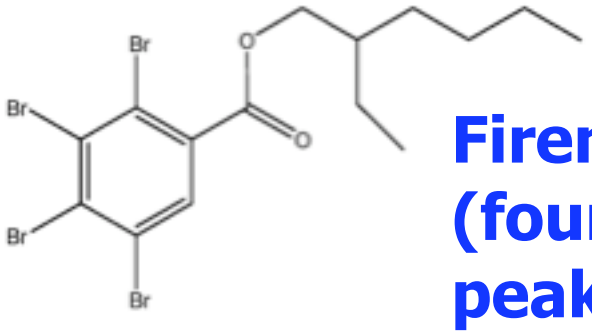
- Estimated as toxic as "regular" dioxins (chlorinated)
- All "dioxin-like" compounds thoughts to act via common mechanisms
- Dioxin-like toxicology:
  - endocrine disruption
  - reproductive system
  - immune system
  - developing organisms…
- TCDD considered a "known human carcinogen"



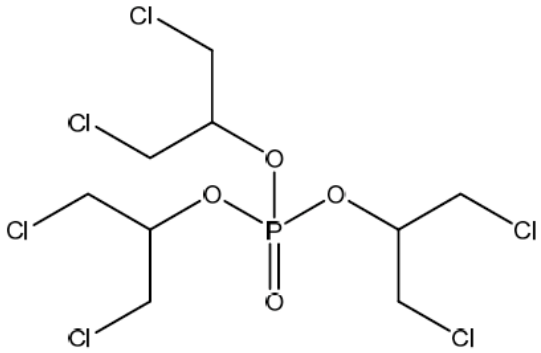
e.g., Birnbaum et al 2003

Replacements for PentaBDE: now found in dust





Firemaster 550
(found via unknown peaks on chromatogram)

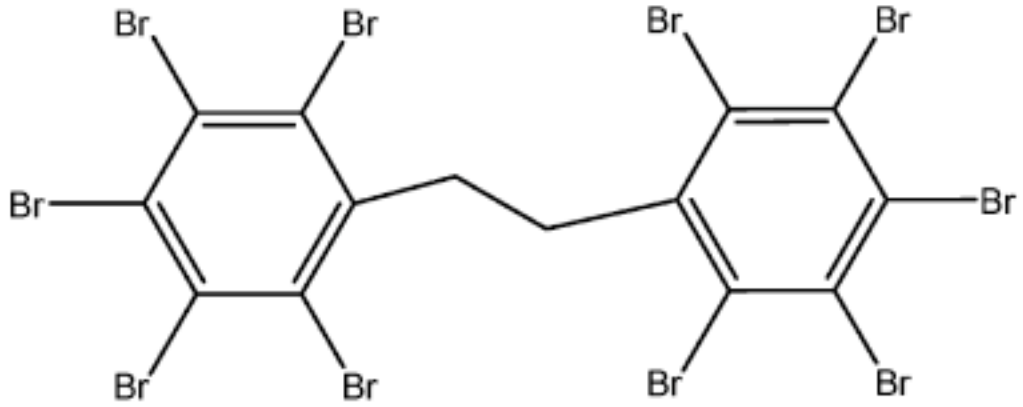


Tris (1,3-dichloro-2-propyl) phosphate
"chlorinated tris"
used in children's sleepware in 1970s
weak mutagen
CPSC "probable human carcinogen"

Less understood than PBDEs

Stapleton et al 2008, 2009

A replacement for deca:



Decabromodiphenyl ethane

We found it in US house dust.

Others found it in wildlife from North America & Asia.

Allen et al 2008, Betts 2008

What are the benefits and risks of flame retardants?

Acknowledgements:

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Study participants

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Wu N, Herrmann T, Paepke O, Tickner J, Hale R, Harvey E, La Guardia M, McClean MD, Webster TF. Human exposure to PBDEs: Associations of PBDE body burdens with food consumption and house dust concentrations. *Environ Sci Technol* 2007; 41(5): 1584-1589.

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