



# Health Impacts of the Industrialized Food System

Food Matters: A Clinical Education and Advocacy Program

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# Farm as Factory

*“The economic reductionism of modern industrial agriculture subjects the farm to the simplification, standardization and abstraction of a factory.”*

- James Scott, 1998

- Focus on inputs / outputs
- Specialization
- Resource intensiveness
- Large-scale



# Externalities of the Industrialized Food System

## HEALTH

- Chronic diseases (cancer, diabetes, obesity)
- Antibiotic resistance & food-borne pathogens
- Pesticide exposure (cancer, reproductive, neuro-developmental, and endocrine impacts)
- Asthma and respiratory illness
- Food injustice (hunger, food deserts)

## SOCIETY

- Local economic decline
- Labor issues

## ENVIRONMENT

- Water and air quality
- Energy use and GHG emissions
- Loss of crop and biological diversity
- Soil erosion

## The Food System, Nutrition, & Beyond

Food systems' impacts on health disparities also go beyond the “eating” pathway. Low-income, minority, and immigrant communities also suffer from high exposure to occupational and community health threats associated with food production and processing methods. (Journal of Hunger & Environmental Nutrition, 2009).

## Where in the Food System do Health Concerns Exist?

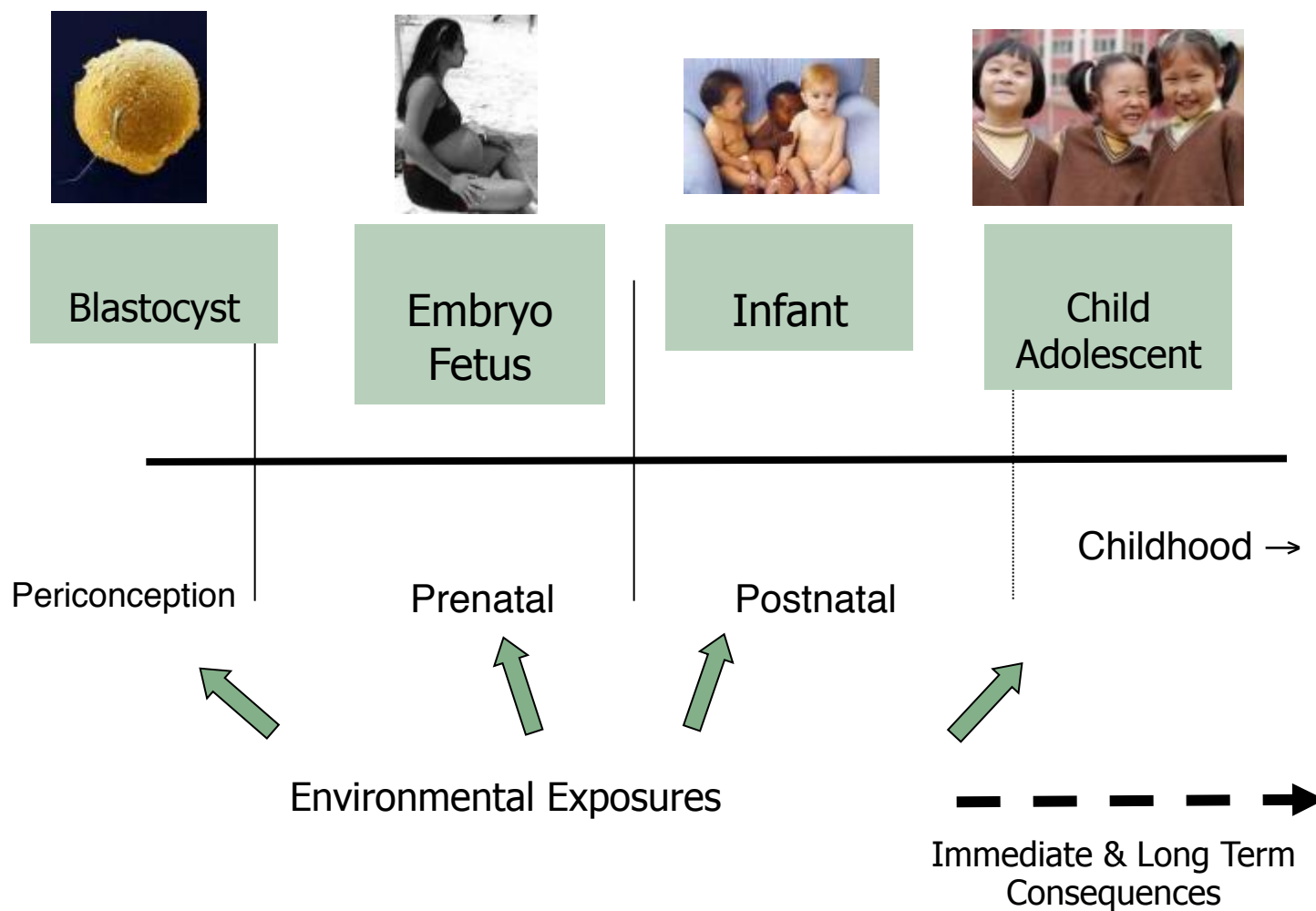
<b>Production</b>	<b>Pesticides</b> , chemical fertilizers, <b>antibiotic and hormone use</b> in meat and dairy production, infectious agents, environmental degradation
<b>Processing</b>	Increased reliance on imported, unregulated processed foods; melamine; residual mercury; <b>food-borne illness</b>
<b>Packaging / Transportation</b>	<b>Bisphenol A (BPA)</b> , phthalates, perfluorochemicals, air quality, food miles, widespread use of plastics leading to large volumes of waste both in landfills and incinerated, environmental degradation
<b>Consumption</b>	Fast food, sugar-sweetened beverages, high fructose corn syrup, marketing, <b>obesogens</b> , nutritionally deplete foods

# Toxins in the Food System

- **Pesticides**
- **Bisphenol A**
- **Phthalates**
- **Dioxins**
  - **PCBs**
- **Metals**
  - **lead, mercury, cadmium, manganese**
- **PBDE flame retardants**

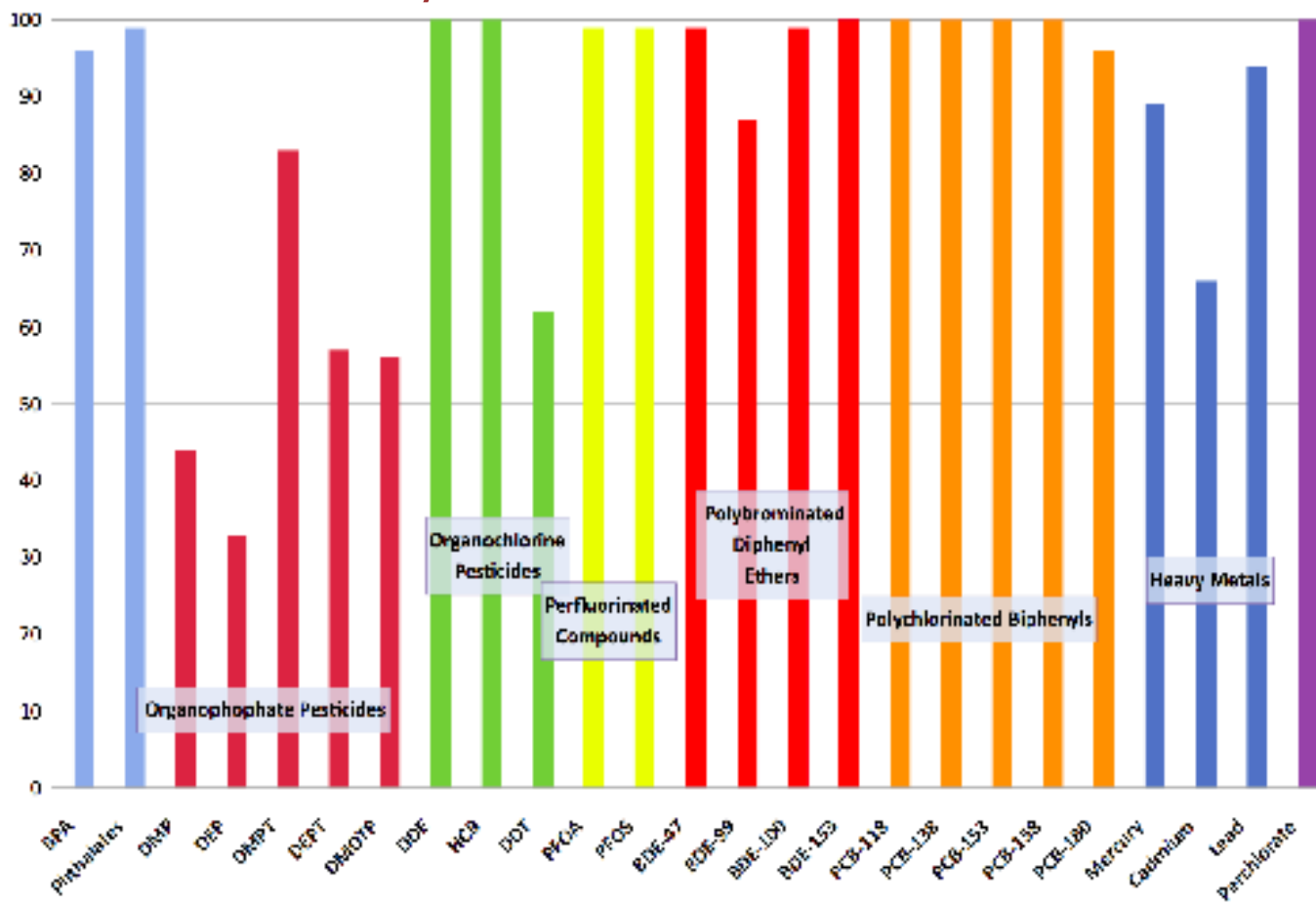


# Critical and Sensitive Windows of Development



# Widespread exposure to chemicals with reproductive/developmental toxicity

Percentage of U.S. Pregnant Women with Detectable Level of Analyte



Based on analysis of representative sample of U.S. population by NHANES 2003-2004.  
Note, not all women were tested for all chemicals



## Body Burden: Pesticide Pollution in Children



Pesticides have been detected in human urine, semen, breast milk, ovarian fluid, cord blood, and amniotic fluid.

Blood from the umbilical cords of 10 infants born in U.S. hospitals in 2004 showed an average of 200 industrial compounds, pollutants, pesticides and other chemicals.

# Breast Milk



- “If breastmilk, nature’s most perfect food, came stamped with an ingredients label, it would read something like this:
  - 4% fat
  - Vitamins A,C,E and K
  - Sugars
  - Essential minerals
  - Proteins
  - Antibodies....
- With traces of:
  - DDT
  - PCBs
  - Trichloroethylene
  - Perchlorate
  - Dibenzofurans
  - mercury, lead, benzene arsenic”

# Our Chemical Environment

## Over 85,000 synthetic chemicals in production

- 3,800 high production volume; used in quantities  $> 1$  million lbs/yr
- ~900 active pesticide ingredients (EPA)
- ~ 3,000 in food processing (FDA)

## Toxic Substances Control Act of 1976 (TSCA)

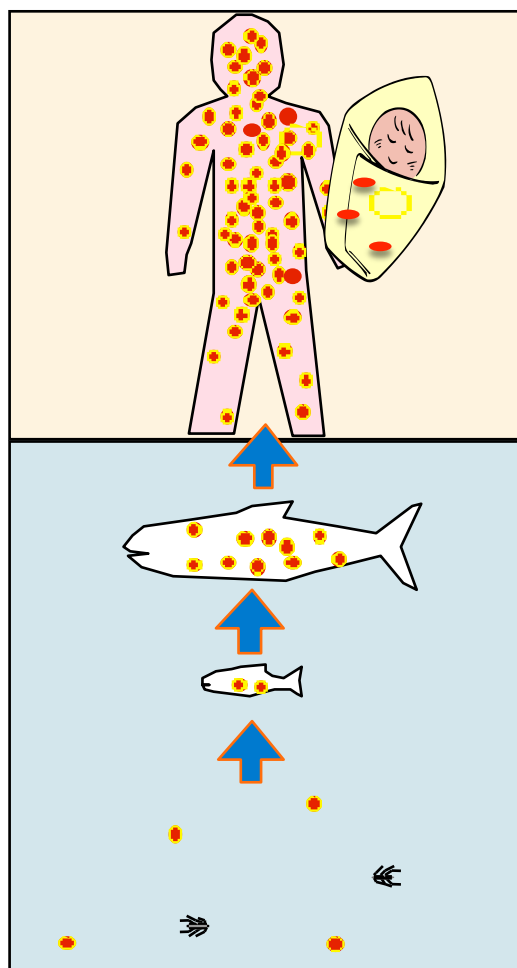
- Health data exists for  $< 10\%$  of chemicals on the market
- 62,000 'grandfathered' in
- Potential for endocrine disruption is not assessed

## Cumulative exposures matter

- Risk assessment and safety standards use a 1-chemical-at-a-time approach



# Persistent Bioaccumulative Toxicants (PBT's)



← Toxicity / vulnerable periods of development

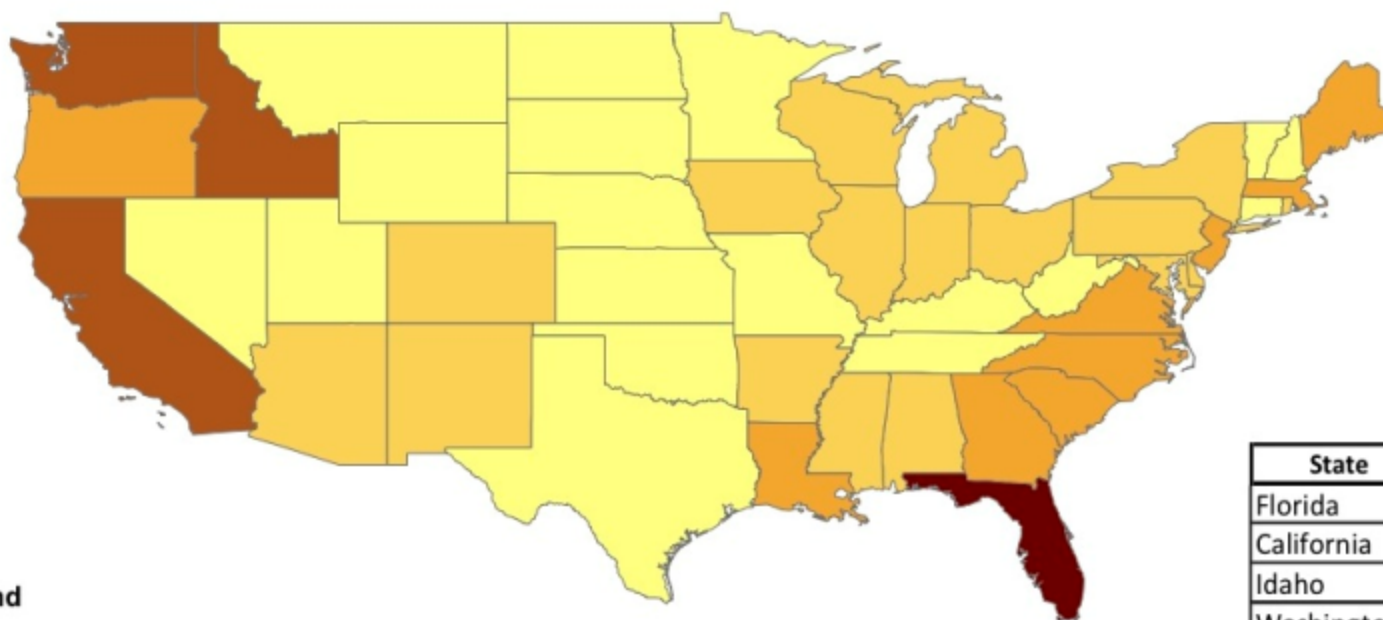
← Bioconcentration

← Persistence

- Mercury
- PBDEs
- Dioxins
  - PCBs
- Pesticides
  - DDT
  - Heptachlor
  - Dieldrin
  - Chlordane

# National Pesticide Use

**TOTAL INSECTICIDE, FUNGICIDE, HERBICIDE, AND OTHER PESTICIDE PER ACRE  
U.S. CROP PRODUCTION: 2002  
Jenks - Natural Breaks Classification**



**Legend**

**TtlPstAc**

- 0.000 - 1.125
- 1.126 - 2.429
- 2.430 - 4.135
- 4.136 - 12.642
- 12.643 - 25.512

State	Lbs/Acre
Florida	25.51
California	12.64
Idaho	6.69
Washington	6.23
North Carolina	4.14
Georgia	3.80
Maine	3.58
New Jersey	3.56
South Carolina	3.26
Virginia	3.23

**SOURCE DATA**

Cropland Acreage per State from 2002 Census Data  
(Quick Stats search parameters Commodity: Ag Land,  
Data Item: Ag Land, Cropland-Acres, Domain: Total, Locale: State  
<http://www.agcensus.usda.gov/Publications/2002/>)

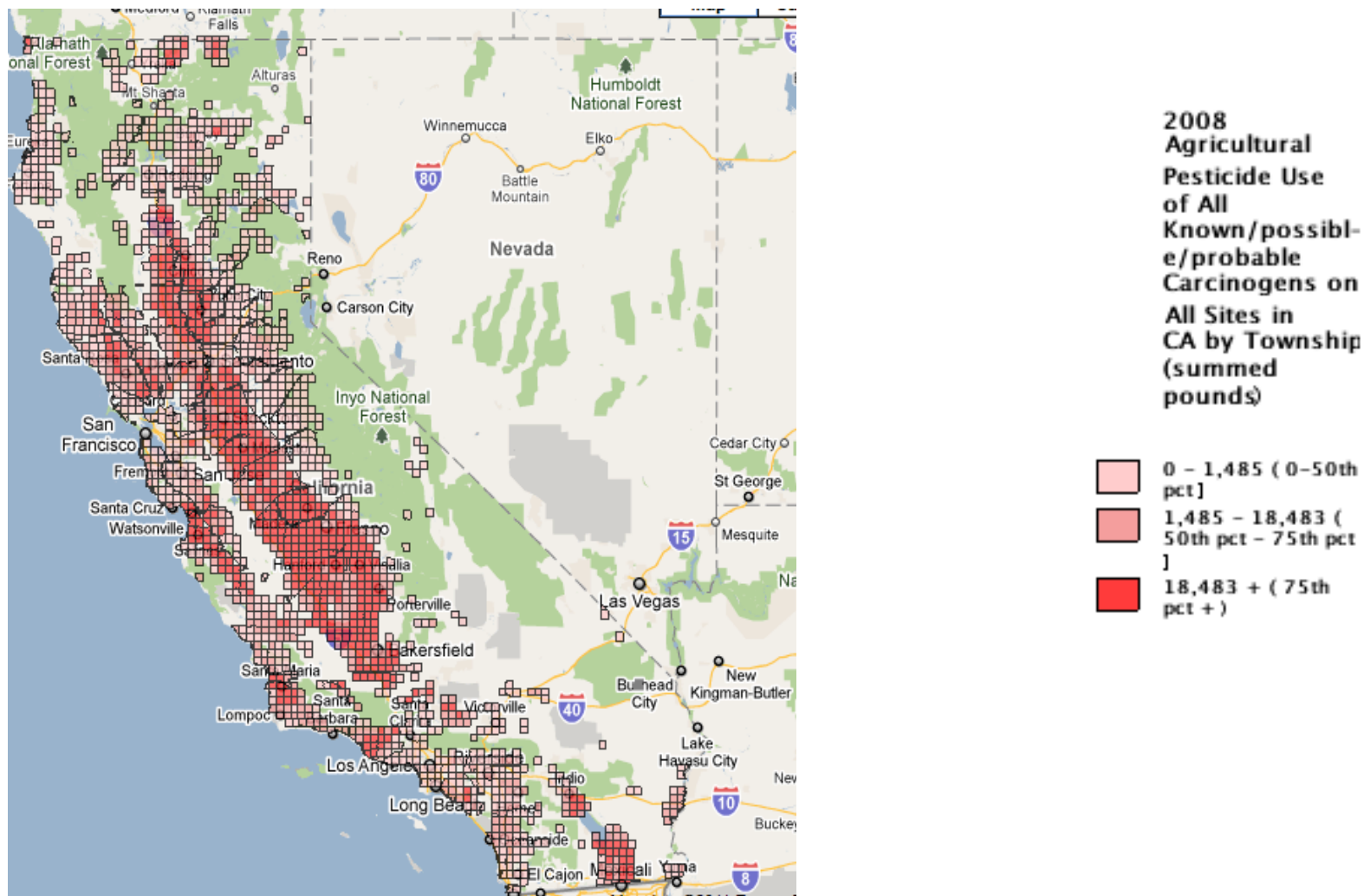
## Cumulative Exposures Add Up

~ 40% of US children may have OP pesticide levels greater than benchmarks for neurological impacts



Payne-Sturges D, Cohen J, Castorina R, et al. Evaluating cumulative organophosphorus pesticide body burden of children: a national case study. Environ Sci Technol. 2009 Oct 15;43(20):7924-30.

# Carcinogenic Pesticide Use in California



CA Department of Pesticide Regulation Pesticide Use Reports, 2008. Mapped by CA Environmental Health Investigations Branch.

# Pesticides and Cancer

## **Occupational exposure and cancer**

- Organophosphate Pesticides – NHL, Leukemia
- Arsenical Pesticides – Lung, Skin cancer
- Triazine herbicides – Ovary

## **Epidemiologic studies associate pesticide exposure with cancer in children**

- Leukemia, neuroblastoma, Wilms' tumor, soft-tissue sarcoma, Ewing's sarcoma, non-Hodgkin's lymphoma, and cancers of the brain, colorectum, and testes



# Non-Cancer Adverse Health Effects

## Prenatal Exposure to Organophosphate Pesticides

- **Decreased Bayley MDI and PDI scores at 36 months**  
(Rauh et al Pediatrics 2006)
- **Greater likelihood of behavioral issues on CBCL**  
(Rauh et al Pediatrics 2006)
- **Abnormal primitive newborn reflexes (Brazelton NBAS)** (Engel et al. Am J of Epid 2007)
- **Decreased birth weight and length**  
(Whyatt et al. EHP 2004)
- **Smaller Head Circumference** (Berkowitz et al. EHP 2004)
- **\*Increased susceptibility to infection** (Winans, et. al; Reprod.toxicol.2011)

# OP Exposure in Children and ADHD

1 139 children ages 8 – 15 (NHANES)

Examined Urinary OP metabolites

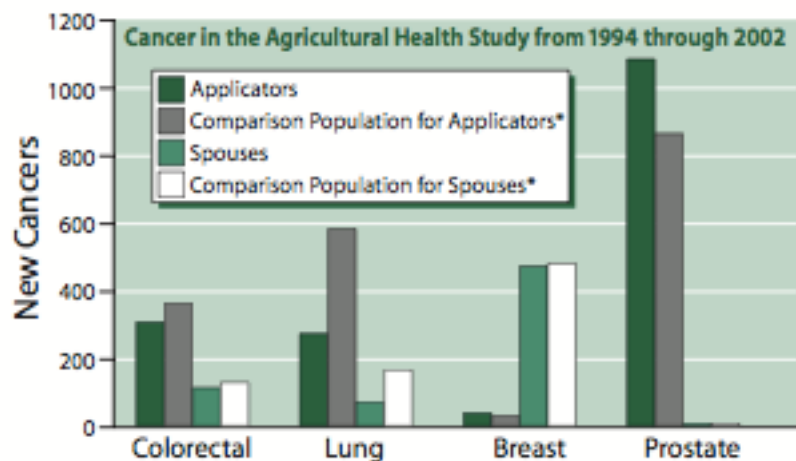
Diagnosis of ADHD by DISC-IV or Med use

- 10-fold ↑ in urinary DMAP associated with an adjusted OR of 1.55 (1.14 – 2.10) for ADHD
- Children with dimethyl thiophosphate > median had OR of 1.93 (1.23 - 3.02) for ADHD compared with children with ND levels

Bouchard et al. *Pediatrics*, 125(6), 2010

# Effects of Adult Male Pesticide Exposure

- Sterility
- Altered semen quality
- Prostate cancer



\*Comparison population is based on age, state, and sex specific rates of disease.



Hauser R. *Semin Reprod Med.* 2006; Swan SH. *Semin Reprod Med.* 2006; Diamanti-Kandarakis E et al. *Endo Rev* 20099

# Effects of Postnatal Female Pesticide Exposure

- Age at puberty and menarche
- Menstrual and ovarian function
- Fertility and fecundity
- Menopause
- Breast cancer

## Science linking environmental contaminant exposures with fertility and reproductive health impacts in the adult female

Pauline Mendola, Ph.D.,<sup>a</sup> Lynne C. Messer, Ph.D.,<sup>a,b</sup> and Kristen Rappazzo, M.P.H.<sup>a,c</sup>

<sup>a</sup> US EPA, Human Studies Division, National Health and Environmental Effects Research Laboratory, Research Triangle Park, North Carolina; <sup>b</sup> Department of Environmental Sciences and Engineering, University of North Carolina, Chapel Hill, North Carolina; and <sup>c</sup> Association of Schools of Public Health Fellow, US EPA, Human Studies Division, National Health and Environmental Effects Research Laboratory, Research Triangle Park, North Carolina

**Study Objective:** To broadly review the recent literature linking environmental factors and adult female reproductive health for the UCSF–CHE Summit on Environmental Challenges to Reproductive Health and Fertility.

**Design:** Reviewed articles indexed in PubMed from 1999–2007 addressing environment and puberty, menstrual and ovarian function, fertility, and menopause.

**Result(s):** The strongest evidence of environmental contaminant exposures interfering with healthy reproductive function in adult females is for heavy metals, particularly lead. Compounds that can influence hormone function, including pesticides and persistent pollutants, are also associated with risk. The pattern of effects for these endocrine-active compounds is often complex, with no clear dose response, but alterations in function and poor reproductive health outcomes are observed. From a clinical perspective, most modifiable risk appears to be associated with exposures in unique populations (contaminated fish consumers) or occupational groups (farmworkers). Many compounds have demonstrated increased risks for reproductive health impairment in women, but the literature is

Mendola P, Messer LC, Rappazzo K.. *Fertil Steril*. 2008;  
Diamanti-Kandarakis E et al. *Endo Rev* 2009

## Farm Workers and Pesticides

- ↑ rates of many cancers & respiratory illness

Mills and Kwong 2001, Linaker and Smedley 2002, Zahm 1997

- ↑ rates of birth defects & childhood leukemia

- Wigle et al. 2009, Van Maele-Fabry et al. 2010.

- 10,000–20,000 acute poisonings per year in the U.S.

EPA 1992, Blondell 1997, Calvert 2008



Mark Harrison © The Seattle Times

## Magnitude of Exposure

**Prenatal OP exposure** in a farm worker cohort associated with lower mental development index scores at 24 months

**Median Maternal Urinary MDA level 0.82 mcg/L**

(Eskenazi et al EHP 2007)

**Child exposure** through conventional produce diet

**Median Child Urinary MDA level 1.5 mcg/L**

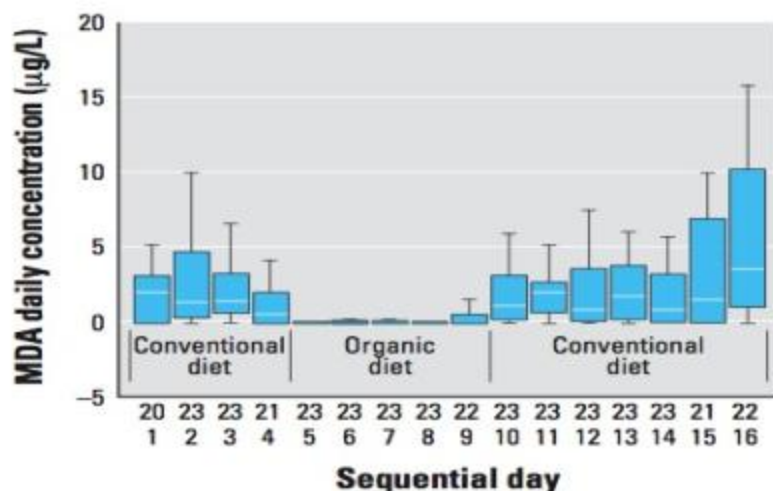
(Lu et al EHP 2006)

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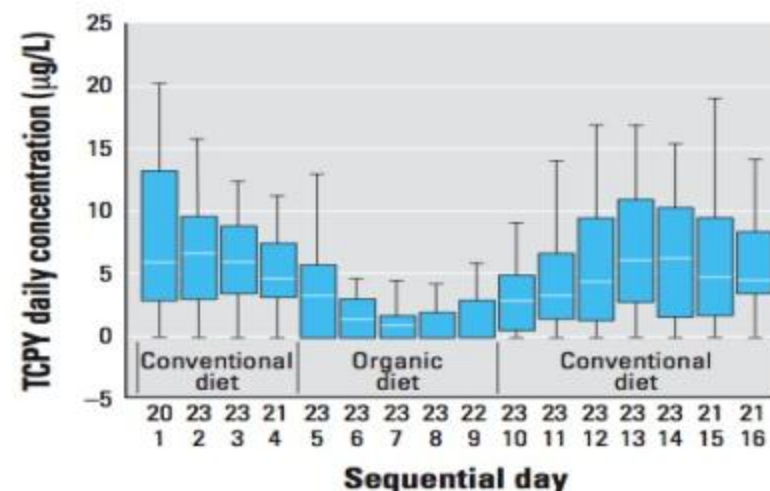
A bit of apples and oranges?

In the same ball park **but** different exposure windows

## Pesticide Exposure Reduction



**Figure 1.** Box plots of DVWA of MDA concentrations in 23 children 3–11 years of age for 15 consecutive days in which conventional and organic diets were consumed. The top row of numbers on the x-axis represents numbers of children.



**Figure 2.** Box plots of DVWA of TCPY concentrations in 23 children 3–11 years of age for 15 consecutive days in which conventional and organic diets were consumed. The top row of numbers on the x-axis represents numbers of children.

### OP residues dramatically reduced (malathion, chlorpyrifos)

- in elementary school children with organic diets substituted for conventional diets for 5 days in a longitudinal design

# Choosing Produce to Reduce Pesticide Exposure

[www.ewg.org/foodnews](http://www.ewg.org/foodnews)



## SHOPPER'S GUIDE TO PESTICIDES

<b>DIRTY DOZEN</b> <i>Buy These Organic</i>		<b>CLEAN 15</b> <i>Lowest in Pesticides</i>	
<b>WORST</b>	1 Peach	<b>BEST</b>	1 Onion
	2 Apple		2 Avocado
	3 Bell Pepper		3 Sweet Corn
	4 Celery		4 Pineapple
	5 Nectarine		5 Mango
	6 Strawberries		6 Asparagus
	7 Cherries		7 Sweet Peas
	8 Kale		8 Kiwi
	9 Lettuce		9 Cabbage
	10 Grapes (Imported)		10 Eggplant
	11 Carrot		11 Papaya
	12 Pear		12 Watermelon
			13 Broccoli
			14 Tomato
			15 Sweet Potato

 ENVIRONMENTAL WORKING GROUP  
[www.foodnews.org](http://www.foodnews.org)



## 10 Minimize Pesticide Exposure

- Wash all produce prior to eating it, even organic — including anything to be peeled or with outer rinds like citrus or watermelon.
- Avoid indoor exposures to pesticides, herbicides, and rodenticides whenever possible, especially in infants and children, and consider alternatives such as orange oil and other natural products.
- Avoid bringing pesticides into your home on clothing or shoes.
- Be aware of agricultural spraying drift near home, work, or schools.

## Recombinant Bovine Growth Hormone (rBGH)

- Used to increase milk production in dairy cows
- ↑ udder infections, necessitating the use of antibiotics
- ↑ levels of insulin-like growth factor (IGF-1) found in milk



Banned in  
Canada, Australia, New Zealand, Japan, all 25  
countries of the European Union

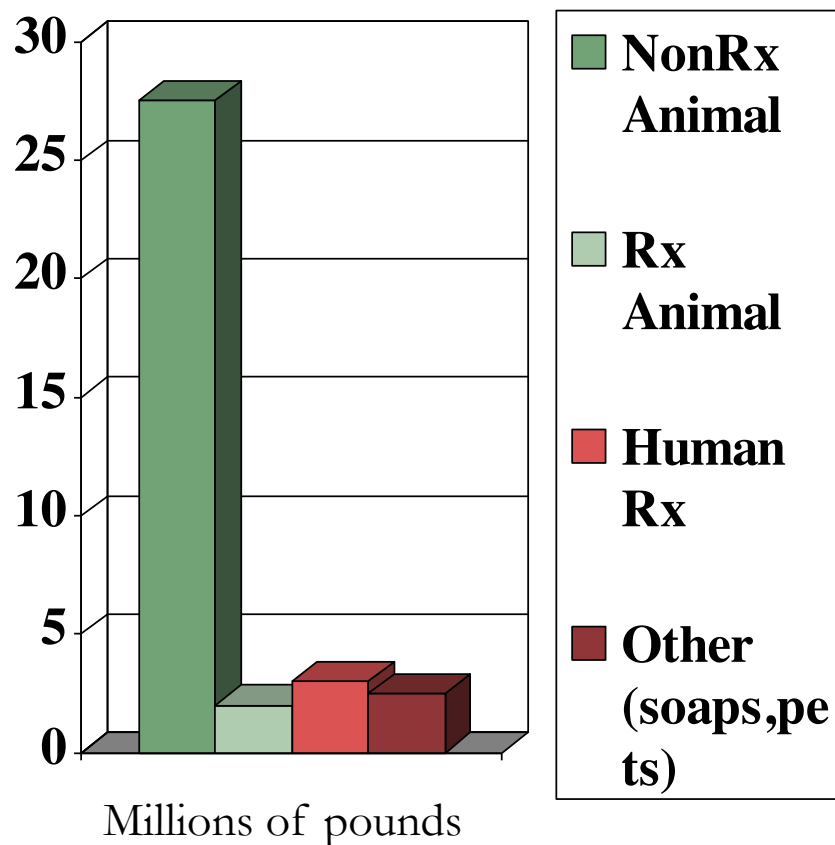
# The Antibiotic Resistance Crisis

Each year in the United States, at least 2 million people become infected with bacteria that are resistant to antibiotics and at least 23,000 people die each year as a direct result of these infections.

<http://www.cdc.gov/drugresistance/threat-report-2013/index.html>



# United States Antibiotic Use



■ ~80% is nontherapeutic use in livestock production

■ Antibiotics widely used in livestock production:

Erythromycin

Tetracycline

Bacitracin

Penicillin

Sulfathiazole

Sulfamethazine

Tylosin (macrolide)

Virginiamycin (streptogramin)

Fluroquinolones

(withdrawn in 2000)

Source: Union of Concerned Scientists, "Hoggin' It" 2001

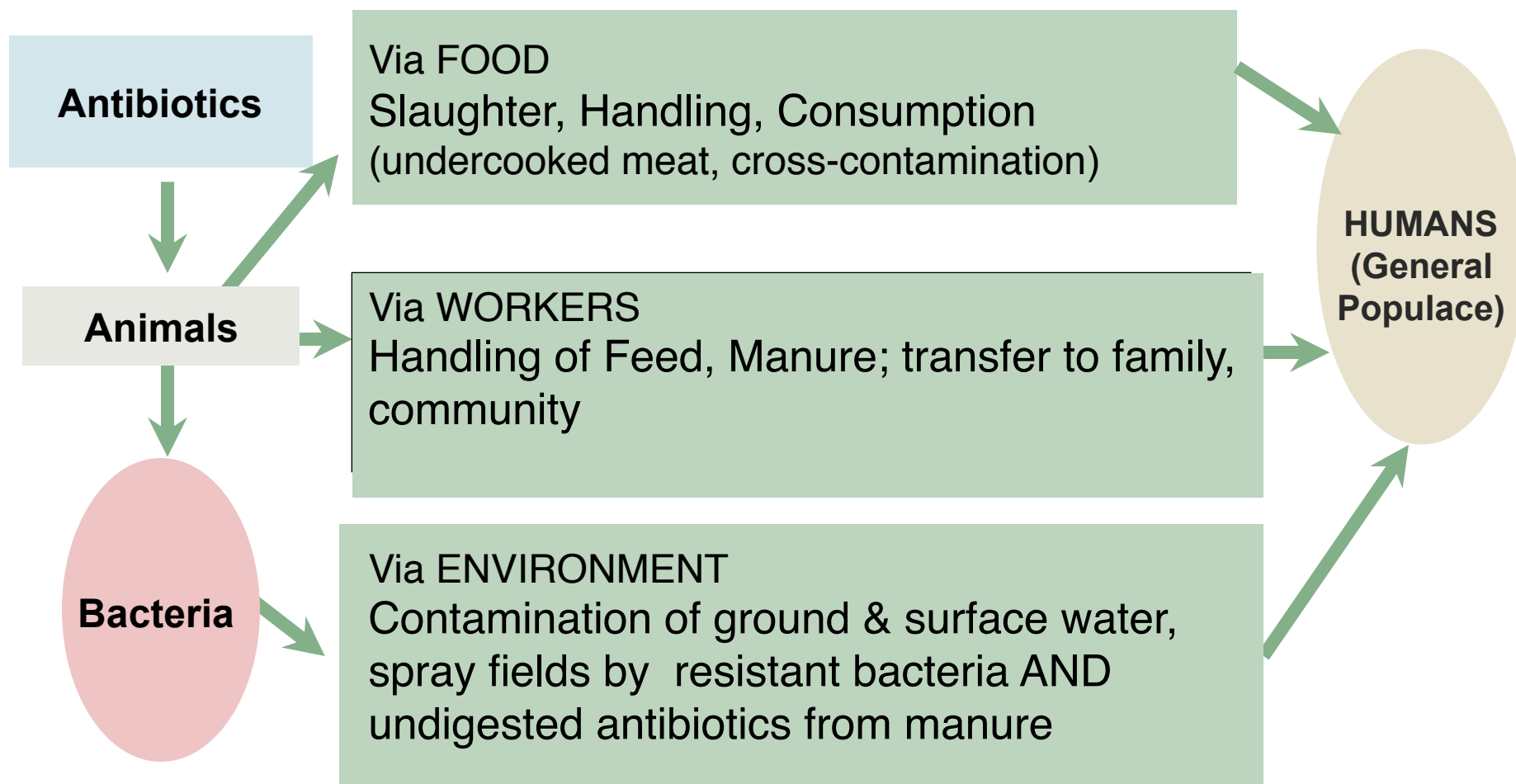
# Agricultural Use of Antibiotics

There is consensus among independent experts that antibiotic use in agriculture contributes to resistant bacteria affecting humans.



Banned in Denmark and  
restricted in the European Union

## Routes of human exposure to resistant bacteria



## Food Borne Illness in the U.S.

- >47.8 million cases annually
  - ~128,000 require hospital care
- ~ 3,000 deaths annually
  - 1/3 are from tainted meat
- Multiple routes of exposure



# “The Isolation of Antibiotic-Resistant Salmonella from Retail Ground Meats”

20% of supermarket samples in Washington D.C.  
were contaminated with salmonella

84% of these isolates were resistant to at least one  
antibiotic

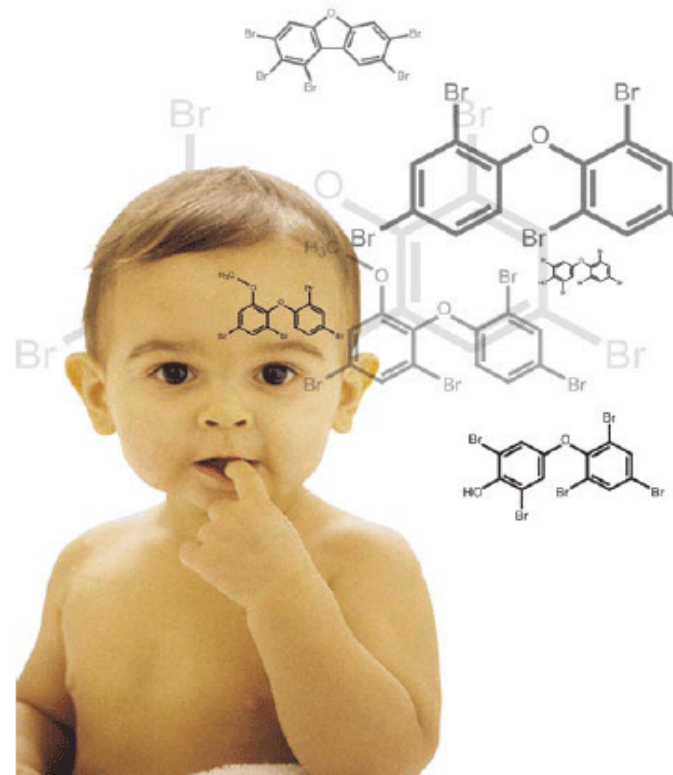


The NEW ENGLAND  
JOURNAL of MEDICINE

Volume 345:1147-1154 October 18, 2001



# Emerging Evidence



# Bisphenol-A (BPA)

## Widespread Human Exposure

- Over 90% of Americans have residues in their urine (CDC)
- > 6 billions lbs produced / year

## Health Concerns

- Endocrine disruption
- Neurodevelopmental impairment
- Developmental toxicity
- Cancers
- Cardiovascular disease & diabetes
- Obesogen/Insulin Resistance



## BPA and Phthalate Exposure: Findings from a Dietary Intervention

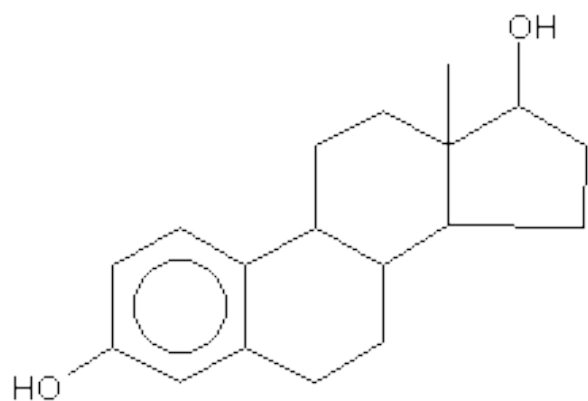
### 3 day “fresh foods” intervention

- Urine levels of BPA and DEHP metabolites ↓ significantly
- ↓ of mean concentrations of BPA by 66% and DEHP by 53-56%

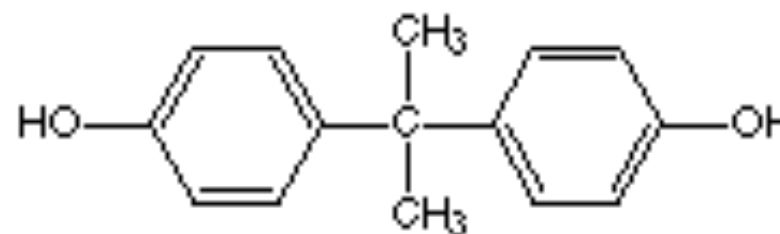


Rudel RA, et al. 2011. *Environ Health Perspect.* 119(7):914-920

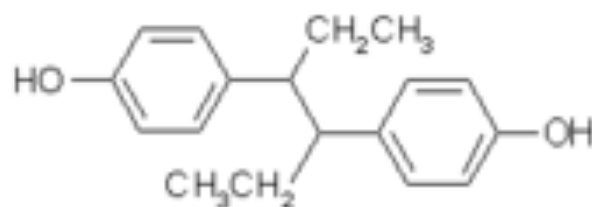
# Chemical Structure



Estradiol



Bisphenol A



4,4'-(1,2-diethyl-1,2-ethene-diyl)bisphenol  
**diethylstilbestrol**  
**DES**

## Endocrine Disrupting Chemicals

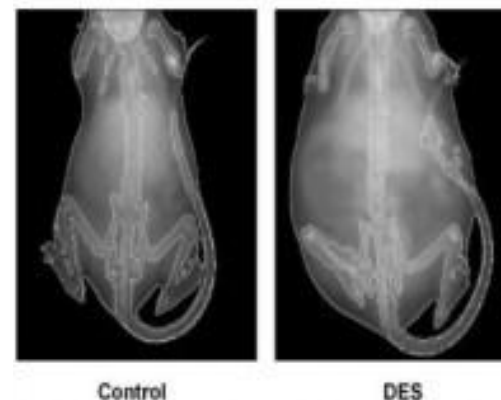
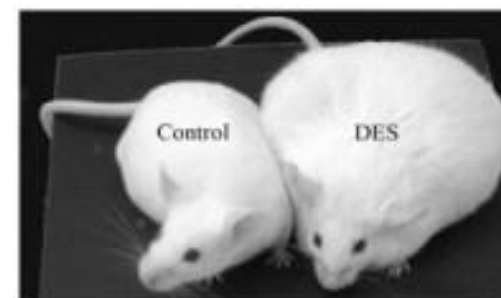
Bisphenol A, PCBs, PBDEs, phthalates,  
organochlorine pesticides, atrazine

- Chemicals that act by interfering with the biosynthesis, secretion, action, or metabolism of naturally occurring hormones
- Health concerns include: reproductive problems, early puberty, brain and behavior problems, impaired immune functions, various cancers

# Obesogens

Bisphenol A, phthalates, non-stick PFOAs,  
and certain organophosphate pesticides

- Chemical compounds hypothesized to disrupt normal development or homeostasis of metabolism of lipids, ultimately resulting in obesity
- Interplay between genes and fetal and early postnatal exposures



## National Academy of Sciences on Animal Data

Studies of comparison between developmental effects in animals and humans find that “there is concordance of developmental effects between animals and humans and that **humans are as sensitive or more sensitive than the most sensitive animal species**”.



## A Precautionary Approach

**An ounce of prevention is worth a pound of cure.**

When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.

-Wingspread Conference on the Precautionary Principle



