Mercury, Air Pollution and Health

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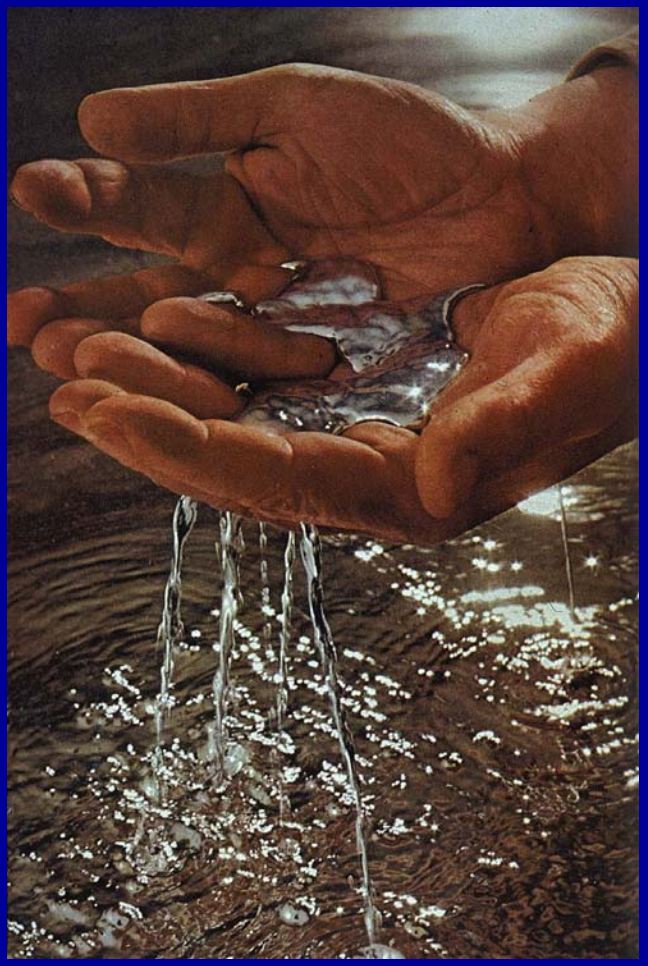
Mercury: An Invisible Poison

Photo credit: Don Breneman/USEPA GLNPO

Quicksilver liquid, like water



Heavy enough to sit on

Mercury- Inorganic & Organic

Hg

Inorganic – Quick Silver

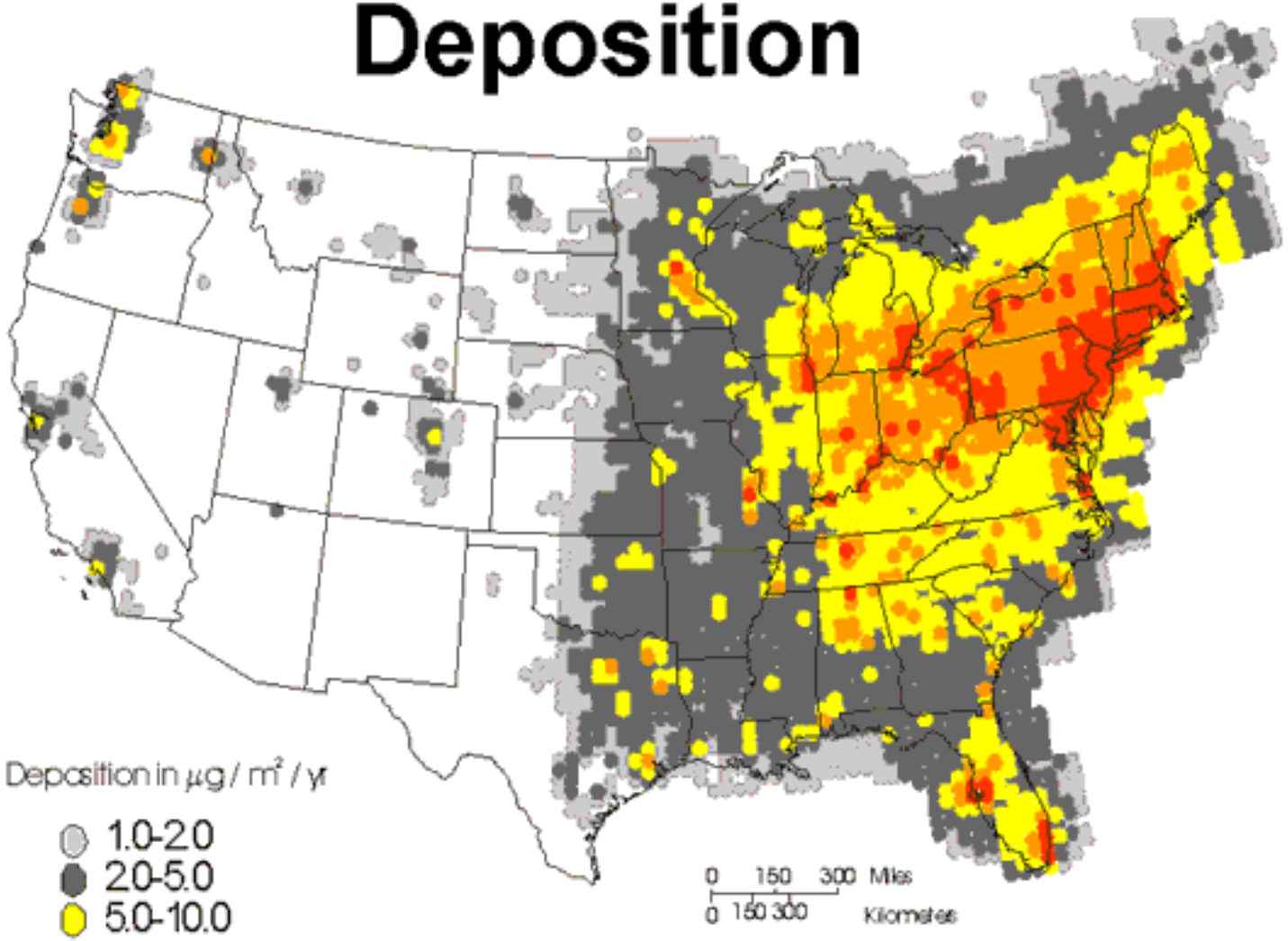
$Hg - CH_3$

Organic – Methyl Mercury

Mercury

- Quicksilver: a liquid metal
- 13.6 times the weight of water
- Evaporates at room temperature
  - Many industrial uses
  - Emitted by coal-fired powerplants
  - Deposited in watersheds
  - Runoff to lakes, streams, ocean
  - Bacteria change to **Methylmercury**

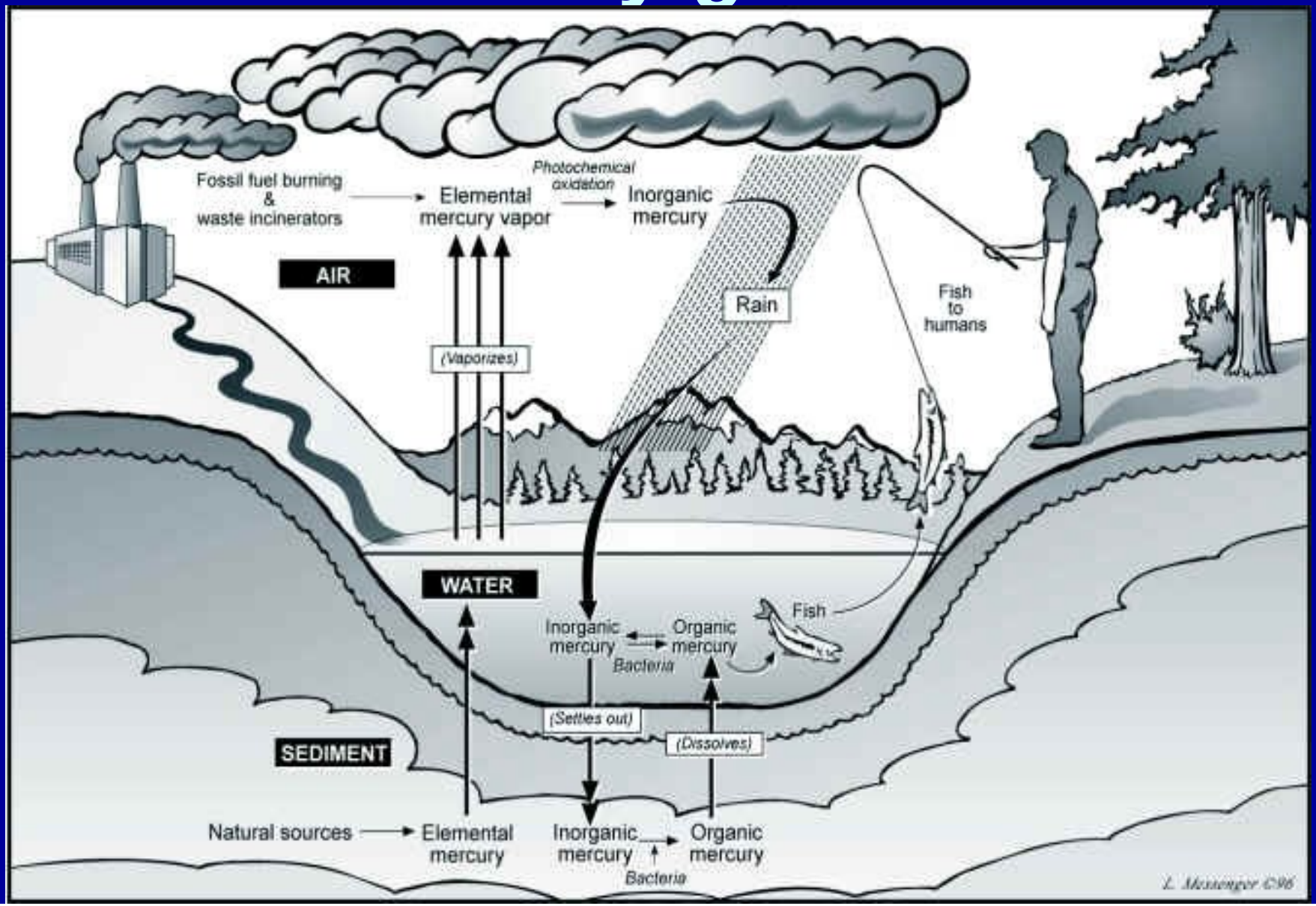
National Atmospheric Hg Deposition



USGS

Source: US EPA, 1998, Mercury Report to Congress

How Mercury gets into Fish



Four Unfortunate Properties of Mercury

- **Biomethylation:** Hg transformed to methyl-Hg form by bacteria
- **Bioaccumulation:** taken up in food web, not removed: concentration increases at each trophic level
- **Global Transport**
- **High Toxicity**

Vulnerable Populations

Native Americans

- Clear Lake, Cal, 1992
- 8-18% fish > 1 ug Hg/g
- 44 tribe members
- Organic Blood Hg
  - Mean 15.6 ug/L
    - Range (3.3-38.8)
  - 9 people (4 women child bearing age) over 20 ug/L
- Population ate 3X more local fish daily than commercial fish

Laurence Cook

Harny, EHP (1997) 105:424-9

Heavy Fish Consumers

Clinic Sample

San Francisco

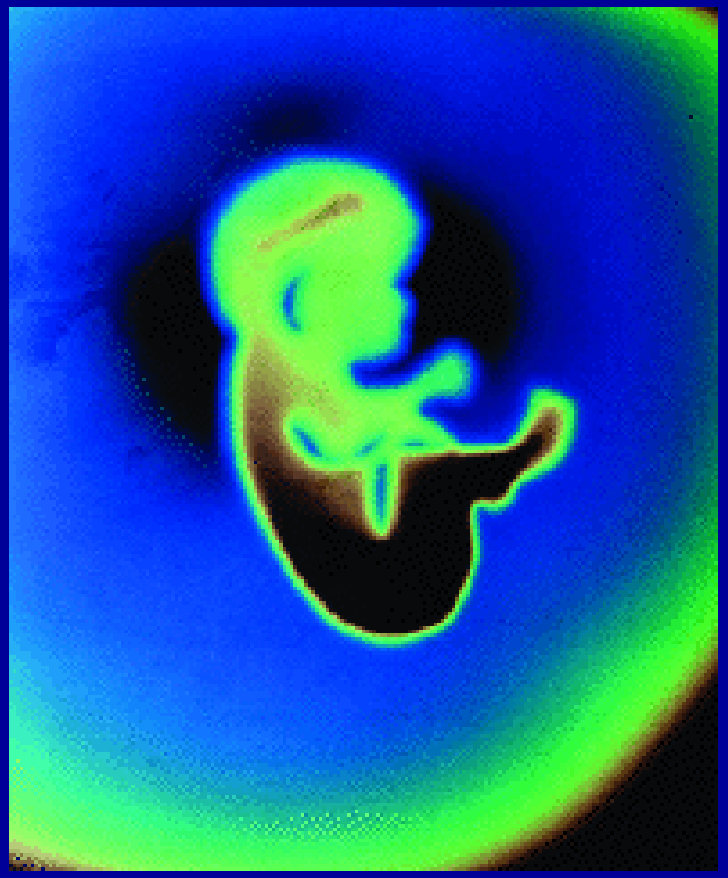
2000-2001

- 89 men/women, 27-87 yo
  - Mean 14.2 ug/L
  - Range 2-89.5 ug/L
- 66 women
  - Mean 15 ug/L
- **Almost 90% <u>ABOVE</u> EPA recommended level**
- Risk Factors
  - Preferred fish (Swordfish)
  - High Socio-Economic Status
  - High Education Level

Hightower, EHP (2003) 111:604-8.

Most Vulnerable

- **The Fetus**
- **Infants and Young Children**



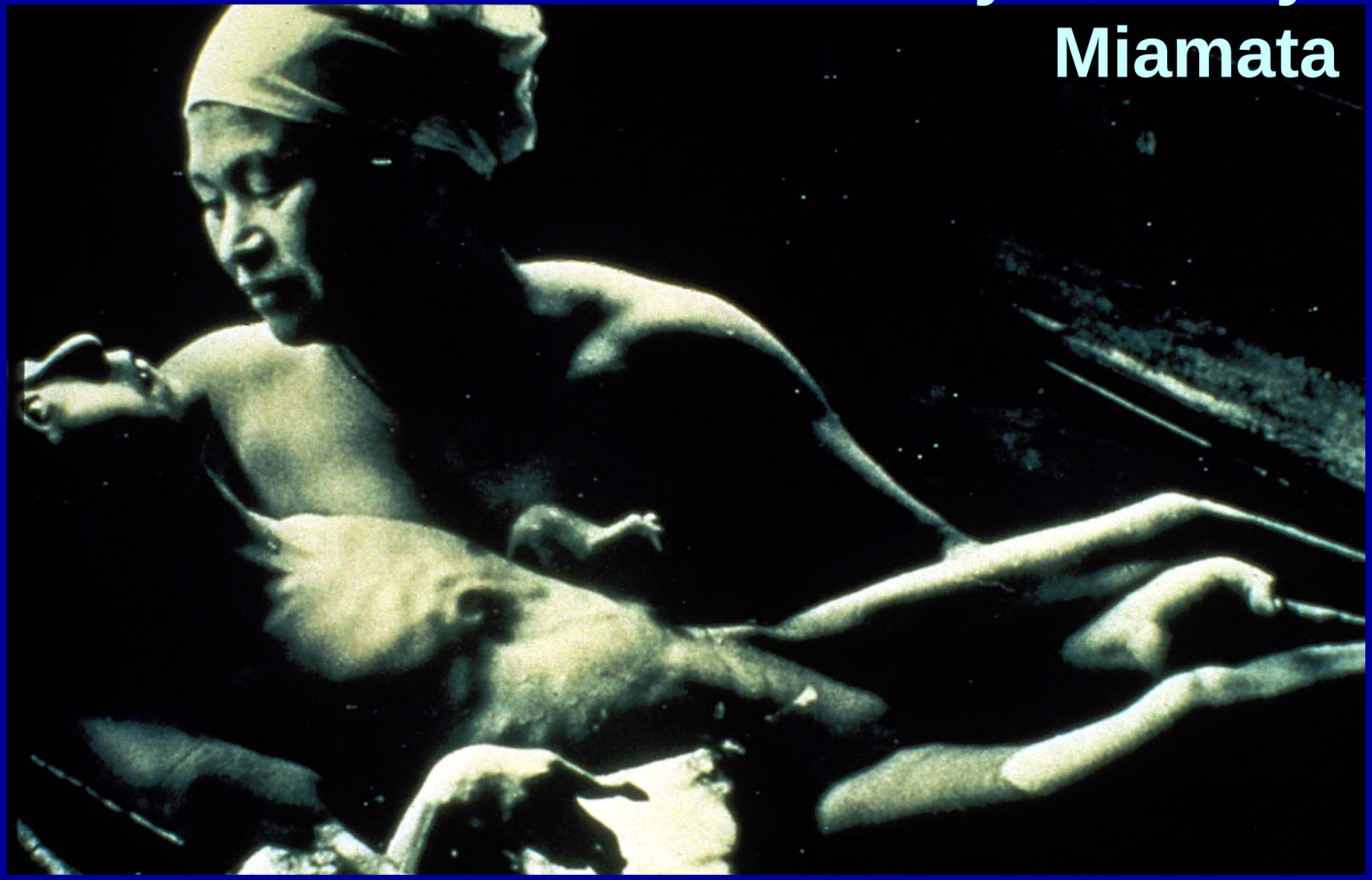
Movement of Methylmercury in Human Body

- Methylmercury is virtually 100% absorbed from the GI tract and widely distributed
  - It crosses the blood brain barrier
  - It crosses the placenta
  - It is secreted in breast milk
- It is degraded slowly by the human body
  - Half-life is 45-70 days
  - Builds up in the brain

Health Effects of Methylmercury

- Death
- Kidney Toxicity
- Cardiovascular Toxicity
- Immunotoxicity
- **NEUROTOXICITY** – The developing fetus is the most sensitive

Fetal Effects of Methylmercury: Miamata



Life-Long Effects of Methylmercury: Miamata

Mechanisms of Developmental Neurotoxicity

- Impedes Nerve Cell Division and Migration
  - Prevents the development of ordered brain architecture
- Interferes with Microtubules of Neurons
- Binds to and distorts DNA and RNA

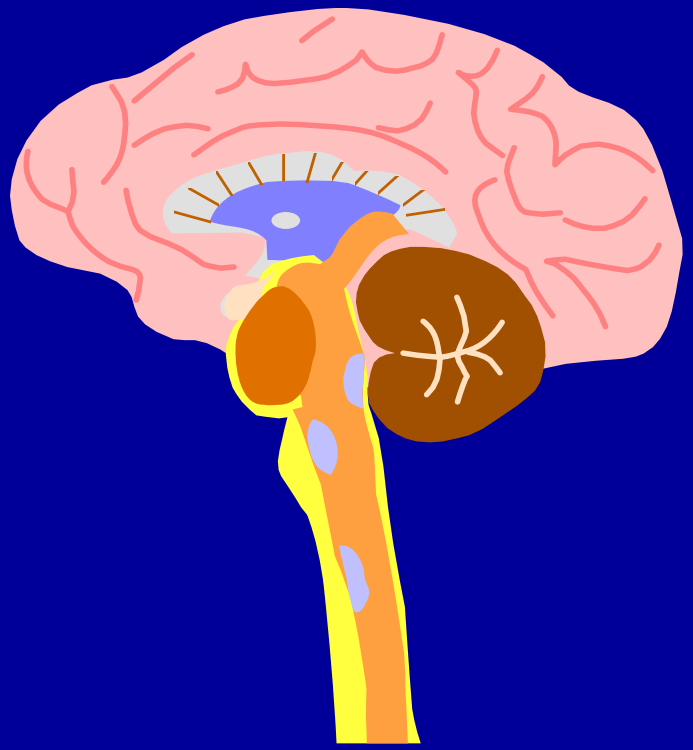
Specific processes disrupted by neurodevelopmental toxicants

proliferation	radiation, ethanol, **mercury**, cholinesterase inhibitors
migration	radiation, **mercury**, ethanol
differentiation	ethanol, nicotine, **mercury**, lead
synaptogenesis	radiation, ethanol, lead, triethyl tin, parathion, PCBs
gliogenesis & myelinization	dec. thyroid, ethanol, lead
apoptosis	ethanol, lead, **mercury**
signaling	ethanol, cholinesterase inhibitors, **mercury**, lead, PCBs

Cellular Events in Neurodevelopment

Summary

- Critical sequence
- Vulnerable to disruption
- Downstream effects
- Size, timing, duration influence impact
- Susceptible throughout adolescence



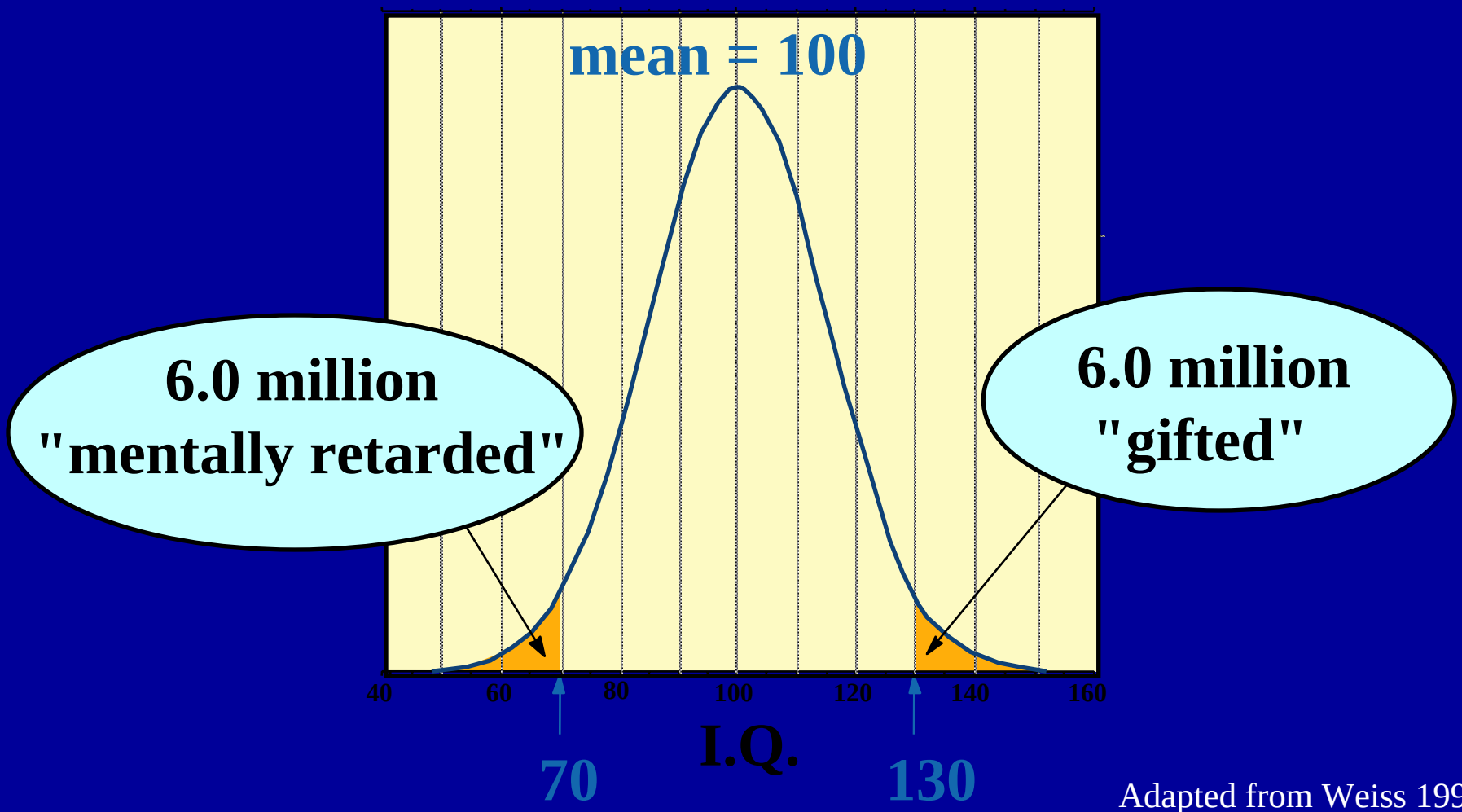
Health Impact Fetus

- 1.16 million US women eat sufficient amounts of mercury contaminated fish to pose a risk to future children
- Small doses cause subtle but permanent impairments of
  - Language
  - Attention and Memory
  - Fine Motor
  - Visual Spatial Skills

Health Impacts Fetus continued

- Studies done and their results
  - New Zealand study showed that IQ lowered by 3 points if women had child born and their hair mercury levels > 6mg/g
  - Seychelle study showed no real evidence of harm except in one test which is the least dependent on translation, had small numbers of study participants

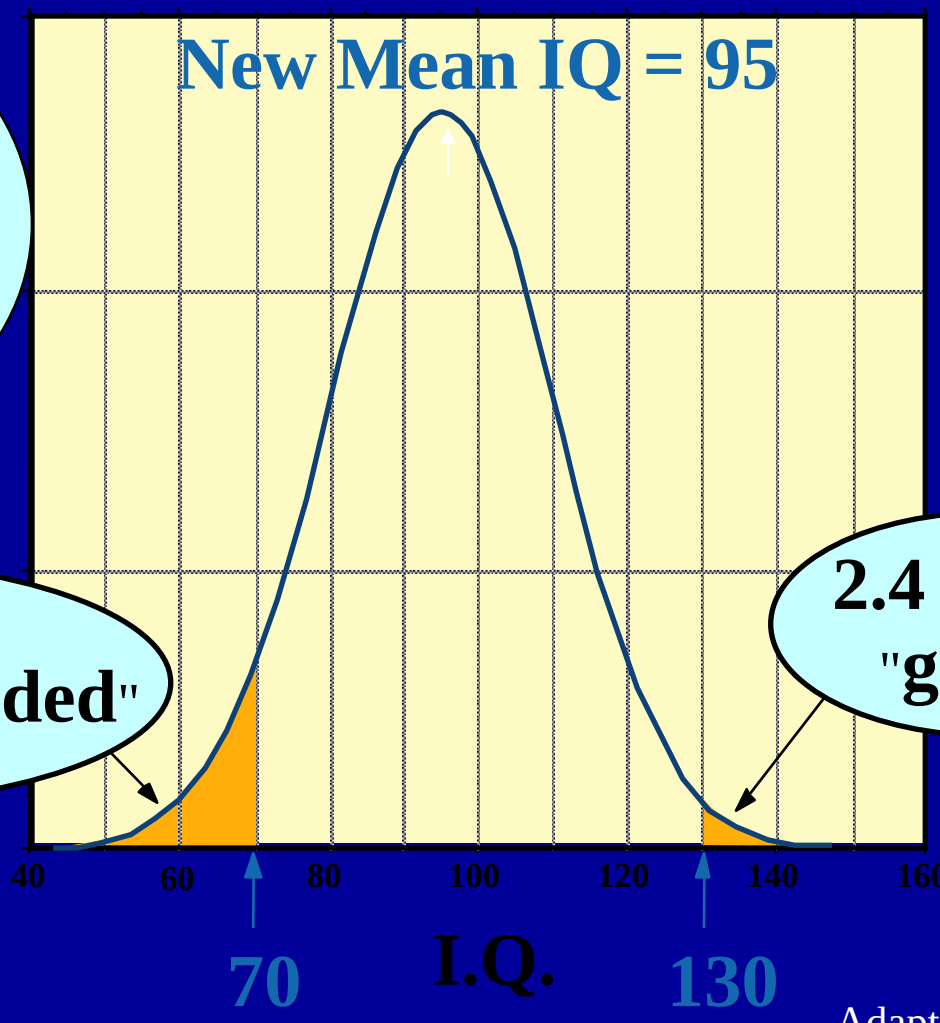
IQ Distribution In Population Of 260 Million



Adapted from Weiss 1997

Population Impact of Low-Level Neurotoxicant Exposure:
5 Point Decrease in Mean IQ

57% INCREASE IN "Mentally Retarded" Population



9.4 million "mentally retarded"

2.4 million "gifted"

Adapted from Weiss 1997

Effects in Children

- Mental Retardation
- Ataxia
- Seizures
- Vision Problems
- Hearing Loss
- Delayed Developmental Milestones
- Attention Disorders
- Deficits in Fine Motor Function
- Visual Spatial Disabilities
- Memory Problems

Neurotoxicity in Adults

- Higher Exposures Required
- Different Findings in Brain
  - Focal Nerve Cell Death,
  - Fibrosis and Atrophy
- Different Symptoms
  - Paresthesias, Ataxia, Weakness, Fatigue, inability to concentrate, shyness, vision and hearing loss, spasticity and tremor, coma and death

1865 ILLUSTRATION BY JOHN TENNIEL

Twinkle, twinkle, little bat
How I wonder what you're at

Risk Assessments for Methylmercury

AGENCY	STUDY USED TO SET LEVEL	SAFE LEVEL (ug/kg/day)
EPA	**Iraq**	**0.1**
ATSDR	Seychelles	0.3
FDA	Minamata	0.4
WHO	Minamata	0.5 (adults)
Health Canada	Seychelles, Faroes, New Zealand	0.2
North Carolina	Seychelles, Faroes	0.17
Washington State	Faroes	0.05
National Research Council	**Faroes, New Zealand**	**0.1**

0.1 ug/kg/day is equivalent to 5.8 ug/L in Blood

Blood Hg Levels in Women Age 16-49

National Environmental Exposure Study

http://www.cdc.gov/exposurereport/pdf/SecondNER.pdf

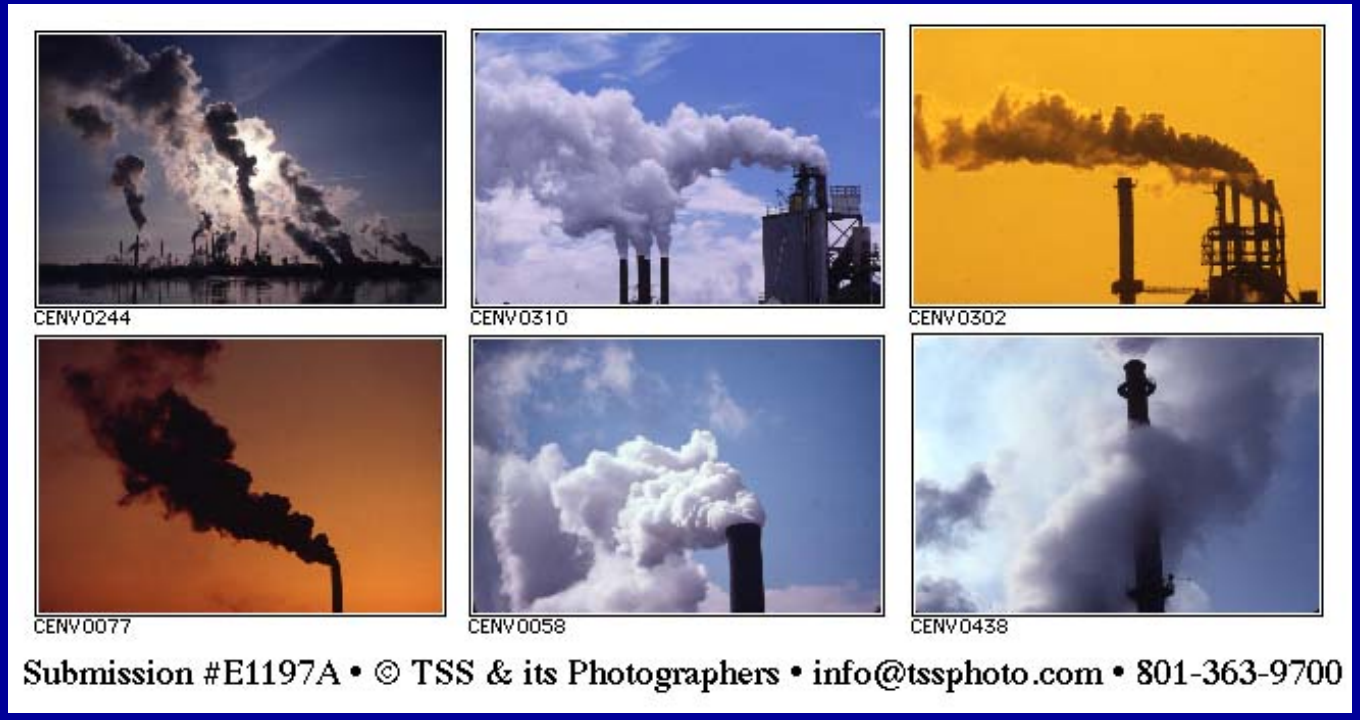
- **Representative sample of the general US population**
  - 1709 women tested
- **Mean: 1.02 ug/L (95% CI 0.86-1.22)**
  - 95th percentile Mean: 7.13 (5.79-8.48)
- **8% of US women of childbearing age above recommended safety level (5.8)**

3.5 MILLION women 20-44 years of age (2000 census)

Fish Advisories for Mercury

- As of 2006, fish consumption advisories have been issued by 48 states (excluding AK, HI)
- Twenty-one states have issued statewide advisories for mercury for freshwater lakes and streams, including Washington (2004 data, released 2005).
- Fifteen states have advisories for all their coastal waters (71% of U.S. coast, excluding AK; 100% of Gulf Coast , HI statewide advisory for marine fish 2003)
- Washington has a statewide advisory for fish, and five specific location advisories

Long-Term Solution:
Reduce Anthropogenic Mercury Pollution



Thanks

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