

Toxicological and ecological impacts of mercury

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Chemical forms of mercury

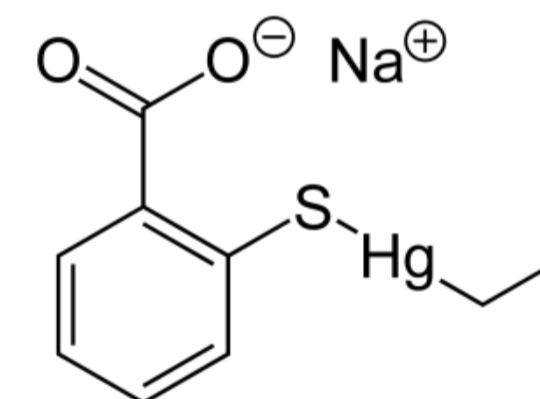


Inorganic mercury

- **Metallic mercury, Hg^0**
- Mercurous mercury (monovalent inorganic mercury), Hg^+
- Mercuric mercury (divalent inorganic mercury), Hg^{2+}

Organic mercury

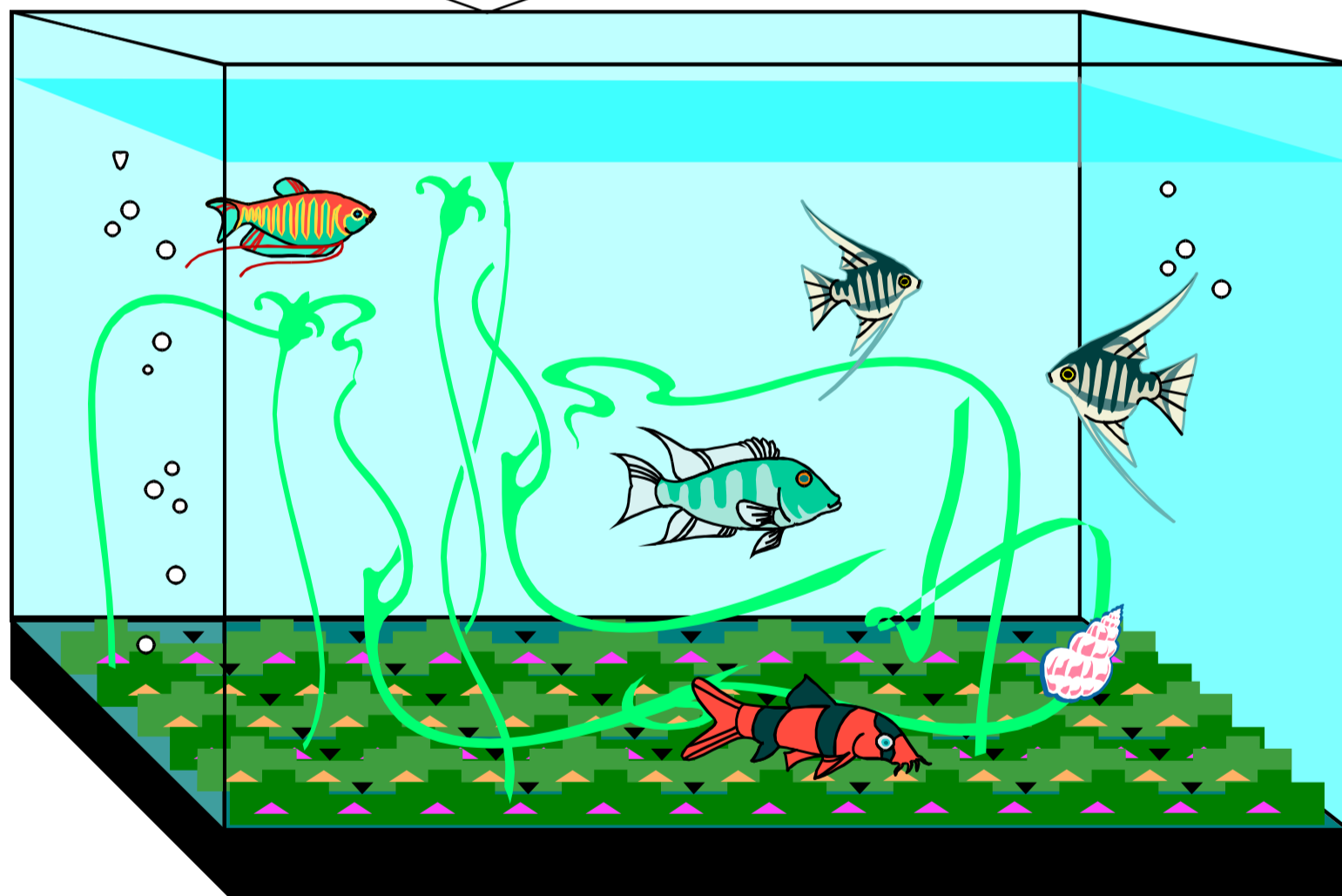
- **Methyl mercury, MeHg**
- Dimethyl mercury, DiMeHg
- Thiomersal
 - (Ethyl(2-mercaptobenzoato-(2-)-O,S) mercurate (1-) sodium





Mercury exposure through the aquatic food chain

Emission and discharge of Hg



Hg methylation by microbial activity in sediments

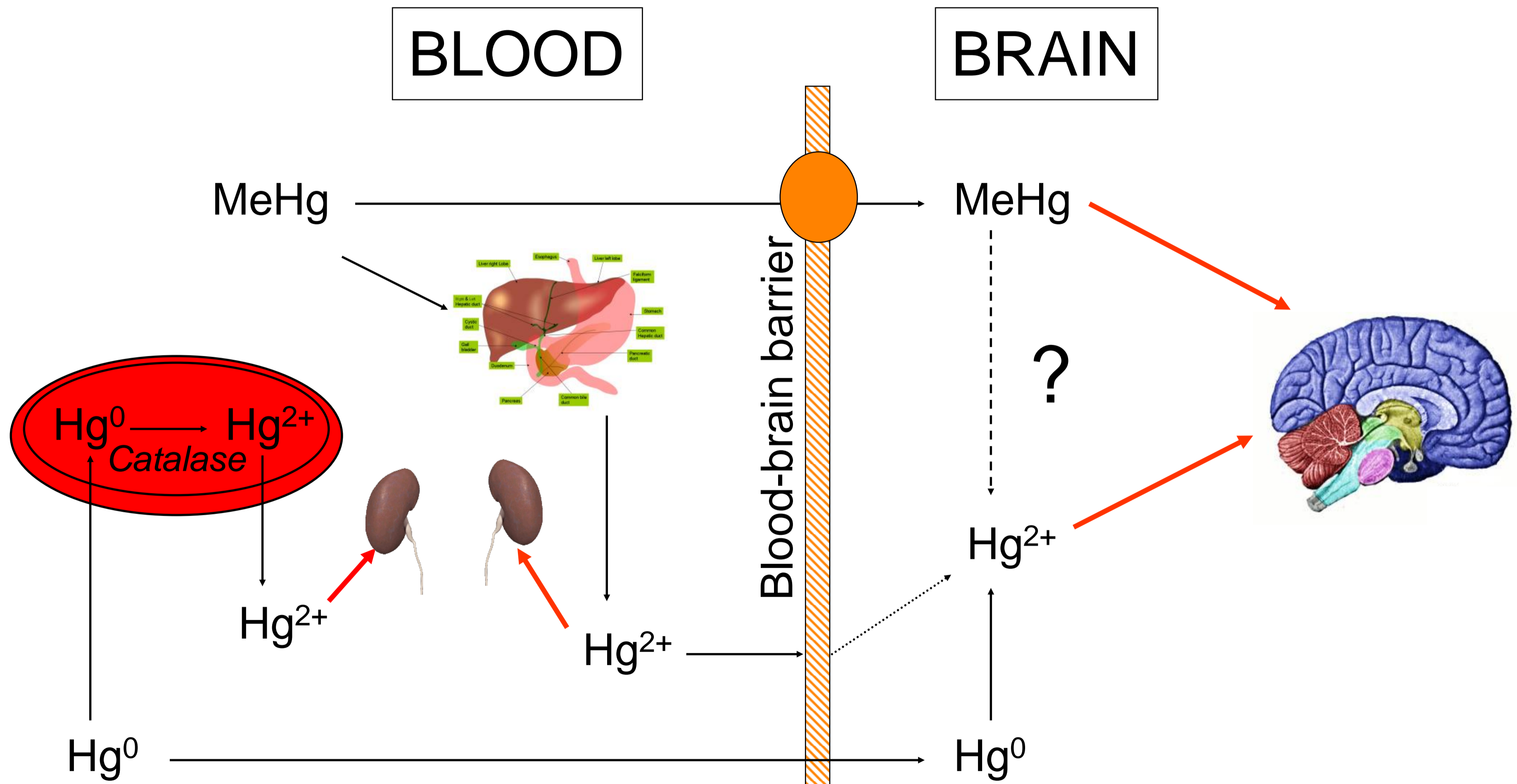


Biomagnification of MeHg in fish

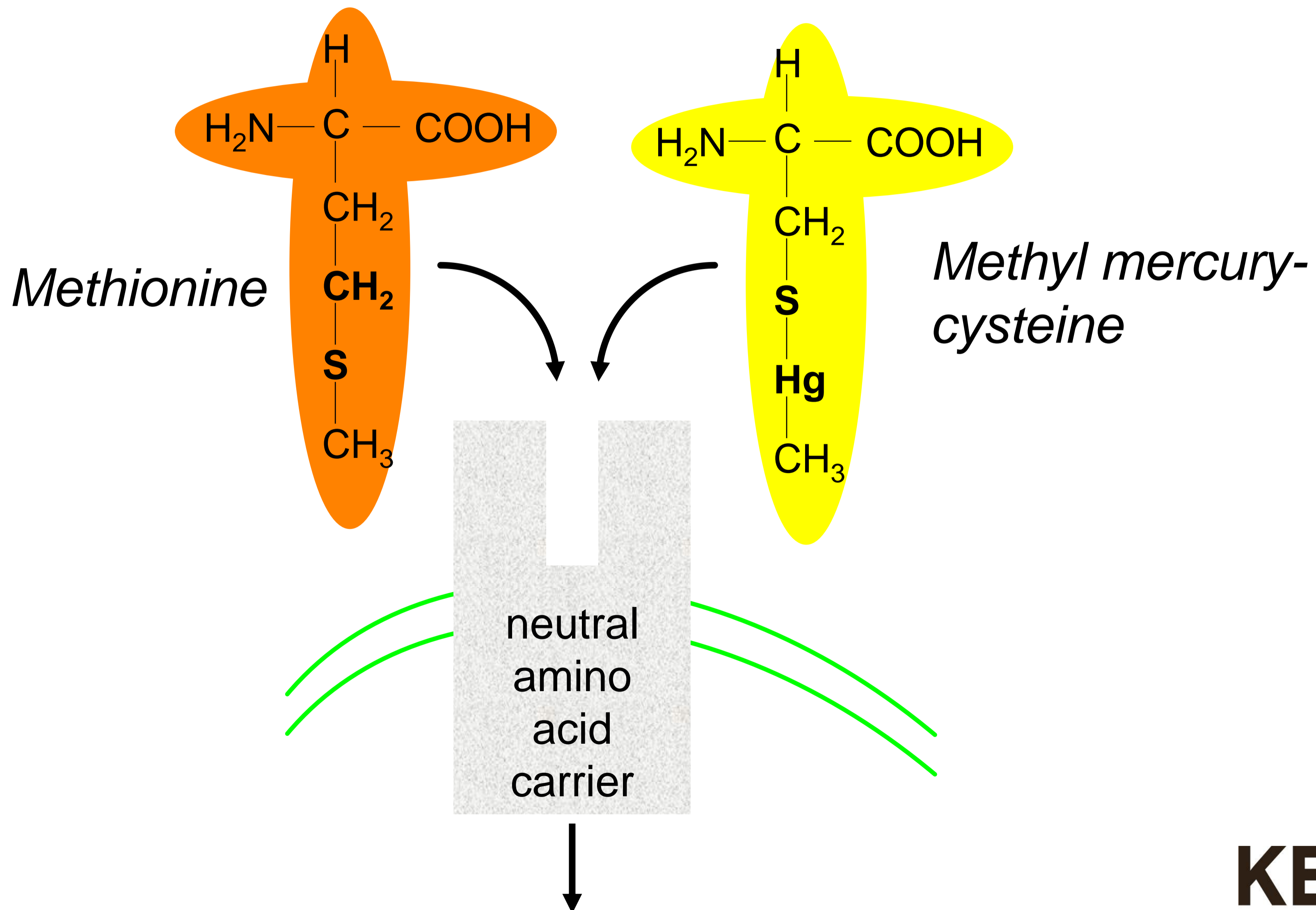
Exposure



Metabolism and retention of mercury



"Molecular Mimicry"



Health effects of inorganic mercury

Inhalation of mercury vapour

>2 mg/m³ - acute pneumonitis, dyspnea, cough

0.1 mg/m³ - loss of appetite, weight loss

>0.1 mg/m³ - tremor, abnormal emotions, gingivitis, proteinuria

Ingestion of inorganic mercury

Irritation GI tract, vomiting, diarrhea, renal failure

Prolonged exposure (children <5 yrs) - irritability, weight loss, painful extremities with pink coloration (acrodynia), rash, photophobia

Elemental mercury in dentistry

1960s:

A statistically significant increase in the in the risk of neonatal mortality for sons of dental nurses vs sons of assistant nurses: hazard ratio (HR) 1.82 (95% confidence interval, CI: 1.04 – 3.22).

Subsequent decades:

No increased risk, but a trend test demonstrate a consistent decrease in the risk over the three decades: HR for trend 0.63 (95% CI: 0.44 – 0.90). The raised mortality risk was limited to neonatal mortality.

Conclusions: The results suggest a modestly raised risk of neonatal mortality, during the 1960s, when exposure to mercury was thought to be highest.

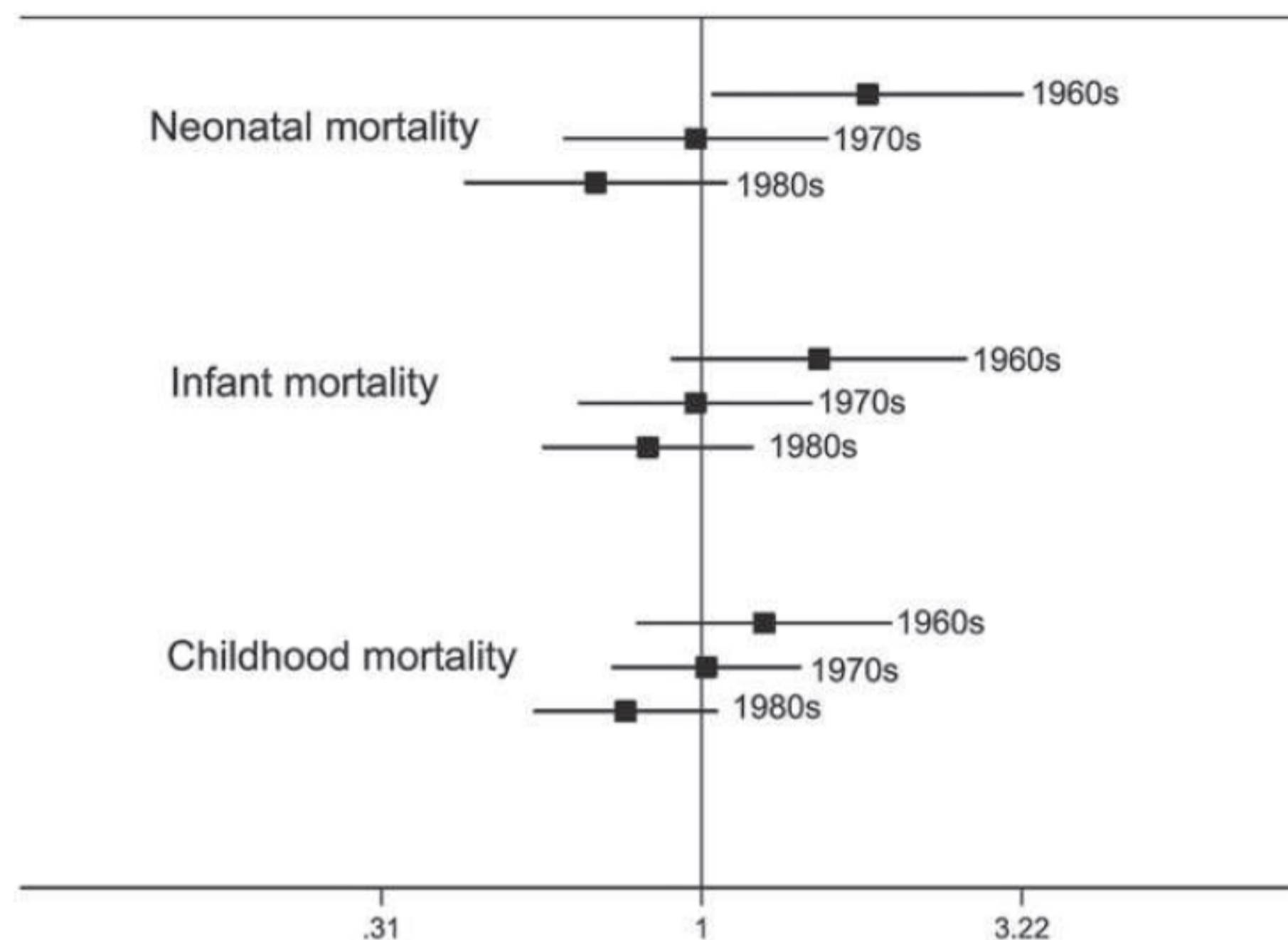


Figure 1 Hazard ratios.

Hazard ratios with 95% confidence intervals for mortality in the comparison between the dental nurse and assistant nurse cohorts, divided by the three time periods. The estimates are derived from regression analyses using Cox regression, adjusted for the father's educational level and mother's age at delivery.

Naimi-Akbar et al., J. Perinat. Med (2014),

Outbreaks of MeHg poisoning

| Date | Place | Cases | Primary source |
|------------|-----------|-------------------|--|
| 1953-60's | Minamata | >3000; 100 deaths | MeHg and other Hg products in plastics factory discharge |
| 1956, 1960 | Iraq | 200 | MeHg-treated grain |
| 1963-65 | Guatemala | 45 | MeHg-treated grain |
| 1965 | Niigata | 665, 55 deaths | Plastics factory discharge |
| 1967 | Ghana | 150 | MeHg-treated grain |
| 1969 | Pakistan | 100 | MeHg-treated grain |
| 1970 | Canada | | Discharge from paper mill |
| 1971-72 | Iraq | 6350, 459 deaths | MeHg-treated grain |

Toxic effects of MeHg

Adults

CNS effects - paresthesia, ataxia, constriction of visual field, dysarthria, affected hearing

Children (prenatal exposure)

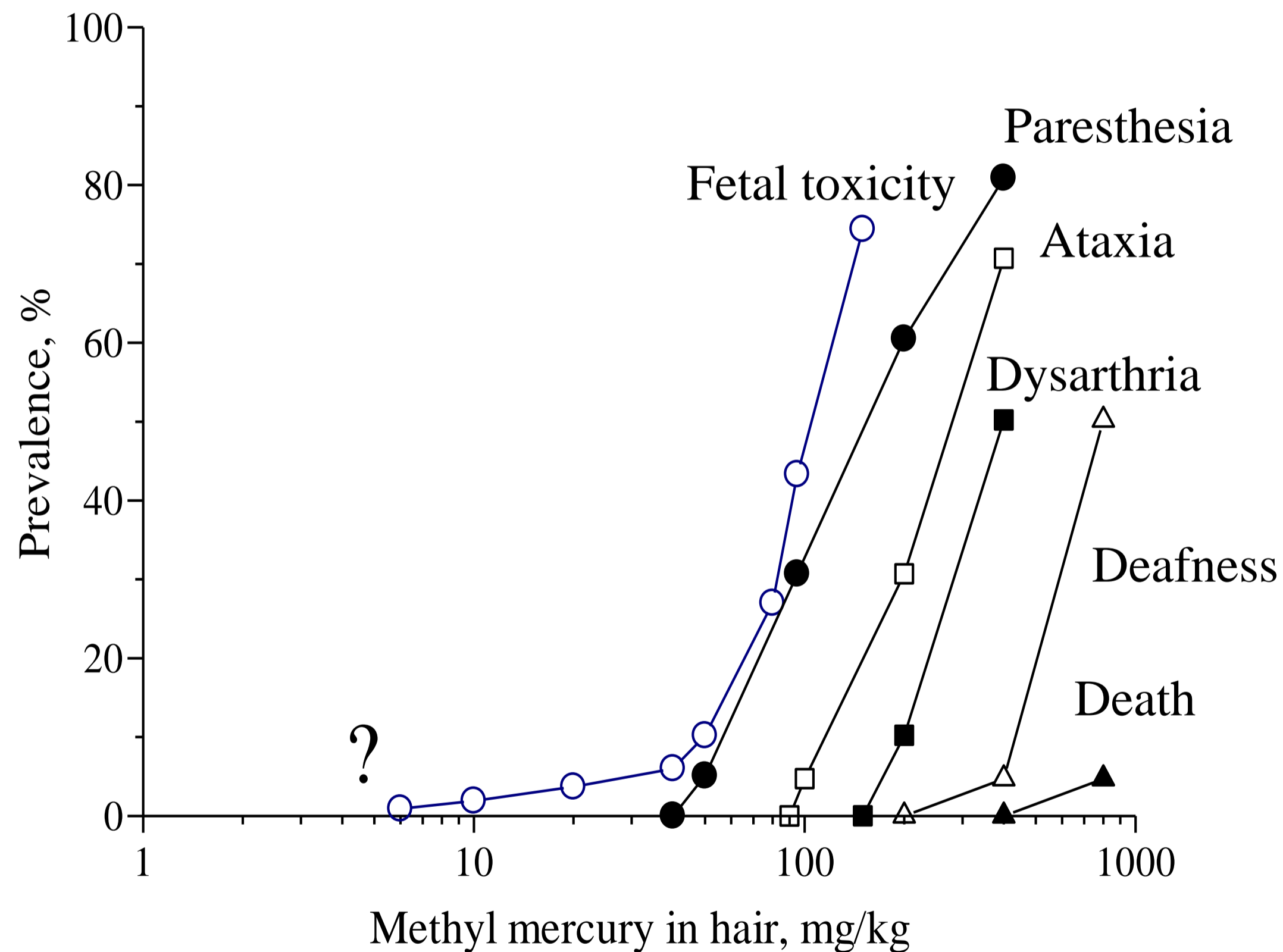
High maternal blood levels:

- microcephaly
- hyperreflexia
- gross motor impairment
- mental impairment
- vision disturbances
- hearing disturbances

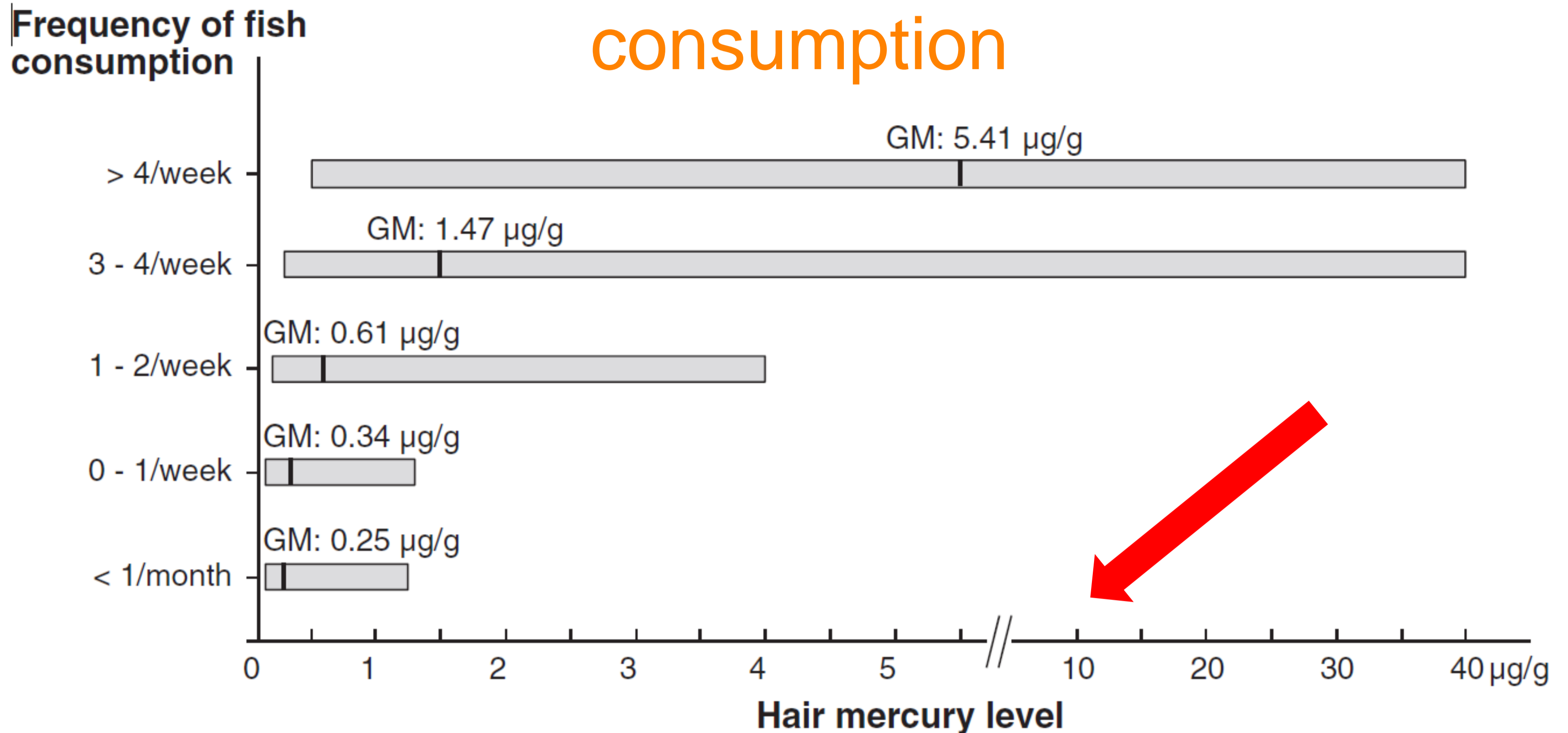
Lower maternal blood levels:

- psychomotor impairment
- neuropsychological dysfunction (language, attention, memory)
- pathological reflexes

Health effects in relation to MeHg exposure



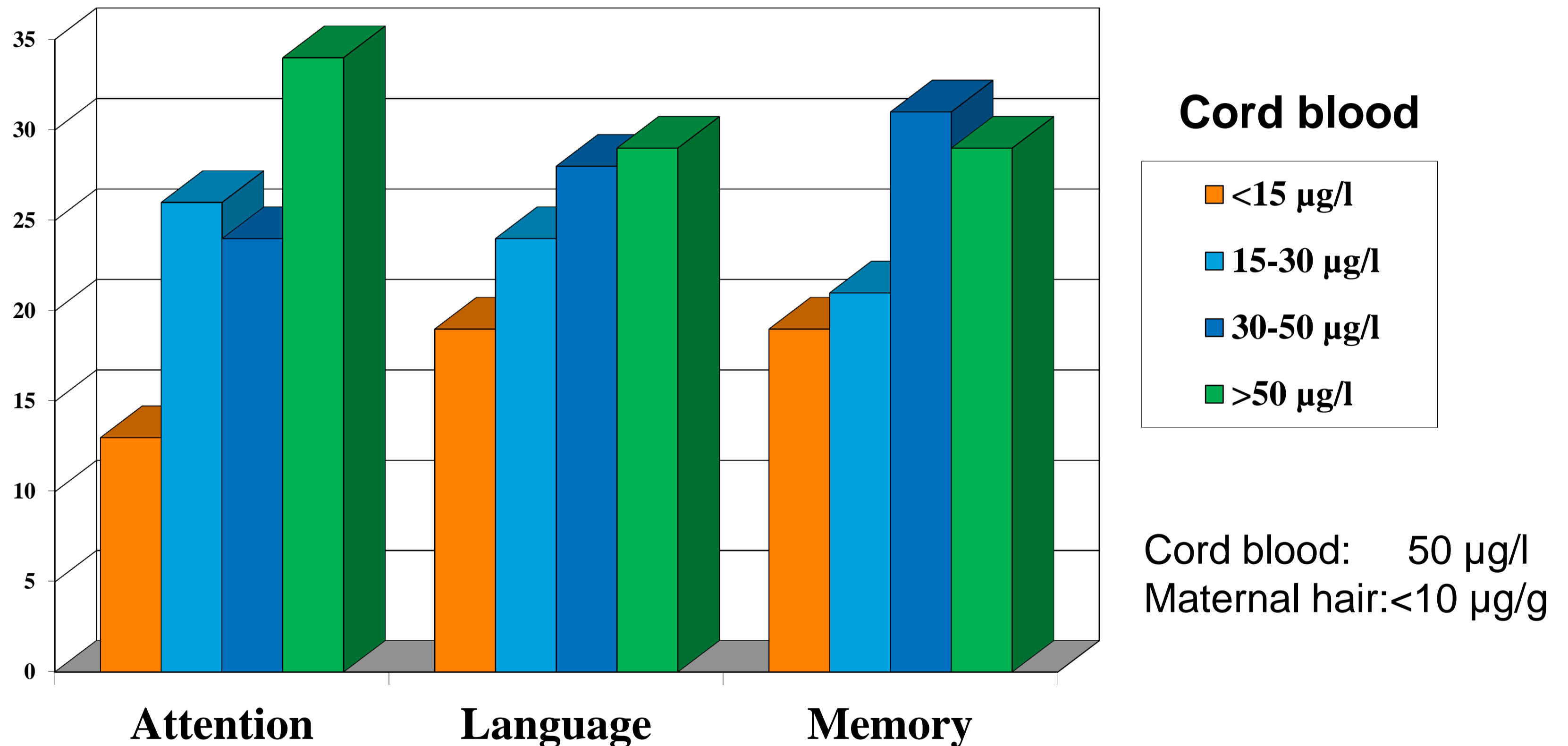
Hair mercury level is related to fish consumption



Geometric means and range of means from studies on general populations

Pirard et al. (2014) Sci. Tot. Env.

Faroe study: Prenatal mercury exposure levels of children with test scores in the lowest quartile



Grandjean et al., 1997

Risk assessment: US National Research Council

Benchmark Dose Level (BMDL):

The lower 95% confidence limit on the dose estimated to result in a 5% increase in the incidence of abnormal scores on the Boston Naming Test

BMDL= 58 ppm in cord blood (12 ppm in maternal hair)

"Uncertainty factor of at least 10"

→ Reference dose (RfD) 0.1 µg/kg bw/day (**0.7 µg/kg bw/week**)

Risk Assessment: WHO Provisional Tolerable Weekly Intakes (PTWI) for MeHg

Embryo and fetus
(pregnant woman) **1.6 µg/kg bw/week***

**Based on studies on neurodevelopmental effects in cohorts of children from Faroe Islands and the Seychelles.*

*The average BMDL/NOEL of 14 µg/g for concentrations of Hg in maternal hair (= maternal blood MeHg 56 µg/l) was calculated as the result of **daily** intake of 1.5 µg/kg bw.*

*An uncertainty factor of 6.4 was applied to arrive at the PTWI 1.6 µg/kg bw per **week***

WHO Guideline: MeHg in fish

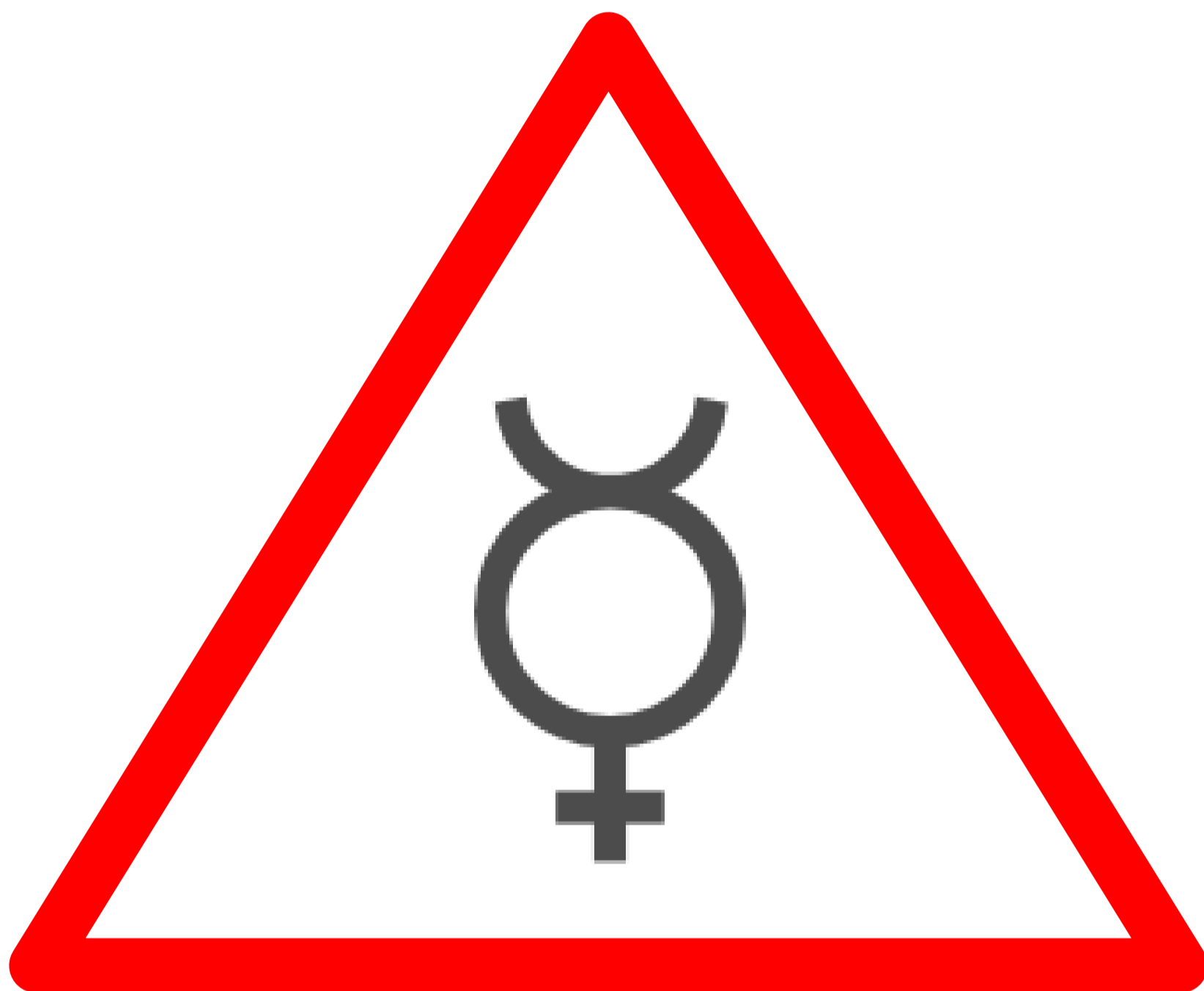
- Predatory fish 1.0 mg/kg
- Non-predatory 0.5 mg/kg

| | |
|-----------------|-----------|
| One fish meal | 200 g |
| Mercury content | 0.5 mg/kg |
| Body weight | 50 kg |
| Dose | 2 µg/kg |

Swedish Occupational Exposure Limits (8 hours)

| | |
|-------------------------------------|------------------------|
| Mercury | 0.03 mg/m ³ |
| Inorganic mercury compounds (as Hg) | 0.03 mg/m ³ |
| Organic mercury compounds (as Hg) | 0.01 mg/m ³ |

AFS 2011:18



Thank you very much for your attention