



# Role of Biomonitoring in Exposure and Community Human Health Studies

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# Outline

- I. Types of health studies and exposure assessment
- II. Exposure assessment issues – chemical dependent
- III. Interpreting biological monitoring data
- IV. Example of community biomonitoring

# I. Types of Health Studies and Exposure Assessment

Purpose: Define any association  
between exposure and disease

Question: How best to assess  
exposure?

# Types of Health Studies: Cohort (Longitudinal)



# Types of Health Studies: Case/Control



# Types of Health Studies: (Cross-Sectional)

**Define Population**

**Assess Exposure and Disease**

Exposed  
Diseased

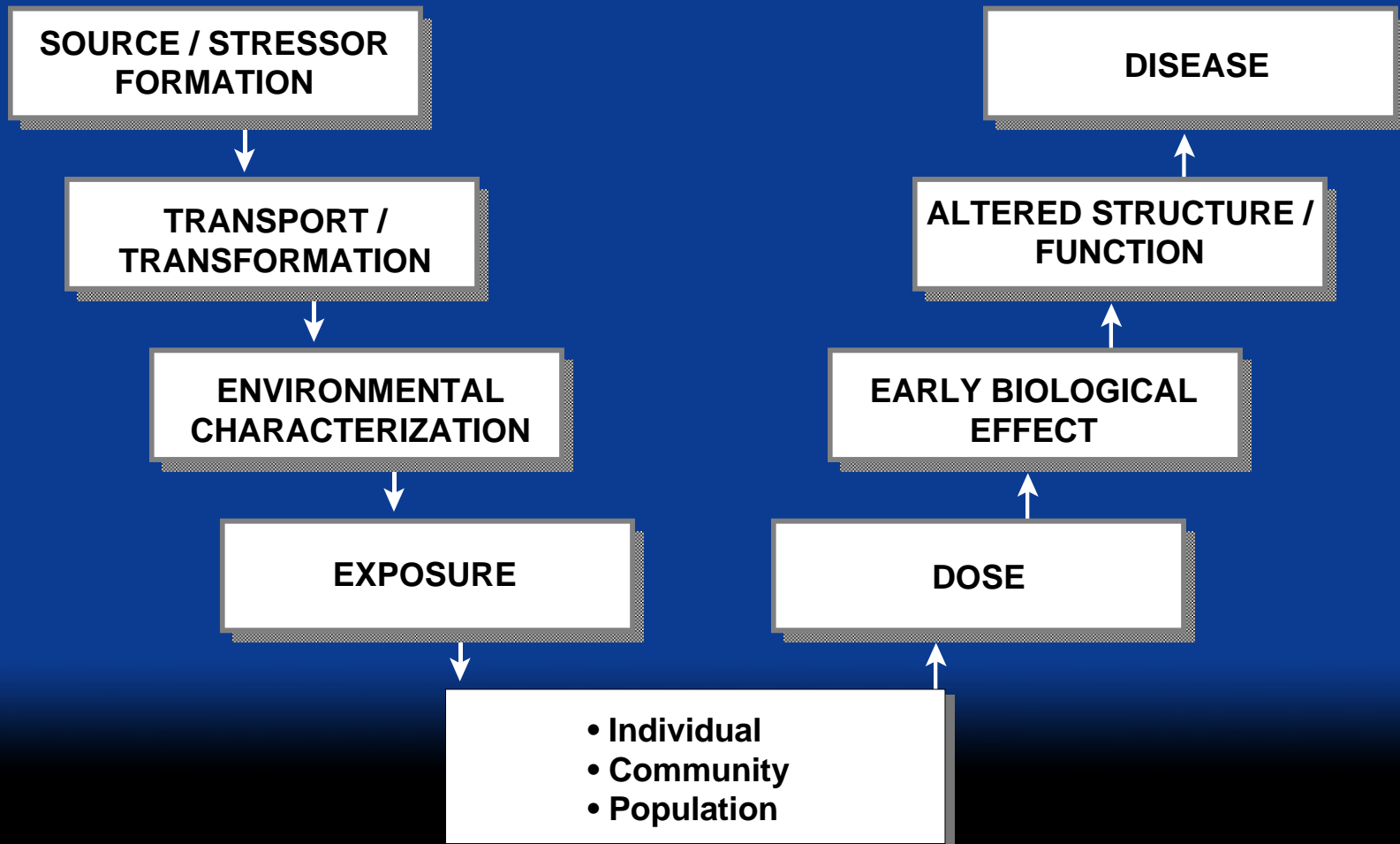
Exposed  
Not Diseased

Not Exposed  
Diseased

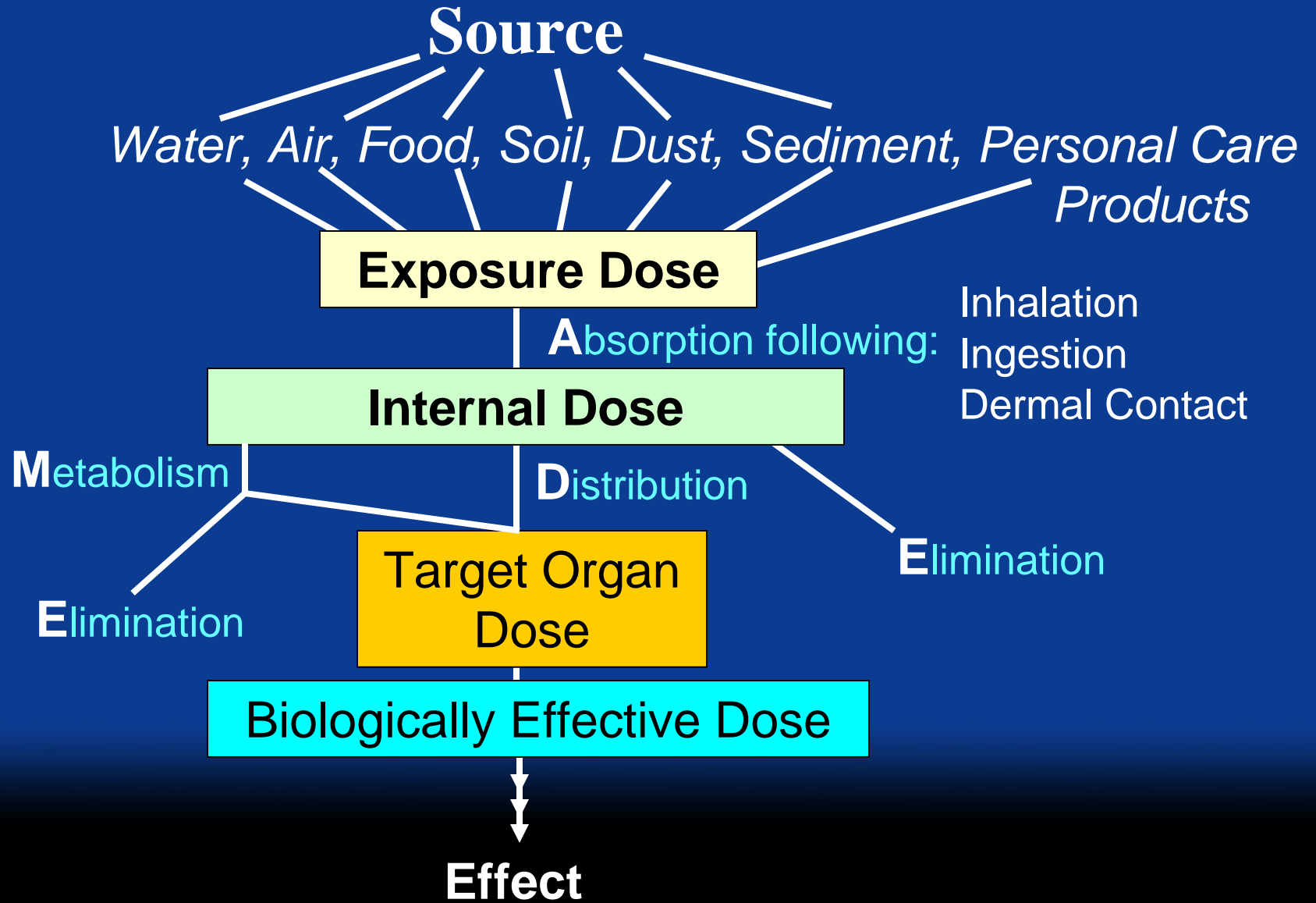
Not Exposed  
Not Diseased

# Environmental Public Health Continuum

For health studies: with certain caveats, the “closer” exposure is assessed to the effects, the more “accurate” is the relation between exposure and effects defined.



# Exposure Pathway



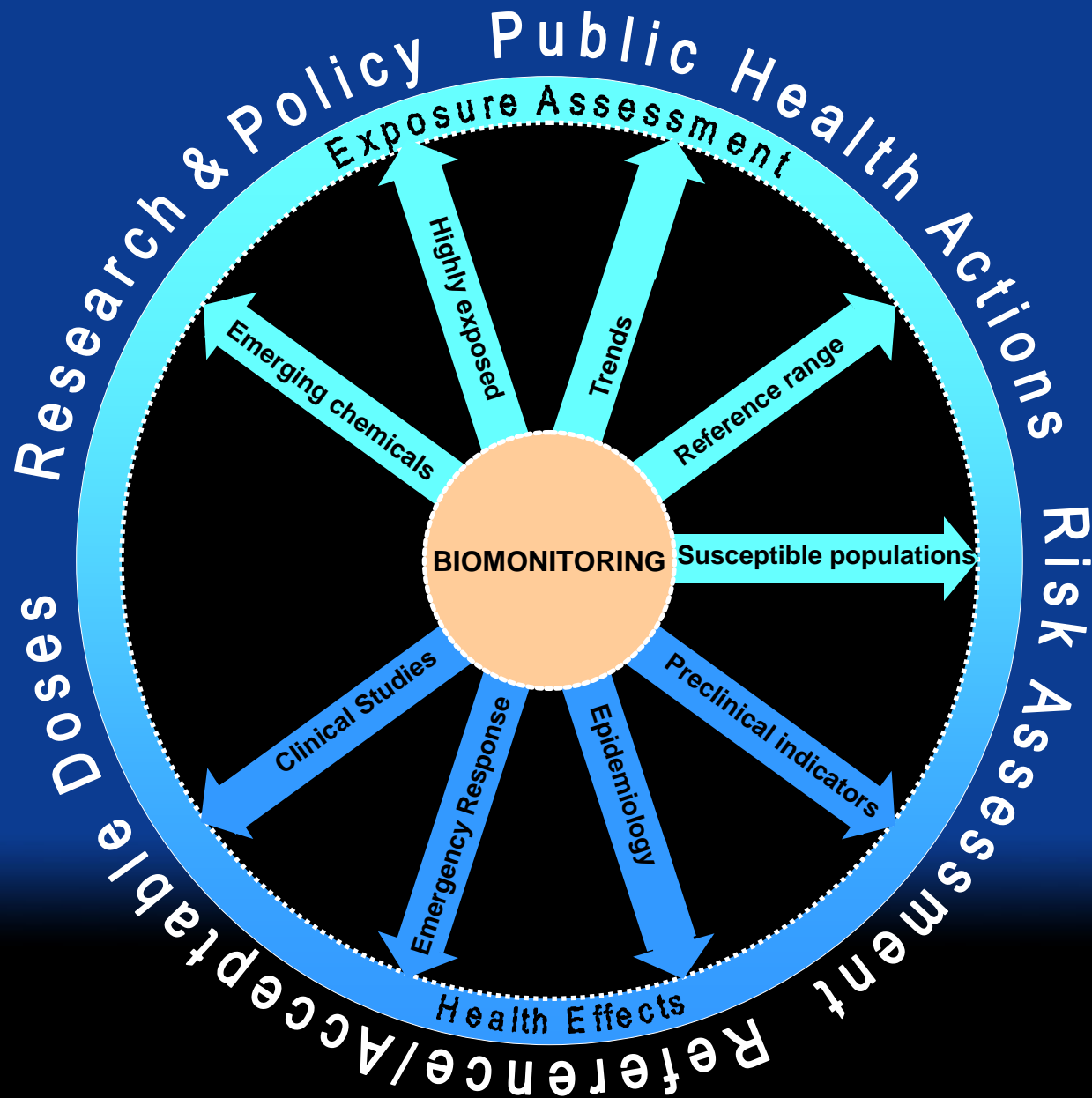


# Predicting Adverse Health Outcomes Following Human Exposure to Environmental Chemicals is Problematic or “Why do people respond differently to similar exposures?”



- \*
  - Genetic factors
  - Demographic factors (age, sex, geography)
  - Environmental and behavioral stressors
  - Nutritional status
  - Other exposures

# Biomonitoring for Disease Prevention

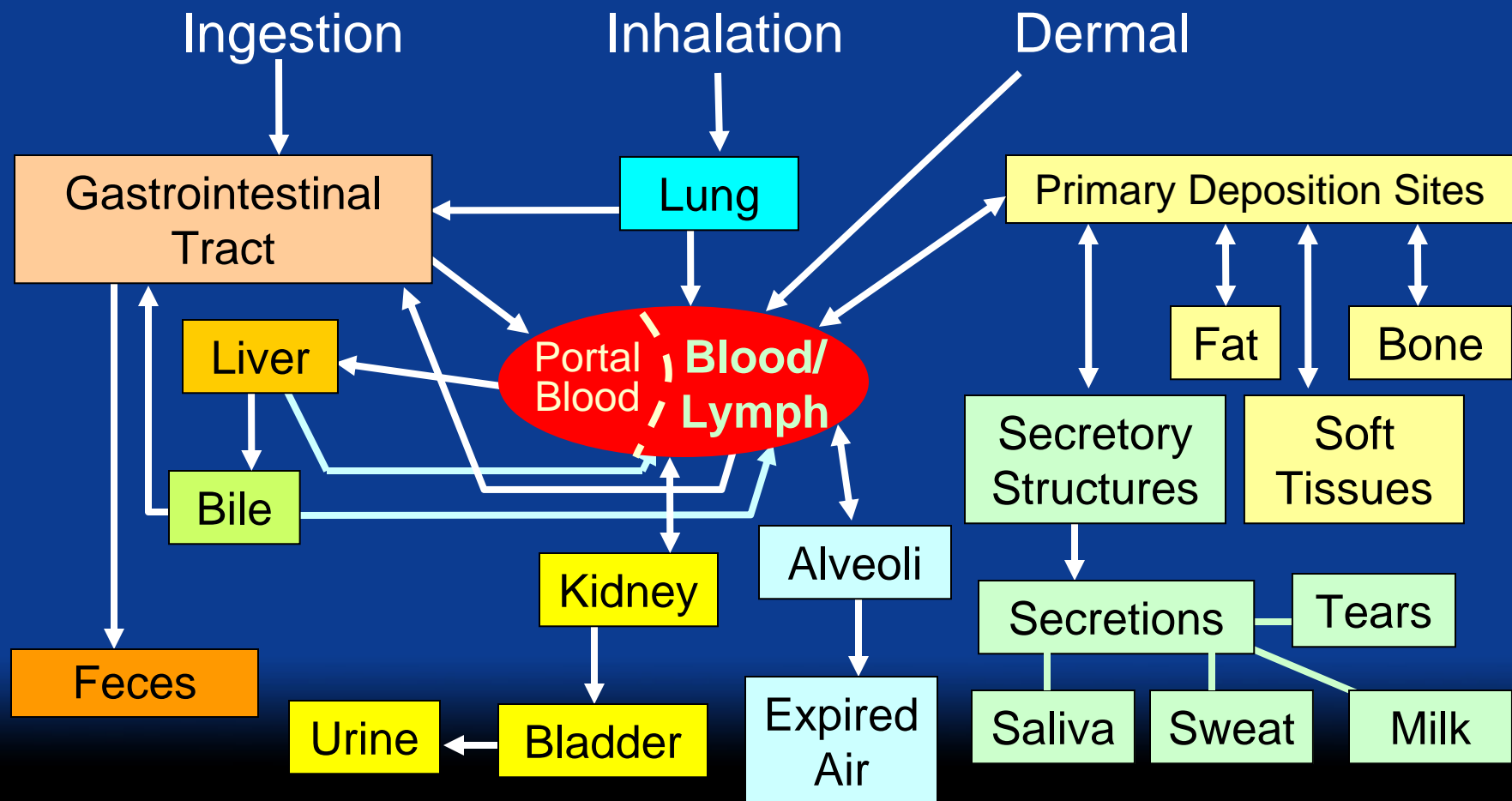


## **II. Exposure Assessment Issues Depending on the Chemical**

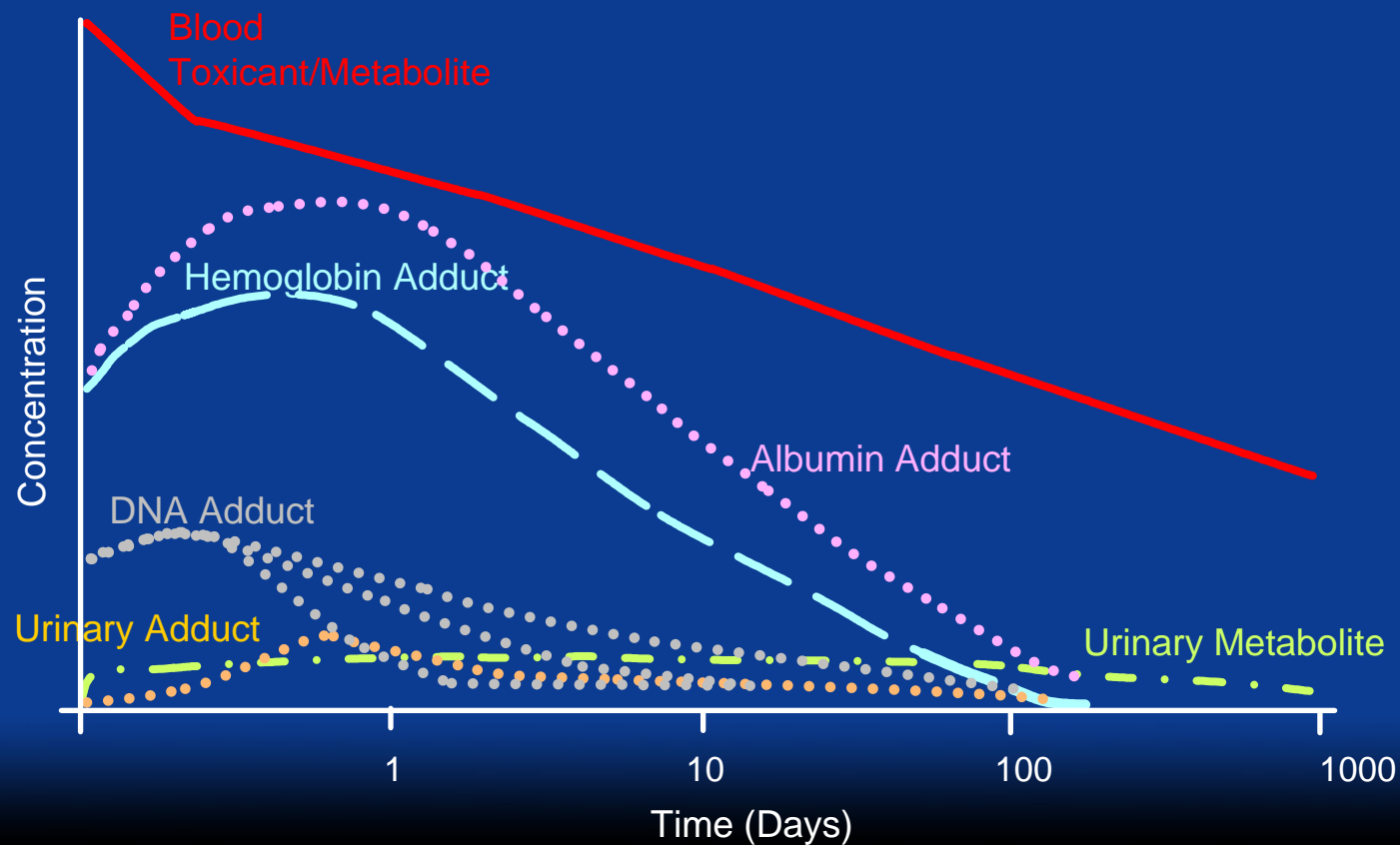
# Two Classes of Chemicals

- Persistent in the Body (Long Half Lives)
- Nonpersistent in the Body (Short Half Lives)

# Pharmacokinetics of Environmental Chemicals in Body and What Matrices Are Available for Analyses

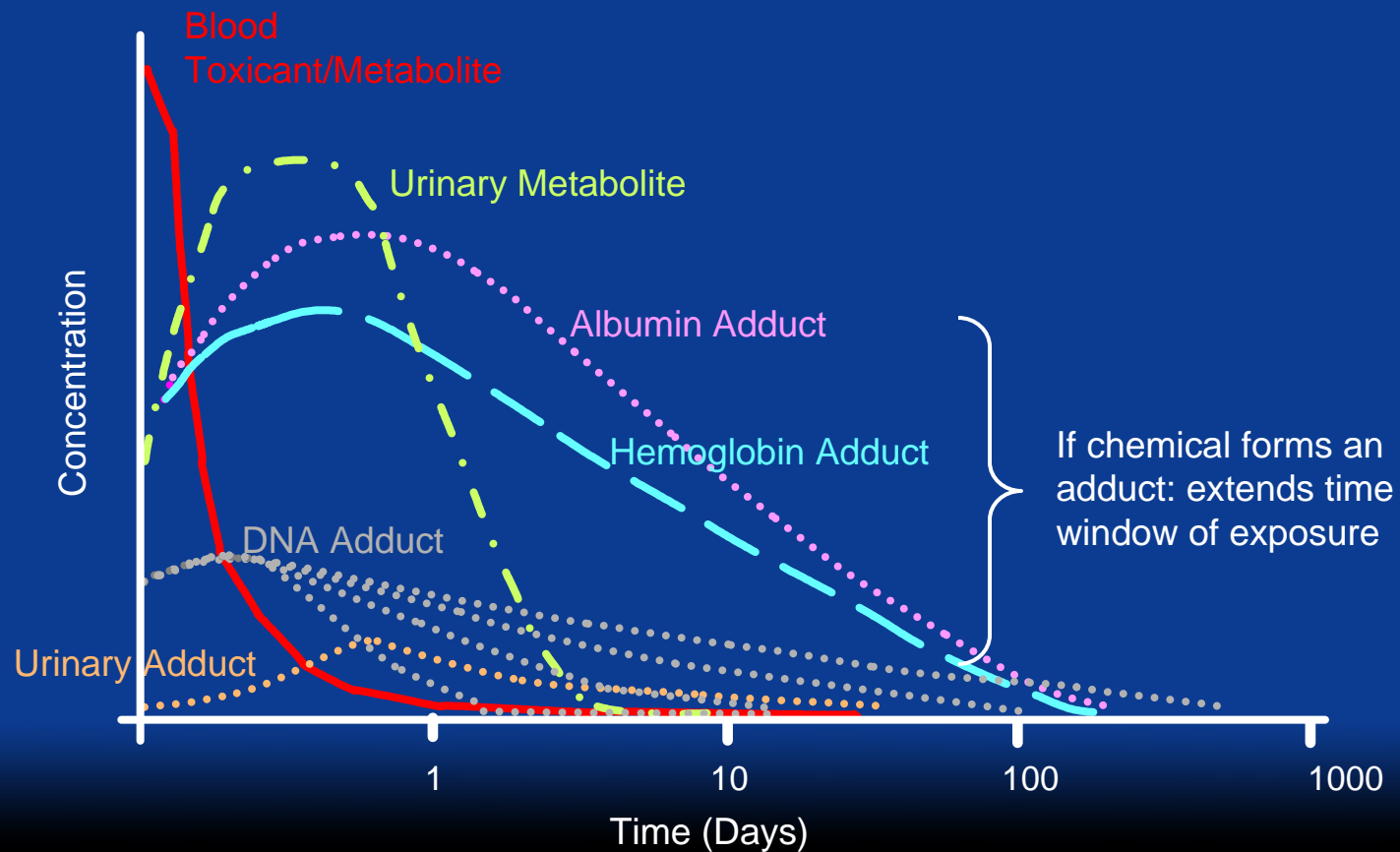


# Post-Exposure Fate of a Persistent Chemical in Blood and Urine



Needham and Sexton, JEAE 10:611-629 (2000)

# Post-Exposure Fate of a Nonpersistent Chemical in Blood and Urine

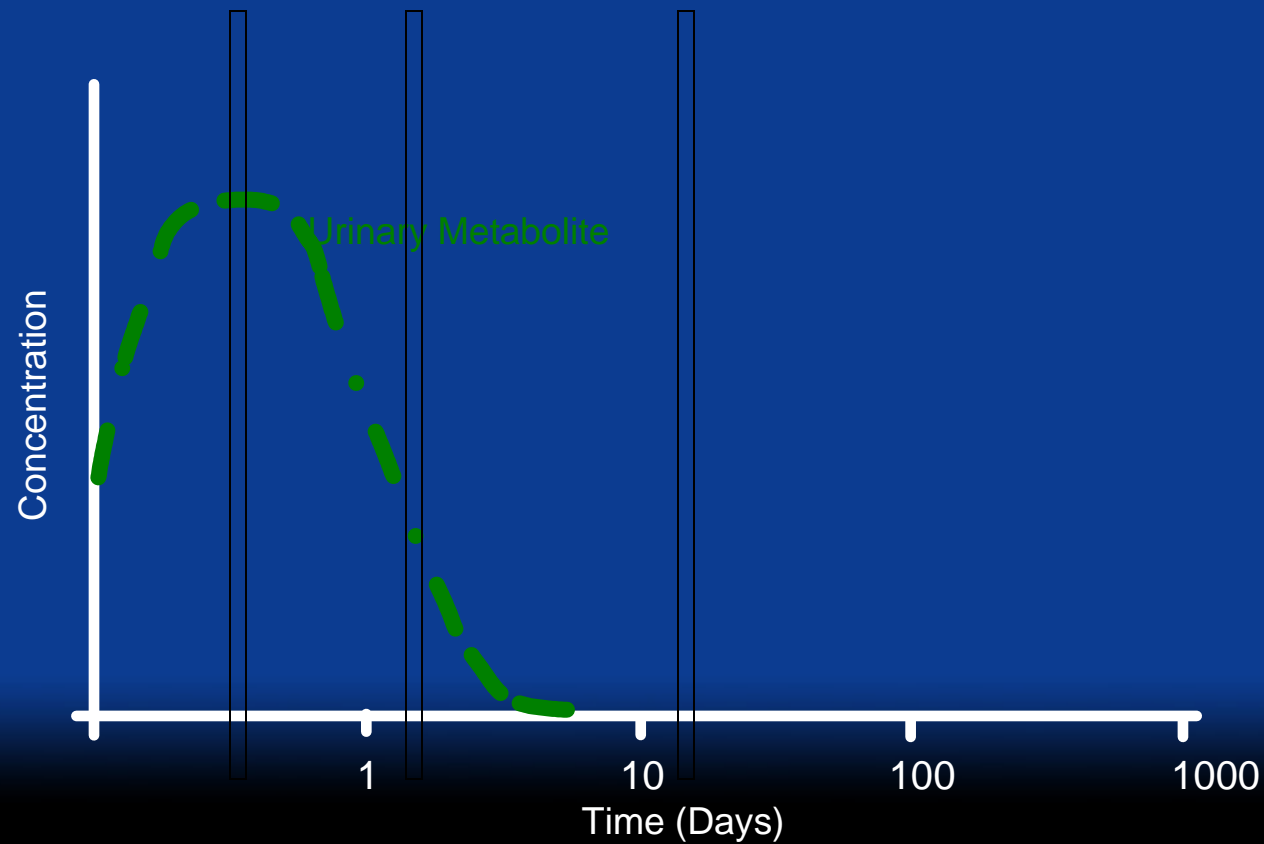


Needham and Sexton, JEAE 10:611-629 (2000)

**Timing of Urine Collection May be Critical**



# Post-Exposure Fate of a Nonpersistent Chemical in Blood and Urine



# CDC's Third *National Report on Human Exposure* – data from NHANES 2001-2002

## Urine

Metals (13)

PAH metabolites

Phthalate metabolites

Pesticides

Organophosphorus

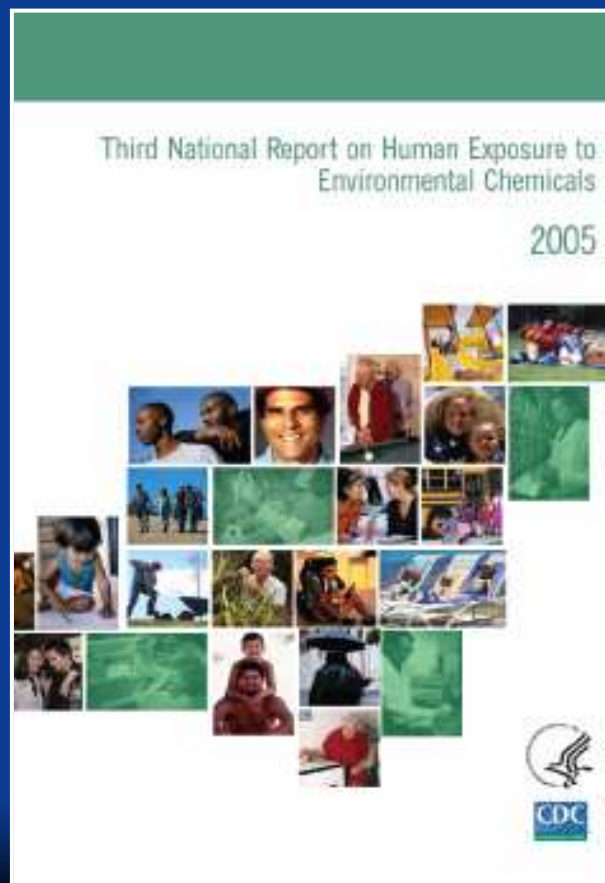
Carbamates

Herbicides

Pyrethroid

Repellants

Phytoestrogens



## Blood

Lead

Cadmium

Mercury

## Serum

Dioxins

Furans

PCBs

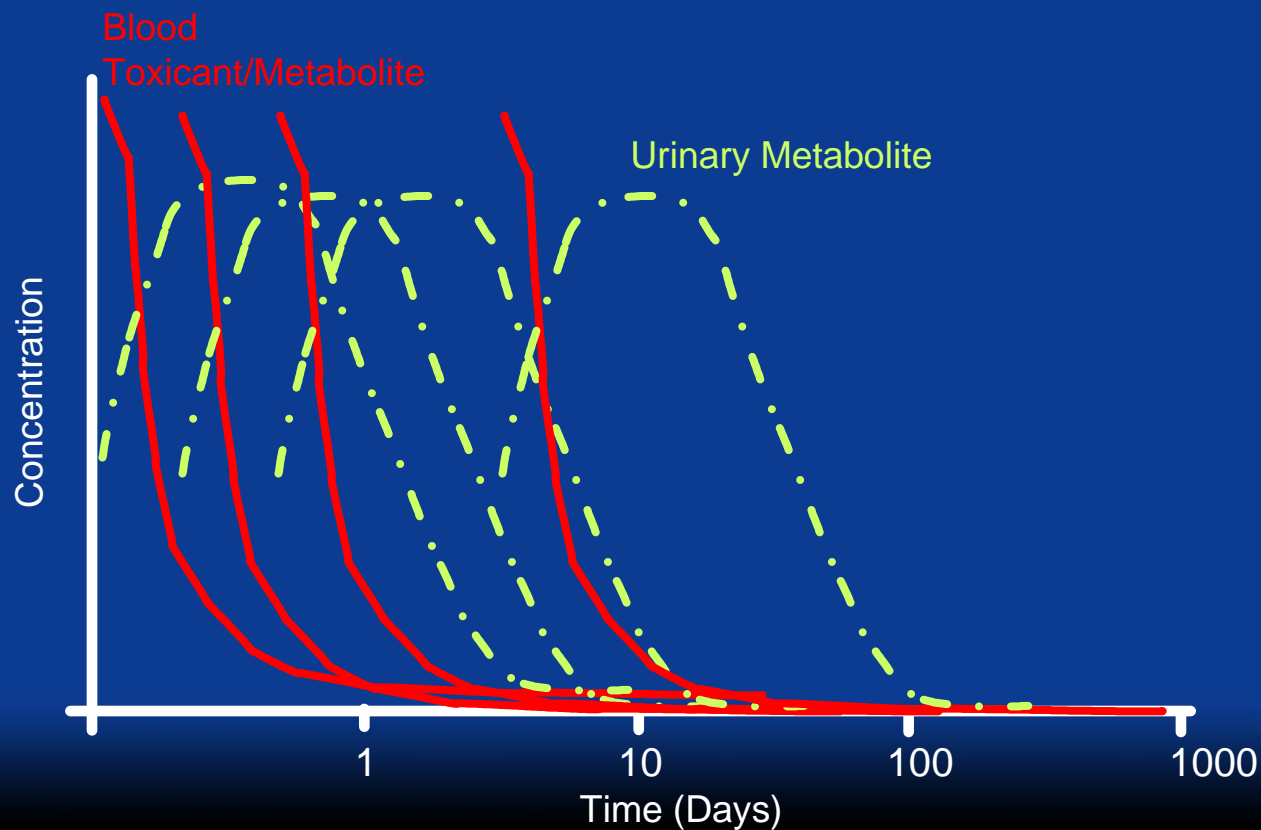
Organochlorine pesticides

Cotinine

Released: July 2005

[www.cdc.gov/exposurereport](http://www.cdc.gov/exposurereport)

# Post-Exposure Fate of a Nonpersistent Chemical in Blood and Urine



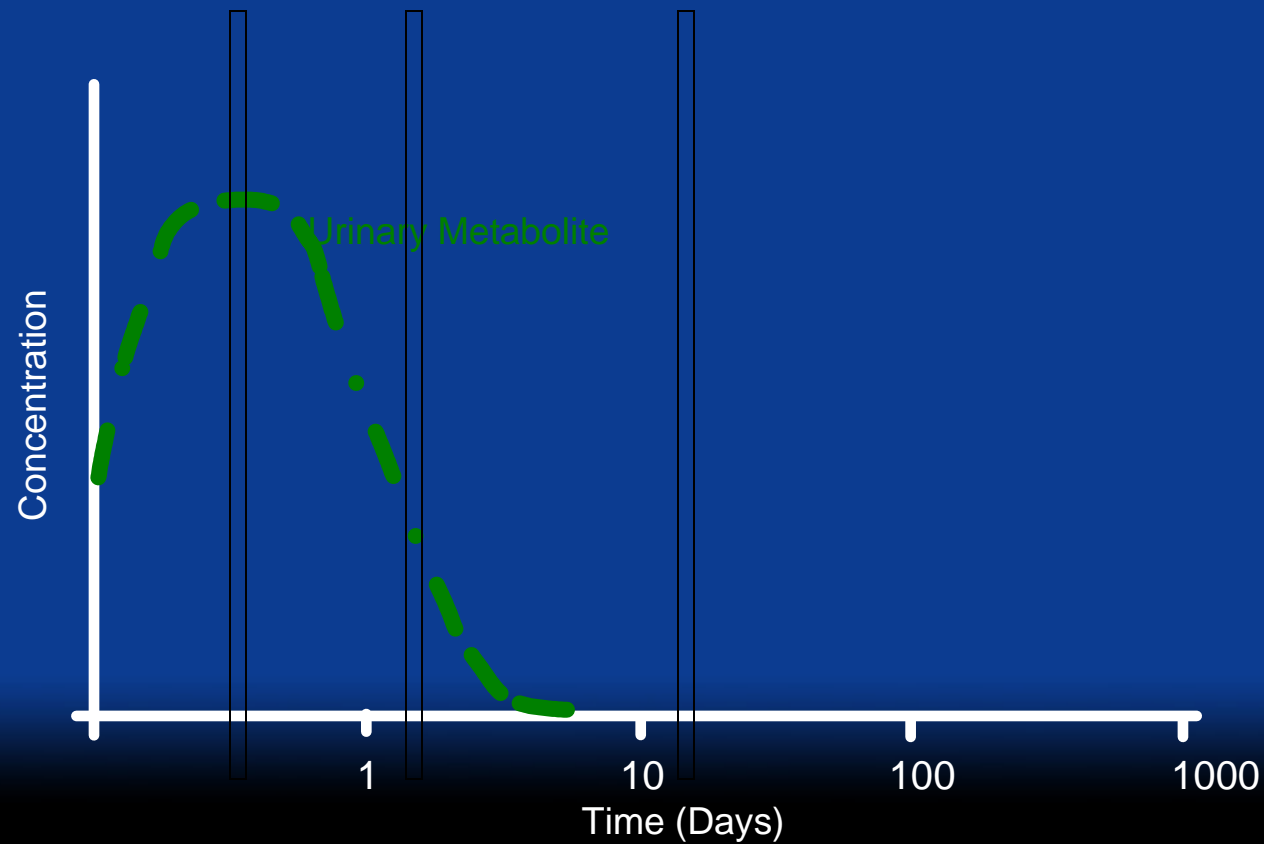
Barr et al., Environ Health Perspect **113**:1083-1091 (2005)

Needham, Barr, and Calafat. Neurotoxicology **26**:547-53(2005)

# Nonpersistent Chemicals: Episodic Exposures

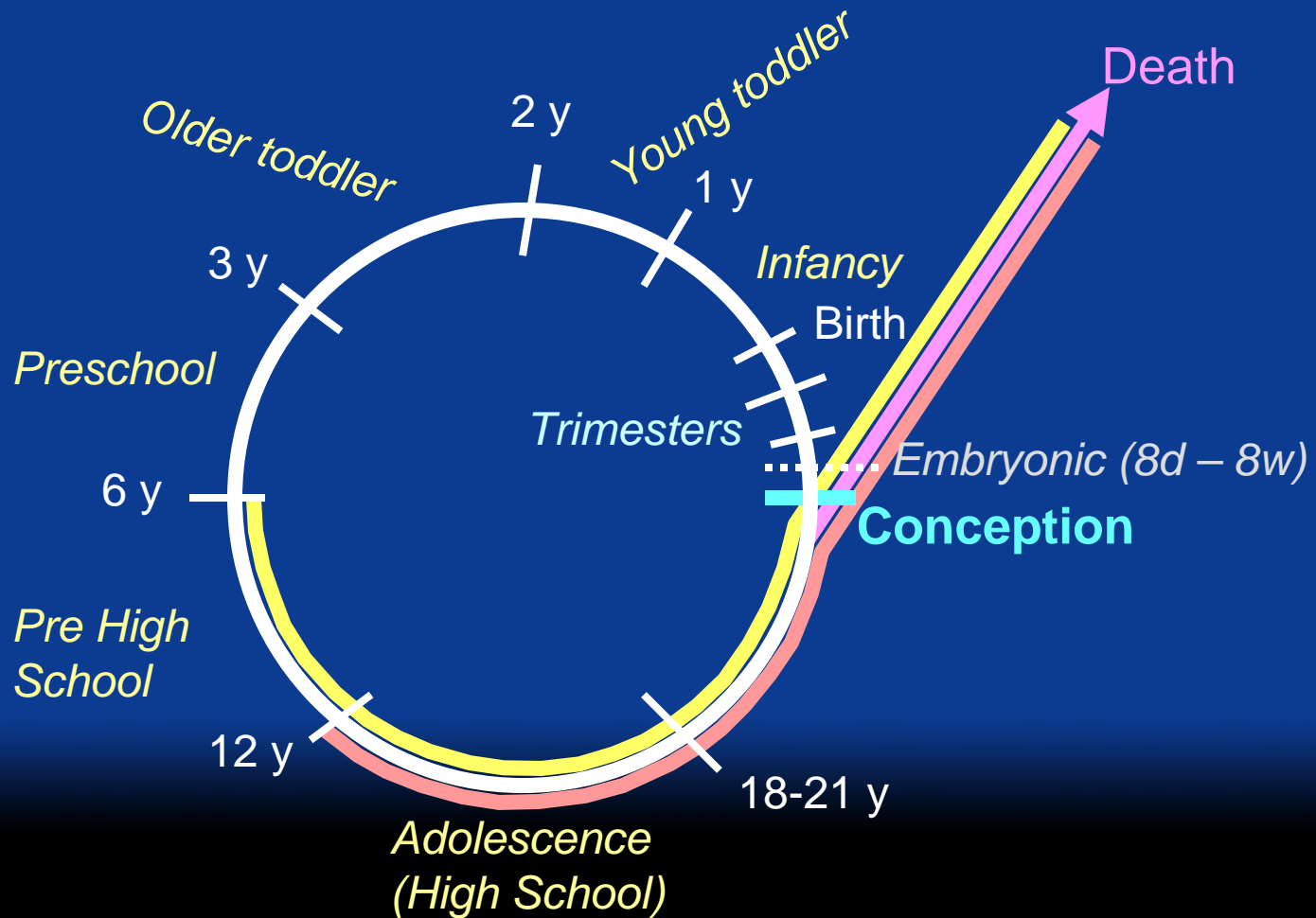
No “good” way to assess exposure!!

# Post-Exposure Fate of a Nonpersistent Chemical in Blood and Urine



# **III. Interpreting Biological Monitoring Data**

# Life Stages of Children: Know Availability of Matrices



# Relative Importance of Various Biological Matrices for Measuring Exposure During the Different Life Stages

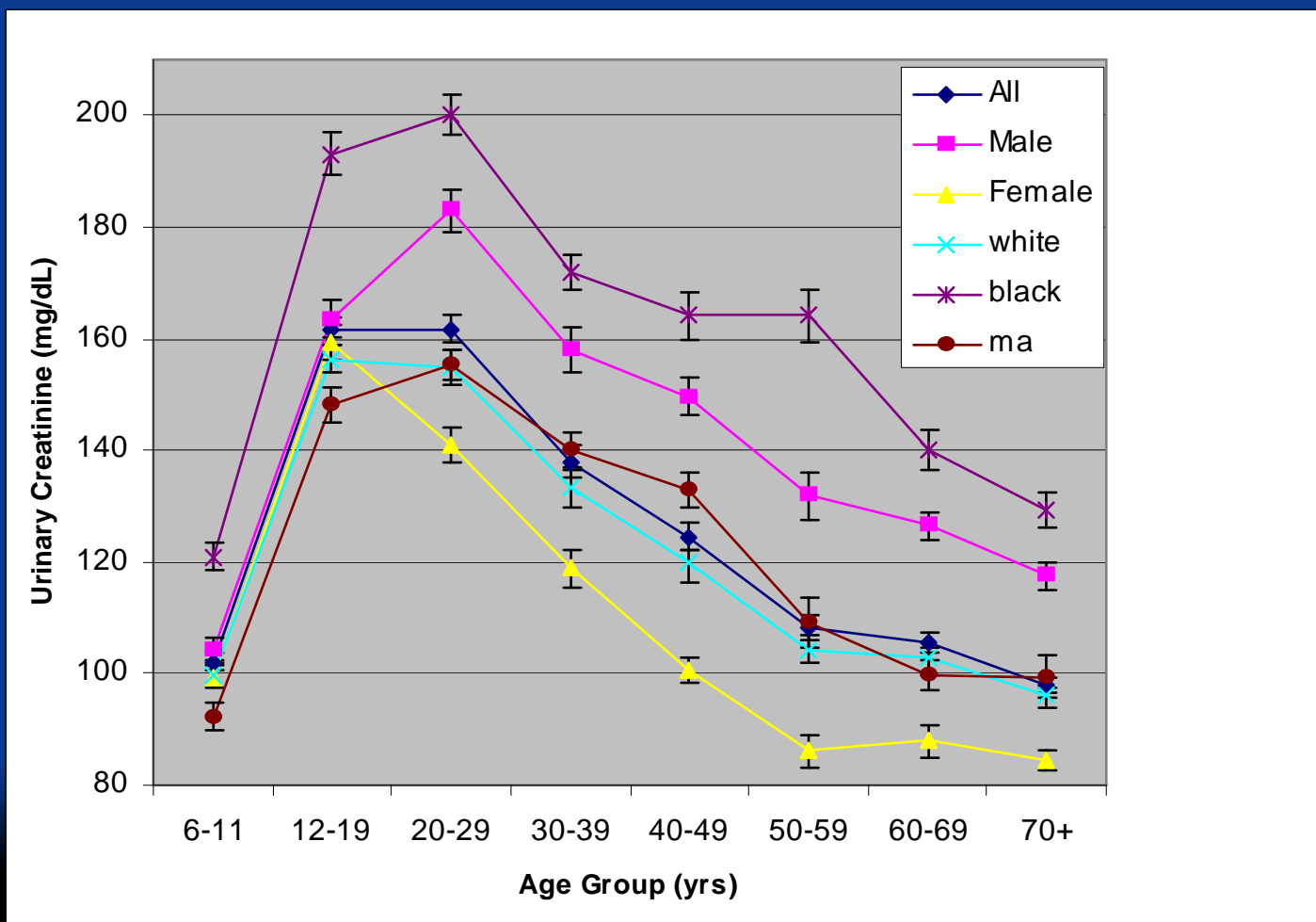
Matrices	Adult preconception	Fetal			0-1 year	2-3 years	4-11 years
		1st	2nd	3rd			
<b>Persistent Organic Chemicals</b>							
Blood (whole)	1				1	1	1
Blood (serum)	1				1	1	1
Blood (plasma)	1				1	1	1
Urine	3				3	3	3
Saliva	3				NA	3	3
Hair	3				3	3	3
Nails	3				3	3	3
Adipose Tissue	1				NA	NA	NA
Feces	3				3	3	3
Semen	3				NA	NA	NA
Breath	3				NA	3	3
Teeth	NA				NA	NA	3
Cord Blood	1	1	1	1	3	3	3
Meconium	3	2	2	2	3	3	3
Milk (maternal)	1	1	1	1	1	3	3
Blood (maternal)	1	1	1	1	1	3	3
Urine (maternal)	3	3	3	3	3	3	3
Hair (maternal)	3	3	3	3	3	3	3



**Creatinine in Urine:  
To Adjust or Not Adjust**

# Creatinine Variability Among Populations

Comparison of Urinary Data Based on Age, Race, and Sex



## **IV. Community Monitoring Example**

# Seveso, Italy Scenario

- Saturday – July 10, 1976
  - ◆ Explosion in a TCP reactor
  - ◆ Atmospheric release of kilogram amount of 2,3,7,8-TCDD
- People potentially exposed
  - ◆ A Zone – 736
  - ◆ B Zone – 4,737
  - ◆ R Zone – 31,800
- Highest measured level
  - ◆ 56,000 ppt (Oct. 1976)

# Map of Seveso Showing Contaminated Area

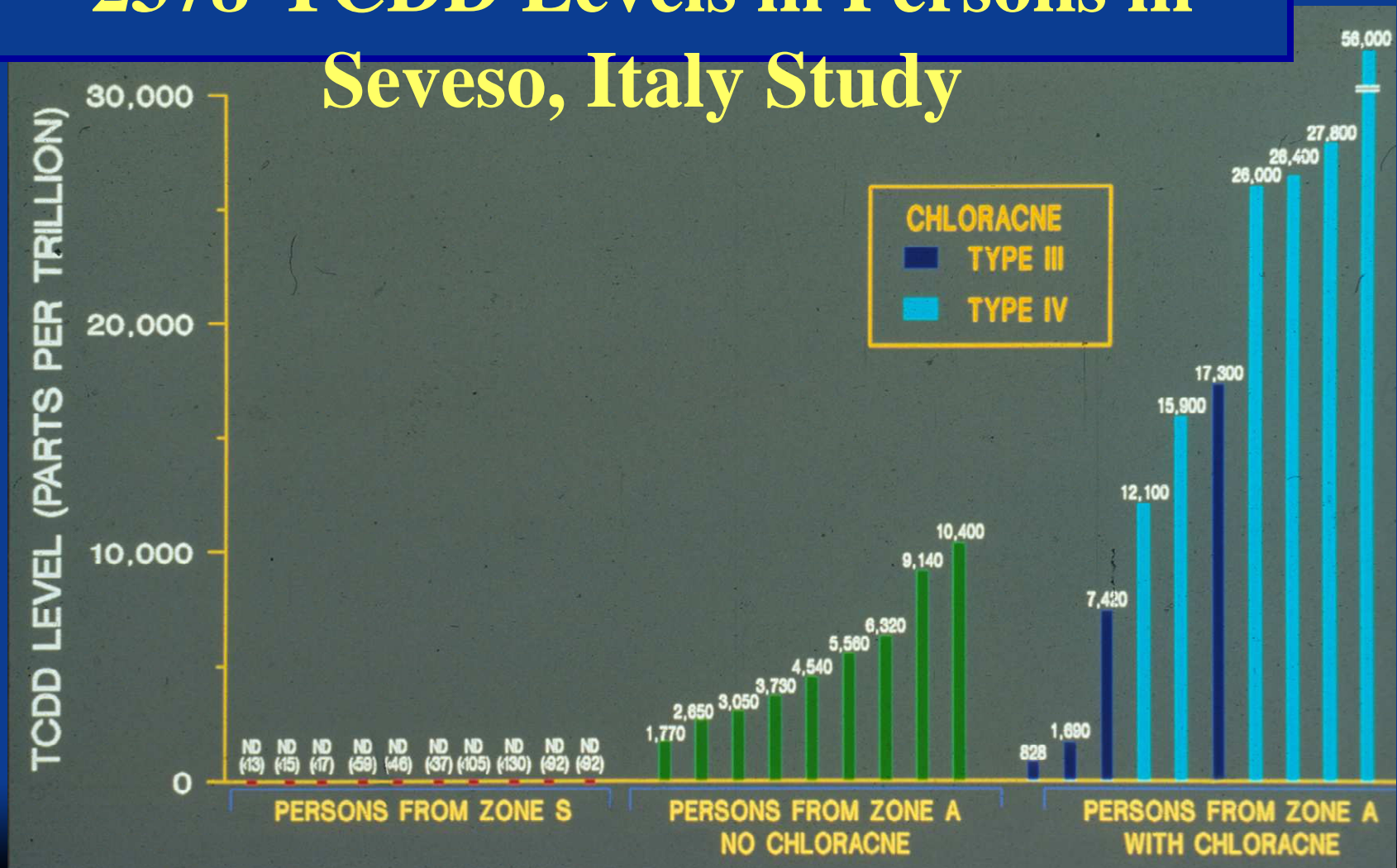




# Seveso, Italy

- Acute exposure
- Wide range of exposure
- Both genders
- Adults and children
- Serum specimens saved from 1976-1985 medical exams

# 2378-TCDD Levels in Persons in Seveso, Italy Study



Mocarelli et al. *J Toxicol Environ Health* 32 (1991) 357-366.



# Change in Sex Ratio with Exposure to Dioxin

- Seveso, Italy Dioxin Explosion
  - ◆ July 10, 1976 factory explosion
  - ◆ A Zone (736 people)
- Normal sex ratio (106 M and 100 F)

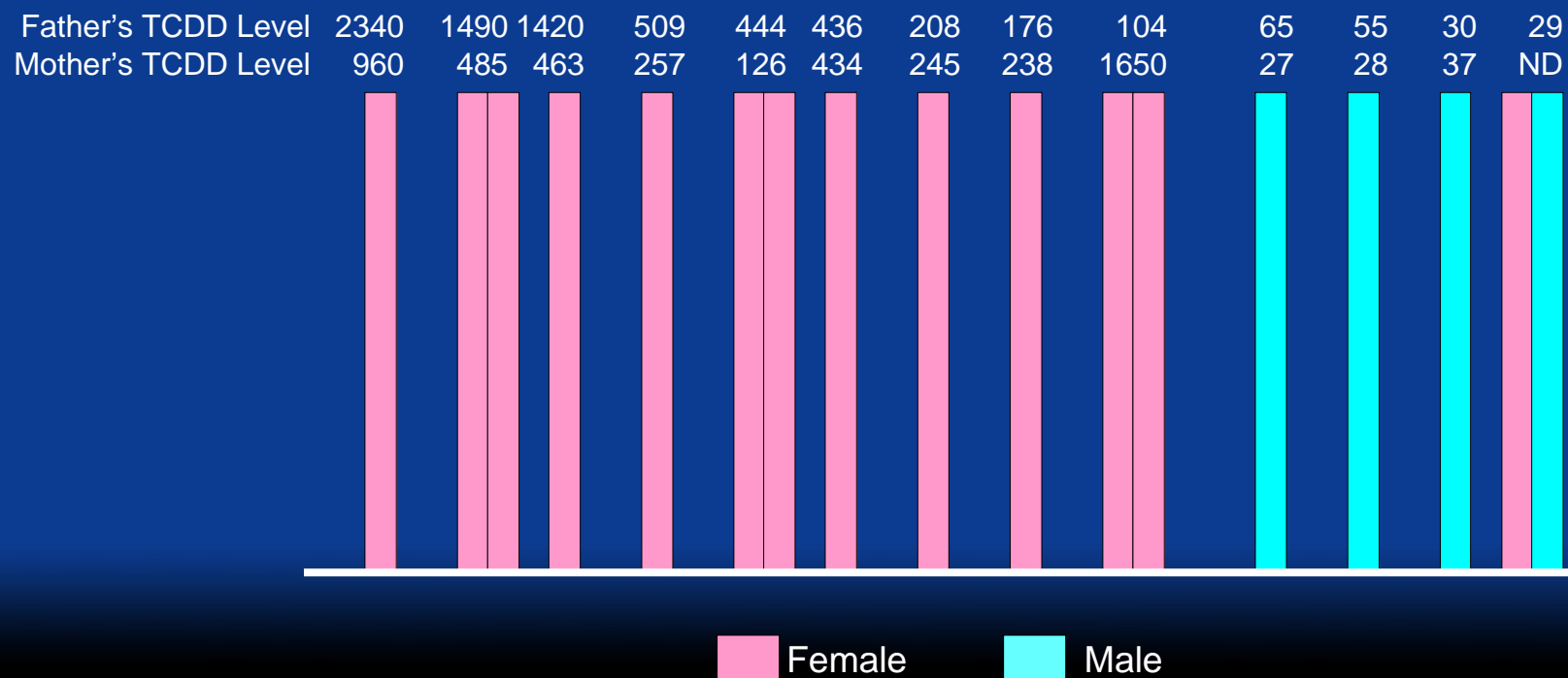
Mocarelli, Brambilla, Gerthoux, Patterson, Needham, *The Lancet*, 348:409 (1996)

# Change in Sex Ratio with Exposure to Dioxin

- 74 Total births from 9 months after accident to December 1984 (~1 half-life of serum TCDD)
  - ◆ Excess of females (26 M vs. 48 F)
  - ◆  $X^2$  ( $P < 0.001$ )
- From 1985 to 1994
  - ◆ 60 Males and 64 Females

Mocarelli, Brambilla, Gerthoux, Patterson, Needham, *The Lancet*, 348:409 (1996)

# Sex Distribution of Children Born April 1977 – December 1984 to Parents with Measured Serum TCDD Levels (ppt) in Zone A – Seveso, Italy



Needham et al. Teratogenesis, Carcinogenesis, and Mutagenesis. 17:225-240 (1997).

# Paternal Concentrations of Dioxin and Sex Ratio Offspring

In Seveso Area:

- From 1977-1996: 346 girls, 328 boys born
- Measured 1971, 1977 TCDD levels in 239 men, 296 women
- No association with lowered sex ratio with maternal TCDD levels
- Lower sex ratio with increasing paternal serum TCDD levels ( $p=0.008$ )
- Fathers exposed when  $<19$  years sired significantly more girls (sex ratio = 0.38; 95% CI = 0.30 – 0.47)

Mocarelli, et al. *The Lancet*, **355**:1858-1863 (2000)