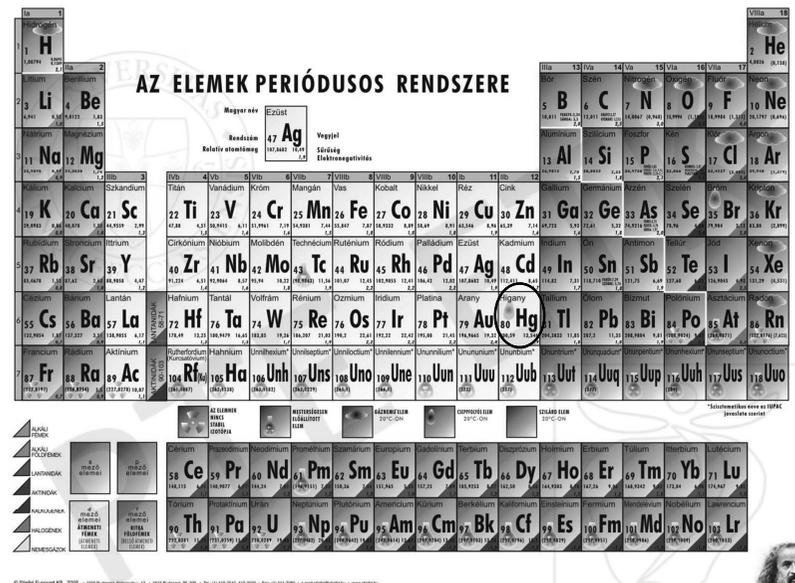


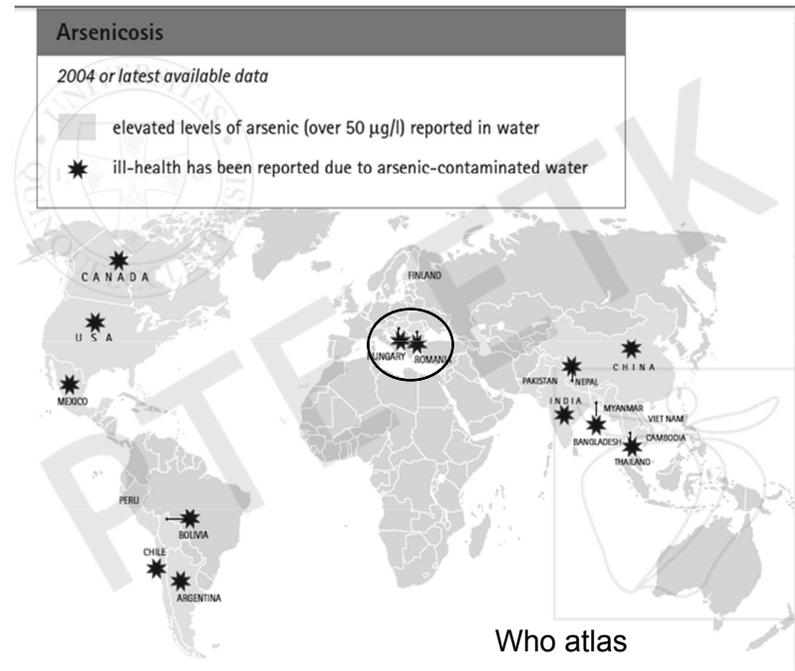


Mercury



Lead May be the Biggest Environmental Risk to Children

- But Mercury is also very serious
- In this talk I will focus mostly on Mercury
- Time will not allow much discussion of Arsenic, Chromium, and Cadmium
 - Important environmental metal toxicants
 - Probably pose more risk to adults than children
 - Arsenic in drinking water is a serious problem in certain localized areas
 - Some of these are European, but highest levels are in parts of Taiwan and in Bangladesh

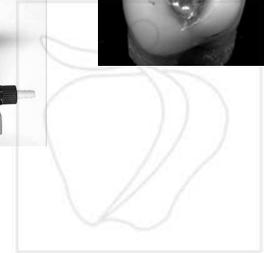
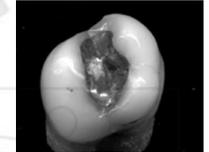
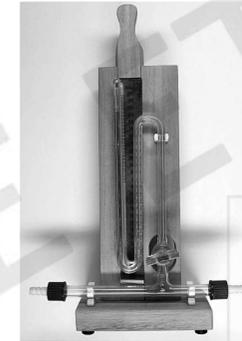
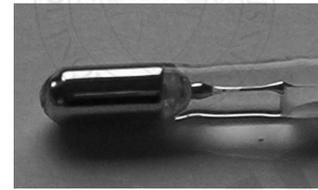


Learning Objectives for This Talk

- Mercury – after this talk you should be able to
 - Describe 3 origins for environmental mercury
 - Explain how mercury becomes methylated
 - Describe at least two developmental stages at risk for mercury poisoning



Application of mercury



6

www.wikipedia.org

Application of mercury II.

- paint
- medication
- pesticide
- battery
- fluorescent light bulbs
- facial creams
- antifungal agent
- vaccination
- chloride-production



7

Main types of mercury

- elementary mercury
- methyl-mercury
- ethyl-mercury



8

How can mercury get into the human body?

- inhaled air
- dental filling
- eating fish and seafood
- other food
- vaccines
- medication



9

Toxic effect of mercury

- well-known for a long time
- medical effects
 - shaking
 - headache
 - vesiculitis
 - loss of memory
 - brain atrophy
 - problems with the nervous system
 - problems with the kidnes
 - dementia
 - problems with walking
- metylation!



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Mercury

- Which of the following is not a significant source of environmental mercury?
 - A. Meteorites
 - B. Burning Coal
 - C. Gold Mining
 - D. Volcanos



The answer is...

A



Mercury Enters the Environment

- Rocks and ocean
 - Natural entry including volatilization from sea
 - Volcanic eruptions
- Human activity
 - Burning coal
 - Waste incineration
 - Mining gold (and mercury)
 - Chlor alkalai chemical production
 - Medical and industrial waste
- Dental amalgam – the “microenvironment”

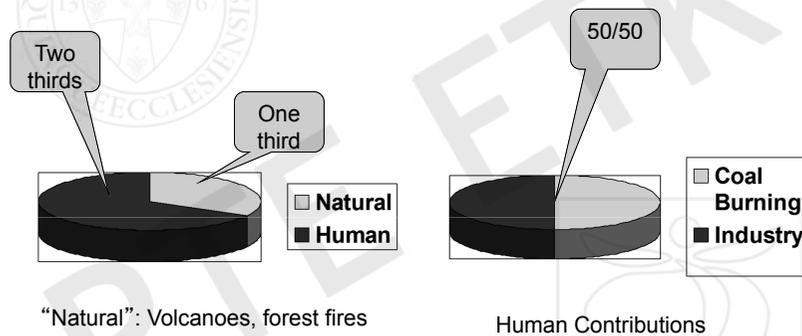


“Natural” vs. Human Mercury

- Which is most correct?
 - A. 50% natural 50% from human activity
 - B. 1/3 natural 2/3 human
 - C. 2/3 natural 1/3 human
 - D. 100% from human activity



Current Estimates for Mercury Deposition in Environment



True or False

- More mercury is currently being added to the environment each year than was the case 150 years ago.
- A. True
- B. False



The Answer was “TRUE”

- One estimate: more than 3.4 times as much mercury is currently entering the environment than 150 years ago even though:
 - In 1856 coal was proportionately more widely used in industry than today and mining was widely practiced without environmental constraints.
 - In the 1848 California “gold rush” 26,000,000 pounds of mercury were used – it is estimated that about 1/3 of this found its way into rivers and entered San Francisco Bay

Industrial Uses of Mercury

- Production of chlorine
 - At least 53 European plants use mercury in large quantities to make chlorine for industry
 - Newer techniques do not rely on mercury
 - Chlorine used largely for plastics (PVC)
 - Also bleach for household, medical, etc.
 - In US – water purification
 - Over 80% of the mercury in this kind of plant in the US is “unaccounted for” – 65 tons (60,000 kilograms)
 - European chlor-alkali emissions said to be < 10% of total (210 tons)

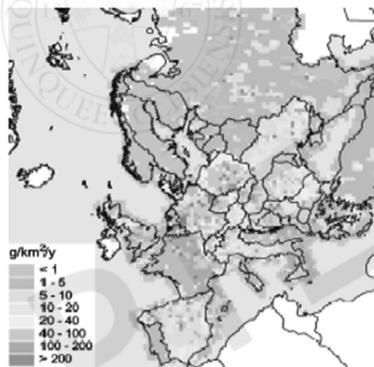


Fig. 3. Spatial distribution of mercury anthropogenic emissions in Europe in 2000

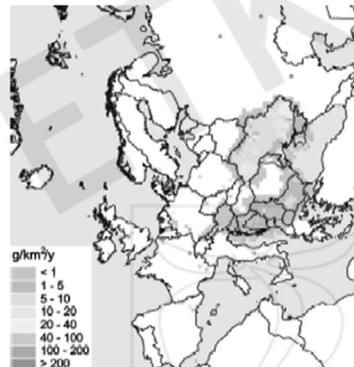


Fig. 4. Mercury emissions from chlor-alkali production in Europe in 2000

Mercury Cell Chlor-Alkali Plants E.U. 2004

Country	Number of Plants	% chlorine capacity
Poland	3 (250,000 tons Chlorine capacity)	50%
Hungary	1 (125,000 tons)	100%
Romania	1 (88,000 tons)	100%
Slovakia	1 (76,000 tons)	100%
Croatia	?	?

How Does Mercury Come to People?

- A. Air we breathe
- B. Food we eat
- C. Water we drink
- D. All of above



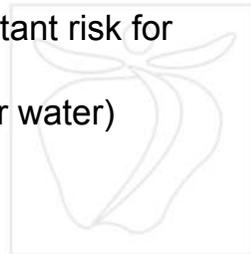
Which is most important source?

- A. Air we breathe
- B. Food we eat
- C. Water we drink
- D. All of above



Mercury Exposure

- We DO risk exposure from all of:
 - Air
 - Water
 - Food
- Of these, food is the most important risk for children
- Most mercury starts as an air (or water) contaminant.
 - How does it get into our food?



How Does Mercury Come Into Our Food?

- A. Broken mercury thermometers at food processing plants
- B. Living close to a chlor-alkali plant that still uses the mercury process
- C. Keeping a lot of gold in your refrigerator that has been refined using mercury
- D. Methylation of mercury



Chlor-alkali Plants

- Recent Swedish study suggests no additional urinary Hg from living near a Swedish or Italian mercury cell plant
 - Sci Total Environ. 2005 Oct 12
- But in Hungary, Romania, Slovakia, and Croatia:
 - A maximum of 30-60% of localized Hg pollution comes from these plants (*average* $\leq 5\%$)
 - In Poland the maximum is lower (10%) probably because other sources contribute significantly

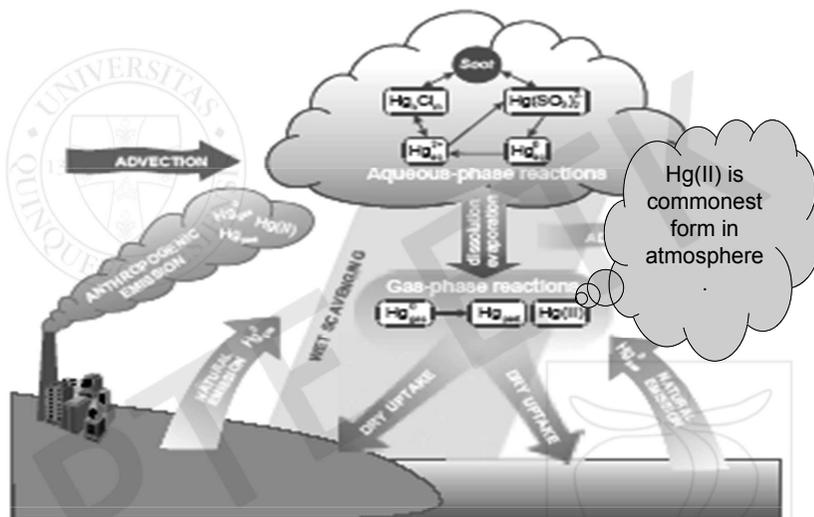


Fig 1. The model scheme of mercury behaviour in the atmosphere MERCURY IS A NON-LOCAL POLLUTANT – IT MOVES!

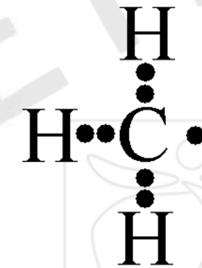
Methylation

- The majority of mercury affects animals in a methylated form.
- Before discussing methylation, let's look how mercury travels between earth, air, and water...

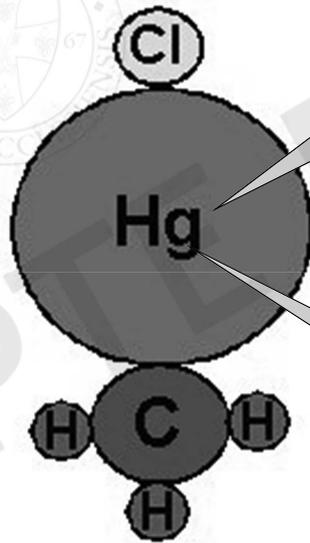
Methylation

- Methylation is the addition of a chemical methyl group to the mercury atom

- Methyl: CH₃



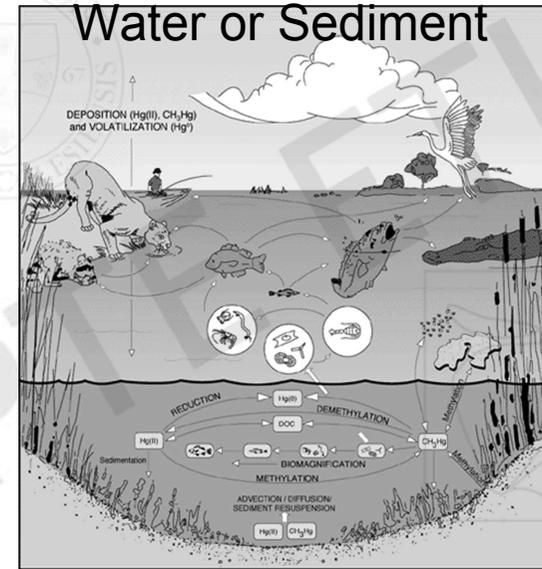
Methylmercury



Very simple
Molecule

Very
Toxic

Methylation: Almost exclusively in Water or Sediment



Methylation occurs primarily in

- A. The ocean
- B. Water with little oxygen and much organic material
- C. Fast flowing river
- D. Large lakes

Methylation: anaerobic process

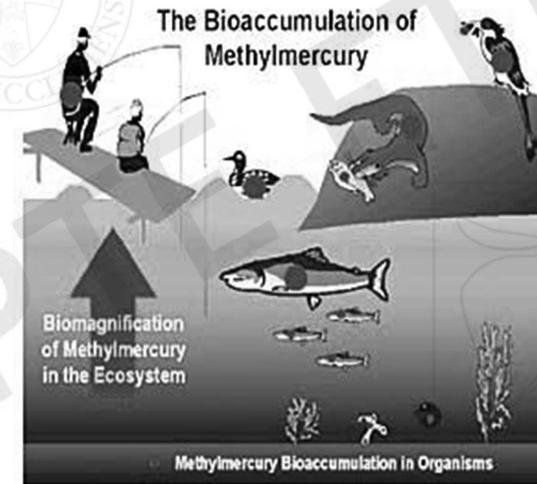
- Methylation is not fully understood
 - Bacteria promote methylation
 - Most of these are anaerobic and produce methane
 - This increases global warming
 - Warm sediments increase rate of methylation
 - “Methylation occurs primarily in aquatic, low pH (acidic) environments with high concentrations of organic matter.”
 - Wetlands
 - River sediments
 - Increased by coal burning and acid rain!

Why is methylation important?

- Methylmercury is absorbed by plants and animals and “moves up the food chain”
- It is very persistent in the environment
- It is very toxic



Methylmercury and the Food Chain



Persistence of Methylmercury

- Because it is an organic compound, methylmercury tends to stay in the foodchain
 - There is probably some reversion to Hg(II) with re-release to the atmosphere and wider dispersion
 - We don't know how much mercury is de-methylated
- There is no simple way to remove methylmercury from the environment



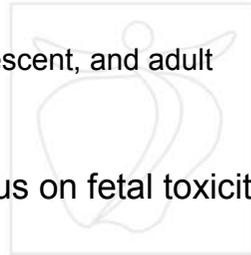
Toxicity of Methylmercury

- Minimata – industrial spill – high levels
- Very sad results (famous Eugene Smith photo):



Toxicity of Methylmercury

- Toxicity of lower levels harder to establish
- Widely recognized that low levels ARE toxic
- Mercury has
 - Definite fetal toxicity
 - Suspected prenatal toxicity
 - Definite but lower childhood, adolescent, and adult toxicity
- Since time is limited, we will focus on fetal toxicity



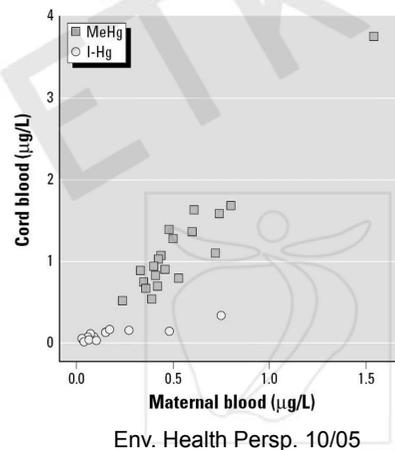
From where does a fetus get methylmercury?

- A. Mother's teeth
- B. Mother's food
- C. Mother's bone stores
- D. All of above



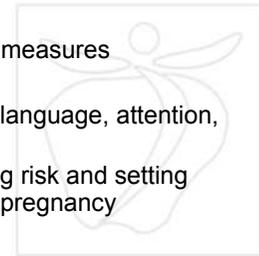
Maternal Blood Levels at Birth

- Infant cord blood levels at birth twice that of mother
 - Good correlation MethylHg with maternal levels
 - Not so close for Hg(I)
- Mothers' levels
 - Methylmercury
 - *Fish in diet*
 - Inorganic mercury
 - Number of fillings
 - New dental work during pregnancy – pregnancy may increase caries
 - Chewing habits (?)



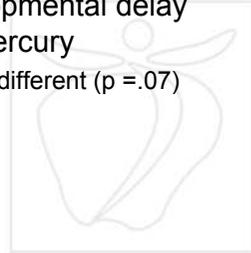
Our Understanding of Toxicity

- Seychelles Study
 - Seychelles – islands with daily fish consumption during pregnancy
 - Maternal exposure: hair levels
 - No dramatic adverse developmental outcomes but power of study only 50% to detect developmental risk
- Faroes Islands Study
 - Similar maternal hair levels + cord blood measures
 - Intake was more episodic – whale meat
 - Developmental deficits noted at 7 years: language, attention, memory
 - Regarded as important study in assessing risk and setting permissible mercury intake levels during pregnancy



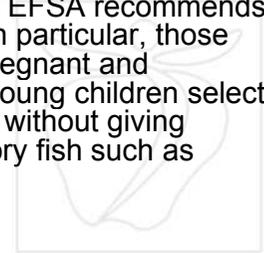
Smaller Studies, Most Recent in Poland

- Jedrychowski et al, 11/2005 Ann. Epidem.
 - Bayley Infant Development Scale at 1 year
 - If cord blood mercury was > 0.8
 - RR of developmental delay was 3.6 (1.4-9.4)
 - Groups with and without developmental delay differed in maternal levels of mercury
 - Cord blood levels not statistically different ($p = .07$)



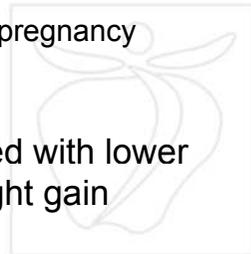
Current Recommendations Based on Best Evidence to Date

- Risk may be evident at 1 part/million in maternal hair or $> 5.8 \mu\text{g/L}$ in cord blood
- How does this translate into maternal fish intake?
 - European Food Safety Authority: “EFSA recommends that women of childbearing age (in particular, those intending to become pregnant), pregnant and breastfeeding women as well as young children select fish from a wide range of species, without giving undue preference to large predatory fish such as swordfish and tuna.”



Fish is Good. Mercury is Bad

- Oken E, Wright RO, Kleinman KP, Bellinger D, Amarasiwardena CJ, Hu H, Rich-Edwards JW, Gillman MW. Maternal fish consumption, hair mercury, and infant cognition in a U.S. Cohort. Environ Health Perspect. 2005 Oct;113(10):1376-80.
- In this study, average 1.2 fish servings/w
 - Maternal Hair Hg was 0.55 (only 10% > 1.2)
 - Visual recognition test at 6 months.
 - Babies did best if mothers, during pregnancy
 - Ate > 2 servings/week
 - Had maternal hair levels below 1.3
- Other data: fish intake associated with lower prematurity and better fetal weight gain



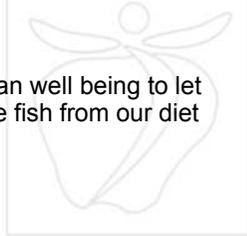
What can we conclude?

- A. Restrict fish consumption in pregnancy
- B. No tuna during pregnancy
- C. Work to reduce further mercury emissions into the environment
- D. Do not restrict fish consumption among pregnant women

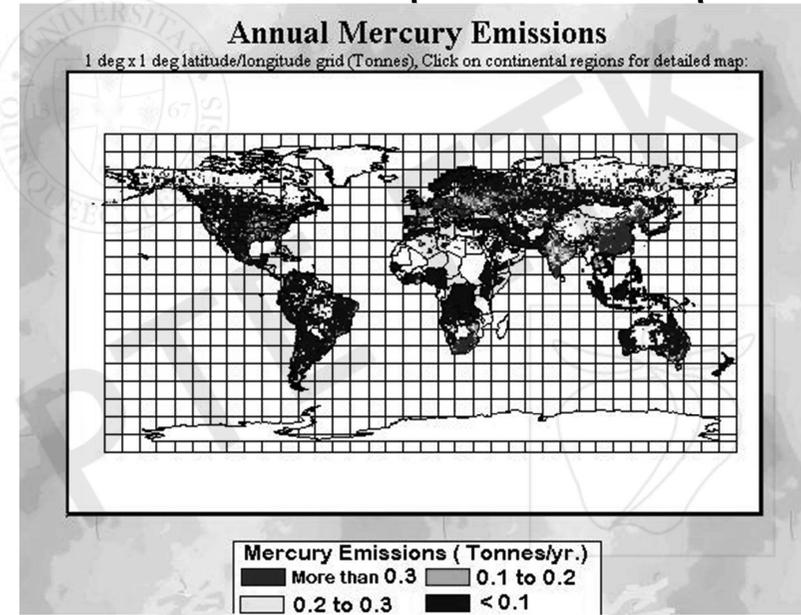


What can we conclude?

- Methylmercury is a developmental toxicant, but the level at which risk occurs remains somewhat uncertain
- Fish is healthy for pregnant women (and other humans)
- We need to identify low mercury fish sources – especially for pregnant women and young children
- We must work to keep new mercury emissions out of the environment
 - This is a political matter
 - Fish consumption is too important to human well being to let increasing environmental pollution remove fish from our diet

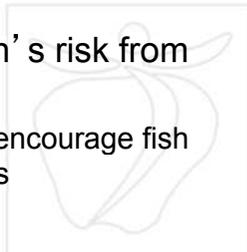


How do we interpret this map?



Conclusion

- Inorganic mercury is toxic, but methylmercury likely poses the greatest human risk
- We must work to reduce coal burning
 - Both for its effect on air pollution and its release of mercury into the environment
- We need further data on children's risk from mercury
 - But pending that data: we should encourage fish consumption by children and adults
 - Avoiding large predator fish



Thank you for your attention!

