MERCURY & REPRODUCTION & BEHAVIOR

BY ROBERT GAMMAL MARCH 2013

Mercury has been known for over 100 years to have profoundly negative effects on reproduction of humans and other animals. Environmentally, this may in part account for the decrease in male fertility in all animals. PCBs in the environment also have a disastrous effect on fertility and reproduction. Mercury, whether from fish or amalgam fillings, is associated with disturbances in reproductive ability and in the neurological and behavioral health of the offspring.

Some of the reported effects that mercury has on reproduction include:

- → Mercury is embryotoxic and teratogenic.
- → Mercury crosses the placenta and is absorbed and retained by the nursing infant.
- → The amount of mercury in the bodies of fetous, newborns and infants is *directly proportional* to the number of amalgams in the mother's mouth.
- → Mercury will cross the breast milk to enter the nursing infant.
- → Mercury will affect number and strength of sperm in humans.
- → Mercury reduces the ability to fall pregnant per cycle.
- → preterm birth,
- → low birth weight,
- → still birth
- → birth deformities
- → dysmenorrhoea,
- → spontaneous abortion,
- → fetal death,
- → other complications of pregnancy,
- → increased neurobehavioral effects in the children,
- → psychomotor retardation in offspring,
- → severe neurodevelopmental changes in the infant,
- → congenital anomalies.
- → exposure to mercury may lead to deposition in the pituitary gland and the testicular tissues causing impairment of testicular function, especially spermatogenesis.
- → sensorineural hearing loss and impaired speech perception
- → nephrotoxicity,
- → autoimmunity,
- → oxidative stress,
- → autism,
- → skin and mucosa alterations
- → Neural tube defects have been noted
- → reduction in IQ for offspring.
- → Delayed psychomotor or mental performance in infants is assumed to be an indicator of later neurocognitive development in children, which may persist into adult life.
- → Mercury may affect the blood pressure and ability to respond to sensory stimuli in exposed children later in life.
- → Neuropsychological tests of motor function, attention, and visuospatial performance showed decrements associated with the hair-mercury concentrations.

As long ago as 1907 it was known that;

> "In women there will be inflammations of the outer genitals, vaginal catarrhs and disturbances of menstruation. That there is a tendency to miscarriage during chronic mercurialism is well known from the toxicology of mercury." "Effects and Use of Inorganic Drugs" H. Schulz, Dept of Pharmacology, Univ. of Greifswald. G. Theime, Leipzig 1907

The Environmental Protection Agency stated;

> "Women chronically exposed to mercury vapour experienced increased frequencies of menstrual disturbances and spontaneous abortions." "A high mortality rate was observed among infants born to women who displayed symptoms of mercury poisoning." EPA Mercury Health Effects update Health Issue Assessment. 1984 EOA- 600/8-84f. USEPA

In April 1995 the German Government issued the following directive;

> "Since foetuses will be exposed to mercury from the mother's amalgam fillings, on the basis of preventive health protection, there should be no placement or no additional amalgam fillings placed, respectively, during pregnancy. Alternative materials should, if possible, be the preferred choice. Since removal of amalgam will cause an additional exposure to mercury, no clinically faultless amalgam restorations should be removed during pregnancy especially."

Since January 2003, Californian dentists must display the following sign in their surgeries, in compliance with Proposition 65 Superior Court California 7 January 2003. "NOTICE TO PATIENTS. PROPOSITION 65:

"Warning on dental amalgam, used in many dental fillings,
causes exposure to mercury,
a chemical known to the state of California
to cause birth defects or other reproductive harm.

Root canal treatments and restorations including fillings, crowns and bridges,
use chemicals known to the state of California to cause cancer."

Caulk Co, the manufacturers of an amalgam called Dispersalloy offered the following warnings to the use of their product: "The use of amalgam is contraindicated;

In proximal or occlusal contact to dissimilar metal restorations.
In patients with severe renal deficiency.
In patients with known allergies to amalgam.
For retrograde or endodontic filling.
As a filling material for cast crown.
In children 6 and under.
In expectant mothers."

Female dental personnel must take great care to minimize or eliminate their exposure to mercury. Female dental personnel should NEVER mix or assist in the placement of mercury amalgam.

> "Exposure to mercury vapour or inorganic mercury compounds can impair fertility in laboratory animals. To study the effects of mercury vapour on fertility in women, eligibility questionnaires were sent to 7000 registered dental assistants in California. The final eligible sample of 418 women, who had become pregnant during the previous four years, were interviewed by telephone. Detailed information was collected on mercury handling practices and the number of menstrual cycles without contraception it had taken them to become pregnant. Dental assistants not working with amalgam served as unexposed controls. Women with high occupational exposure to mercury were less fertile than unexposed controls. The fecundability (probability of conception each menstrual cycle) of women who prepared 30 or more amalgams per week and who had five or more poor mercury hygiene factors was only 63% of that for unexposed women (95% CI 42%-96%) after controlling for covariates." Rowland AS Baird DD Weinberg CR Shore DL Shy CM Wilcox AJ The effect of occupational exposure to mercury vapour on the fertility of female dental assistants [see comments] Occup Environ Med (1994 Jan) 51(1):28-34

Since 1990 there have been two landmark studies that demonstrated the link between mercury from amalgam fillings and reproduction.

The first is the 'Sheep Study' by Vimy et al which uniquely demonstrated the movement of mercury from amalgam across the placenta and the breast milk.

> "In humans, the continuous release of Hg vapor from dental amalgam tooth restorations is markedly increased for prolonged periods after chewing. The present study establishes a time-course distribution for amalgam Hg in body tissues of adult and fetal sheep. Under general anesthesia, five pregnant ewes had twelve occlusal amalgam fillings containing radioactive 203Hg placed in teeth at 112 days gestation. Blood, amniotic fluid, feces, and urine specimens were collected at 1- to 3-day intervals for 16 days. From days 16-140 after amalgam placement (16-41 days for fetal lambs), tissue specimens were analyzed for radioactivity, and total Hg concentrations were calculated. Results demonstrate that Hg from dental amalgam will appear in maternal and fetal blood and amniotic fluid within 2 days after placement of amalgam tooth restorations. Excretion of some of this Hg will also commence within 2 days. All tissues examined displayed Hg accumulation. Highest concentrations of Hg from amalgam in the adult occurred in kidney and liver, whereas in the fetus the highest amalgam Hg concentrations appeared in liver and pituitary gland. The placenta progressively concentrated Hg as gestation advanced to term, and milk concentration of amalgam Hg postpartum provides a potential source of Hg exposure to the newborn. It is concluded that accumulation of amalgam Hg progresses in maternal and fetal tissues to a steady state with advancing gestation and is maintained. Dental amalgam usage as a tooth restorative material in pregnant women and children should be reconsidered." Vimy MJ Takahashi Y Lorscheider FL Maternal-fetal distribution of mercury (203Hg) released from dental amalgam fillings. Am J Physiol (1990 Apr) 258(4 Pt 2):R939-45

The second demonstrated a **linear relationship** between the number of amalgams in the mother's mouths and the amount of mercury in the fetus and newborn.

> "ABSTRACT: The total mercury concentrations in the liver (Hg-L), the kidney cortex (Hg-K) and the cerebral cortex (Hg-C) of 108 children aged I day to 5 years, and the Hg-K and Hg-L of 46 foetuses were determined. As far as possible, the mothers were interviewed and their dental status was recorded. The results were compared to mercury concentrations in the tissues of adults from the same geographical area. The Hg-K (n = 38) and Hg-L (n = 40) of foetuses and Hg-K (n = 35) and Hg-C (n = 35) of older infants (11-50 weeks of life) correlates significantly with the number of dental amalgam fillings of the mother. The toxicological relevance of the unexpected high Hg-K of older infants from mothers with higher numbers of dental amalgam fillings is discussed.
>
> Conclusion: Future discussion on the pros and cons of dental amalgam should not be limited to adults or children with their own amalgam fillings, but also include fetal exposure. The unrestricted application of amalgam for dental restorations in women before and during the child bearing age should be reconsidered." Mercury Burden of Human Fetal and Infant Tissues. Drasch, G; Schupp, I; Hofl, H; Reinke, R; Roider, G. EurJPediatrics, 153(8):607-10, 1994.

Whether it be elemental mercury from amalgam,
ethyl mercury from vaccines or
methyl mercury from fish,
the end result is still disastrous.
Mercury has profound effects on the whole of the reproductive cycle.

HUMAN STUDIES 1990-2012

NOTE: ALL **BOLD** TEXT HIGHLIGHTS HAVE BEEN INSERTED BY ME.

1. Vimy MJ Takahashi Y Lorscheider FL Maternal-fetal distribution of mercury (203Hg) released from dental amalgam fillings. Am J Physiol (1990 Apr) 258(4 Pt 2):R939-45

   In humans, the continuous release of Hg vapor from dental amalgam tooth restorations is markedly increased for prolonged periods after chewing. The present study establishes a time-course distribution for amalgam Hg in body tissues of adult and fetal sheep. Under general anesthesia, five pregnant ewes had twelve occlusal amalgam fillings containing radioactive 203Hg placed in teeth at 112 days gestation. Blood, amniotic fluid, feces, and urine specimens were collected at 1- to 3-day intervals for 16 days. From days 16-140 after amalgam placement (16-41 days for fetal lambs), tissue specimens were analyzed for radioactivity, and total Hg concentrations were calculated. Results demonstrate that Hg from dental amalgam will appear in maternal and fetal blood and amniotic fluid within 2 days after placement of amalgam tooth restorations. Excretion of some of this Hg will also commence within 2 days. All tissues examined displayed Hg accumulation. Highest concentrations of Hg from amalgam in the adult occurred in kidney and liver, whereas in the fetus the highest amalgam Hg concentrations appeared in liver and pituitary gland. The placenta progressively concentrated Hg as gestation advanced to term, and milk concentration of amalgam Hg postpartum provides a potential source of Hg exposure to the newborn. It is concluded that accumulation of amalgam Hg progresses in maternal and fetal tissues to a steady state with advancing gestation and is maintained. Dental amalgam usage as a tooth restorative material in pregnant women and children should be reconsidered.

2. Hansen JC Tarp U Bohm J Prenatal exposure to methyl mercury among Greenlandic polar Inuits. Arch Environ Health (1990 Nov-Dec) 45(6):355-8

   During the period 1982 to 1988, 37 paired samples of blood from Inuit women and their newborn children were collected in North Greenland. The samples were analyzed for whole blood content of total mercury (tot-Hg) and for content of methyl mercury (Me-Hg). In maternal blood, 80% of the tot-Hg was found to be methylated in contrast to 98% in cord blood. Concentrations of Me-Hg in maternal and cord blood were significantly correlated, and the mean ratio between fetal and maternal blood Me-Hg was 1.9. Concentrations of Me-Hg in cord blood were closely related to the marine food intake of the mothers. Eighty- four percent of the mothers had blood concentrations of Me-Hg above 0.11 mumol/l (23 micrograms/l), which corresponds to the provisional limit of tolerable intake set by the World Health Organization. This indicates that the majority of the pregnant woman have an unacceptable high intake of methyl mercury.

3. Lorscheider FL Vimy MJ Mercury from dental amalgam [letter; comment] Lancet (1990 Dec 22-29) 336(8730):1578-9

4. Larsson KS Sagulin GB Placental transfer of mercury from amalgam [letter] [see comments]Lancet (1990 Nov 17) 336(8725):1251

5. Wakisaka I Yanagihashi T Sato M Nakano A [Factors contributing to the difference of hair mercury concentrations between the sexes]. Nihon Eiseigaku Zasshi (1990 Jun) 45(2):654-64

Scalp hair samples were collected by mail from 97 married couples who were living in several places in Okinawa-prefecture and supposedly had no specific exposure to mercury compounds. They were selectively analysed for organic and inorganic mercury content and the difference of hair mercury concentration between the sexes was discussed in relation to the frequency of fish intake, fish species, drinking habits and permanent-wave hair treatment. Results obtained were as follows: 1) The increase in hair levels of organic and inorganic mercury concentrations was roughly proportional to the dietary intake of fish in the range from none or low to moderate frequencies for both husbands and wives. However, this increase was not proportional to the dietary intake of fish in the range from moderate to high frequencies, showing almost the same level irrespective of the frequency of fish intake. 2) Though husbands and wives had dietary consumption patterns quite similar to each other, husbands were found to have higher hair organic mercury levels than wives, the average values being 6.40 ppm with a standard deviation of 4.69 ppm for husbands and 2.86 ppm with a standard deviation of 1.97 ppm for wives, respectively. The difference was statistically significant. No significant difference between the sexes was detected for inorganic mercury concentrations. However, a highly significant positive correlation coefficient for organic mercury and also a significant positive correlation coefficient for inorganic mercury were found between husbands and wives. 3) Hair without permanent-wave treatment showed higher levels of organic mercury concentrations than hair with permanent-wave treatment for both husbands and wives. Drinkers also had higher levels of hair mercury as compared to non-drinkers. However, the lower levels of organic mercury concentrations in women's hair than in men's hair were not fully explained by these factors. 4) Both men and women who showed higher hair levels of organic mercury had a preference for highly predatory fish such as tuna and bonito, which probably contributed most to the human intake of mercury.

6. Hansen JC Jensen TG Tarp U Changes in blood mercury and lead levels in pregnant women in Greenland 1983-1988. Arctic Med Res (1991) Suppl:605-7

7. Cordier S Deplan F Mandereau L Hemon D Paternal exposure to mercury and spontaneous abortions. Br J Ind Med (1991 Jun) 48(6):375-81

The potential reproductive toxicity of mercury vapour was investigated by comparing the rate of spontaneous abortions among the wives of 152 workers occupationally exposed to mercury vapour with the rate among the wives of 374 controls in the same plant. **The results indicate an increase in the rate of spontaneous abortions with an increasing concentration of mercury in the fathers' urine before pregnancy. At concentrations above 50 micrograms/l the risk of spontaneous abortion doubles** (odds ratio (OR) = 2.26; 95% confidence interval (95% CI) = 0.99-5.23). Special care was taken to avoid bias in reporting abortions and known risk factors of spontaneous abortions do not seem to explain the results. Several biological mechanisms might account for them including, in particular, direct action of mercury on the paternal reproductive system and indirect toxicity to the mother or embryo through transport of mercury from the father. These indications could be of practical importance and should therefore be further documented.

8. Fitzgerald WF Clarkson TW Mercury and monomethylmercury: present and future concerns. Environ Health Perspect (1991 Dec) 96:159-66

Global atmospheric changes carry the potential to disrupt the normal cycling of mercury and its compounds. Acid rain may increase methylmercury levels in freshwater fish. Global warming and increased ultraviolet radiation may affect the global budget of methylmercury, including its formation and degradation in both biotic and abiotic environments. In this article we review current knowledge on mercury and monomethylmercury with regard to their environmental fate and the potential for human health effects. Recent findings indicate that atmospheric Hg deposition readily accounts for the total mass of Hg in fish, water, and sediment of Little Rock Lake, a representative temperate seepage lake in north-central Wisconsin. It is strikingly evident that modest increases in atmospheric Hg loading could lead directly to elevated levels in the fish stock. It is doubtful, given the experimental limitations in many recent studies, that the temporal pattern for Hg emissions, for background atmospheric Hg concentrations, and for changes in Hg depositional fluxes has been identified. Thus, the present and future questions of whether the environmental impact is of local, regional, or hemispheric significance remain. Contemporary investigations must address these important questions. Human exposure to methylmercury in the United States is probably increasing due to increased consumption of fish and fish products. A recent epidemiological investigation indicates high susceptibility to brain damage during prenatal exposures to Hg. An important objective for future investigation is to establish the lowest effect level for human exposure to methylmercury.

9. Soong YK Tseng R Liu C Lin PW Lead, cadmium, arsenic, and mercury levels in maternal and fetal cord blood. J Formos Med Assoc (1991 Jan) 90(1):59-65

In this study the levels of lead, arsenic, cadmium and mercury were measured by the method of graphite-furnace atomic absorption spectrophotometry in paired maternal and fetal cord blood (n = 168) collected from three cities in Taiwan, (Kaohsiung, Taipei and Keelung). The mean values of those heavy metals were within normal limits. There was no difference in levels by maternal parity or fetal sex. The mean value for the level of lead in maternal blood was 64.8 micrograms/L, and 40.9 micrograms/L for the umbilical-cord blood; comparing the three locations by ANOVA analysis, there was no difference in maternal or fetal blood levels. Mean maternal As concentrations (6.8 +/- 0.58 micrograms/L) and umbilical cord blood levels (7.9 +/- 0.67 micrograms/L) were within reference levels. The mean Cd concentrations in maternal blood were (1.30 micrograms/L) significantly higher than that of the umbilical-cord blood concentrations (0.78 micrograms/L). The maternal Cd concentrations (1.62 micrograms/L) of Kaohsiung were significantly higher than that (1.24 micrograms/L) of Taipei. The fetal Cd concentrations of Kaohsiung (1.04 micrograms/L) were also significantly higher than those (0.7 micrograms/L, 0.6 micrograms/L) of Taipei and Keelung. The mean umbilical-cord blood Hg concentration (28.8 micrograms/L) was higher than that (19.4 micrograms/L) of maternal blood. The maternal Hg concentrations of Taipei were significantly higher than those of Keelung. The fetal Hg concentrations (28.8 micrograms/L) of Taipei were also marginally higher than that of Keelung and Kaohsiung.

10. Chia SE Ong CN Lee ST Tsakok FH Blood concentrations of lead, cadmium, mercury, zinc, and copper and human semen parameters. Arch Androl (1992 Sep-Oct) 29(2):177-83

The study consisted of 35 male subjects attending an andrology clinic. The subjects all had poor sperm parameters that could not be attributed to any known medical cause. The objective was to evaluate the relation between various seminal characteristics (volume, total sperm count, sperm viability, proportion of progressively motile sperm, and different sperm morphology) and the blood concentrations of lead, cadmium, mercury, copper, and zinc. The mean blood concentrations of lead, mercury, copper, and zinc were within the normal values; cadmium

concentration (1.35 micrograms/L) was much higher than the norms. Asthenozoospermic subjects had significantly (p less than .025) higher blood cadmium levels than normozoospermic subjects. No significant differences were noted between the two groups for mean concentration of mercury, zinc, and copper in blood. Significant correlations were observed between blood cadmium levels and volume of semen, midpiece defects, and immature forms of spermatozoa. High blood cadmium levels may have an effect on spermatogenesis. Possible reasons for the high blood cadmium levels among the subjects are discussed.

11. Grandjean P Weihe P Jorgensen PJ Clarkson T Cernichiari E Videro T Impact of maternal seafood diet on fetal exposure to mercury, selenium, and lead. Arch Environ Health (1992 May-Jun) 47(3):185-95

    Umbilical cord blood from 1,023 consecutive births in the Faroe Islands showed a median blood-mercury concentration of 121 nmol/l (24.2 micrograms/l); 250 of those samples (25.1%) had blood-mercury concentrations that exceeded 200 nmol/l (40 micrograms/l). Maternal hair mercury concentrations showed a median of 22.5 nmol/g (4.5 micrograms/g), and 130 samples (12.7%) contained concentrations that exceeded 50 nmol/g (10 micrograms/g). Frequent ingestion of whale meat dinners during pregnancy and, to a much lesser degree, frequent consumption of fish, and increased parity or age were associated with high mercury concentrations in cord blood and hair. Blood-mercury levels were slightly lower if the mother had occasionally ingested alcoholic beverages. Mercury in blood correlated moderately with blood selenium (median, 1.40 mumol/l). Increased selenium concentrations were associated with intake of whale meat, alcohol abstention, delivery after term, and high parity. Lead in cord blood was low (median, 82 nmol/l), particularly if the mothers had frequently had fish for dinner and had abstained from smoking.

12. Soria ML Sanz P Martinez D Lopez-Artiguez M Garrido R Grilo A Repetto M Total mercury and methylmercury in hair, maternal and umbilical blood, and placenta from women in the Seville area. Bull Environ Contam Toxicol (1992 Apr) 48(4):494-501

13. Boadi WY Urbach J Brandes JM Yannai S In vitro effect of mercury on enzyme activities and its accumulation in the first-trimester human placenta. Environ Res (1992 Feb) 57(1):96-106

    The effect of incubating young placental explants with HgCl2 on the activities of aryl hydrocarbon hydroxylase (AHH) (a phase I enzyme), quinone reductase (QR), catecholamine-O-methyltransferase (COMT) (both phase II enzymes), and glucose-6-phosphate dehydrogenase (G-6- PD) is described. Mercury (Hg) at low doses significantly elevated placental phase I and phase II enzyme activities, but decreased the activity of G-6-PD. The increase in activities, which was time- and dose-dependent, was higher in explants incubated for 24 hr than in those incubated for 6 hr. The decrease in placental G-6-PD activity was drastic at low Hg dose levels but at higher levels the inhibitory effect was milder for both incubation periods. Placental explants accumulated Hg in amounts proportional to its concentration in the incubation medium and this accumulation was greater in explants incubated for 24 hr. The data suggest that contamination with low Hg levels from the environment during pregnancy may affect placental enzymatic activity. The accumulation of Hg during short incubation indicates a strong placental cell affinity for Hg, which could affect its other metabolic functions. The system used in sensitive, as it shows alteration in enzyme activity even with relatively low concentrations of the metal and the response is dose-related.

14. Eto K Oyanagi S Itai Y Tokunaga H Takizawa Y Suda I A fetal type of Minamata disease. An autopsy case report with special reference to the nervous system. Mol Chem Neuropathol (1992 Feb-Apr) 16(1-2):171-86

    Our knowledge concerning the pathology of fetal cases of human Minamata disease (methylmercury poisoning) is relatively limited. We report here a case with description of the distribution of mercury in the systemic organs, and the ultrastructural changes of the nervous system after a survival of 29 yr. The patient was a female born in 1957, with a body wt of 3000 g, who died in 1987. She carried a diagnosis of cerebral palsy, and had a convulsion at age 3 yr. Mercury levels in her mother's hair were 101 micrograms/g at the time of examination in 1959. At autopsy, the body measured 43 cm and weighed 23 kg. The brain weighed 920 g and showed marked cerebral atrophy, mild neuronal loss in the calcarine, postcentral and precentral cortices, cerebellar atrophy, and segmental demyelination of peripheral nerves. Mercury granules were present in the brain, kidney, and liver. Ultrastructural examination of the calcarine, post- and precentral cortices, and cerebellar cortices, showed severe atrophy of nerve cells, with a decrease in rough ER and an increase in nuclear chromatin and preservation of mitochondria. Autophagosomes were increased in number. In addition, high electron density, globular and dense bodies, measuring 0.3-1.8 microns in diameter, were found, surrounded by limited membrane, within both cerebral and cerebellar neurons. In the cellebellum, synapses were well-preserved.

15. Thorp JM Boyette DD Watson WJ Cefalo RC Elemental mercury exposure in early pregnancy. Obstet Gynecol (1992 May) 79(5 (Pt 2)):874-6

    We present a case of first-trimester elemental mercury exposure and review the literature to demonstrate that the reproductive toxicity of mercury varies depending on the form of mercury to which one is exposed. It appears that elemental mercury exposure poses less of a reproductive threat than the well-known hazards of exposure to organic mercurials. It is critical to determine the form of exposure when counseling patients at risk.

16. Sakamoto M Nakano A Akagi H Kitano T Futatsuka M [Difference by sex and age of mercury concentration in red blood cells]. Nihon Eiseigaku Zasshi (1993 Dec) 48(5):911-9

    The mercury concentration in red blood cells (RBCs) is one of the most useful indicators for people exposed to methylmercury. Sex- and age-related differences in mercury concentrations in red blood cells were studied by considering fish consumption in 1,253 adults (511 males and 742 females) participating in a mass health examination conducted in a town of Kumamoto Prefecture in 1989. The results were as follows: 1. The mercury concentrations in RBCs showed lognormal distributions for both sexes with a higher mode in males than in females. The geometric mean of the mercury concentrations in the RBCs was 28.5 ng/g (ranging from 5.6 to 71.0 ng/g) for males and 20.4 ng/g (ranging from 3.7 to 70.4 ng/g) for females and was significantly higher in males than in females. The mercury concentration in RBCs decreased with aging for both sexes. 2. The mercury concentrations in RBCs significantly increased with the amount of fish consumption for both sexes. The mercury concentrations in RBCs were significantly higher in drinkers than in non-drinkers for males and the concentrations increased significantly with body weight for females. 3. The mercury concentrations in RBCs were higher in males than in females and decreased with aging for both sexes under conditions of a constant level of fish consumption. 4. In couples who consumed same amount of fish, the mercury concentrations in RBCs were significantly higher in husbands than in wives. These results suggest that the mercury concentrations in RBCs are higher in males than in females and decreases with aging under a constant level of fish consumption.

17. Kinjo Y Kato H Shibata Y Takizawa Y [Influence of age and sex on threshold dose of mercury in Minamata disease as determined by hair mercury concentration]. Nihon Koshu Eisei Zasshi (1993 May) 40(5):380-6

    The influence of age and sex on the threshold dose of mercury in Minamata disease was studied by dose-response analysis based on mercury concentrations in hair obtained mainly from adults living near the Agano River at the beginning of Niigata Minamata disease outbreak in 1965. The subjects were 174 male and 694 female inhabitants of polluted areas including 55 males and 66 females officially recognized as Minamata disease patients. Because of the large sex differences in numbers and age distributions, the data were analyzed separately for males and females. While revealing no sex difference in the threshold dose, hockey-stick regression analysis indicated an effect of age on threshold dose in females. Logistic regression analysis showed no interaction between age and hair mercury concentration. These results suggest that, in adults, neither sex nor age exert a considerable effect on the threshold dose of mercury in Minamata disease.

18. Ong CN Chia SE Foo SC Ong HY Tsakok M Liouw P Concentrations of heavy metals in maternal and umbilical cord blood. Biometals (1993 Spring) 6(1):61-6

    Concentrations of lead, cadmium, methylmercury and total mercury were measured in maternal and umbilical cord blood using graphite atomic absorption spectrometry. Two essential metals, copper and zinc, were also determined using ion chromatography. Lead, copper and zinc were found to be lower in the cord blood whereas methylmercury and total mercury were higher in cord blood than in maternal blood. Little differences were noted for cadmium in maternal and cord blood. Significant positive correlations were observed between the concentrations in maternal and cord blood with regard to lead (correlation coefficient, r = 0.44), copper (r = 0.34), zinc (r = 0.29), methylmercury (r = 0.44) and total mercury (r = 0.58). These results suggest that, like essential metals**, most heavy metals can move rather freely across the human placenta**. The potential health effects of heavy metal transfer from mothers to young infants cannot be discounted.

19. Fu WZ [Effects of mercury exposure on reproduction in female workers] Chung Hua Yu Fang I Hsueh Tsa Chih (1993 Nov) 27(6):347-9

    Reproductive hazards in 704 female workers exposed to low-level metallic mercury and 583 controls were investigated. Females exposed to low-level mercury for a long term mainly manifested dysmenorrhoea, and the incidence of dysmenorrhoea increased with exposure dose, suggesting a dose-response relationship. At a level over 0.06 mg/m3 of mercury, incidence of hypomenorrhea significantly increased, and in general, at a level below 0.06 mg/m3, menstrual cycles, quantity and duration of menstrual flow did not change significantly. Differences in incidences of preterm delivery, spontaneous abortion, fetal death, still birth, and complications of pregnancy between the group exposed to 0.06-0.1 mg/m3 of mercury and the control group did not reach a significant level. Incidences of birth defect, neonatal asphyxia, neonatal death, infant infection, low birth weight, retardation on physical and mental development in offsprings of the exposed females were not significantly higher than in those of controls.

20. Grandjean P Weihe P Neurobehavioral effects of intrauterine mercury exposure: potential sources of bias. Environ Res (1993 Apr) 61(1):176-83

    Sources of bias were examined in a study of neurobehavioral effects of intrauterine exposure to methyl mercury in the Faroe Islands. The cohort of 1000 children was born during a 21-month

period and did not differ from Faroese births in general as regards major obstetrical parameters. However, high mercury concentrations in the cord blood was associated with increased birth weight, presumably because other constituents of marine fish may cause a prolongation of the gestation period. Thus, children with high mercury exposures were somewhat protected against low birth weight and its associated neurobehavioral risks. Less than 25% of the women indicated occasional alcohol drinking during pregnancy, thus suggesting a limited fetal exposure to this neurobehavioral risk factor. However, maternal alcohol drinking caused a decrease in mercury concentrations in cord blood, probably because of a toxicokinetic interaction between ethanol and mercury. Any alcohol-related effect on neurobehavioral development would then be associated with lower levels of mercury exposures. The effects of these confounders would tend to bias the results of the study toward the null hypothesis.

21. Davis LE Kornfeld M Mooney HS Fiedler KJ Haaland KY Orrison WW Cernichiari E Clarkson TW Methylmercury poisoning: long-term clinical, radiological, toxicological, and pathological studies of an affected family. Ann Neurol (1994 Jun) 35(6):680-8

    For 3 months in 1969 a family in the United States that included a pregnant mother consumed pork containing methylmercury. Children, aged 20, 13, and 8 years and a neonate, developed severe neurological signs. Twenty-two years later, the 2 oldest had cortical blindness or constricted visual fields, diminished hand proprioception, choreoathetosis, and attentional deficits. Magnetic resonance images showed tissue loss in the calcarine and parietal cortices and cerebellar folia. The youngest had quadriplegia, blindness, and severe mental retardation until their deaths. The brain of the 8-year- old who died at age 30 showed cortical atrophy, neuronal loss, and gliosis, most pronounced in the paracentral and parietooccipital regions. The total mercury level in formalin-fixed, left occipital cortex was 1,974 ng/gm as measured by atomic absorption. Regional brain mercury levels correlated with extent of brain damage. A control patient had 38.5 ng of mercury/gm in the occipital cortex. Systemic organs in the patient and a control subject had comparable mercury levels. In mercury-intoxicated rats, we found that only 5 to 10% of total brain mercury was lost by formalin fixation. Brain inorganic mercury in the patient ranged from 82 to 100%. Since inorganic mercury crosses the blood-brain barrier poorly, biotransformation of methyl to inorganic mercury may have occurred after methylmercury crossed the blood-brain barrier, accounting for its persistence in brain and causing part of the brain damage.

22. Chai C Feng W Qian Q Guan M Li X Lu Y Zhang X Total and methyl mercury levels in human scalp hairs of typical populations in China by NAA, GC(EC), and other techniques. Biol Trace Elem Res (1994 Fall) 43-45:423-33

    The contents of total and methyl mercury in scalp hair samples of 1179 fishermen living in a typical Hg-polluted region in northeast China and 27 lying-in women and their newborns in Beijing have been determined by INAA, GC(EC), and other techniques. Only 18 of all fishermen had Hg contents above 5 micrograms/g, which indicates that the Hg pollution there has been substantially alleviated. The longitudinal Hg patterns of the lying-in women showed a gradually lowering tendency during pregnant period. Further, the Hg contents of the newborn babies generally were above or close to those of their mothers, confirming the mechanism that the methyl Hg, an organic species of Hg with high toxicity, is readily able to penetrate the placental barrier and to accumulate in the fetus. Thus, the mercury poison has occurred at the early stage of pregnancy.

23. Grandjean P Weihe P Nielsen JB Methylmercury: significance of intrauterine and postnatal exposures. Clin Chem (1994 Jul) 40(7 Pt 2):1395-400

    Outbreaks of methylmercury poisoning in Japan and Iraq have demonstrated the sensitivity of the fetus to neurotoxic effects. Based on toxicokinetics and considerations of practicability, the optimal biomarker of methylmercury exposure is the hair concentration, but whole-blood measurements of mercury are also useful. Dose-response relations are still incompletely known, especially concentrating developmental neurotoxicity under conditions of chronic exposure. Available evidence indicates that neurobehavioral dysfunction in children may occur if the maternal mercury concentration in hair is > 6 micrograms/g (30 nmol/g). This value corresponds to a blood mercury concentration of approximately 24 micrograms/L (120 nmol/L). The period of maximum sensitivity of the nervous system to methylmercury toxicity is unknown, but the transfer of mercury to the newborn through human milk may represent an additional risk. In view of the wide occurrence of mercury contamination in developing countries, increased use of the exposure biomarkers is encouraged.

24. Drasch G Schupp I Hofl H Reinke R Roider G Mercury burden of human fetal and infant tissues [see comments] Eur J Pediatr (1994 Aug) 153(8):607-10

    The total mercury concentrations in the liver (Hg-L), the kidney cortex (Hg-K) and the cerebral cortex (Hg-C) of 108 children aged 1 day-5 years, and the Hg-K and Hg-L of 46 fetuses were determined. As far as possible, the mothers were interviewed and their dental status was recorded. The results were compared to mercury concentrations in the tissues of adults from the same geographical area. The Hg-K (n = 38) and Hg-L (n = 40) of fetuses and Hg-K (n = 35) and Hg-C (n = 35) of older infants (11-50 weeks of life) correlated significantly with the number of dental amalgam fillings of the mother. The toxicological relevance of the unexpected high Hg-K of older infants from mothers with higher numbers of dental amalgam fillings is discussed. CONCLUSION: Future discussion on the pros and cons of dental amalgam should not be limited to adults or children with their own amalgam fillings, but also include fetal exposure. The unrestricted application of amalgam for dental restorations in women before and during the child-bearing age should be reconsidered.

25. Bruhn CG Rodriguez AA Barrios C Jaramillo VH Becerra J Gonzales U Gras NT Reyes O Seremi-Salud Determination of total mercury in scalp hair of pregnant and nursing women resident in fishing villages in the Eighth Region of Chile. J Trace Elem Electrolytes Health Dis (1994 Jun) 8(2):79-86

    Total mercury (Hg-T) content in scalp hair of 59 pregnant and nursing women-with normal to high fish and seafood consumption-resident in fishing villages distributed throughout the coastal zone of the Eighth Region of Chile, and of 7 pregnant and nursing women-with negligible or no fish and seafood consumption-resident in a town located inland (Pinto) in the same region, was determined. Hair samples were collected, washed and stored according to IAEA recommendations, and were wet-digested in sealed Pyrex ampoules prior to the determination of Hg-T by gold amalgamation cold-vapour atomic absorption spectrometry. The absolute detection limit was estimated as 0.13 +/- 0.01 ng Hg-T (3 x sigma B1). Accuracy and precision were assessed with the aid of various biological and environmental certified and standard reference materials including human hair, and were satisfactory for ppm and sub-ppm Hg-T. Instrumental neutron activation analysis was used as a reference method for external quality control. The Hg-T content in hair of the study group (2.06 +/- 1.45(8) mg/Kg) was significantly higher than that of the control group (0.43 +/- 0.18(4) mg/kg) (p = 0.0001). These results were

characterized according to geographical location, fish and seafood consumption, age and residence period in the fishing village.

26. Rowland AS Baird DD Weinberg CR Shore DL Shy CM Wilcox AJ The effect of occupational exposure to mercury vapour on the fertility of female dental assistants [see comments] Occup Environ Med (1994 Jan) 51(1):28-34

    Exposure to mercury vapour or inorganic mercury compounds can impair fertility in laboratory animals. To study the effects of mercury vapour on fertility in women, eligibility questionnaires were sent to 7000 registered dental assistants in California. The final eligible sample of 418 women, who had become pregnant during the previous four years, were interviewed by telephone. Detailed information was collected on mercury handling practices and the number of menstrual cycles without contraception it had taken them to become pregnant. Dental assistants not working with amalgam served as unexposed controls. Women with high occupational exposure to mercury were less fertile than unexposed controls. The fecundability (probability of conception each menstrual cycle) of women who prepared 30 or more amalgams per week and who had five or more poor mercury hygiene factors was only 63% of that for unexposed women (95% CI 42%-96%) after controlling for covariates. Women with low exposure were more fertile, however, than unexposed controls. Possible explanations for the U shaped dose response and limitations of the exposure measure are discussed. Further investigation is needed that uses biological measures of mercury exposure.

27. Oskarsson A Palminger Hallen I Sundberg J Exposure to toxic elements via breast milk. Analyst (1995 Mar) 120(3):765-70

    Breast milk is the ideal nutrient for the newborn, but unfortunately also a route of excretion for some toxic substances. Very little attention has been paid to breast milk as a source of exposure to toxic elements. The dose-dependent excretion is breast milk and the uptake in the neonate of inorganic mercury, methylmercury and lead were studied in an experimental model for rats and mice. The transfer of mercury from plasma to milk was found to be higher in dams exposed to inorganic mercury than to methylmercury. In contrast, the uptake of mercury from milk was higher in the sucklings of dams exposed to methylmercury than to inorganic mercury. Pre- and postnatal exposure to methylmercury resulted in increased numbers and altered proportions of the thymocyte subpopulation and increased lymphocyte activities in the offspring of mice and also effects on the levels of noradrenaline and nerve growth factor in the developing brain of rats. Mercury in blood and breast milk in lactating women in Sweden was studied in relation to the exposure to mercury from, fish and amalgam. Low levels were found; the mean levels were 0.6 ng g-1 in milk and 2.3 ng g-1 in blood. **There was a statistically significant correlation between mercury levels in blood and milk, showing that milk levels were approximately 30% of the levels in blood. Inorganic mercury exposure from amalgam was reflected in blood and milk mercury levels.** Recent exposure to methylmercury from consumption of fish was reflected in mercury levels in the blood but not in milk.

28. Soderstrom S Fredriksson A Dencker L Ebendal T The effect of mercury vapour on cholinergic neurons in the fetal brain: studies on the expression of nerve growth factor and its low- and high-affinity receptors. Brain Res Dev Brain Res (1995 Mar 16) 85(1):96-108

    The effects of mercury vapour on the production of nerve growth factor during development have been examined. Pregnant rats were exposed to two different concentrations of mercury vapour during either embryonic days E6-E11 (early) or E13-E18 (late) in pregnancy, increasing the postnatal concentration of mercury in the brain from 1 ng/g tissue to 4 ng/g tissue (low-dose

group) or 11 ng/g (high-dose group). The effect of this exposure in offspring was determined by looking at the NGF concentration at postnatal days 21 and 60 and comparing these levels to age-matched controls from sham-treated mothers. Changes in the expression of mRNA encoding NGF, the low- and high-affinity receptors for NGF (p75 and p140 trk, respectively) and choline acetyltransferase (ChAT) were also determined. When rats were exposed to high levels of mercury vapour during early embryonic development there was a significant (62%) increase in hippocampal NGF levels at P21 accompanied by a 50% decrease of NGF in the basal forebrain. The expression of NGF mRNA was found to be unaltered in the dentate gyrus. The expression of p75 mRNA was significantly decreased to 39% of control levels in the diagonal band of Broca (DB) and to approximately 50% in the medial septal nucleus (MS) whereas no alterations in the level of trk mRNA expression were detectable in the basal forebrain. ChAT mRNA was slightly decreased in the DB and MS, significantly in the striatum. These findings suggest that low levels of prenatal mercury vapour exposure can alter the levels of the NGF and its receptors, indicating neuronal damage and disturbed trophic regulations during development.

29. Bruhn CG Rodriguez AA Barrios CA Jaramillo VH Gras NT Becerra J Nunez E Reyes OC [Mercury in the hair of pregnant and lactating Chilean women] Bol Oficina Sanit Panam (1995 Nov) 119(5):405-14

    Seafood contaminated with large amounts of mercury is the main source of mercury consumption in the diet. Fish concentrates and transforms mercury from its inorganic form to the even more toxic organic form, methylmercury. Studies since 1977 have shown that the Bio-Bio River and coastal zone of Chile's Eighth Region are contaminated with mercury-containing wastes originating in the heavy industry of the area. A study was conducted to determine the relationship between consumption of seafood contaminated with mercury and the capillary concentration of mercury in the hair of pregnant and breast feeding women along the coast and in the interior of the Eighth Region. Mercury concentration in the hair is greater than that in other body tissue or fluids and is easy to sample. The 5 mm of hair closest to the scalp permit calculation of the amount of mercury consumed during the preceding two or three weeks. Pregnant women, 13-35 years old, without occupational exposure to mercury, who lived in 11 small fishing villages and who attended prenatal clinics between 1992 and 1993 were studied, along with breast feeding women who attended the same clinics in 1991. 26 pregnant and breast feeding women in 2 interior villages served as controls. The 1991 subjects were questioned only about fish consumption, while the others were asked about seafood consumption in general. Spectrophotometry was used to determine the total mercury concentration in samples of 100 mg of hair from the 153 pregnant and breast feeding women and the 26 controls. The arithmetic mean of the total mercury concentration was 1.81 mg/kg of body weight for the study group and 0.42 mg/kg for the controls. The difference was statistically significant. Pairwise comparisons showed statistically significant differences between the means for the control group and the women in the 9 villages closest to the source of contamination, but not the two villages farthest away. Mercury concentration was significantly higher for women who stated they ate fish 7 or more times weekly, in those who ate fish, shellfish, or algae 5 or more times weekly, and in those who had lived in the village for 20 or more years.

30. Warfvinge K Mercury exposure of a female dentist before pregnancy [see comments] Br Dent J (1995 Feb 25) 178(4):149-52

    A 30-year-old female dentist was exposed to mercury vapour from a leaking amalgamator for approximately one year. No toxic effect was noted. During and after the exposure urine samples were regularly taken for mercury analysis. The highest value during this period was 60 micrograms Hg/l urine (expressed in micrograms/g creatinine: 42; the normal value for

unexposed persons is a few micrograms/g creatinine). The mercury concentration in air was at most 840 micrograms/m3 at the amalgamator (threshold limit for occupational exposure: 50 micrograms/m3). The dentist became pregnant and during pregnancy her average urine mercury concentration was 18 micrograms/g creatinine. Ultrasound examination of the fetus at 20 weeks of gestation showed a mild bilateral hydronephrosis. At 32 weeks of gestation the hydronephrosis had resolved. The dentist gave birth to a normal-weight baby boy, who, at the time of writing, is 2 years of age and appears clinically healthy.

31. Grandjean P Weihe P Needham LL Burse VW Patterson DG Sampson EJ Jorgensen PJ Vahter M Patterson DG Jr Relation of a seafood diet to mercury, selenium, arsenic, and polychlorinated biphenyl and other organochlorine concentrations in human milk. Environ Res (1995 Oct) 71(1):29-38

    Human transition milk was sampled from 88 mothers at the Faroe Islands, where the seafood diet includes pilot whale meat and blubber. Milk mercury concentrations (median, 2.45 micrograms/liter) were significantly associated with mercury concentrations in cord blood and with the frequency of pilot whale dinners during pregnancy. Milk selenium concentrations (mean, 19.1 micrograms/liter) correlated significantly with concentrations in cord blood but not with seafood consumption. Arsenic concentrations were very low. Twenty-four of the milk samples were separated into four pools based on fish intake and milk mercury concentrations. The polychlorinated biphenyl (PCB) concentrations (1.8-3.5 micrograms/g lipid) were high and mainly due to congener numbers 153, 180, and 138. One pool contained a congener 77 concentration of 1380 ppt, which is the highest ever reported in a human specimen for a coplanar PCB. The highest PCB concentrations were seen in the pools from women who had eaten frequent whale dinners and whose milk contained high mercury concentrations. The concentrations of chlorinated dibenzo-p-dioxins and furans were not similarly elevated. Given the advantages associated with breast- feeding, advice to nursing mothers in this population should take into regard the possible risks associated with long-term exposure to milk contaminants.

32. Drasch G Roider G [Dental amalgam and pregnancy]Zahnamalgam und Schwangerschaft.

33. Anttila A Sallmen M Effects of parental occupational exposure to lead and other metals on spontaneous abortion. J Occup Environ Med (1995 Aug) 37(8):915-21

    The aim of this article was to summarize the epidemiologic studies on the possible impact of parental occupational exposure to lead or other metals on spontaneous abortion. For paternal exposure, the total number of abortions in the studies with adequate exposure contrast were 340 for lead, 240 for mercury, and 90 for unspecified metals and, correspondingly, for maternal exposure, about 80 for lead, 80 for mercury, 70 for nickel, and 130 for exposure to unspecified metals. Epidemiologic studies indicate that paternal exposure to lead or mercury might be associated with the risk of spontaneous abortion. For maternal exposure, no clear conclusion could be reached. In particular, paternal occupational exposure levels to metals were substantial compared with population values. Even though there are shortcomings in the present knowledge, protective goals for paternal exposure to lead and mercury are warranted. More well-designed studies on metals are needed.

34. Marsh DO Turner MD Smith JC Allen P Richdale N Fetal methylmercury study in a Peruvian fish-eating population. Neurotoxicology (1995 Winter) 16(4):717-26

    Maternal consumption during pregnancy of methylmercury (MeHg)- contaminated fish in Japan and of MeHg-contaminated bread in Iraq caused psychomotor retardation in the offspring.

Studies in Iraq suggested adverse fetal effects when maternal hair mercury concentrations were as low as 20 ppm. This prospective study involved 131 infant-mother pairs in Mancora, Peru with peak maternal hair MeHg levels during pregnancy from 1.2 ppm to 30.0 ppm, geometric mean 8.3. The MeHg was believed to be derived from marine fish in the diet. There was no increase in the frequency of neurodevelopmental abnormalities in early childhood. The possible role of selenium or other protective mechanisms in marine fish is discussed. This previously unpublished study was conducted between 1981 and 1984. Our report of August 1985 to the funding agencies has been circulated, and the data were presented at the Twelfth International Neurotoxicology Conference in Hot Spring, Arkansas, October 30 to November 2, 1994. The current account has not been modified or updated since 1985. For reference to interim publications on fetal MeHg studies in Iraq and New Zealand see Marsh et al., 1995.

35. Myers GJ Davidson PW Cox C Shamlaye CF Tanner MA Marsh DO Cernichiari E Lapham LW Berlin M Clarkson TW Summary of the Seychelles child development study on the relationship of fetal methylmercury exposure to neurodevelopment. Neurotoxicology (1995 Winter) 16(4):711-16

    The Seychelles Child Development Study is examining the association between fetal methylmercury exposure from a maternal diet high in fish and subsequent child development. The study is double blind and uses maternal hair mercury as the index of fetal exposure. An initial cross-sectional pilot study of 804 infants aged 1 to 25 months suggested that mercury may affect development. A follow up of 217 pilot children at 66 months of age also suggested that neurodevelopmental effects might be present, but the result was dependent on outcomes in a small number of children. On the basis of initial results in the pilot study a prospective, longitudinal main study with more covariates and expanded endpoints was begun on a new cohort of 779 children. No association with neurodevelopment was seen at 6 1/2, 19, or 29 months of age, but there was an inverse relationship at 29 months in boys only between mercury level and activity as judged by the examiner. Adverse neurodevelopmental effects from fetal mercury exposure in the pilot study are highly dependent on how the data are analyzed and no definite effects have been detected through 29 months of age in the main study. In a related study, 32 brains were obtained at autopsy from Seychellois infants. These were examined histologically and analyzed for mercury. No clear histological abnormalities were found. Mercury levels ranged from a background of about 50 ppb up to 300 ppb, and correlated well between brain regions. For 27 brains maternal hair from delivery was available and hair mercury correlated well with brain mercury.

36. Cernichiari E Brewer R Myers GJ Marsh DO Lapham LW Cox C Shamlaye CF Berlin M Davidson PW Clarkson TW Monitoring methylmercury during pregnancy: maternal hair predicts fetal brain exposure. Neurotoxicology (1995 Winter) 16(4):705-10

    Autopsy brains were obtained from infants dying from a variety of causes within a few days of birth in a population exposed to methylmercury in fish. Infant and maternal blood and hair samples were also obtained. The concentration of total mercury in 6 major brain regions were highly correlated with maternal hair levels. This correlation was confirmed by a sequence of comparisons of maternal hair to maternal blood to infant blood and finally to infant brain. The results lend support to the use of maternal hair in assessing fetal exposure to methylmercury in fish-eating populations.

37. Davidson PW Myers GJ Cox C Shamlaye CF Marsh DO Tanner MA Berlin M Sloane-Reeves J Cernichiari E Choisy O et al Longitudinal neurodevelopmental study of Seychellois children following in utero exposure to methylmercury from maternal fish ingestion: outcomes at 19 and 29 months.

38. Neurotoxicology (1995 Winter) 16(4):677-88

Despite the importance of defining developmental consequences for humans of in utero exposure to low levels of methylmercury, it is not yet clear if there are postnatal effects in fish-eating populations. The Seychelles Child Development Study (SCDS), now underway in the Republic of Seychelles, is following children to test the hypothesis that prenatal exposure to low concentrations of MeHg through maternal ingestion of fish is related to child development outcomes. In this study, children were evaluated with the Bayley Scales of Infant Development (BSID) at 19 mos. of age (N = 738). The cohort was evaluated again at 29 mos. (N = 736) with the BSID and the Bayley Infant Behavior Record. Mercury exposure determined by cold vapor atomic absorption analysis of maternal hair segments corresponding to pregnancy revealed a median exposure of 5.9 ppm (Range 0.5 - 26.7 ppm). The association between maternal hair mercury concentrations and neurodevelopmental outcomes at 19 and 29 mo. of age was examined by multiple regression analysis with adjustment for confounding variables. Results: BSID Intertester reliability was ascertained by the Kappa statistic and was high. The mean BSID Mental Scale Indexes at both 19 and 29 mo. were comparable to the mean performance of US children. The mean BSID Psychomotor Scale Indexes at 19 and 29 mo. were 2 SD units above US norms, but consistent with previous findings of motoric precocity in children reared in African countries. No effect of mercury was detected on BSID scores at either age. On the Bayley Infant **Behavior Record, activity level in boys, but not girls, decreased with increasing mercury exposure.** Only one subjective endpoint was correlated with prenatal exposure to mercury. This study may have implications for environmental health policies concerning mercury in fish or fish consumption during pregnancy. Follow-up data are needed to determine if adverse effects occur at older ages and if such effects are determined to be related to mercury.

39. Myers GJ Davidson PW Cox C Shamlaye CF Tanner MA Choisy O Sloane-Reeves J Marsh D Cernichiari E Choi A et al Neurodevelopmental outcomes of Seychellois children sixty-six months after in utero exposure to methylmercury from a maternal fish diet: pilot study. Neurotoxicology (1995 Winter) 16(4):639-52

The Seychelles Child Development Study (SCDS) is testing the hypothesis that prenatal exposure to low concentrations of methylmercury from a maternal diet high in fish is related to the child's developmental outcome. In this report, 217 children from a pilot cohort were reevaluated at 66 months of age. The evaluation included the McCarthy Scales of Children's Abilities, the Preschool Language Scale, and age-appropriate sub-tests from the Woodcock- Johnson Tests of Achievement. Maternal hair total mercury, measured by cold vapor atomic absorption in a maternal hair segment corresponding to pregnancy, revealed a median exposure of 7.1 ppm. The association between maternal hair mercury levels and neurodevelopmental outcomes at 66 months of age was examined by multiple linear regression analysis with adjustment for important confounding variables. The results indicated that mercury exposure was negatively associated with four endpoints (the McCarthy General Cognitive Index and Perceptual Performance subscale and The Preschool Language Scale Total Language and Auditory Comprehension subscale). After normalizing the data by removal of a small number of outliers or highly influential scores, the mercury effects were no longer significant except for auditory comprehension. These results should be viewed as preliminary and interpreted with caution, since the SCDS main study 66-month evaluations, which are better controlled with more detailed endpoints are being analyzed. This study highlights the difficulties in interpreting epidemiologic studies of this type and the

degree to which overall results in multivariate analyses can be influenced by a very small number of cases.

40. Myers GJ Marsh DO Cox C Davidson PW Shamlaye CF Tanner MA Choi A Cernichiari E Choisy O Clarkson TW A pilot neurodevelopmental study of Seychellois children following in utero exposure to methylmercury from a maternal fish diet. Neurotoxicology (1995 Winter) 16(4):629-38

    It is not known if fetal neurodevelopmental damage occurs in humans at the low-level methylmercury exposure achieved by eating fish. To address this question, a cohort of 804 children in the Republic of Seychelles was identified who had fetal methylmercury exposure from a maternal diet high in oceanic fish. Mercury was determined by measuring the maternal total hair mercury during pregnancy, a standard index of methylmercury exposure. The median fetal mercury exposure was 6.6 ppm. Children were evaluated once between 5 to 109 weeks of age. Testing included the revised Denver Developmental Screening Test (DDST-R) and a neurological examination. The association between maternal hair mercury levels and developmental outcome was evaluated by multiple logistic regression analysis. Covariates for the child included gender, birth weight, one and five- minute Apgar score, age at testing, and medical problems, and, for the mother, age, tobacco and alcohol consumption during pregnancy, and medical problems. An association between fetal mercury exposure and development was found when DDST-R scores of questionable and abnormal were combined, a procedure used by previous investigators. These results should be viewed with caution since the association disappeared when DDST-R scores of questionable were treated in the standard manner as passes.

41. Cernichiari E Toribara TY Liang L Marsh DO Berlin MW Myers GJ Cox C Shamlaye CF Choisy O Davidson P et al The biological monitoring of mercury in the Seychelles study. Neurotoxicology (1995 Winter) 16(4):613-28

    The concentration of total mercury in maternal hair during pregnancy was used as a measure of fetal exposure to methylmercury in a study of a fish-eating population in the Seychelles islands. A segment of scalp hair approximately 10 centimeters in length, that grew during pregnancy, was selected for measurement. Total and inorganic mercury were measured by cold vapor atomic absorption (CVAA) using the Magos reagents (Magos, 1971). For comparative purposes, total mercury was measured by X-ray Fluorescent Spectrometry (XRF) and methylmercury by gas chromatography/atomic fluorescence detection (GC/AFD) in a subset of hair samples. A limited number of fish samples were also analyzed. Extensive interlaboratory testing was conducted to ensure accuracy of the mercury measurements. Concentrations of organic mercury calculated as the difference between total and inorganic mercury as measured by CVAA agreed with those of methylmercury measured on the same samples of hair by GC/AFD. Methylmercury measured by GC/AFD and organic mercury measured by CVAA accounted for over 80% of the total mercury in hair and over 90% of the total mercury in fish muscle. To test the accuracy of recapitulation by hair sampling, hair samples were collected from mothers at the time of delivery and 6 months later. The segment corresponding to the pregnancy term was selected for measurement assuming a hair growth rate of 1.1 cm/month. Results from both samples were in close agreement. As part of both a pilot investigation followed by the main study, maternal hair samples were collected each year from 1986 to 1989 for a total of 1604 samples. The median and mean values for each year's collection fell in the range of 5.9 to 8.2 ppm and exhibited no statistically significant trend with time. The highest recorded concentration was 36 ppm. In hair samples from 654 mothers, the mean concentration of total mercury was compared with the mean concentrations in segments corresponding to each trimester, approximately 3.3

centimeters in length. A high degree of correlation was found between mean levels in each trimester versus the entire pregnancy segment.

42. Shamlaye CF Marsh DO Myers GJ Cox C Davidson PW Choisy O Cernichiari E Choi A Tanner MA Clarkson TW The Seychelles child development study on neurodevelopmental outcomes in children following in utero exposure to methylmercury from a maternal fish diet: background and demographics. Neurotoxicology (1995 Winter) 16(4):597-612

    Studies in Japan showed that fetal exposure to methylmercury during pregnancy can lead to severe neurodevelopmental changes in the infant while the mother suffers no or minimal effects. Fish contains methylmercury and there is concern that adverse neurodevelopmental effects may occur secondary to low-dose methylmercury exposure in utero from maternal fish consumption. The Seychelles Child Development Study has been examining the relationship between prenatal exposure to methylmercury during pregnancy in a population with high fish consumption and the neurodevelopmental outcome. Over 80% of Seychellois women eat fish daily, and the median fish meals per week during pregnancy is 12. Following a pilot study of 804 mother-infant pairs, a longitudinal main study of another 779 mother- infant pairs was initiated. The main study design includes collection of educational and socioeconomic information about the family and periodic standardized neurodevelopmental tests at specific ages from 6 1/2 months to 66 months of age. In this paper, we describe the background to the studies and give demographic characteristics of both the pilot and main study cohorts.

43. Marsh DO Clarkson TW Myers GJ Davidson PW Cox C Cernichiari E Tanner MA Lednar W Shamlaye C Choisy O et al The Seychelles study of fetal methylmercury exposure and child development: introduction. Neurotoxicology (1995 Winter) 16(4):583-96

    Studies of outbreaks of methylmercury poisoning in Japan and Iraq from consumption of methylmercury (MeHg)-contaminated fish or bread proved that brain was the target organ, the toxic effects were dose- related, and the fetal brain was especially susceptible. Previous population studies suggested that a 5% risk of minimal fetal effect may be associated with a maternal hair mercury concentration during pregnancy of 10-20 ppm (mu g/g), a level that can be readily achieved by frequent consumers of fish. However, these studies had limitations, and as a result no definite conclusion concerning the lowest effect level could be reached and the question of a possible hazard to public health remained unanswered. There was a clear need for a more definitive study that would be prospective, involve a large enough cohort for risk analysis and adhere to accepted epidemiological principles. An appropriate site for such a study is the Republic of Seychelles, a location that afforded successful collaboration between the Seychelles Ministry of Health and faculty of the University of Rochester. A pilot study of 804 infant-mother pairs was followed by a main study of 779 mother-infant pairs. In the pilot study children were examined once between 5 and 109 weeks of age; in the main study they are being evaluated longitudinally starting at 6 1/2 months of age. This paper introduces both the pilot and main studies, describes their design, and summarizes the findings through 6 1/2 months of age. When the Seychelles study is completed, the analyses will provide a database for those nations that choose to regulate their citizens' fish consumption and/or provide dietary education.

44. Grandjean P Weihe P White RF Milestone development in infants exposed to methylmercury from human milk. Neurotoxicology (1995 Spring) 16(1):27-33

    Breastfeeding seems to confer an advantage to the infant with regard to neurobehavioral development, possibly in part due to essential nutrients in human milk. However, human milk may be contaminated by environmental neurotoxicants, such as methylmercury. At the Faroe

Islands where maternal consumption of pilot whale meat and blubber may well cause a considerable transfer of these neurotoxicants into human milk, 583 infants were followed by district health nurses during the first 12 months after birth. Three developmental milestones that are usually reached between between 5 and 12 months of age, i.e., sitting, creeping and standing, were examined. Infants who reached milestone criteria early had significantly higher mercury concentrations in the hair at 12 months of age. This association is contrary to what would be expected from possible neurotoxic effects of mercury. However, early milestone development was clearly associated with breastfeeding which was again related to increased hair-mercury levels. Milestone development was not associated with indicators of prenatal methylmercury exposure, such as the maternal hair-mercury concentration at parturition. The relationship between early milestone development and high hair-mercury levels in the infant therefore seems to be due to confounding caused by the duration of breastfeeding. No other potential confounder played any role in this regard. This study therefore suggests that, if methylmercury exposure from human milk had any adverse effect on milestone development in these infants, the effect was compensated for or overruled by advantages associated with nursing.

45. Lutz E Lind B Herin P Krakau I Bui TH Vahter M Concentrations of mercury, cadmium and lead in brain and kidney of second trimester fetuses and infants. J Trace Elem Med Biol (1996 Jun) 10(2):61-7

The concentrations of mercury (Hg), cadmium (Cd) and lead (Pb) in brain (cerebrum) and kidney during fetal (second trimester terminations or abortions, n = 20) and postnatal (infants deceased before three months of age, n = 15) development have been studied. Information on possible sources of exposure was obtained from the mothers of the fetuses, but not from those of the infants. The median concentration of Hg in the brain was 4 micrograms/ kg wet weight in both fetuses and infants (total range < or = 2-23 micrograms/kg). The concentrations of Hg in the kidneys were significantly higher than in brain, median of Hg 6 micrograms/kg (range < or = 5-34 micrograms/kg) in fetuses and 10 micrograms/kg (< or = 7-37) in infants. There was a tendency of increasing concentration of Hg in the fetal kidney, but not in the brain, with increasing number of amalgam fillings in the mothers. The concentration of Cd in the brain was less than 1 microgram/kg in most cases, both in fetuses and infants. The concentration of Cd in the kidneys was significantly higher, with a median of about 2 micrograms/kg (1-8 micrograms/kg) in both groups. There was no detectable association between tissue Cd concentrations and the smoking habits of the mothers. The concentration of Pb in brain was below 10 micrograms/kg in most cases. In the kidneys, the concentrations of Pb were significantly higher, with a median of 12 micrograms/kg in the fetuses (range < or = 6-20 micrograms/kg) and 15 micrograms/kg (< or = 9-36 micrograms/kg) in the infants. In general, the concentrations of Cd and Pb were lower than in previously reported studies.

46. Sandborgh-Englund G Nygren AT Ekstrand J Elinder CG No evidence of renal toxicity from amalgam fillings. Am J Physiol (1996 Oct) 271(4 Pt 2):R941-5

Dental amalgam continuously releases mercury. Studies of sheep [Boyd et al., Am. J. Physiol. 261 (Regulatory Integrative Comp. Physiol. 30): R1010-R1014, 1991] showed decreased renal function after placement of amalgam fillings. In this study, renal function was investigated in 10 healthy volunteers before and after amalgam removal. The subjects had an average of 18 tooth surfaces filled with amalgam, which was removed during one dental session. One week before and sixty days after removal, the glomerular filtration rate (GFR) was determined by 51Cr-EDTA clearance technique. Blood and urine samples were collected for analysis of mercury, creatinine, beta 2-microglobulin, N-acetyl-beta-glucosaminidase (NAG), and albumin 1 wk before and 1, 2, and 60

days after amalgam removal. The plasma mercury concentration increased significantly 1 day after removal. Sixty days later, significantly lower mercury levels were found in blood, plasma, and urine. The GFR values were similar before and after mercury exposure (mean 94 and 94 ml/min per 1.73 m2, respectively). No detectable effects occurred on excretion of NAG, beta 2-microglobulin, or albumin. It is concluded that no signs of renal toxicity could be found in conjunction with mercury released from amalgam fillings.

47. Oskarsson A Schultz A Skerfving S Hallen IP Ohlin B Lagerkvist BJ Total and inorganic mercury in breast milk in relation to fish consumption and amalgam in lactating women. Arch Environ Health (1996 May-Jun) 51(3):234-41

    Total mercury concentrations (mean +/- standard deviation) in breast milk, blood, and hair samples collected 6 wk after delivery from 30 women who lived in the north of Sweden were 0.6 +/- 0.4 ng/g (3.0 +/- 2.0 nmol/kg), 2.3 +/- 1.0 ng/g (11.5 +/- 5.0 nmol/kg), and 0.28 +/- 0.16 microg/g (1.40 +/- 0.80 micromol/kg), respectively. In milk, an average of 51% of total mercury was in the form of inorganic mercury, whereas in blood an average of only 26% was present in the inorganic form. Total and inorganic mercury levels in blood ($r = .55$, $p = .003$; and $r = .46$, $p = .01$ 6; respectively) and milk ($r = .47$, $p = .01$; and $r = .45$, $p = .018$; respectively) were correlated with the number of amalgam fillings. The concentrations of total mercury and organic mercury (calculated by subtraction of inorganic mercury from total mercury) in blood ($r = .59$, $p = .0006$, and $r = .56$, $p = .001$; respectively) and total mercury in hair ($r = .52$, $p = .006$) were correlated with the estimated recent exposure to methylmercury via intake of fish. There was no significant between the milk levels of mercury in any chemical form and the estimated methylmercury intake. A significant correlation was found between levels of total mercury in blood and in milk ($r = .66$, $p = .0001$), with milk levels being an average of 27% of the blood levels. There was an association between inorganic mercury in blood and milk ($r = .96$, $p < .0001$); the average level of inorganic mercury in milk was 55% of the level of inorganic mercury in blood. No significant correlations were found between the levels of any form of mercury in milk and the levels of organic mercury in blood. The results indicated that there was an efficient transfer of inorganic mercury from blood to milk and that, in this population, mercury from amalgam fillings was the main source of mercury in milk. Exposure of the infant to mercury from breast milk was calculated to range up to 0.3 microg/kg x d, of which approximately one-half was inorganic mercury. **This exposure, however, corresponds to approximately one-half the tolerable daily intake for adults recommended by the World Health Organization.** We concluded that efforts should be made to decrease mercury burden in fertile women.

48. Bjerregaard P Hansen JC Effects of smoking and marine diet on birthweight in Greenland. Arctic Med Res (1996 Oct) 55(4):156-64

    The associations of maternal smoking and blood mercury concentration on birthweight were studied in 1106 liveborn singletons from Greenland with a gestational period of 37+ weeks. After control for population group, smoking was significantly associated with low birthweight while consumption of marine mammals, maternal or cord blood mercury concentration were not. Only in West Greenlanders a week association was found between mercury and low birthweight. The Greenlandic diet of marine mammals has high concentrations of mercury and organochlorines which may reduce birthweight, and it is rich in n- 3 fatty acids which have been shown to prolong pregnancy and thereby increase birthweight. In the present study neither previous reports of a negative influence of marine diet on birthweight due to methylmercury or previous reports of a positive influence of marine diet on birthweight due to n-3 fatty acids were supported.

49. Dahl R White RF Weihe P Sorensen N Letz R Hudnell HK Otto DA Grandjean P Feasibility and validity of three computer-assisted neurobehavioral tests in 7-year-old children. Neurotoxicol Teratol (1996 Jul-Aug) 18(4):413-9

Three tests from the computerized Neurobehavioral Examination System (NES) were administered to a group of 917 Faroese children at approximately 7 years of age. The NES Continuous Performance Test (CPT) was modified to use animal silhouettes as stimuli instead of letters. Almost all children completed Finger Tapping (FT), the modified CPT, and Hand-Eye Coordination (HE). However, 18% of the children missed at least 25% of the stimuli on the CPT (full test period), and 37% of the children did not improve their HE performance by at least 10%, as compared to the first trial. Boys obtained better results than girls, and older children performed better than younger ones. However, both factors were confounded by acquaintance with computer games. Children who used glasses, who had strabismus, or who had decreased contrast sensitivity obtained less satisfactory scores, especially on CPT and HE. The NES performance was significantly associated with functional neurological performance, including catching a ball, diadochokinesia, and finger agnosia. Slight, though statistically significant, decrements were seen with increased levels of prenatal exposure to neurotoxicants, as indicated by the mercury concentrations in cord blood obtained at the time of birth. In conclusion, the tests were feasible in this age group after slight modifications, and the test results showed meaningful associations with major predictors, thus supporting the validity of the data.

50. Rice DC Evidence for delayed neurotoxicity produced by methylmercury. Neurotoxicology (1996 Fall-Winter) 17(3-4):583-96

Delayed toxicity as a result of developmental methylmercury exposure was identified in mice two decades ago by Spyker, who observed kyphosis, neuromuscular deficits, and other severe abnormalities as the mice aged. Delayed neurotoxicity was also observed in monkeys treated with methylmercury from birth to seven years of age. When these monkeys reached 13 years of age, individuals began exhibiting clumsiness not present previously. Further exploration revealed that treated monkeys required more time to retrieve treats than did nonexposed monkeys and displayed abnormalities on a clinical assessment of sense of touch in hands and feet, despite the fact that clinical examinations performed routinely during the period of dosing had not yielded abnormal results. Another group of monkeys, dosed from in utero to four years of age, also took longer to retrieve treats when assessed years after cessation of exposure. These observations were pursued in both groups of monkeys by objective assessment of somatosensory function in the hands: both groups of monkeys exhibited impaired vibration sensitivity. These results are strongly suggestive of a delayed neurotoxicity manifested when these monkeys reached middle age. Data from persons with Minamata disease also provide evidence for delayed neurotoxicity. Perhaps the strongest piece of evidence comes from a study of over 1100 Minamata patients over 40 years old, in which difficulty in performing daily activities increased as a function of age compared to matched controls. Methylmercury may represent the only environmental toxicant for which there is good evidence for delayed neurotoxicity that may be manifested many years after cessation of exposure.

51. Boischio AA Henshel DS Risk assessment of mercury exposure through fish consumption by the riverside people in the Madeira Basin, Amazon, 1991.: Neurotoxicology (1996 Spring) 17(1):169-75

Aquatic food chain mercury pollution is one of the consequences of the gold rush in the Amazon, which started in the late 1970s. This paper addresses the risks of methylmercury (MeHg) toxicity by a riverside population of heavy fish eaters along the Madeira river, in the Amazon, based on their hair mercury (Hg) concentration. Given the vulnerability of the developing nervous system,

NOEL/LOEL values were used based on prenatal (LOELp = 0.7 microgram/ kg bw), and adult and childhood (LOELa = 3 micrograms/kg bw) Hg exposures. Based on hair Hg concentrations, we observed that approximately 95% of infants were at risk of absorbing Hg through the previous placental exposure, and/or by ingesting Hg from mother's milk, and/or fish consumption, at a level as great as the LOELp. The hazard quotient derived from the LOELp for neurobehavioral effects was 64 based on an estimated mean Hg daily intake of 4.5 micrograms/kg bw. Approximately 45% of the mothers of the infants and other women of child bearing age were at risk of ingesting Hg at a level equivalent to the LOELp. This also translates into a derived hazard quotient for neurobehavioral effects of 17 for all potential mothers in the population. The non-infant population at the highest risk was fish-eating children under 5 years old. This sub-population had a mean estimated Hg daily intake of 6.4 micrograms/kg bw. This resulted in a probability that almost 60% of this sub-population ingested Hg at a level equivalent to the LOELa or higher. For this sub-population, there was a hazard quotient of 21. These data strongly indicate that the young children of this riverside fish-eating population may be ingesting Hg doses that have been correlated with neurological damage from Hg poisoning.

52. Vimy MJ Lorscheider FL Renal function and amalgam mercury. Am J Physiol (1997 Sep) 273(3 Pt 2):R1199-200

53. Yang J Jiang Z Wang Y Qureshi IA Wu XD Maternal-fetal transfer of metallic mercury via the placenta and milk. Ann Clin Lab Sci (1997 Mar-Apr) 27(2):135-41

    To clarify the situation of trans-placental movement and milk screening of metallic mercury in human, the content of mercury was detected in the maternal blood, umbilical cord blood, milk, and placental tissues. In 18 parturient women, 9 had been occupationally exposed to metallic mercury whereas the other 9 had not. Mercury was detected by means of cold vapor atomic absorption spectrophotometry. **Results showed that the concentrations of mercury of the umbilical cord blood and placental tissues were higher than that of maternal blood**. The ratio of organic and total mercury of milk was markedly lower than that of maternal blood in the exposed group ($P < 0.01$). The ratio of inorganic to total mercury of milk was significantly higher than that of maternal blood ($P < 0.01$). **Therefore, this study concluded that the metallic mercury can be transferred to the fetus via the placenta and secreted to a newborn via milk.**

54. Goyer RA Toxic and essential metal interactions. Annu Rev Nutr (1997) 17:37-50

    Cadmium, lead, mercury, and aluminum are toxic metals that may interact metabolically with nutritionally essential metals. Iron deficiency increases absorption of cadmium, lead, and aluminum. Lead interacts with calcium in the nervous system to impair cognitive development. Cadmium and aluminum interact with calcium in the skeletal system to produce osteodystrophies. Lead replaces zinc on heme enzymes and cadmium replaces zinc on metallothionein. Selenium protects from mercury and methylmercury toxicity. Aluminum interacts with calcium in bone and kidneys, resulting in aluminum osteodystrophy. Calcium deficiency along with low dietary magnesium may contribute to aluminum-induced degenerative nervous disease.

55. dell'Omo M Muzi G Bernard A Filiberto S Lauwerys RR Abbritti G Long-term pulmonary and systemic toxicity following intravenous mercury injection. Arch Toxicol (1997) 72(1):59-62

    Long-term pulmonary and systemic toxicity following mercury intravenous injection has rarely been assessed. We present the results of a detailed investigation assessing pulmonary and

systemic long-term toxic effects in a subject who had pulmonary and systemic mercury microembolism diagnosed more than 11 years previously. Radiographic examination showed the persistence of mercury microemboli in both lungs and elsewhere in the body. Lung function tests revealed a decreased diffusing capacity for carbon monoxide and PO2 probably indicative of microscopic inflammation of lung interstitium. Electroneuromyography showed signs of mild axonopathy in both legs. At semen analysis, a high proportion of motionless spermatozoa was present. Urinary excretion of mercury was high. **Signs of interstitial lung impairment, peripheral axonopathy and asthenozoospermia in a subject who had mercury microembolism** persisting for more than 11 years might be evidence of long-term mercury toxicity.

56. Vimy MJ Hooper DE King WW Lorscheider FL Mercury from maternal "silver" tooth fillings in sheep and human breast milk. A source of neonatal exposure. Biol Trace Elem Res (1997 Feb) 56(2):143-52

    Neonatal uptake of mercury (Hg) from milk was examined in a pregnant sheep model, where radioactive mercury (Hg203)/silver tooth fillings (amalgam) were newly placed. A crossover experimental design was used in which lactating ewes nursed foster lambs. In a parallel study, the relationship between dental history and breast milk concentration of Hg was also examined in 33 lactating women. Results from the animal studies showed that, during pregnancy, a primary fetal site of amalgam Hg concentration is the liver, and, after delivery, the neonatal lamb kidney receives additional amalgam Hg from mother's milk. **In lactating women with aged amalgam fillings, increased Hg excretion in breast milk and urine correlated with the number of fillings or Hg vapor concentration levels in mouth air.** It was concluded that Hg originating from maternal amalgam tooth fillings transfers across the placenta to the fetus, across the mammary gland into milk ingested by the newborn, and ultimately into neonatal body tissues. Comparisons are made to the U. S. minimal risk level recently established for adult Hg exposure. These findings suggest that placement and removal of "silver" tooth fillings in pregnant and lactating humans will subject the fetus and neonate to unnecessary risk of Hg exposure.

57. Harnly M Seidel S Rojas P Fornes R Flessel P Smith D Kreutzer R Goldman L Biological monitoring for mercury within a community with soil and fish contamination. Environ Health Perspect (1997 Apr) 105(4):424-9

    To assess the impact of elevated levels of inorganic mercury in soil and dust and organic mercury in fish, biological monitoring was conducted among Native Americans living next to an inactive mercury mine in Clear Lake, California. Of resident tribal members, 46% (n = 56) participated in biomonitoring. Urine mercury levels are equivalent to background, indicating that soil and dust exposures among study participants are not substantial. The average blood organic mercury level among study participants is 15.6 +/- 8.8 micrograms/l (n = 44), which is higher than levels reported by others among those who do not consume fish (2 micrograms/l). Consistent with results from other studies, a correlation between fish consumption and blood organic mercury is observed (p = 0.03). The margin between observed and established adverse effect levels for adults is examined for blood organic mercury and found to be less than 10-fold for 20% of the study population. Protective public health efforts for the study population and other similarly exposed populations, notably those who consume commercial fish products, are considered.

58. Myers GJ Davidson PW Shamlaye CF Axtell CD Cernichiari E Choisy O Choi A Cox C Clarkson TW Effects of prenatal methylmercury exposure from a high fish diet on developmental milestones in the Seychelles Child Development Study. Neurotoxicology (1997) 18(3):819-29

    Mercury is widespread in the environment and exists in several physical and chemical forms. Prenatal exposure to methylmercury disrupts brain development. The most common mode of

prenatal methylmercury exposure is maternal fish consumption. Studies of human prenatal exposure in Iraq following maternal ingestion of methylmercury treated grain suggested that maternal hair mercury concentrations above 10 ppm may be related to delayed developmental milestones and neurological abnormalities. This level of exposure can be achieved by frequent consumption of fish. The Seychelles Child Development Study analyzed developmental milestones similar to those determined in Iraq in a large controlled, prospective study of children exposed prenatally to methylmercury when their mothers ate fish. As part of this ongoing study, cohort children were evaluated at 6.5, 19, 29, and 66 months of age. At 19 months care-givers were asked at what age the child walked (n=720 out of 738) and talked (n=680). Prenatal mercury exposure was determined by atomic absorption analysis of maternal hair segments corresponding to hair growth during the pregnancy. The median mercury level in maternal hair was 5.8 ppm with a range of 0.5-26.7 ppm. The mean age (in months) at walking was 10.7 (SD = 1.9) for females and 10.6 (SD = 2.0) for males. The mean age at talking (in months) was 10.5 (SD = 2.6) for females, and 11.0 (SD = 2.9) for males. After adjusting for covariates and statistical outliers, no association was found between the age at which Seychellois children walked or talked and prenatal exposure to mercury. Normal ages at achievement of the developmental milestones walking and talking were found in Seychellois toddlers following prenatal exposure to methylmercury from a maternal fish diet. These results do not support the lowest effect levels in young children following prenatal methylmercury exposure predicted by the dose response analysis of the Iraq data. More detailed studies in older children are needed to determine if there are adverse effects in fish eating populations.

59. Elghany NA Stopford W Bunn WB Fleming LE Occupational exposure to inorganic mercury vapour and reproductive outcomes. Occup Med (Lond) (1997 Aug) 47(6):333-6

    The effect of exposure to inorganic mercury on the pregnant woman and her foetus has received little attention. Transport of elemental inorganic mercury into foetal tissues has been reported, and prior studies indicate a higher incidence of adverse pregnancy outcome. The effects of occupational exposure to inorganic mercury on pregnancy were investigated among 46 exposed women workers: controls were 19 women working in non-production areas of the same factory. There were 104 recorded total pregnancies during the period 1948-77. The study revealed a higher frequency of adverse reproductive outcomes, especially congenital anomalies, among the women exposed to inorganic mercury levels at or substantially lower than 0.6 mg/m3; no significant differences in the stillbirth or miscarriage rates were noted between the two groups of women. The overall foetal death rate in this study was similar to New York state (USA) and national levels for the same period.

60. Schuurs AH [Working with mercury: cause of infertility in women? Werken met kwik: oorzaak van vruchtbaarheidsproblemen voor vrouwen? Ned Tijdschr Tandheelkd (1998 Nov) 105(11):401-3

    According to animal experiments, case reports and epidemiological studies, exposition to a high concentration of metallic mercury vapour may cause an increase in reproductive problems. A report on this matter is summarized here as far as it regards women. It seems warranted to conclude that negative reproductive effects are unlikely unless, due to a failing hygiene, the concentration of mercury vapour exceeds the MAC (maximum approved concentration) for women. However, the relationship between concentrations smaller than females' MAC value and problems with cycle and conception need more research.

61. Barbosa AC Silva SR Dorea JG Concentration of mercury in hair of indigenous mothers and infants from the Amazon basin. Arch Environ Contam Toxicol (1998 Jan) 34(1):100-5

Hair mercury concentration, as an indicator of mercury body load, was studied in 251 samples of indigenous women and children living in selected areas of the Amazonian region. The mothers or women of child- bearing age, either non-Indians or Indians, and their children were sampled along the Madeira River and in the Kayapo reservation (Fresco River), respectively. Among the sampled individuals there were mothers with infants less than 2 years old. Total mercury in hair was determined by cold vapor atomic absorption spectrometry after alkaline digestion. The distribution of hair mercury concentration greater than 10 microg/g occurred in 67.4% of non-Indian women and 25% of Indian women; overall only 1% of non-Indian women had concentrations of hair mercury above 50 microg/g. In women of child- bearing age, the median and range of hair mercury concentration was 14.08 microg/g, and 0.8-94.7 microg/g for non-Indians, and 8.30 microg/g, and 0.8-13.3 microg/g for Indians. **The correlation between maternal hair mercury and mercury in hair of infants (less than 2 years of age) still breast-feeding, was statistically significant only for non-Indians** (r = 0.555 p < 0. 001). **The correlation between length of breast-feeding and mercury concentration in infant's hair was significant for Indian children** (r = 0.512; p = 0.029) but not for non-Indian children (r = 0.025; p = 0.832). A subsampling of 30 mothers had segmented hair analysis that showed a mean decrease of 20% in body burden during pregnancy, thus **indicating the extent of placental transference of mercury to fetuses**.

62. Rhainds M Levallois P Dewailly E Ayotte P Lead, mercury, and organochlorine compound levels in cord blood in Quebec, Canada. Arch Environ Health (1999 Jan-Feb) 54(1):40-7

    We conducted this study to evaluate blood levels of lead, mercury, and organochlorine compounds in newborns in the Province of Quebec. During 1993 to 1995, we carried out a survey in 10 hospitals located in southern Quebec. During that time, umbilical cord blood samples were obtained from 1109 newborns, and we analyzed each for lead, mercury, 14 polychlorinated biphenyl congeners, and 11 chlorinated pesticides. We used the geometric mean and 95% confidence interval (CI) to describe the results. Mean concentrations of lead and mercury in cord blood were 0.076 micromol/l (95% CI = 0.074, 0.079) and 4.82 nmol/l (95% CI = 4.56, 5.08), respectively. The mean concentrations of total polychlorinated biphenyls (Aroclor 1260) and dichlorodiphenyl dichloroethylene were 0.514 microg/l (95% CI = .493, 0.536) and 0.412 microg/l (95% CI = 0.390, 0.435), respectively. **We observed a statistically significant relationship between maternal age and cord blood concentrations of (a) lead, (b) mercury, (c) polychlorinated biphenyls, and (d) dichlorodiphenyl dichloroethylene. In addition, maternal smoking during pregnancy was associated with cord blood lead levels.** The cord blood concentrations of lead, mercury, polychlorinated biphenyls, and dichlorodiphenyl dichloroethylene we measured in our study were the lowest levels recently reported in industrialized countries. The results of this study underline the role of public health authorities in the evaluation of biological levels of environmental contaminants among children for the assessment of risk of adverse health effects.

63. Cordier S Grasmick C Paquier-Passelaigue M Mandereau L Weber JP Jouan M Mercury exposure in French Guiana: levels and determinants. Arch Environ Health (1998 Jul-Aug) 53(4):299-303

    Mercury is used widely for gold extraction in French Guiana and throughout the entire Amazon basin. To evaluate contamination among the general population, the authors chose individuals who attended 13 health centers and maternity hospitals dispersed geographically across the territory and served Guiana's different populations. Five hundred individuals (109 pregnant women, 255 "other" adults, and 136 children) who received care at one of the centers were selected randomly for this study. Each individual answered a questionnaire and provided a hair

sample. The authors determined *mercury in hair* with atomic absorption spectrometry. The following mean levels of mercury were observed: 1.6 microg/g (95% confidence interval [CI]=1.3, 1.9) among pregnant women; 3.4 microg/g (95% CI=3.0, 3.9) among other adults; and 2.5 microg/g (95% CI=2.1, 3.0) among children. Diet factors contributed the most to mercury levels, especially consumption of freshwater fish (mean=6.7 microg/g for individuals who ate fish more than 5 times/wk) and livers from game. Other factors, including age, dental amalgams, use of skin-lightening cosmetics, and residence near a gold-mining community, did not contribute significantly to mercury levels. Overall, 12% of the samples contained mercury levels in excess of 10 microg/g, but in some Amerindian communities up to 79% of the children had hair mercury levels that exceeded 10 microg/g. The results of this study indicated that (a) diet played a predominant role in total mercury burden, and (b) in some communities, mercury contamination exceeded safe levels.

64. Chai Z Feng W Qian Q Guan M Correlation of mercury with selenium in human hair at a typical mercury-polluted area in China. Biol Trace Elem Res (1998 Aug) 63(2):95-104

    The levels of mercury (Hg) and selenium (Se) and their correlation in human scalp hair of 29 pairs of pregnant women and their newborns living at a high-Hg and low-Se area, the Second Song-Hua-Jiang River System, have been studied by instrumental neutron activation analysis. Our results indicate that the Hg level in infant hair samples are roughly close to that in their mothers, whereas the Se level in infants is much higher. Furthermore, the molar ratios of Se/Hg in newborns are also 40% higher than those in mothers. It demonstrates that infants are able to absorb more selenium from their mothers' bodies to protect against or alleviate the intoxication of Hg. This "autoprotective mechanism" likely plays a critical role during fetal development. The possible chemical species of Hg and Se in hair is also discussed.

65. Muckle G Dewailly E Ayotte P Prenatal exposure of Canadian children to polychlorinated biphenyls and mercury. Can J Public Health (1998 May-Jun) 89 Suppl 1:S20-5, 22-7

    This article documents the exposure to environmental contaminants within sub-groups of the Canadian population who are considered to be at risk as a result of the food they eat. We measured the concentrations of polychlorinated biphenyls (PCBs) and mercury in the blood drawn from the umbilical cords of newborns in various Aboriginal communities, in a coastal community and in the general population. Average concentrations of Aroclor 1260 ranged between 0.3 and 2.0 micrograms/L and were clearly highest among the Inuit of Nunavik and Baffin Island and among the Montagnais of Quebec. In these groups, we found contaminant levels in the blood of newborns that exceed the threshold beyond which cognitive impairments are expected to result. Average concentrations of mercury ranged between 1.0 and 14.2 micrograms/L; the Inuit of Nunavik and the NWT exhibited the highest exposure levels. A portion of the Nunavik and NWT Inuit had concentrations beyond the critical threshold for the appearance of neurological consequences. The variations in exposure levels resulted from the different nutritional practices of these Canadian sub-groups.

66. Dickman MD Leung KM Mercury and organochlorine exposure from fish consumption in Hong Kong. Chemosphere (1998 Aug) 37(5):991-1015

    The average person in Hong Kong consumes fish or shellfish four or more times a week averaging about 60 Kg of fish per year. Even though the mean mercury level in store-bought Hong Kong fish was only 0.12 mg/kg, corroborating evidence is presented from numerous studies to support the view that mercury bioaccumulates. By the time a typical Hong Kong male reaches 30 years of age he will have accumulated approximately 4 mg/kg mercury in his hair. By age 60, his hair mercury

levels will have increased to about 7.5 mg/kg. Hair is a useful indicator of mercury exposure. In the U.S. over a million hair samples have been examined for mercury (mean, 1.5 mg/kg). The mean hair mercury concentration for over 200 Hong Kong residents was 3.3 mg/kg which is more than double the U.S. mean (well over one standard deviation above the U.S. mean). Two lines of evidence support the hypothesis that fish is the major source of methyl mercury in the diet of Hong Kong residents. 1. Individuals consuming 4 or more meals of fish per week had a hair mercury of 4.07 mg/kg dry weight of hair while those consuming fish less frequently had significantly lower levels (2.56 mg/kg). 2. Hong Kong residents that consume no fish had only 0.38 mg/kg hair mercury. The World Health Organization has adopted the U.S. EPA levels for mercury and recommends that food with mercury concentrations of 0.5 mg/kg or more should not be sold for human consumption. Data presented in this paper are consistent with the notion that adoption of a 0.3 mg/kg mercury guideline would benefit residents in countries where rates of fish consumption are significantly higher than in the U.S. Japan, for example, has already adopted a 0.3 mg/kg mercury guideline. In Hong Kong there is a significant correlation ($p < 0.05$) between male subfertility and the level of mercury in the hair of males between the ages of 25 and 75. Our study of individuals who have been eating mercury contaminated fish steadily for many years suggests that a daily mercury intake of only 0.3 to 0.7 mg/kg body weight may be sufficient to inhibit spermatogenesis in some Hong Kong males. Male subfertility has been correlated with both elevated mercury and the presence of various organochlorines in the diet. To determine whether fish sold in Hong Kong with elevated levels of mercury also had elevated levels of organochlorines we analyzed fish for both mercury and organochlorine content of their dorsal muscle tissue. Because analysis of fish tissue for lipids and a wide range of organochlorines is both very time consuming and expensive, only 15 different species of fish were tested. Organochlorine concentrations were low and there was no correlation between mercury and organochlorine in the 15 fish tested for both organochlorines and mercury. **As a result of these tests we concluded that mercury could not be ruled out as the principal causal factor associated with the lack of fertility in Hong Kong males.**

67. Myers GJ Davidson PW Prenatal methylmercury exposure and children: neurologic, developmental, and behavioral research. Environ Health Perspect (1998 Jun) 106 Suppl 3:841-7

Mercury is present in the earth's crust and is methylated by bacteria in aquatic environments to methylmercury (MeHg). It is then concentrated by the food chain so predatory fish and sea mammals have the highest levels. Thus, consuming seafood leads to exposure. MeHg readily crosses the placenta and the blood-brain barrier and is neurotoxic. The developing fetal nervous system is especially sensitive to its effects. Prenatal poisoning with high dose MeHg causes mental retardation and cerebral palsy. Lower level exposures from maternal consumption of a fish diet have not been consistently associated with adverse neurodevelopmental outcomes. However, most studies have considerable uncertainty associated with their results. Two large controlled longitudinal studies of populations consuming seafood are underway that are likely to determine if any adverse effects can be identified. No adverse associations have been found in the Seychelles, where exposure is mainly from fish consumption. In the Faroe Islands where exposure is primarily from consumption of whale meat and not fish, adverse associations have been reported. The Seychelles population consumes large amounts of marine fish containing MeHg concentrations similar to commercial fish in the United States. Current evidence does not support the hypothesis that consumption of such fish during pregnancy places the fetus at increased neurodevelopmental risk.

68. Kehrig HA Malm O Akagi H Guimaraes JR Torres JP Methylmercury in fish and hair samples from the Balbina Feservoir, Brazilian Amazon. Environ Res (1998 May) 77(2):84-90

    The present study aimed to evaluate methylmercury in fish and human hair samples from an important hydroelectrical reservoir, Balbina (Brazil, Amazon). It presents a quite intense fishing activity and there is no known goldmining activity in its watershed. Fish and human hair were analyzed with a new extraction technique and measured by GC-ECD. Analytical quality was checked through intercomparisons between two laboratories with local samples and certified standards from IAEA. Methylmercury in hair ranged from 2.0 to 21.6 microg . g-1 with a mean of 8.76+/-5.20 microg . g-1 (N=20), while the methylmercury percentages were above 90. Fish presented methylmercury levels ranging from 0.03 to 0.9 microg small middle dot g-1 wet wt with a mean of 0.24+/-0.18 microg small middle dot g-1 wet wt (N=32), which is below the limit established for food by Brazilian legislation (0.5 microg small middle dot g-1 wet wt) and methylmercury mean percentages were above 95%. The total mean daily methylmercury intake ranged from 11 to 55 microg for 70% of the sampled population from the village based on a daily consumption of about 110 g of fish with methylmercury concentrations in the range of 0.1 to 0.5 microg . g-1. This calculation is consistent with methylmercury concentrations in hair samples in the range of 2.6 to 13.1 microg . g-1.

69. Boischio AA Cernichiari E Boischio AAP Longitudinal hair mercury concentration in riverside mothers along the Upper Madeira river (Brazil).Environ Res (1998 May) 77(2):79-83

    Mercury releases from gold mining occurred during the 1980s in the Upper Madeira river, a Southern tributary of the Amazon. Downstream from these areas, riverside residents rely on fish consumption for subsistence. In July of 1993, hair samples were collected for mercury analysis from a group of mothers and their infants and one pregnant woman. By assuming a constant rate of hair growth (1.1 cm per month), a temporal profile of the methylmercury exposure was determined for the previous 2 to 3 years. The length of hair segments corresponded to hair growth during pregnancy and the subsequent breastfeeding periods. During all periods, hair mercury concentrations in six mothers were in the range of 4.5-26.8 ppm, slightly lower than those of their infants (8.2-28.4 ppm). Further segmental analyses of hair mercury from another six mothers showed concentrations in the range of 12.2-41.0 ppm during the three trimesters of pregnancy and 4.0- 33.5 ppm during breast feeding-slightly lower than their infants (11.6-50.4 ppm). Another four mothers showed hair mercury concentrations in the range of 21. 3-84.4 ppm.

70. Gerhard I Monga B Waldbrenner A Runnebaum B Heavy metals and fertility. J Toxicol Environ Health A (1998 Aug 21) 54(8):593-611

    Heavy metals have been identified as factors affecting human fertility. This study was designed to investigate whether the urinary heavy metal excretion is associated with different factors of infertility. The urinary heavy metal excretion was determined in 501 infertile women after oral administration of the chelating agent 2,3- dimercaptopropane-1-sulfonic acid (DMPS). Furthermore, the influence of trace element and vitamin administration on metal excretion was investigated. Significant correlations were found between different heavy metals and clinical parameters (age, body mass index, nationality) as well as gynecological conditions (uterine fibroids, miscarriages, hormonal disorders). Diagnosis and reduction of an increased heavy metal body load improved the spontaneous conception chances of infertile women. The DMPS test was a useful and complementary diagnostic method. Adequate treatment provides successful alternatives to conventional hormonal therapy.

71. Drasch G Aigner S Roider G Staiger F Lipowsky G Mercury in human colostrum and early breast milk. Its dependence on dental amalgam and other factors. J Trace Elem Med Biol (1998 Mar) 12(1):23-7

    The mercury concentration in 70 breast milk samples (Hg-M) from 46 mothers, collected within the first 7 days after delivery, was determined by cold vapour atomic absorption spectrometry. For comparison, 9 formula milk samples (reconstituted with Hg-free water) were investigated. The Hg-M in the human milk samples ranged from < 0.2 to 6.86 micrograms/L (median 0.37), in the formula milk samples from 0.4 to 2.5 micrograms/L (median 0.76). The Hg-M in the breast milk samples correlates positively with the number of maternal teeth with dental amalgam. The mean Hg-M of amalgam-free mothers was < 0.2 microgram/L, while milk from mothers with 1-4 amalgam fillings contained 0.57 microgram/L, with 5-7 fillings 0.50 microgram/L and with more than 7 fillings 2.11 micrograms/L. Hg-M correlated negatively to the day after delivery. Frequency of fish consumption tends to influence Hg-M positively, while the age of the mother shows no significant correlation. In the first 2 to 3 days after delivery some colostrum samples with Hg-M higher than in formula milk were found. Later on, the Hg-concentration in the breast milk was equal or even lower to that in formula milk. The higher Hg burden of infants' tissues from mothers with dental amalgam, as reported previously, must be explained (1) by a prenatal transfer of Hg from the mother's fillings through the placenta to the fetus, followed by a redistribution of this Hg in the body of the newborn, and (2) an additional burden via breast milk. Nevertheless, the comparison of Hg- M in breast and formula milk, the relatively moderate Hg burden in both kinds of milk, and the multiple manifest advantages of breast feeding speak against any limitation of nursing, even for mothers with a large number of dental amalgam fillings.

72. Davidson PW Myers GJ Cox C Axtell C Shamlaye C Sloane-Reeves J Cernichiari E Needham L Choi A Wang Y Berlin M Clarkson TW Effects of prenatal and postnatal methylmercury exposure from fish consumption on neurodevelopment: outcomes at 66 months of age in the Seychelles Child Development Study. JAMA (1998 Aug 26) 280(8):701-7

    CONTEXT: Human neurodevelopmental consequences of exposure to methyl- mercury (MeHg) from eating fish remain a question of public health concern. OBJECTIVE: To study the association between MeHg exposure and the developmental outcomes of children in the Republic of Seychelles at 66 months of age. DESIGN: A prospective longitudinal cohort study. PARTICIPANTS: A total of 711 of 779 cohort mother-child pairs initially enrolled in the Seychelles Child Development Study in 1989. SETTING: The Republic of Seychelles, an archipelago in the Indian Ocean where 85% of the population consumes ocean fish daily. MAIN OUTCOME MEASURES: Prenatal and postnatal MeHg exposure and 6 age- appropriate neurodevelopmental tests: the McCarthy Scales of Children's Abilities, the Preschool Language Scale, the Woodcock- Johnson Applied Problems and Letter and Word Recognition Tests of Achievement, the Bender Gestalt test, and the Child Behavior Checklist. RESULTS: The mean maternal hair total mercury level was 6.8 ppm and the mean child hair total mercury level at age 66 months was 6.5 ppm. No adverse outcomes at 66 months were associated with either prenatal or postnatal MeHg exposure. CONCLUSION: In the population studied, consumption of a diet high in ocean fish appears to pose no threat to developmental outcomes through 66 months of age.

73. Berglund F [Dental work with amalgam fillings during pregnancy is not without risks]Amalgamarbeten under graviditet ar inte ofarliga. Lakartidningen (1998 Sep 9) 95(37):3918

74. Moienafshari R Bar-Oz B Koren G Occupational exposure to mercury. What is a safe level? Can Fam Physician (1999 Jan) 45:43-5

QUESTION: One of my pregnant patients, a dental hygienist, uses mercury in her workplace, but appears to have no symptoms of mercury toxicity. She has heard that mercury might affect her fetus. What should I recommend to her? What is a safe level of mercury in the air for pregnant women? ANSWER: Testing for levels of mercury in whole blood and, preferably, urine is useful for confirming exposure. Currently, mercury vapour concentrations greater than 0.01 mg/m3 are considered unsafe. **Also, women of childbearing age should avoid contact with mercury salts in the workplace**.

75. Nickle RA Mercury. Top of the hit parade for eight years. Drug Chem Toxicol (1999 Feb) 22(1):129-42

The Agency for Toxic Substances and Disease Registry (ATSDR) is the lead agency within the U.S. Department of Health and Human Services (HHS) for providing support to the federal response to releases of hazardous substances in the environment. Since the Comprehensive Environmental Response Compensation and Liability Act was passed and amended, ATSDR has represented HHS on the National Response Team (NRT). The NRT role, and the subsequently established National Response System, are described in the National Contingency Plan for Oil and Hazardous Substances Releases (Title 40 Code of Federal Regulations, Section 300). As part of the National Response System, ATSDR can be called when a hazardous substance is released. Consistently, one of the most common substances ATSDR is called about is mercury, usually elemental mercury. This presentation will provide some background statistics on these calls and some general response options. Several specific cases that have occurred in the last few years will be reviewed. These reviews will deal less with remedial options than with describing common issues that arose, issues unique to the specific case, and the impact of that case on the community. A brief discussion of risk communication issues and ATSDR's response to those issues concludes the presentation.

76. More evidence of mercury effects in children. Environ Health Perspect (1999 Nov) 107(11):A554-5

In research published last summer, scientists revealed that prenatal exposure to methylmercury, an organic form of mercury that accumulates in animal tissues, may affect the blood pressure and ability to respond to sensory stimuli in exposed children later in life. The team is now also confirming findings of mercury-related neurodevelopmental effects among the Faroese subjects by studying a cohort of Madeiran children.

77. Grandjean P White RF Nielsen A Cleary D de Oliveira Santos EC Methylmercury neurotoxicity in Amazonian children downstream from gold mining. Environ Health Perspect (1999 Jul) 107(7):587-91

In widespread informal gold mining in the Amazon Basin, mercury is used to capture the gold particles as amalgam. Releases of mercury to the environment have resulted in the contamination of freshwater fish with methylmercury. In four comparable Amazonian communities, we examined 351 of 420 eligible children between 7 and 12 years of age. In three Tapajos villages with the highest exposures, more than 80% of 246 children had hair-mercury concentrations above 10 microg/g, a limit above which adverse effects on brain development are likely to occur. Neuropsychological tests of motor function, attention, and visuospatial

performance showed decrements associated with the hair- mercury concentrations. Especially on the Santa Ana form board and the Stanford-Binet copying tests, similar associations were also apparent in the 105 children from the village with the lowest exposures, where all but two children had hair-mercury concentrations below 10 microg/g. Although average exposure levels may not have changed during recent years, prenatal exposure levels are unknown, and exact dose relationships cannot be generated from this cross- sectional study. However, the current mercury pollution seems sufficiently severe to cause adverse effects on brain development.

78. Murata K Weihe P Araki S Budtz-Jorgensen E Grandjean P Evoked potentials in Faroese children prenatally exposed to methylmercury. Neurotoxicol Teratol (1999 Jul-Aug) 21(4):471-2

A study of 7-year-old children from a fishing village on Madeira has suggested that latencies of evoked potentials may be delayed because of increased exposures to methylmercury during development. Data from a previously published prospective study in the Faroe Islands have therefore been reexamined. Because of changes in instrumentation, results obtained during the second year of examination were excluded. After this restriction, the results show significant mercury- associated delays of the peak III latency and the I-III interpeak latency of the auditory brainstem evoked potentials. Mercury concentrations in both maternal hair at parturition and in cord blood indicated this association, whereas no such relationship was apparent with the child's current hair-mercury concentration. Thus, in agreement with the findings from Madeira, a delay of the peak III latency of the brainstem auditory evoked potentials appears to serve as a marker of prenatal methylmercury toxicity from contaminated seafood.

79. Ramirez GB Cruz MC Pagulayan O Ostrea E Dalisay C The Tagum study I: analysis and clinical correlates of mercury in maternal and cord blood, breast milk, meconium, and infants' hair. Pediatrics (2000 Oct) 106(4):774-81

CONCLUSION: The higher prevalence and levels of Hg in the fetal compartments reflect the ease of placental transfer with fetal trapping. Hg determinations in the mothers' blood underestimate the degree and extent of fetal exposure. There is a significant difference in each compartment's ability to reflect Hg exposure of the fetus. A small HC may be associated with the presence of Hg in meconium. Hg in meconium should be measured in addition to cord blood to determine the load of fetal Hg.

80. Luglie PF Frulio A Campus G Chessa G Fadda G Dessole S [Mercury determination in human amniotic fluid]Dosaggio del mercurio nel liquido amniotico umano. Minerva Stomatol (2000 Apr) 49(4):155-61

BACKGROUND: One of the components of Ag amalgam is mercury which, owing to its organic derivatives, can pass into the organs and biological fluids. One particularly interesting but worrying aspect of this transition is the possibility that mercury may pass through the placental barrier and reach the fetus. The aim of this study was to evaluate the concentration of total mercury in human amniotic fluid and compare it with the number and occlusal extension of fillings using Ag amalgam. METHODS: A group of 56 pregnant women were selected due to undergo amniocentesis. A dental check-up was carried out in each patient to identify the number and extension of amalgam fillings. Mercury levels in the amniotic liquid were assayed using a spectrophotometer with atomic absorption and a FIAS-amalgam technique. RESULTS: Mercury concentrations in the samples examined ranged from a minimum of 0.00 ng/ml to a maximum of 2.55 ng/ml, mean 0.44 +/- 0.53 ng/ml. The correlations between the variables examined were evaluated by calculating the coefficient of linear regression. No direct relationship was found with mercury levels. The data obtained were used to construct a model of logistic regression showing scant statistical significance (p = 0.05) between the number of fillings and mercury

levels, whereas the occlusal extension of dental repairs was significantly correlated with metal concentrations ($p < 0.05$). CONCLUSIONS: The authors recommend that silver amalgam should be used with considerable caution during pregnancy.

81. Hacon S Yokoo E Valente J Campos RC da Silva VA de Menezes AC de Moraes LP Ignotti E Exposure to mercury in pregnant women from Alta Floresta-Amazon basin, Brazil. Environ Res (2000 Nov) 84(3):204-10

    The region of Alta Floresta in the South of the Amazon basin, close to the Teles Pires River, was one of the main prospecting gold areas in the Amazon Basin until the beginning of the 1990s. The economic growth was accompanied by a considerable increase in the population, due to a massive influx of migrants from the southern region of the country. Women had an important role during that process. They worked in the "garimpos" in different activities, such as cooking or managing, where they were exposed mainly to indoor elemental mercury during burning of amalgam. They also worked in gold dealers' shops, where a great amount of amalgam was burned daily. Fish consumption was an important dietary protein source and also a possible exposure pathway, due to the high Hg concentrations reported in carnivorous species. The present study evaluates the mercury uptake and consequent risks involved for pregnant women from Alta Floresta at the end of the gold rush period. The survey included women at different pregnancy stages and it was supported by clinical exams, followed by an interview with a specific questionnaire. Mercury hair concentrations ranging from 0.05 to 8.2 microg/g were found among women, with 13% of them showing concentrations above 2 microg/g. According to the results, mean differences in hair mercury concentration were statistically higher for pregnant women if they had worked in gold mining areas, they had consumed alcohol, their husbands had worked as "garimpeiros," they ate fish, and/or they had malaria before and/or during pregnancy

82. Vahter M Akesson A Lind B Bjors U Schutz A Berglund M Longitudinal study of methylmercury and inorganic mercury in blood and urine of pregnant and lactating women, as well as in umbilical cord blood.Environ Res (2000 Oct) 84(2):186-94

    We have investigated exposure to methylmercury (MeHg) and mercury vapor (Hg0) in pregnant women and their newborns in Stockholm. The women were followed for 15 months post delivery. MeHg, inorganic Hg (I-Hg), and total Hg (T-Hg) in maternal and cord blood were determined by automated alkaline solubilization/reduction and cold vapor atomic fluorescence spectrometry. T-Hg in urine was determined by inductively coupled plasma mass spectrometry. About 72% of the Hg in blood (n = 148) in early pregnancy was MeHg (median 0.94 microg/L, maximum 6.8 microg/L). Blood MeHg decreased during pregnancy, partly due to decreased intake of fish in accordance with recommendations to not eat certain predatory fish during pregnancy. Cord blood MeHg (median 1.4 microg/L, maximum 4.8 microg/L) was almost twice that in maternal blood in late pregnancy and was probably influenced by maternal MeHg exposure earlier and before pregnancy. Blood I-Hg (median 0.37 microg/L, maximum 4.2 microg/L) and urine T-Hg (median 1.6 microg/L, maximum 12 microg/L) in early pregnancy were highly correlated, and both were associated with the number of amalgam fillings. The concentrations decreased during lactation, probably due to excretion in milk. Cord blood I-Hg was correlated with that in maternal blood. The results show the importance of speciation of Hg in blood for evaluation of exposure and health risks.

83. Boischio AA Henshel DS Linear regression models of methyl mercury exposure during prenatal and early postnatal life among riverside people along the upper Madeira river, Amazon. Environ Res (2000 Jun) 83(2):150-61

    This research is focused on prenatal and early postnatal mercury (Hg) exposure among the riverside people along the Upper Madeira river in the Amazon. Linear regression models were developed to predict the hair Hg concentration in infants. The independent variables included in the model of Group 1 (87 pairs of mothers and their infants) were the average maternal hair Hg concentration and maternal age. Group 2 (31 pairs) included maternal segmental hair Hg concentrations. For the segmental hair Hg analysis over time, it was assumed that hair grows at a rate of 11 cm per month. Thus, information on the timing of the dates of pregnancy and breast feeding from the birth history was used to cut the hair strands into segments, making them correspond to the mother's reproductive stage of life (31 pairs of mothers and their infants). Breast milk Hg concentration results were included with segmental and average maternal hair Hg concentration values (22 and 44 pairs of mothers and their infants, respectively). The models including the breast milk Hg concentration indicated that 61 and 55% of the variability of the infant hair Hg concentrations were due to the independent variables: segmental maternal hair Hg with breast milk Hg and average maternal hair Hg with breast milk Hg, respectively. The regression coefficients were in the range of 0.19 to 0.90, and P values were in the range of 0.0001 to 0.1490. Further recommendations include fish advisories to prevent critical Hg exposures during reproductive life and investigation of neurobehavioral performance of this study population.

84. Satoh H Occupational and environmental toxicology of mercury and its compounds.: Ind Health (2000 Apr) 38(2):153-64

    Mercury exists in various chemical forms. The important forms from a toxicological viewpoint are the metallic form, also called the elemental form, the divalent inorganic forms and methylmercury compounds. Elemental (Hg0) mercury has a high vapor pressure and the vapor causes a number of cases of poisoning via inhalation. Classical mercury poisoning is characterized by a triad of signs, namely tremors, erethism and gingivitis. Mercurial erethism, which is characterized by behavioral and personality changes such as extreme shyness, excitability, loss of memory, and insomnia are also observed. Recently, the effects of mercury exposure at levels around **0.05 mg/m3** or lower have been of concern and may include minor renal tubular damage, increased complaints of tiredness, memory disturbance and other symptoms, subclinical finger tremor, abnormal EEG by computerized analysis and impaired performance in neurobehavioral or neuropsychological tests. Abnormal gait, dysarthria, ataxia, deafness and constriction of the visual field are typical of the symptoms of methylmercury poisoning observed in Minamata and Iraqi outbreaks, as well as in occupational methylmercury poisoning cases. Furthermore, an infant born to a mother with excessive methylmercury consumption showed various neurological disturbances and delayed development. Since several populations are believed to be still exposed to methylmercury through the consumption of fish and sea mammals, neurobehavioral deviations in children of these populations have recently been investigated.

85. Zadorozhnaja TD Little RE Miller RK Mendel NA Taylor RJ Presley BJ Gladen BC Concentrations of arsenic, cadmium, copper, lead, mercury, and zinc in human placentas from two cities in Ukraine. J Toxicol Environ Health A (2000 Oct 27) 61(4):255-63

    Ukraine is a highly industrialized country with major environmental problems and deteriorating reproductive health. Heavy metals are known reproductive toxins; a study was undertaken to determine whether they were present at sufficient concentrations to be playing a major role in

these health problems. Placental concentrations of arsenic, cadmium, copper, lead, mercury, and zinc were determined in 200 women from the general population of two urban areas of Ukraine, Kyiv and Dniprodzerzhinsk. Arsenic was detected in only 5% of the samples, lead in 22%, and mercury in 28%. Cadmium was detected in almost all samples, with a median of 5.2 ng/g. Concentrations of lead, mercury, and cadmium were low compared to those reported elsewhere, while zinc and copper concentrations were comparable.

86. Weber RF de Baat C [Male fertility. Possibly affected by occupational exposure to mercury]De mannelijke fertiliteit. Mogelijke gevolgen door beroepsmatig contact met kwik. Ned Tijdschr Tandheelkd (2000 Dec) 107(12):495-8

    In the last decades there is circumstantial evidence for an increased incidence of cryptorchidisme and hypospadia in new-born boys and an increased incidence of testicular cancer in adults. Moreover, there are indications that sperm quality is declining. Exposure to endocrine disrupters in utero and during adulthood is a possible explanation for the impairment of male reproductive health. Exposure to mercury may lead to deposition in the pituitary gland and the testicular tissues causing impairment of testicular function, especially spermatogenesis.

87. Stern AH Gochfeld M Weisel C Burger J Mercury and methylmercury exposure in the New Jersey pregnant population. Arch Environ Health (2001 Jan-Feb) 56(1):4-10

    Methylmercury is a known fetal developmental neurotoxicant. The only significant source of fetal exposure is maternal fish consumption; however, few recent data on exposure of the pregnant population are available. The authors undertook a study of methylmercury exposure in the New Jersey pregnant population to investigate the distribution of exposure and to identify predictors of elevated exposure. Mainly first-trimester pregnant women were recruited through six New Jersey obstetric practices. Hair and blood samples were analyzed for total mercury, and a subset was analyzed for methylmercury. A questionnaire on demographics, life style, and fish-consumption practices was also administered. Although 85-90% of the pregnant population had hair mercury levels that were less than 1.0 microg/gm, 1-2% had levels in a range of possible concern for adverse developmental effects (> 4.0 microg/gm). Regression analysis suggested that blacks and individuals with some college education experienced lower exposures to methylmercury.

88. Leung TY Choy CM Yim SF Lam CW Haines CJ Whole blood mercury concentrations in sub-fertile men in Hong Kong. Aust N Z J Obstet Gynaecol (2001 Feb) 41(1):75-7

    We aimed to investigate the association between whole blood mercury concentrations and semen quality in sub-fertile men. Fifty-nine male partners of infertile couples attending the Assisted Reproduction Unit of the Chinese University of Hong Kong between 1997 and 1998 were recruited into our study. Blood was taken from each subject for whole blood mercury concentration and hormone profile. Semen samples were obtained for computer assisted semen analysis using the Hobson sperm tracker. The semen parameters and hormone profile were compared between subjects with normal and those with elevated mercury concentrations. Twenty-one subjects (35.6%) had a whole blood mercury concentration higher than the normal range (0-50 nmol/l). All parameters of the semen analysis including the concentration of sperm, percentage of morphologically normal sperm, percentage of motile sperm, curvilinear velocity, straight-line velocity, average path velocity, and amplitude of lateral head displacement, were reduced in those with elevated blood mercury concentrations, although the difference was not statistically significant. We failed to demonstrate a statistically significant effect on the measurement of semen quality, but other adverse effects cannot be excluded. From a public

heath perspective, **these findings confirm that mercury toxicity is a potentially serious problem affecting the local community.**

89. Razagui IB Haswell SJ Mercury and selenium concentrations in maternal and neonatal scalp hair: relationship to amalgam-based dental treatment received during pregnancy. Biol Trace Elem Res (2001 Jul) 81(1):1-19

    Mercury and selenium concentrations were determined in scalp hair samples collected postpartum from 82 term pregnancy mothers and their neonates. Maternal mercury and selenium had median concentrations of 0.39 microg/g (range 0.1-2.13 microg/g) and 0.75 microg/g (range 0.1- 3.95 microg/g), respectively, and corresponding median neonatal values were 0.24 microg/g (range 0.1-1.93 microg) and 0.52 microg/g (range (0.1-3.0 microg/g). Amalgam-based restorative dental treatment received during pregnancy by 27 mothers (Group I) was associated with significantly higher mercury concentrations in their neonates ($p < 0.0001$) compared to those born to 55 mothers (Group II) whose most recent history of such dental treatment was dated to periods ranging between 1 and 12 yr prior to pregnancy. In the Group I mother/neonate pairs, amalgam removal and replacement in 10 cases was associated with significantly higher mercury concentrations compared to 17 cases of new amalgam emplacement. Selenium concentrations showed no significant intergroup differences. However, the selenium/mercury molar ratio values were lowest in the Group I neonates, compared to their mothers and to the Group II mother/neonate pairs. This ratio decreased as mercury concentration increased, and this interrelation was statistically significant in both groups of mother/neonate pairs. **The data from this preliminary study suggest that amalgam-based dental treatment during pregnancy is associated with higher prenatal exposure to mercury, particularly in cases of amalgam removal and replacement**. The ability of a peripheral biological tissue, such as hair, to elicit such marked differences in neonatal mercury concentrations provides supporting evidence of high fetal susceptibility to this form of mercury exposure. The data are discussed in relation to the differences between maternal and fetal mercury metabolisms and to mercury-selenium metabolic intereactions in response to mercury exposure.

90. Grandjean P Bjerve KS Weihe P Steuerwald U Birthweight in a fishing community: significance of essential fatty acids and marine food contaminants. Int J Epidemiol (2001 Dec) 30(6):1272-8

    BACKGROUND: Marine food provides essential fatty acids that are important during pregnancy, but the benefits may be limited at high intakes and by seafood contaminants. METHODS: In the fishing community of the Faroe Islands, 182 pregnant women with spontaneous singleton births were consecutively recruited for a cohort in 1994- 1995. Concentrations of fatty acids and seafood contaminants in blood samples were analysed as predictors of gestational length and birthweight. RESULTS: Serum concentrations of eicosapentaenoic acid (EPA) increased with maternal marine food intake, while the tendency was less clear for docosahexaenoic acid (DHA). An increase in the relative concentration of DHA in cord serum phospholipids by 1% was associated with an increased duration of gestation by 1.5 days (95% CI : 0.7-2.2). However, birthweight adjusted for gestational length decreased by 246 g (95% CI : 16-476) for each increase by 1% of the EPA concentration in cord serum. Concentrations of the seafood pollutants mercury and polychlorinated biphenyls (PCB) were associated with fatty acids levels, but the contaminants did not appear to affect any of the outcome parameters. CONCLUSION: An increased intake of marine fats appears to prolong the duration of gestation, but birthweight adjusted for gestational age may decrease at high intake levels. This effect does not seem to be due to increased exposures to seafood contaminants.

91. Goldman LR Shannon MW Technical report: mercury in the environment: implications for pediatricians. Pediatrics (2001 Jul) 108(1):197-205

    Mercury is a ubiquitous environmental toxin that causes a wide range of adverse health effects in humans. Three forms of mercury (elemental, inorganic, and organic) exist, and each has its own profile of toxicity. Exposure to mercury typically occurs by inhalation or ingestion. Readily absorbed after its inhalation, mercury can be an indoor air pollutant, for example, after spills of elemental mercury in the home; however, industry emissions with resulting ambient air pollution remain the most important source of inhaled mercury. Because fresh-water and ocean fish may contain large amounts of mercury, children and pregnant women can have significant exposure if they consume excessive amounts of fish. The developing fetus and young children are thought to be disproportionately affected by mercury exposure, because many aspects of development, particularly brain maturation, can be disturbed by the presence of mercury. Minimizing mercury exposure is, therefore, essential to optimal child health. This review provides pediatricians with current information on mercury, including environmental sources, toxicity, and treatment and prevention of mercury exposure.

92. Kakita A Inenaga C Sakamoto M Takahashi H Neuronal migration disturbance and consequent cytoarchitecture in the cerebral cortex following transplacental administration of methylmercury. Acta Neuropathol (2002 Oct) 104(4):409-17

    To understand the effects of methylmercury (MeHg) on neuronal migration in the developing cerebral cortex, we performed double administrations of MeHg and 5-bromo-2-deoxyuridine (BrdU) to pregnant rats on different embryonic days (E11, E13, E16 or E21). Histopathological examination of a proportion of the offspring on postnatal day 28 revealed no apparent cytoarchitectural abnormalities in the primary motor and primary somatosensory cortices of the cerebrum. Morphometric analysis revealed no significant differences in total neuron population in either of these areas, and no differences in subpopulations of cells in any of the cortical layers, between any of the MeHg-exposed groups and the control animals. However, BrdU immunohistochemistry revealed an abnormally widespread distribution of the labeled cells throughout cortical layers II-VI of offspring exposed to MeHg on E16 and E21, indicating disruption of the inside-out pattern of neuronal migration. We examined one aspect of cell-fate determination by applying immunohistochemistry with antibodies against calbindin, parvalbumin, calretinin, and gamma- aminobutyric acid, but found no differences in the topographic distributions of the antibody-labeled cells in the cortex between the controls and the MeHg-exposed offspring. These results suggest that it is the extrinsic circumstances - rather than the timing of neuron generation - that regulates the expression of these proteins.

93. Ask K Akesson A Berglund M Vahter M Inorganic mercury and methylmercury in placentas of Swedish women. Environ Health Perspect (2002 May) 110(5):523-6

    We determined levels of inorganic mercury (I-Hg) and methylmercury in placentas from 119 Swedish women, not selected with respect to high exposure of mercury. Our objective was to relate placental Hg species with maternal and fetal blood concentrations and to evaluate possible associations with selenium. We performed the analyses using automated alkaline solubilization/reduction and cold-vapor atomic fluorescence spectrophotometry. I-Hg levels in placenta increased with an increasing number of maternal dental amalgam fillings ($p < 0.001$). Despite placental accumulation (median, 1.3 microg/kg; range, 0.18- 6.7 microg/kg wet weight), a substantial fraction of maternal blood I- Hg, probably as Hg(0), reached the fetus. Although MeHg

transferred easily to the fetus, it also accumulated in the placenta. On average, 60% of placental Hg was in the form of MeHg. The median concentration was 1.8 microg/kg (range, 0-6.2 microg/kg wet weight), more than twice the maternal blood concentration. We found significant associations between MeHg and selenium in both maternal and umbilical cord blood but not in the placenta. The associations were particularly obvious in freshwater fish consumers, probably reflecting that fish is a source of both MeHg and selenium. We found no correlations between I-Hg and selenium. This study increases the understanding of Hg, in its different forms, in human placenta and how they are related to maternal and fetal exposure.

94. Karimi A Moniri F Nasihatkon A Zarepoor MJ Alborzi A Mercury exposure among residents of a building block in Shiraz, Iran. Environ Res (2002 Jan) 88(1):41-3

    Exposure to mercury can cause serious multiorgan damage affecting the central nervous system, kidneys, liver, lungs, spleen, bone marrow, and skin. At the end of the summer of 1999, the accidental leakage of 4 liters of mercury from a container into the waterway canals resulted in mass exposure to elemental mercury among the residents of a building block of a residential area of the city of Shiraz, in the south of Iran. One hundred and eleven individuals who experienced exposure to elemental mercury were investigated. Twenty-four-hour measurement of the urine mercury level-revealed a toxic level of more than 20 microg/L in 6 children and 3 adults (including a pregnant woman). Despite normal physical and laboratory (CBC, renal and liver function tests, and urinalysis) findings, dimercaprol was prescribed. One month later during the course of the follow-up the urine mercury level in 6 patients, including the pregnant woman from the same family, was found to be again at a toxic level. The pregnant mother from the same family aborted her fetus; however, due to the lack of equipment for measuring the serum mercury level, it was not possible to confirm the relation between the mercury toxicity and the abortion. This family had kept mercury in their kitchen against health workers' instructions. The attractive physical and chemical properties of mercury could explain the continuity of exposure and poisoning in these 6 cases. It is concluded that prophylactic therapy in the presence of toxic levels of mercury, despite the presence of an asymptomatic state in exposed residents, is effective in preventing the development of signs and symptoms, though instruction of high-risk cases is the best way to combat it.

95. Choy CM Yeung QS Briton-Jones CM Cheung CK Lam CW Haines CJ Relationship between semen parameters and mercury concentrations in blood and in seminal fluid from subfertile males in Hong Kong.Fertil Steril (2002 Aug) 78(2):426-8

96. Belles-Isles M Ayotte P Dewailly E Weber JP Roy R Cord blood lymphocyte functions in newborns from a remote maritime population exposed to organochlorines and methylmercury. J Toxicol Environ Health A (2002 Jan 25) 65(2):165-82

    The consumption of fish and sea mammals can be an important source of exposure to organochlorine compounds (OCs) and heavy metals in populations relying on seafood for subsistence. Exposure to these substances, especially during the prenatal period, has been shown to induce immunotoxic effects in mammals. Immunological status was assessed in 48 newborns from a remote maritime population living on the Lower and Mid North Shore of the St. Lawrence River (subsistence fishing group) and 60 newborns from the coastal urban center of Sept- Iles (reference group). Women were recruited upon arrival at Sept- Iles regional hospital to give birth. Cord blood samples were collected for organochlorine and heavy metal analyses and to isolate lymphocytes for immunological assays (proportions and functional responses of the main cellular

subsets T, B, and NK (natural killer) cells. Concentrations of polychlorinated biphenyls (PCBs) and mercury were respectively three- and twofold higher, significantly greater, in the subsistence fishing group than in the reference group. Compared to the reference group, the subsistence fishing group showed significant decreases in the proportion of the naive helper T-cell subset CD4+CD45RA, T-cell proliferation following an in vitro mitogenic stimulation, and plasma immunoglobulin M (IgM) level, while plasma IgC level was increased. NK cytolytic activities were similar in both groups. The proportion of CD4+CD45RA cells was inversely correlated to mercury and PCBs, while T-cell clonal expansion was negatively associated with PCBs and p,p'-DDE. Mercury was inversely correlated to plasma IgM. Data show that subtle functional alterations of the developing human immune system may result from in utero exposure to OCs and mercury. Epidemiological studies are needed to determine the relevance of these alterations in predicting detrimental health effects in the developing child.

97. Lindow SW Knight R Batty J Haswell SJ Maternal and neonatal hair mercury concentrations: the effect of dental amalgam. BJOG (2003 Mar) 110(3):287-91

    OBJECTIVE: To evaluate maternal and fetal hair mercury levels in relation to the placement of dental amalgam tooth restorations. DESIGN: Cross sectional study involving women who never had dental amalgam restorations placed, women who had amalgam restorations placed before pregnancy and women who had restorations placed during the index pregnancy. SETTING: North of England Maternity Hospital. SAMPLE: Fifty-three healthy women who delivered healthy babies at term. METHODS: Maternal and fetal hair was collected in a standardised manner in the first few days following delivery. MAIN OUTCOME MEASURES: Maternal and neonatal hair mercury concentrations. RESULTS: When compared with women without restorations, there was a significant increase in the maternal hair mercury concentration in women who had dental amalgam placed outside of the index pregnancy and also in women who had dental amalgam placed during the index pregnancy. **The fetal hair mercury concentration was significantly higher in babies when mothers had been exposed to dental amalgam either before pregnancy or during pregnancy compared with unexposed babies.** There was no difference in the maternal or fetal hair mercury levels in the groups of patients who had dental amalgam placed before or during pregnancy. CONCLUSIONS: Maternal and fetal hair mercury levels were significantly higher in women who previously had dental amalgam restorations placed.

98. Bilrha H Roy R Moreau B Belles-Isles M Dewailly E Ayotte P In vitro activation of cord blood mononuclear cells and cytokine production in a remote coastal population exposed to organochlorines and methyl mercury. Environ Health Perspect (2003 Dec) 111(16):1952-7

    Remote coastal populations that rely on seafood for subsistence often receive unusually high doses of organochlorines and methyl mercury. Immunosuppression resulting from prenatal exposure to organochlorines has been reported in wildlife species and humans. In this study, we assessed lymphocyte activation and associated cytokine secretion in 47 newborns from a remote maritime population living on the Mid and Lower North Shore regions of the St. Lawrence River (Quebec, Canada; subsistence fishing group) and 65 newborns from nearby urban settings (reference group). Cord blood samples were collected for organochlorine and mercury analyses and also to isolate cord blood mononuclear cells (CBMCs) for the in vitro assessment of cytokine production and expression of surface markers after mitogenic stimulation (CD4(+)CD45RO(+), CD8(+)CD45RO(+), CD3(+)CD25(+), and CD8(+)HLA-DR(+)). Blood mercury and plasma concentrations of polychlorinated biphenyls (PCBs), 1,1-dichloro-2,2-bis(4- chlorophenyl)ethylene (p,p'-DDE), and hexachlorobenzene (HCB) were significantly higher in the subsistence fishing group than in the reference group ($p < 0.001$). No difference was observed between the two

groups regarding subsets of lymphocytes showing markers of activation. In vitro secretion of cytokines by CBMCs after mitogenic stimulation was lower in the subsistence fishing group than in the reference group ($p < 0.05$). Moreover, we found an inverse correlation between tumor necrosis factor-alpha (TNF-alpha) secretion and plasma PCB, p,p'-DDE, and HCB concentrations ($p < 0.05$). Our data support a negative association between TNF-alpha secretion by CBMCs and prenatal organochlorine exposure. If the relationship between organochlorine and TNF-alpha secretion is causal, it would suggest a role for this important proinflammatory cytokine in mediating organochlorine-induced immunotoxicity in infants developmentally exposed to these compounds.

99. Bjornberg KA Vahter M Petersson-Grawe K Glynn A Cnattingius S Darnerud PO Atuma S Aune M Becker W Berglund M Methyl mercury and inorganic mercury in Swedish pregnant women and in cord blood: influence of fish consumption. Environ Health Perspect (2003 Apr) 111(4):637-41

We studied exposure to methyl mercury (MeHg) in Swedish pregnant women (total mercury [T-Hg] in hair) and their fetuses (MeHg in cord blood) in relation to fish intake. The women were recruited at antenatal care clinics in late pregnancy to participate in an exposure study of environmental pollutants. Fish consumption was evaluated using food frequency questionnaires including detailed questions on fish consumption. In addition, we determined inorganic mercury (I-Hg) and selenium (Se) in cord blood. On average, the women consumed fish (all types) 6.7 times/month (range 0-25 times/month) during the year they became pregnant. They reported less consumption of freshwater fish--species that might contain high concentrations of MeHg--during than before pregnancy. T-Hg in maternal hair (median 0.35 mg/kg; range 0.07-1.5 mg/kg) was significantly associated ($R2 = 0.53$; $p < 0.001$) with MeHg in cord blood (median 1.3 microg/L; range 0.10-5.7 microg/L). Both hair T-Hg and cord blood MeHg increased with increasing consumption of seafood ($r = 0.41$; $p < 0.001$ and $r = 0.46$; $p < 0.001$, respectively). Segmental hair analysis revealed that T-Hg closer to the scalp was lower and more closely correlated with MeHg in cord blood than T-Hg levels in segments corresponding to earlier in pregnancy. We found a weak association between Se (median 86 microg/L; range 43-233 microg/L) and MeHg in cord blood ($r = 0.26$; $p = 0.003$), but no association with fish consumption. I-Hg in cord blood (median 0.15 microg/L; range 0.03-0.53 microg/L) increased significantly with increasing number of maternal dental amalgam fillings.

100. Gopal KV Neurotoxic effects of mercury on auditory cortex networks growing on microelectrode arrays: a preliminary analysis. Neurotoxicol Teratol (2003 Jan-Feb) 25(1):69-76

Mercury is known to cause sensorineural hearing loss and impaired speech perception. However, there is still a lack of a quantitative description of mercury toxicity on central auditory structures. This is a preliminary study using the novel technique of microelectrode array (MEA) recordings to evaluate acute and chronic neurotoxic effects of mercury on auditory cortex networks (ACNs) in vitro. Morphological and electrophysiological effects of mercuric chloride (HgCl(2)) were studied. Neurons dissociated from auditory cortices of 14-day-old mouse embryos were grown on photoetched MEAs containing 64 transparent indium-tin oxide (ITO) electrodes. For acute electrophysiological experiments, the spontaneous spiking and bursting activity from ACNs were compared before and after application of HgCl(2). For chronic electrophysiological experiments, auditory cortex cultures were treated with various concentrations of HgCl(2) from the day of seeding, and were tested 4 weeks later for the presence of spontaneous activity. Morphological analysis was conducted on 8-day-old ACNs treated with HgCl(2) for 3 days. Results of acute experiments indicated that <75 mM of HgCl(2) had an excitatory effect of variable magnitude on the spontaneous activity of ACNs; however, concentrations above 100 microM completely and

irreversibly inhibited spike and burst activity. Chronic exposure of ACNs to 10 microM HgCl(2) completely blocked the spontaneous activity. Morphological analysis indicated that 10 microM HgCl(2) caused neuronal cell death in 3 days. It is concluded that HgCl(2) has a more toxic effect on auditory networks when exposed chronically, and the levels of mercury showing toxic effects on ACNs are within the dose range shown to cause neurologic symptoms in humans.

101. Stewart PW Reihman J Lonky EI Darvill TJ Pagano J Cognitive development in preschool children prenatally exposed to PCBs and MeHg. Neurotoxicol Teratol (2003 Jan-Feb) 25(1):11-22

A number of epidemiological studies have shown predictive relationships between prenatal exposure to polychlorinated biphenyls (PCBs) and subtle deficits in cognitive development in infancy through the preschool years [Child Dev. 56 (1985) 853; J. Pediatr. 116 (1990) 38; J. Pediatr. 134 (1999) 33; Toxicol. Lett. 102-103 (1998) 423; Neurotox. 21 (6) (2000) 1029-1038]. However, since not all studies have demonstrated these relationships (J. Pediatr. 119 (1991) 58-63), debate regarding the role of prenatal PCB exposure in cognitive development continues. The current study was designed to provide additional data to assist in resolving this question. Two hundred twelve children enrolled in the Oswego Newborn and Infant Development Project were assessed using the McCarthy Scales of Children's Abilities at 38 months of age, followed by a reassessment at 54 months of age. The relationship between prenatal exposure to PCBs (cord blood PCBs) and McCarthy performance was assessed at both ages after first controlling for a wide range of important predictors of cognitive development, including socioeconomic status (SES), maternal IQ, maternal education, home environment, cigarette smoking, and many others. Cord blood PCBs were statistically significant predictors of small but measurable deficits in McCarthy performance at 38 months of age. Moreover, a significant interaction between cord blood PCBs and maternal hair mercury (MeHg) was found, such that negative associations between prenatal MeHg exposure and McCarthy performance were found in subjects with higher levels of prenatal PCB exposure. No relationship between PCBs and/or MeHg and McCarthy performance was observed when the children were reassessed almost 1.5 years later (54 months of age). Inspection of the age-related trajectory of McCarthy performance revealed that the more highly exposed children caught up with the least exposed children by 54 months. Although the current data partially replicate the findings of Jacobson et al., Patandin et al., and Walkowiak et al. [J. Pediatr. 116 (1990) 38; J. Pediatr. 134 (1999) 33; Lancet 358 (2001) 1602], results reported here suggest that functional recovery may occur. Moreover, the interaction between PCB and MeHg cannot be considered conclusive until it has been replicated in subsequent investigations.

102. Mahaffey KR Clickner RP Bodurow CC Blood organic mercury and dietary mercury intake: National Health and Nutrition Examination Survey, 1999 and 2000. Environ Health Perspect (2004 Apr) 112(5):562-70

Blood organic mercury (i.e., methyl mercury) concentrations among 1,709 women who were participants in the National Health and Nutrition Examination Survey (NHANES) in 1999 and 2000 (1999-2000 NHANES) were 0.6 microg/L at the 50th percentile and ranged from concentrations that were nondetectable (5th percentile) to 6.7 microg/L (95th percentile). Blood organic/methyl mercury reflects methyl mercury intake from fish and shellfish as determined from a methyl mercury exposure parameter based on 24-hr dietary recall, 30- day food frequency, and mean concentrations of mercury in the fish/shellfish species reported as consumed (multiple correlation coefficient > 0.5). Blood organic/methyl mercury concentrations were lowest among Mexican Americans and highest among participants who designated themselves in the Other racial/ethnic category, which includes Asians, Native Americans, and Pacific Islanders. Blood organic/methyl mercury concentrations were 1.5 times higher among women 30-49 years of age

than among women 16-29 years of age. Blood mercury (BHg) concentrations were seven times higher among women who reported eating nine or more fish and/or shellfish meals within the past 30 days than among women who reported no fish and/or shellfish consumption in the past 30 days. Blood organic/methyl mercury concentrations greater than or equal to 5.8 microg/L were lowest among Mexican Americans (2.0%) and highest among examinees in the Other racial/ethnic category (21.7%). Based on the distribution of BHg concentrations among the adult female participants in 1999-2000 NHANES and **the number of U.S. births in 2000, > 300,000 newborns each year in the United States may have been exposed in utero to methyl mercury concentrations higher than those considered to be without increased risk of adverse neurodevelopmental effects associated with methyl mercury exposure.**

103. Morrissette J Takser L St-Amour G Smargiassi A Lafond J Mergler D Temporal variation of blood and hair mercury levels in pregnancy in relation to fish consumption history in a population living along the St. Lawrence River. Environ Res (2004 Jul) 95(3):363-74

Fish consumption from the Great Lakes and the St. Lawrence River has been decreasing over the last years due to advisories and increased awareness of the presence of several contaminants. Methylmercury (MeHg), a well-established neurotoxicant even at low levels of exposure, bioaccumulates to differing degrees in various fish species and can have serious adverse effects on the development and functioning of the human central nervous system, especially during prenatal exposure. …. Results showed that maternal blood and hair Hg levels decreased significantly between the second and third trimesters of pregnancy. However, cord blood Hg was significantly higher than maternal blood at birth. Maternal hair was correlated with Hg blood concentration and was highly predictive of the organic fraction in cord blood. A strong dose relation was observed between the frequency of fish consumption before and during pregnancy and Hg exposure in mothers and newborns. Fish consumption prior to and during pregnancy explained 26% and 20% of cord blood Hg variance, respectively. For this population, detailed multivariate analyses showed that during pregnancy market fish (fresh, canned, and frozen) were more important sources of Hg exposure than were fish from the St. Lawrence River. These results should be taken into account for future advisories and intervention strategies, which should consider Hg levels in different species from all sources in order to maximize the nutritional input from fish and minimize the toxic risk.

104. Sakamoto M Kubota M Liu XJ Murata K Nakai K Satoh H Maternal and fetal mercury and n-3 polyunsaturated fatty acids as a risk and benefit of fish consumption to fetus. Environ Sci Technol (2004 Jul 15) 38(14):3860-3

Maternal fish consumption brings both risks and benefits to the fetus from the standpoint of methylmercury (MeHg) and n-3 PUFA (polyunsaturated fatty acids). MeHg is one of the most risky substances to come through fish consumption, and mercury concentrations in red blood cells (RBC-Hg) are the best biomarker of MeHg exposure. Docosahexaenoic acid (DHA, C22:6n-3), which is one of the most important fatty acids for normal brain development and function, is also derived from fish consumption. Our objective in this study was to examine the relationships between RBC-Hg and plasma fatty acid composition in mother and fetus at parturition. … A significant correlation was observed between maternal and fetal DHA concentrations ($r = 0.37$, $p < 0.01$). Further, a significant correlation was observed between RBC-Hg and plasma DHA in fetus ($r = 0.35$, $p < 0.01$). These results confirm that both MeHg and DHA which originated from fish consumption transferred from maternal to fetal circulation and existed in the fetal circulation with a positive correlation. Pregnant women in particular need not give up eating fish to obtain

such benefits. However, they would do well to at least consume smaller fish, which contain less MeHg, thereby balancing the risks and benefits from fish comsumption.

105. Blood mercury levels in young children and childbearing-aged women-- United States, 1999-2002. MMWR Morb Mortal Wkly Rep (2004 Nov 5) 53(43):1018-20

Exposure to high levels of mercury (Hg) can cause neurologic and kidney disorders. Because methylated Hg (methyl-Hg) in the aquatic environment accumulates in animal tissues up the food chain, persons in the United States can be exposed by eating freshwater fish, seafood, and shellfish. Exposure of childbearing-aged women is of particular concern because of the potential adverse neurologic effects of Hg in fetuses. To determine levels of total blood Hg in childbearing-aged women and in children aged 1-5 years in the United States, CDC's National Health and Nutrition Examination Survey (NHANES) began measuring blood Hg levels in these populations in 1999. This report summarizes NHANES results for 1999-2002 and updates previously published information. The findings confirmed that blood Hg levels in young children and women of childbearing age usually are below levels of concern. However, approximately 6% of childbearing-aged women had levels at or above a reference dose, an estimated level assumed to be without appreciable harm (> or =5.8 microg/L). Women who are pregnant or who intend to become pregnant should follow federal and state advisories on consumption of fish.

106. Despres C Beuter A Richer F Poitras K Veilleux A Ayotte P Dewailly E Saint-Amour D Muckle G Neuromotor functions in Inuit preschool children exposed to Pb, PCBs, and Hg. Neurotoxicol Teratol (2005 Mar-Apr) 27(2):245-57

The aim of this study was to examine the effects of prenatal and postnatal chronic exposure to mercury (Hg), polychlorinated biphenyls (PCBs) and lead (Pb) on the neuromotor development of preschool children. The study population consisted of 110 preschool Inuit children from Nunavik (Canada). Blood Hg, PCBs and Pb concentrations were measured at birth (cord blood) and at the time of testing. Gross motor functions were evaluated and a neurological examination was performed. Fine neuromotor performance was assessed using quantitative measures of postural hand tremor, reaction time, sway oscillations, as well as alternating and pointing movements. Potential covariates were documented including demographic and familial characteristics, other prenatal neurotoxicants (alcohol, tobacco) and nutrients (selenium (Se), Omega-3 polyunsaturated fatty acids (n-3 PUFA)). Hierarchical multivariate regression analyses were performed, controlling for significant covariates. Gross motor development was not linked to prenatal exposures. However, significant associations were observed between blood Pb concentration at testing time and changes in reaction time, sway oscillations, alternating arm movements and action tremor. For some of these outcomes, neuromotor effects of Pb exposure are observed at blood concentrations below 10 microg/dl. Negative effects of PCBs on neuromotor development were not clearly observed, neither were the potential beneficial effects of n-3 PUFA and selenium. Tremor amplitude was related to blood Hg concentrations at testing time, which corroborate an effect already reported among adults.

107. Cohen JT Bellinger DC Shaywitz BA A quantitative analysis of prenatal methyl mercury exposure and cognitive development. Am J Prev Med (2005 Nov) 29(4):353-65

Although a rich source of n-3 polyunsaturated fatty acids (PUFAs) that may confer multiple health benefits, some fish also contain methyl mercury (MeHg), which may harm the developing fetus. U.S. government recommendations for women of childbearing age are to modify consumption of high MeHg fish to reduce MeHg exposure, while recommendations encourage fish consumption among the general population because of the nutritional benefits. The Harvard Center for Risk

Analysis convened an expert panel (see acknowledgements) to quantify the net impact of resulting hypothetical changes in fish consumption across the population. This paper quantifies the impact of prenatal MeHg exposure on cognitive development. Other papers quantify the beneficial impact of prenatal intake of n-3 PUFAs on cognitive function and the extent to which fish consumption protects against coronary heart disease mortality and stroke in adults. This analysis aggregates results from three major prospective epidemiology studies to quantify the association between prenatal MeHg exposure and cognitive development as measured by intelligence quotient (IQ). It finds that prenatal MeHg exposure sufficient to increase the concentration of mercury in maternal hair at parturition by 1 microg/g decreases IQ by 0.7 points. This paper identifies important sources of uncertainty influencing this estimate, concluding that the plausible range of values for this loss is 0 to 1.5 IQ points.

108. Pamphlett R Eide R Danscher G Does selenium deficiency unmask mercury toxicity in motor neurons? Neurotoxicol Teratol (2005 Mar-Apr) 27(2):241-4

OBJECTIVE: Inorganic mercury enters in particular motor neurons and has been implicated in motor neuron diseases. One way that cells protect themselves from mercury toxicity is via selenium, so we sought to determine whether the motor neurons of mice on a low selenium diet would be more susceptible to mercury toxicity. … CONCLUSION: Diets low or high in selenium did not damage motor neurons with or without mercury. This suggests that changes in the selenium environment are unlikely to precipitate mercury toxicity in motor neurons.

109. Luglie PF Campus G Chessa G Spano G Capobianco G Fadda GM Dessole S Effect of amalgam fillings on the mercury concentration in human amniotic fluid. Arch Gynecol Obstet (2005 Feb) 271(2):138-42

BACKGROUND: Methyl mercury (MeHg) and metallic Hg are well known as neurotoxic agents. Dental amalgam contributes significantly to elemental Hg vapour exposure in the general population. There is little information about Hg concentration in human amniotic fluid (AF) of pregnant women and its potential toxic effect on the fetuses. OBJECTIVE: Primary to assess the relationship between the presence of detectable mercury (Hg) concentration in human AF, number and surface areas of amalgam fillings of pregnant women; secondary to analyse their obstetric history and perinatal complications. …RESULTS: The overall mean Hg concentration in AF among all patients was 0.37+/- 0.49 ng/ml. Nineteen (26.4%) women had a Hg concentration <0.08 ng/ml (Hg negative group). In 53 (73.6%) patients, with a concentration > or = 0.08 ng/ml (Hg positive group), the mean value of Hg was 0.49+/- 0.52 ng/ml. The average number of amalgam fillings was 2.26 +/- 3.19 in the Hg negative group and 5.32+/-3.03 in the Hg positive group (ANOVA one-way p=0.04). A dependence of mercury concentration on number of amalgam fillings (p=0.03), surface area of the amalgam fillings (p=0.04) and fish consumption (p=0.04) was observed but not at a significant level. In stepwise logistic procedure the number of amalgam fillings gave a contribution to the model (p=0.04), although null value was included in the confidence intervals. We observed no statistically significant differences (chi2 test) among the patients with a Hg concentration <0.08 ng/ml (n=19) and those with a concentration > or = 0.08 (n=53) with regard to obstetric history and perinatal complications. **CONCLUSIONS: Number and surface areas of amalgam fillings influenced positively Hg concentration in AF but not at a significant level**.

110. Mohan S Tiller M van der Voet G Kanhai H Mercury exposure of mothers and newborns in Surinam: a pilot study.: Clin Toxicol (Phila) (2005) 43(2):101-4

AIM: To study mercury levels in hair from mothers and newborns in Surinam. …CONCLUSION: Mercury accumulates during pregnancy in the unborn. Further study is needed to elucidate the background and consequences of this finding.

111. Bjornberg KA Vahter M Berglund B Niklasson B Blennow M Sandborgh-Englund G Transport of methylmercury and inorganic mercury to the fetus and breast-fed infant. Environ Health Perspect (2005 Oct) 113(10):1381-5

It is well established that methylmercury (MeHg) and mercury vapor pass the placenta, but little is known about infant exposure via breast milk. We measured MeHg and inorganic mercury (I-Hg) in blood of Swedish mothers (n = 20) and their infants, as well as total mercury (T-Hg) in breast milk up to 13 weeks postpartum. Infant blood MeHg was highly associated with maternal blood MeHg at delivery, although more than twice as high. Infant MeHg decreased markedly until 13 weeks of age. Infant blood I-Hg was associated with, and about as high as, maternal blood I-Hg at delivery. Infant I-Hg decreased until 13 weeks. In breast milk, T-Hg decreased significantly from day 4 to 6 weeks after delivery but remained unchanged thereafter. At 13 weeks, T-Hg in breast milk was associated with infant MeHg but not with maternal MeHg. Conversely, T-Hg in breast milk was associated with maternal I-Hg but not with infant I- Hg. From the findings of the present study in which the exposure to both MeHg and I-Hg was low, we conclude that the exposure to both forms of mercury is higher before birth than during the breast- feeding period, and that MeHg seems to contribute more than I-Hg to infant exposure postnatally via breast milk.

112. Takser L Mergler D Baldwin M de Grosbois S Smargiassi A Lafond J Thyroid hormones in pregnancy in relation to environmental exposure to organochlorine compounds and mercury. Environ Health Perspect (2005 Aug) 113(8):1039-45

Polychlorinated biphenyls (PCBs), chlorinated pesticides, and mercury are global environmental contaminants that can disrupt the endocrine system in animals and humans. However, there is little evidence that they can interfere with endocrine status in pregnant women and neonates at low levels of exposure. The aim of this study was to examine thyroid hormone levels during pregnancy and in cord blood in relation to blood concentrations of organochlorine compounds (OCs) and Hg in healthy women recruited during pregnancy. We found a significant negative correlation between maternal total triiodothyronine levels and three non-coplanar congeners (PCB-138, PCB-153, and PCB-180), three pesticides (p,p -DDE, cis-nanochlor, and hexachlorobenzene), and inorganic Hg independently, without any other changes in thyroid status. No significant relationships were observed between OCs and cord serum thyroid hormones. Cord serum free thyroxin was negatively correlated with inorganic Hg. **These results suggest that at even low levels of exposure, persistent environmental contaminants can interfere with thyroid status during pregnancy.**

113. Grandjean P Budtz-JÃ¸rgensen E JÃ¸rgensen PJ Weihe P Umbilical cord mercury concentration as biomarker of prenatal exposure to methylmercury. Environ Health Perspect (2005 Jul) 113(7):905-8

Biomarkers are often applied to assess prenatal exposure to methylmercury in research and surveillance. In a prospective study in the Faroe Islands, the main exposure biomarkers were the mercury concentrations in cord blood and maternal hair obtained at parturition. We have now supplemented these exposure biomarkers with mercury analyses of umbilical cord tissue from 447 births. In particular, when expressed in relation to the dry weight of the tissue, the cord mercury concentration correlated very well with that in cord blood. Structural equation model analysis showed that these two biomarkers have average total imprecision of about 30%, which is much higher than the laboratory error. The imprecision of the dry- weight-based concentration

was lower than that of the wet-weight- based parameter, and it was intermediate between those of the cord blood and the hair biomarkers. In agreement with this finding, regression analyses showed that the dry-weight cord mercury concentration was almost as good a predictor of methylmercury- associated neuropsychologic deficits at 7 years of age as was the cord-blood mercury concentration. Cord mercury analysis can therefore be used as a valid measure of prenatal methylmercury exposure, but appropriate adjustment for the imprecision should be considered.

114. Stern AH A revised probabilistic estimate of the maternal methyl mercury intake dose corresponding to a measured cord blood mercury concentration. Environ Health Perspect (2005 Feb) 113(2):155-63

In 2001, the U.S. Environmental Protection Agency (EPA) adopted a revised reference dose (RfD) for methyl mercury (MeHg) of 0.1 microg/kg/day. The RfD is based on neurologic developmental effects measured in children associated with exposure in utero to MeHg from the maternal diet. The RfD derivation proceeded from a point of departure based on measured concentration of mercury in fetal cord blood (micrograms per liter). The RfD, however, is a maternal dose (micrograms per kilogram per day). Reconstruction of the maternal dose corresponding to this cord blood concentration, including the variability around this estimate, is a critical step in the RfD derivation. The dose reconstruction employed by the U.S. EPA using the one-compartment pharmacokinetic model contains two areas of significant uncertainty: It does not directly account for the influence of the ratio of cord blood: maternal blood Hg concentration, and it does not resolve uncertainty regarding the most appropriate central tendency estimates for pregnancy and third- trimester-specific model parameters. A probabilistic reassessment of this dose reconstruction was undertaken to address these areas of uncertainty and generally to reconsider the specification of model input parameters. On the basis of a thorough review of the literature and recalculation of the one-compartment model including sensitivity analyses, I estimated that the 95th and 99th percentiles (i.e., the lower 5th and 1st percentiles) of the maternal intake dose corresponding to a fetal cord blood Hg concentration of 58 microg/L are 0.3 and 0.2 microg/kg/day, respectively. For the 99th percentile, this is half the value previously estimated by the U.S. EPA.

115. Grandjean P Jorgensen PJ Measuring mercury concentration. Epidemiology (2005 Jan) 16(1):133

116. Mutter J Naumann J Walach H Daschner F [Amalgam risk assessment with coverage of references up to 2005]Amalgam: Eine Risikobewertung unter Berucksichtigung der neuen Literatur bis 2005. Gesundheitswesen (2005 Mar) 67(3):204-16

Amalgam, which has been in use in dentistry for 150 years, consists of 50 % elemental mercury and a mixture of silver, tin, copper and zinc. Minute amounts of mercury vapour are released continuously from amalgam. Amalgam contributes substantially to human mercury load. Mercury accumulates in some organs, particularly in the brain, where it can bind to protein more tightly than other heavy metals (e. g. lead, cadmium). Therefore, the elimination half time is assumed to be up to 1 - 18 years in the brain and bones. Mercury is assumed to be one of the most toxic non-radioactive elements. There are pointers to show that mercury vapour is more neurotoxic than methyl-mercury in fish. Review of recent literature suggests that mercury from dental amalgam may lead to nephrotoxicity, neurobehavioural changes, autoimmunity, oxidative stress, autism, skin and mucosa alterations or non-specific symptoms and complaints. The development of Alzheimer's disease or multiple sclerosis has also been linked to low- dose mercury exposure. There may be individual genetical or acquired susceptibilities for negative effects from dental

amalgam. Mercury levels in the blood, urine or other biomarkers do not reflect the mercury load in critical organs. Some studies regarding dental amalgam reveal substantial methodical flaws. Removal of dental amalgam leads to permanent improvement of various chronic complaints in a relevant number of patients in various trials. **Summing up, available data suggests that dental amalgam is an unsuitable material for medical, occupational and ecological reasons**.

117. Shim SM Lasrado JA Dorworth LE Santerre CR Mercury and omega-3 fatty acids in retail fish sandwiches. J Food Prot (2005 Mar) 68(3):633-5

Mercury and fatty acids were measured in fish sandwiches from six retail restaurant chains. Average mercury concentrations ranged from 5 to 132 ppb and were well below the Food and Drug Administration action level (1,000 ppb). The average concentrations of eicosapentaenoic acid plus docosahexaenoic acid ranged from 91 to 620 mg per sandwich. Consuming one or two fish sandwiches per week could result in the consumption of 2 to 40% of the reference dose for mercury for a 60-kg individual and would provide 18 to 126% of the adequate intake for eicosapentaenoic acid plus docosahexaenoic acid as recommended for a pregnant or lactating woman.

118. Herba E Pojda-Wilczek D Pojda SM Plech AR Makowiecka-Obidzinska K Plech A Szkilnik R Brus R [Visual evoked potentials (FVEP) after the prenatal exposure to heavy metals--experimentals studies]Wzrokowe potencjaly wywolane (FVEP) po prenatalnym stosowaniu soli metali ciezkich--badania doswiadczalne. Klin Oczna (2005) 107(10-12):599-602

PURPOSE: To find out, if any and how deep alterations in visual tract are due to prenatal intoxication by heavy metals such as: cadmium (Cd), lead (Pb), mercury (Hg) and manganese (Mn). The measure of these alterations were the changes in flash visual evoked potentials after prenatal intoxication. … CONCLUSIONS: The heavy metals prolonged the latencies and diminished the amplitudes of flash visual evoked potentials, so may be, they are not only neurotoxic but also ophthalmotoxic factors.

119. Sato RL Li GG Shaha S Antepartum seafood consumption and mercury levels in newborn cord blood. Am J Obstet Gynecol (2006 Jun) 194(6):1683-8

OBJECTIVE: The purpose of this study was to determine the level of fetal mercury exposure by measuring mercury levels in newborn cord blood and to analyze the association with fish consumption during pregnancy. …. RESULTS: The mean mercury level in cord blood was 4.82 microg/L; 28.3% of the participants had measured mercury levels above the US Environmental Protection Agency's recommended reference dose (5.8 microg/L). A significant relationship was noted between the amount of fish consumed during pregnancy and rising mercury levels in cord blood. CONCLUSION: In an island state with high levels of fish consumption, women were 3 times more likely to have elevated cord blood mercury levels, compared with the national average.

120. Jedrychowski W Jankowski J Flak E Skarupa A Mroz E Sochacka-Tatara E Lisowska-Miszczyk I Szpanowska-Wohn A Rauh V Skolicki Z Kaim I Perera F Effects of prenatal exposure to mercury on cognitive and psychomotor function in one-year-old infants: epidemiologic cohort study in Poland. Ann Epidemiol (2006 Jun) 16(6):439-47

PURPOSE: The aim of the study is to assess the cognitive and psychomotor status of 1-year-old infants whose mothers were exposed to low, but varying, amounts of mercury during pregnancy. … RESULTS: The geometric mean (GM) for maternal blood mercury level for the group of infants

with normal neurocognitive performance was lower (GM = 0.52 mug/L; 95% confidence interval [CI], 0.46-0.58) than that observed in the group with delayed performance (GM = 0.75 mug/L; 95% CI, 0.59-0.94), and this difference was significant (p = 0.010). The GM of cord blood mercury level in the normal group also was lower (GM = 0.85 mug/L; 95% CI, 0.78-0.93) than that observed in the group with delayed performance (GM = 1.05 mug/L; 95% CI, 0.87-1.27), and this difference was of borderline significance (p = 0.070). The relative risk (RR) for delayed performance increased more than threefold (RR = 3.58; 95% CI, 1.40-9.14) if cord blood mercury level was greater than 0.80 mug/L. Risk for delayed performance in the group of infants with greater maternal mercury levels (>0.50 mug/L) also was significantly greater (RR = 2.82; 95% CI, 1.17-6.79) compared with children whose mothers had mercury levels less than 0.50 mug/L. CONCLUSIONS: **The results may be of public health importance because delayed psychomotor or mental performance in infants is assumed to be an indicator of later neurocognitive development in children, which may persist into adult life.**

121. Chien LC Han BC Hsu CS Jiang CB You HJ Shieh MJ Yeh CY Analysis of the health risk of exposure to breast milk mercury in infants in Taiwan. Chemosphere (2006 Jun) 64(1):79-85

The aim of this study was to assess the total concentration and health risk to infants of breast milk mercury in urban mothers and mothers married to fishermen in relation to fish intake in Taiwan. A total of sixty-eight healthy mothers were recruited for the study. The breast milk mercury geometric mean concentration was 2.02 microgl(-1) (n=56, range: 0.24-9.45 microgl(-1)) for the city group and 2.04 microgl(-1) (n=12, range: 0.26-8.62 microgl(-1)) for the fishermen's group. Of the three sources of mercury exposure (i.e., ingestion (breast milk), inhalation (ambient air), and dermal exposure (shower)), breast-feeding was found to be the largest (96.3- 99.6% of the total). From a Monte Carlo simulation, in which methyl mercury accounted for about 50% of total mercury, the hazard quotient (exposure estimate/oral minimal risk level or target organ toxicity dose) exceeded 1.0 for 12.9% of urban babies and 18.8% of fishermen's babies (chronic oral minimal risk level and target organ toxicity dose: 3 x 10(-4)mgkg(-1)d(-1)). The calculated mercury exposure was 3.02 x 10(-1) microgkg(-1)d(-1) for a 3.49 kg urban baby boy and 3.06 x 10(-1) microgkg(-1)d(-1) for a 3.44 kg urban baby girl. These results suggest the life style of mothers (eating raw fish and shellfish such as used in 51Sashimi51 and 51Sushi,51 and vitamin supplementation) may influence the mercury concentration in breast milk.

122. Dorea JG Donangelo CM Early (in uterus and infant) exposure to mercury and lead. Clin Nutr (2006 Jun) 25(3):369-76

Mercury and lead are toxic metals widely spread in the environment with bio-accumulative features that raises public health concerns. Both metals are equally dispersed in the human food chain but exposure and risk of toxicity during early human development are modulated by the diet and nutritional status. Understanding how Hg and Pb occur and interact with nutrients is fundamental to establish guidelines for diminishing exposure and the risk of toxicity. The risk of fetal and infant exposure to Hg can be influenced by maternal amalgam filling (inorganic Hg) and fish consumption (monomethyl Hg), whereas the risk of exposure to Pb is complex: maternal absorption depends on nutrient interactions (Ca and P); and maternal body Pb accumulation responds to all factors known to interact with bone and calcium metabolism. Maternal exposure to Hg and Pb is more important during fetal development than during breastfeeding. Moreover, these metals (especially Pb) are frequently higher in infant formulas which do not carry the nutritional and psychological advantages and protection of breastfeeding. Infant's reference dose is lower for Hg than for Pb, but risk of Pb contamination for fetuses and infant (breast- or formula-fed) is higher and lasts longer than Hg. Breastfeeding is essential to complete infant

development. Interruption or suppression of breast-feeding with cow's milk-based formulas is not an option to environmental pollution.

123. Brender JD Suarez L Felkner M Gilani Z Stinchcomb D Moody K Henry J Hendricks K Maternal exposure to arsenic, cadmium, lead, and mercury and neural tube defects in offspring. Environ Res (2006 May) 101(1):132-9

Arsenic, cadmium, lead, and mercury are neurotoxins, and some studies suggest that these elements might also be teratogens. Using a case-control study design, we investigated the relation between exposure to these heavy metals and **neural tube defects** (NTDs) in offspring of Mexican-American women living in 1 of the 14 Texas counties bordering Mexico. A total of 184 case-women with NTD-affected pregnancies and 225 control-women with normal live births were interviewed about their environmental and occupational exposures during the periconceptional period. Biologic samples for blood lead and urinary arsenic, cadmium, and mercury were also obtained for a subset of these women. Overall, the median levels of these biomarkers for heavy metal exposure did not differ significantly ($P > 0.05$) between case- and control-women. However, among women in the highest income group, case-women were nine times more likely (95% confidence interval (CI) 1.4-57) than control-women to have a urinary mercury 5.62 microg/L. Case-women were 4.2 times more likely (95% CI 1.1-16) to report burning treated wood during the periconceptional period than control- women. Elevated odds ratios (ORs) were observed for maternal and paternal occupational exposures to arsenic and mercury, but the 95% CIs were consistent with unity. The 95% CIs of the ORs were also consistent with unity for higher levels of arsenic, cadmium, lead, and mercury in drinking water and among women who lived within 2 miles at the time of conception to industrial facilities with reported emissions of any of these heavy metals. Our findings suggest that maternal exposures to arsenic, cadmium, or lead are probably not significant risk factors for NTDs in offspring. However, the elevated urinary mercury levels found in this population and exposures to the combustion of treated wood may warrant further investigation.

124. Butler Walker J Houseman J Seddon L McMullen E Tofflemire K Mills C Corriveau A Weber JP LeBlanc A Walker M Donaldson SG Van Oostdam J Maternal and umbilical cord blood levels of mercury, lead, cadmium, and essential trace elements in Arctic Canada. Environ Res (2006 Mar) 100(3):295-318

Maternal and umbilical cord blood levels of mercury (Hg), lead (Pb), cadmium (Cd), and the trace elements copper (Cu), zinc (Zn), and selenium (Se) are reported for Inuit, Dene/Metis, Caucasian, and Other nonaboriginal participants from Arctic Canada. This is the first human tissue monitoring program covering the entire Northwest Territories and Nunavut for multiple contaminants and establishes a baseline upon which future comparisons can be made. Results for chlorinated organic pesticides and PCBs for these participants have been reported elsewhere. Between May 1994 and June 1999, 523 women volunteered to participate by giving their written informed consent, resulting in the collection of 386 maternal blood samples, 407 cord samples, and 351 cord:maternal paired samples. Geometric mean (GM) maternal total mercury (THg) concentrations ranged from 0.87 microg/L (SD = 1.95) in the Caucasian group of participants (n = 134) to 3.51 microg/L (SD = 8.30) in the Inuit group (n = 146). The GM of the Inuit group was 2.6-fold higher than that of the Dene/Metis group (1.35 microg/L, SD = 1.60, n = 92) and significantly higher than those of all other groups ($P<0.0001$). Of Inuit women participants, 3% (n = 4) were within Health Canada's level of concern range (20-99 microg/L) for methylmercury (MeHg) exposure. Of Inuit and Dene/Metis cord samples, 56% (n = 95) and 5% (n = 4), respectively, exceeded 5.8 microg/L MeHg, the revised US Environmental Protection Agency lower benchmark dose. GM maternal Pb was significantly higher in Dene/Metis (30.9 microg/L or 3.1 microg/dL; SD

= 29.1 microg/L) and Inuit (31.6 microg/L, SD = 38.3) participants compared with the Caucasian group (20.6 microg/L, SD = 17.9) (P < 0.0001). Half of all participants were smokers. GM blood Cd in moderate smokers (1-8 cigarettes/day) and in heavy smokers (> 8 cigarettes/day) was 7.4-fold higher and 12.5-fold higher, respectively, than in nonsmokers. The high percentage of smokers among Inuit (77%) and Dene/Metis (48%) participants highlights the need for ongoing public health action directed at tobacco prevention, reduction, and cessation for women of reproductive age. Pb and THg were detected in more than 95% of all cord blood samples, with GMs of 21 microg/L and 2.7 microg/L, respectively, and Cd was detected in 26% of all cord samples, with a GM of 0.08 microg/L. Cord:maternal ratios from paired samples ranged from 0.44 to 4.5 for THg, from 0.5 to 10.3 for MeHg, and 0.1 to 9.0 for Pb. On average, levels of THg, MeHg, and Zn were significantly higher in cord blood than in maternal blood (P < 0.0001), whereas maternal Cd, Pb, Se, and Cu levels were significantly higher than those in cord blood (P < 0.0001). There was no significant relationship between methylmercury and selenium for the range of MeHg exposures in this study. Ongoing monitoring of populations at risk and traditional food species, as well as continued international efforts to reduce anthropogenic sources of mercury, are recommended.

125. Maramba NP Reyes JP Francisco-Rivera AT Panganiban LC Dioquino C Dando N Timbang R Akagi H Castillo MT Quitoriano C Afuang M Matsuyama A Eguchi T Fuchigami Y Environmental and human exposure assessment monitoring of communities near an abandoned mercury mine in the Philippines: a toxic legacy. J Environ Manage (2006 Oct) 81(2):135-45

Abandoned mines are an important global concern and continue to pose real or potential threats to human safety and health including environmental damage/s. Very few countries had government mine regulation and reclamation policies until the latter part of the century where legal, financial and technical procedures were required for existing mining operations. Major reasons for mine closure may be mainly due to poor economies of the commodity making mining unprofitable, technical difficulties and national security. If the mine is abandoned, more often than not it is the government that shoulders the burden of clean-up, monitoring and remediation. The topic of abandoned mines is complex because of the associated financial and legal liability implications. Abandoned mercury mines have been identified as one of the major concerns because of their significant long-term environmental problems. Primary mercury production is still ongoing in Spain, Kyrgzystan, China, Algeria, Russia and Slovakia while world production declined substantially in the late 1980s. In the Philippines, the mercury mine located southeast of Manila was in operation from 1955 to 1976, before ceasing operation because of the decline in world market price for the commodity. During this time, annual production of mercury was estimated to be about 140,000 kg of mercury yearly. Approximately 2,000,000 t of mine-waste calcines (retorted ore) were produced during mining and roughly 1,000,000 t of these calcines were dumped into nearby Honda Bay to construct a jetty to facilitate mine operations where about 2000 people reside in the nearby three barangays. In October, 1994 the Department of Health received a request from the Provincial Health Office for technical assistance relative to the investigation of increasing complaints of unusual symptoms (e.g. miscarriages, tooth loss, muscle weakness, paralysis, anemia, tremors, etc.) among residents of three barangays. Initial health reports revealed significant elevation of blood mercury levels exceeding the then recommended exposure level of 20ppb in 12 out of the 43 (27.9%) residents examined. The majority of the volunteers were former mine workers. In this study the abnormal findings included gingivitis, mercury lines, gum bleeding and pterydium. The most common neurologic complaints were numbness, weakness, tremors and incoordination. Anemia and elevated liver function tests were also seen in a majority of those examined. The assessment also revealed a probable association between blood mercury level and eosinophilia. The same

association was also seen between high mercury levels and the presence of tremors and working in the mercury mine. To date, there are very limited environmental and health studies on the impact of both total and methylmercury that have been undertaken in the Philippines. Thus, this area of study was selected primarily because of its importance as an emerging issue in the country, especially regarding the combined effects of total and methylmercury low-dose and continuous uptake from environmental sources. At present the effects of total mercury exposure combined with MeHg consumption remain an important issue, especially those of low-dose and continuous uptake. Results of the study showed that four (4) species of fish, namely ibis, tabas, lapu-lapu and torsillo, had exceeded the recommended total mercury and methylmercury levels in fish (NV>0.5 microg/gf.w., NV>0.3 microg/gf.w., respectively). Saging and kanuping also exceeded the permissible levels for methylmercury. Total and methylmercury in canned fish, and total mercury in rice, ambient air and drinking water were within the recommended levels, however, additional mercury load from these sources may contribute to the over- all body burden of mercury among residents in the area. Surface water quality at the mining area, Honda Bay and during some monitoring periods at Palawan Bay exceeded total mercury standards (NV>0.002 ng/mL). Soil samples in two sites, namely Tagburos and Honda Bay, exceeded the EPA Region 9 Primary Remediation Goal recommended values for total mercury for residential purposes (NV>23 mg/kg). The hand to mouth activity among infants and children is another significant route for mercury exposure. Statistically significant results were obtained for infants when comparing the results after one year of monitoring for methylmercury levels in hair for both exposed and control sub-groups. Likewise, comparing the initial and final hair methylmercury levels among pregnant women/mothers in the exposed group showed statistically significant ($p<0.05$) results. Comparing the exposed and control sub-groups' mercury hair levels per sub-group showed statistically significant results among the following: (a) initial and final total mercury hair levels among children, (b) initial and final methylmercury hair levels among children, (c) final total mercury hair levels among pregnant women, (d) initial and final total mercury hair levels among mothers, and (e) initial and final methyl hair levels among mothers.

126. Davidson PW Myers GJ Weiss B Shamlaye CF Cox C Prenatal methyl mercury exposure from fish consumption and child development: a review of evidence and perspectives from the Seychelles Child Development Study. Neurotoxicology (2006 Dec) 27(6):1106-9

Evidence from an outbreak of methyl mercury (MeHg) poisoning in Iraq suggested that adverse effects of prenatal exposure on child development begin to appear at or above 10ppm measured in maternal hair. To test this hypothesis in a fish-eating population, we enrolled a cohort of 779 children (the main cohort) in the Seychelles Child Development Study (SCDS). The cohort was prenatally exposed to MeHg from maternal fish consumption, and the children started consuming fish products at about 1 year of age. Prenatal exposure was measured in maternal hair and recent postnatal exposure in the child's hair. The cohort has been examined six times over 11 years using extensive batteries of age-appropriate developmental tests. Analyses of a large number of developmental outcomes have identified frequent significant associations in the appropriate direction with numerous covariates known to affect child development, but only one adverse association between prenatal MeHg exposure and a developmental endpoint. Because such results could be ascribed to chance, there is no convincing evidence for an association between prenatal exposure and child development in this fish-eating population. Secondary analyses have generally supported the primary analyses, but more recently have suggested that latent or delayed adverse effects might be emerging at exposure above 10-12ppm as the children mature. This suggests that the association between prenatal exposure and child development

may be more complex than originally believed. This paper reviews the SCDS main cohort study results and presents our current interpretations.

127. van Wijngaarden E Beck C Shamlaye CF Cernichiari E Davidson PW Myers GJ Clarkson TW Benchmark concentrations for methyl mercury obtained from the 9-year follow-up of the Seychelles Child Development Study. Neurotoxicology (2006 Sep) 27(5):702-9

128. Newland MC Reed MN LeBlanc A Donlin WD Brain and blood mercury and selenium after chronic and developmental exposure to methylmercury. Neurotoxicology (2006 Sep) 27(5):710-20

129. Huffling K The effects of environmental contaminants in food on women's health. J Midwifery Womens Health (2006 Jan-Feb) 51(1):19-25

An essential element of a health-promoting lifestyle is eating nutritious, healthy foods. However, food can be a source of exposure to many types of toxins, and current food production methods can have negative effects on the environment and consumers. This article identifies several of the contaminants present in food and describes adverse health effects from exposure to specific contaminants. Recommendations for how exposure can be prevented or minimized are presented.

130. Park S Johnson MA Awareness of fish advisories and mercury exposure in women of childbearing age. Nutr Rev (2006 May) 64(5 Pt 1):250-6

Methylmercury crosses the placenta and increases the risk of impaired neurodevelopment in the fetus. Federal guidelines for fish intake and fish advisories are in place to help people of all ages limit their exposure to mercury from fish. However, recent studies suggest that the awareness of fish advisories is low among women of childbearing age. Fish intake is strongly correlated with hair mercury concentrations. In women in states with fish advisories, hair mercury concentrations were 7-fold higher in women who consumed 20 or more servings of fish than in those who reported nofish consumption in the past 3 months (0.59 vs. 0.08 microg/g). Among this high fish consumption group, the 75th and 95th percentile of hair mercury concentrations were 0.99 and 2.29 microg/g, respectively. This is of concern because the US Environmental Protection Agency (EPA) recommends that hair mercury be less than 1 microg/g. Public health campaigns to reduce mercury exposure need further refinement to reach women of childbearing age.

131. Hsu CS Liu PL Chien LC Chou SY Han BC Mercury concentration and fish consumption in Taiwanese pregnant women. BJOG (2007 Jan) 114(1):81-5

OBJECTIVE: The aim of this study was to assess the relationship between fish consumption and total mercury concentration in maternal blood, umbilical cord blood, and placenta tissue of pregnant women in Taiwan. DESIGN: Cross-sectional study. SETTING: A medical centre in Taipei, Taiwan. SAMPLE: Sixty-five pregnant women delivered between July 2004 and March 2005. METHODS: We administered a questionnaire to each woman in the third trimester and collected blood samples and placenta tissue after delivery. Mercury concentrations in the maternal blood, cord blood and placenta tissue were measured using mercury analyser (Hiranuma HG-310, Hitachi, Japan). A dietitian calculated the quantity of fish consumed from the questionnaire. MAIN OUTCOME MEASURES: The total mercury concentration in maternal blood, cord blood and placenta tissue. RESULTS: The mean total mercury concentration in maternal blood, cord blood

and placenta tissue was 9.1 +/- 0.40 microgram/l, 10.0 +/- 0.55 microgram/l and 19.2 +/- 1.8 ng/g, respectively. Eighty-nine percent of the maternal blood mercury concentrations exceeded the US National Research Council recommended value of 5.8 microgram/l. Fish consumption while pregnant correlated significantly with maternal blood and cord blood mercury concentrations. CONCLUSIONS: Total mercury concentrations of maternal blood, cord blood and placenta tissue commonly exceeded recommended values, and were higher in women who ate fish more than three times a week while pregnant.

132. Santos EO Jesus IM Camara Vde M Brabo Eda S Jesus MI Fayal KF Asmus CI Correlation between blood mercury levels in mothers and newborns in Itaituba, Para State, Brazil. Cad Saude Publica (2007) 23 Suppl 4:S622-9

This study evaluated transplacental mercury transfer by measuring Hg in blood samples of mothers and newborns (umbilical cord) in hospitals in the municipality (county) of Itaituba, Para State, Brazil. Epidemiological and mercury exposure data were collected, besides clinical birth data. Mercury tests were performed by cold- vapor atomic absorption spectrophotometry. A total of 1,510 women and an equal number of their newborns participated in the study. Mean blood mercury was 11.53 microg/L in mothers and 16.68 microg/L in newborns (umbilical cord). The highest Hg levels were in the 31-40- year maternal age group and their newborns, with 14.37 microg/L and 21.87 microg/L, respectively. However, in all age groups the mean mercury level was higher in newborns than in mothers. There was a strong positive correlation between Hg levels in newborns and mothers (r = 0.8019; p = 0.000), with a significant linear regression model (r = 0.5283; p = 0.000). The results highlight the importance of monitoring pregnant women exposed to mercury as part of public health surveillance.

133. Rignell-Hydbom A Axmon A Lundh T JÃ¶nsson BA Tiido T Spano M Dietary exposure to methyl mercury and PCB and the associations with semen parameters among Swedish fishermen. Environ Health (2007) 6:14

Dietary POP exposure have shown negative effects on sperm motility and sperm chromatin integrity, as well as an increased proportion of Y-chromosome bearing sperms. …men with low MeHg and high CB-153 had slightly higher DNA Fragmentation Index and fraction of Y-chromosome bearing sperms than men with low levels of both compounds, the effects were not statistically significant.

134. Axelrad DA Bellinger DC Ryan LM Woodruff TJ Dose-response relationship of prenatal mercury exposure and IQ: an integrative analysis of epidemiologic data. Environ Health Perspect (2007 Apr) 115(4):609-15

BACKGROUND: Prenatal exposure to mercury has been associated with adverse childhood neurologic outcomes in epidemiologic studies. Dose- response information for this relationship is useful for estimating benefits of reduced mercury exposure. OBJECTIVES: We estimated a dose-response relationship between maternal mercury body burden and subsequent childhood decrements in intelligence quotient (IQ), using a Bayesian hierarchical model to integrate data from three epidemiologic studies. … RESULTS: We find a central estimate of -0.18 IQ points (95% confidence interval, -0.378 to -0.009) for each parts per million increase of maternal hair mercury, similar to the estimates for both the Faroe Islands and Seychelles studies, and lower in magnitude than the estimate for the New Zealand study. Sensitivity analyses produce similar results, with the IQ coefficient central estimate ranging from -0.13 to -0.25. CONCLUSIONS: IQ is a useful end point for estimating neurodevelopmental effects, but may not fully represent cognitive deficits associated with mercury exposure, and does not represent deficits related to

attention and motor skills. Nevertheless, the integrated IQ coefficient provides a more robust description of the dose-response relationship for prenatal mercury exposure and cognitive functioning than results of any single study.

135. Xue F Holzman C Rahbar MH Trosko K Fischer L Maternal fish consumption, mercury levels, and risk of preterm delivery. Environ Health Perspect (2007 Jan) 115(1):42-7

BACKGROUND: Pregnant women receive mixed messages about fish consumption in pregnancy because unsaturated fatty acids and protein in fish are thought to be beneficial, but contaminants such as methylmercury may pose a hazard. METHODS: In the Pregnancy Outcomes and Community Health (POUCH) study, women were enrolled in the 15th to 27th week of pregnancy from 52 prenatal clinics in five Michigan communities. At enrollment, information was gathered on amount and category of fish consumed during the current pregnancy, and a hair sample was obtained. A segment of hair closest to the scalp, approximating exposure during pregnancy, was assessed for total mercury levels (70-90% methylmercury) in 1,024 POUCH cohort women. RESULTS: Mercury levels ranged from 0.01 to 2.50 pg/g (mean = 0.29 microg/g; median = 0.23 microg/g). Total fish consumption and consumption of canned fish, bought fish, and sport-caught fish were positively associated with mercury levels in hair. The greatest fish source for mercury exposure appeared to be canned fish. Compared with women delivering at term, women who delivered before 35 weeks' gestation were more likely to have hair mercury levels at or above the 90th percentile (> or = 0.55 microg/g), even after adjusting for maternal characteristics and fish consumption (adjusted odds ratio = 3.0; 95% confidence interval, 1.3-6.7). CONCLUSION: This is the first large, community-based study to examine risk of very preterm birth in relation to mercury levels among women with low to moderate exposure. Additional studies are needed to see whether these findings will be replicated in other settings.

136. Jedrychowski W Perera F Jankowski J Rauh V Flak E Caldwell KL Jones RL Pac A Lisowska-Miszczyk I Fish consumption in pregnancy, cord blood mercury level and cognitive and psychomotor development of infants followed over the first three years of life: Krakow epidemiologic study. Environ Int (2007 Nov) 33(8):1057-62

BACKGROUND: Although the maternal fish consumption is supposed to have beneficial effects on development of infants, it may be harmful for child cognitive development since fish is a common source of methylmercury. … Subsequent BSID-II testing at 24 and 36 months did not confirm significant association between exposure and cognitive or psychomotor function. The estimates of association between mercury prenatal exposure and the development of infants, which were based on the longitudinal analysis of all BSID-II measurements done in the follow-up (generalized estimating equations statistical model) showed that the performance deficit observed at 12 months of age was of border significance.

137. Fok TF Lam HS Ng PC Yip AS Sin NC Chan IH Gu GJ So HK Wong EM Lam CW Fetal methylmercury exposure as measured by cord blood mercury concentrations in a mother-infant cohort in Hong Kong. Environ Int (2007 Jan) 33(1):84-92

This study was designed to examine newborn infants in Hong Kong prenatally exposed to levels of methylmercury considered to increase risk of neurotoxic effects and to examine subject characteristics that modify the degree of prenatal mercury exposure. …Increasing maternal fish consumption and maternal age were found to be associated with increased cord blood mercury concentrations. Marine fish consumption increased cord blood mercury concentrations more than freshwater fish (5.09%/kg vs 2.86%/kg). Female babies, maternal alcohol consumption and increasing maternal height were associated with decreased cord blood mercury concentrations.

Pregnant women in Hong Kong consume large amounts of fish and as a result, most of their offspring have been prenatally exposed to moderately high levels of mercury. In this population, pregnant women should choose freshwater over marine fish and limit fish consumption.

138. Gao Y Yan CH Tian Y Wang Y Xie HF Zhou X Yu XD Yu XG Tong S Zhou QX Shen XM Prenatal exposure to mercury and neurobehavioral development of neonates in Zhoushan City, China. Environ Res (2007 Nov) 105(3):390-9

Exposure to hazardous Hg can adversely affect children's neurodevelopment. However, few data are available on either Hg levels in neonates and their mothers or the impact of prenatal exposure to Hg on neonates' neurobehavioral development in the Chinese population. Therefore, this study examined Hg levels in neonates and their mothers and the relationship between prenatal exposure to Hg and neonates' neurobehavioral development in Zhoushan City, Zhejiang Province, China. …according to the reference dose of Hg levels (RfD 5.8 microg/L) derived by EPA, 69.9% of newborns had levels at or above the RfD, an estimated level assumed to be without appreciable harm. There was a strong correlation between maternal hair and cord blood Hg levels ($r = 0.82$, $P < 0.01$). Frequency of fish consumption was associated with hair Hg ($r = 0.48$, $P < 0.01$) and cord blood Hg levels ($r = 0.54$, $P < 0.01$). Increased prenatal Hg exposure was associated with decreased behavioral ability for males (OR = 1.235, 95%CI of OR = 1.078-1.414, $P < 0.001$), but not for females. Our results provide some support for the hypothesis that there is neurodevelopmental risk for males from prenatal MeHg exposure resulting from fish consumption. But the findings of this study may be due to chance, and long-term follow-up research is needed to evaluate cumulative effects of exposure to mercury.

139. Sakamoto M Kaneoka T Murata K Nakai K Satoh H Akagi H Correlations between mercury concentrations in umbilical cord tissue and other biomarkers of fetal exposure to methylmercury in the Japanese population. Environ Res (2007 Jan) 103(1):106-11

Methylmercury (MeHg) is one of the most risky substances to affect humans through fish consumption, and the fetus is known to be in the most susceptible group. Our objective in this study is to examine the relationships of total mercury (THg) and MeHg concentrations between umbilical cord tissue and other tissues as biomarkers of fetal exposure to MeHg in the Japanese population. … More than 90% of Hg in cord tissue, cord blood, and maternal blood was MeHg. THg and MeHg in cord blood was about two times higher than in maternal blood. A strong correlation was found between THg and MeHg in cord tissue. The cord tissue THg and MeHg showed a strong correlation with cord blood Hg, which is recognized as the best biomarker for fetal exposure to MeHg. The findings of this study indicate the significance of cord tissue THg and MeHg as biomarkers for fetal exposure to MeHg at parturition.

140. Marques RC Dorea JG Fonseca MF Bastos WR Malm O Hair mercury in breast-fed infants exposed to **thimerosal-preserved vaccines**. Eur J Pediatr (2007 Sep) 166(9):935-41

Because of uncertainties associated with a possible rise in neuro- developmental deficits among vaccinated children, thimerosal- preserved vaccines have not been used since 2004 in the USA (with the exception of thimerosal-containing influenza vaccines which are routinely recommended for administration to pregnant women and children), and the EU but are widely produced and used in other countries. **We investigated the impact of thimerosal on the total Hg in hair of 82 breast-fed infants during the first 6 months of life.** The infants received three doses of the hepatitis-B vaccine (at birth, 1 and 6 months) and three DTP (diphtheria, tetanus, and pertussis) doses at 2, 4 and 6 months, according to the immunization schedule recommended by the Ministry of Health of Brazil. The thimerosal in vaccines provided an ethylmercury (EtHg)

exposure of 25 microgHg at birth, 30, 60 and 120 days, and 50 microgHg at 180 days. The exposure to vaccine-EtHg represents 80% of that expected from total breast milk-Hg in the first month but only 40% of the expected exposure integrated in the 6 months of breastfeeding. However, the Hg exposure corrected for body weight at the day of immunization was much higher from thimerosal- EtHg (5.7 to 11.3 microgHg/kg b.w.) than from breastfeeding (0.266 microgHg/kg b.w.). While mothers showed a relative decrease (-57%) in total hair-Hg during the 6 months lactation there was substantial increase in the infant's hair-Hg (446%). We speculate that dose and parenteral mode of thimerosal-EtHg exposure modulated the relative increase in hair-Hg of breast-fed infants at 6 months of age.

141. Jones L Bunnell J Stillman J A 30-year follow-up of residual effects on New Zealand School Dental Nurses, from occupational mercury exposure. Hum Exp Toxicol (2007 Apr) 26(4):367-74

This paper reports possible residual adverse effects from occupational mercury exposure in dentistry, Thirty years ago, the all- women exposed group worked with both silver and copper amalgam filling material without protective gloves or a ventilation system, resulting in chronic mercury exposure. The aim of the study was to test the null hypothesis in a survey of general and reproductive health, and a battery of nine neurobehavioral tests. The population was the 115 graduates of one school for dental nurses from 1968 to 1971. The sample was 43 mercury-exposed women and 32 matched controls. Statistical comparisons revealed that the two groups were equivalent on cognitive tasks and four of the six mood subscales. Significant between-group differences were found in current health symptom experience and reproductive health, especially early hysterectomy experience. Reporting of Occupational Overuse Syndrome was strongly positively correlated with years of work. In general, the study suggests that acute symptoms from mercury exposure may be reversible, while some residual health effects may be becoming more of a concern with the women's increasing age.

142. Marques RC Garrofe Dorea J Rodrigues Bastos W de Freitas Rebelo M de Freitas Fonseca M Malm O Maternal mercury exposure and neuro-motor development in breastfed infants from Porto Velho (Amazon), Brazil. Int J Hyg Environ Health (2007 Jan) 210(1):51-60

Fish is an important item in the diet of Amazonians, and per se is their best single source of essential nutrients. Rapid urbanization and migration are bringing changes in dietary habits of Amazonians. Exposure to fish-Hg during pregnancy and lactation were studied in 100 women and newborns from Porto Velho. Tissue-Hg concentrations and neurodevelopment (Gesell Developmental Schedules) were assessed at birth and at 6 months in exclusively breastfed infants. Maternal mean frequency of fish consumption was low (<2 meals/week; range 0->7 meals/week) compared to Amazonian standards. Women consuming <2 fish meals/week showed less median hair-Hg (3.5 microgg-1) than women that consumed 2 fish meals/week (5.7 microgg). Median total Hg in maternal hair (5.4 microgg-1) was higher than in newborns (1.6 microgg-1). Significant correlation was observed between maternal hair-Hg and infant hair-Hg at birth ($r=0.353$; $p<0.01$) and at six months ($r=0.510$; $p<0.01$). Placenta-Hg was also significantly correlated to maternal hair-Hg ($r=0.321$; $p<0.01$), newborn hair-Hg ($r=0.219$; $p<0.05$), maternal blood-Hg ($r=0.250$; $p<0.01$) and to umbilical cord-Hg ($r=0.857$; $p<0.01$). Most infants (74%) had normal Gesell Schedules but among the 26% showing neuro-motor development delays only six (7%) had multiple (motor, language, and adaptative) delays. The infants with multiple delays were born from mothers with range of hair-Hg comparable to mothers of normally developed infants. Coincidentally, mothers of infants with multiple delays also showed the lowest range of income and level of education. Fish consumption, income, and level of education varied greatly among these breastfeeding urban mothers. It seems that development delays of exclusively

breastfed infants are a component of the health inequalities that accompanies socioeconomic disadvantages.

143. Jedrychowski W Perera F Rauh V Flak E Mroz E Pac A Skolicki Z Kaim I Fish intake during pregnancy and mercury level in cord and maternal blood at delivery: an environmental study in Poland. Int J Occup Med Environ Health (2007) 20(1):31-7

OBJECTIVES: The purpose of this study was to estimate the amount of absorbed mercury (Hg) by mothers and their infants as a result of fish consumption during pregnancy. ….CONCLUSIONS: The study shows that in Poland, babies are exposed to moderate levels of mercury prior to birth and that fish eating in pregnancy significantly contributes to prenatal Hg exposure. The findings also suggest that the level of cord blood Hg should not be used for describing inter-individual differences in maternal exposure to Hg unless a proper correction factor is introduced.

144. Myers GJ Davidson PW Strain JJ Nutrient and methyl mercury exposure from consuming fish. J Nutr (2007 Dec) 137(12):2805-8

There is controversy about the risks and benefits of consuming fish. Fish consumption provides nutrients, some of which are essential for brain growth and development. All fish, however, contain methyl mercury (MeHg), a known neurotoxicant. The toxic effect of MeHg seems most damaging during brain development, and thus, prenatal exposure is of greatest concern.

145. Murata K Dakeishi M Shimada M Satoh H [Usefulness of umbilical cord mercury concentrations as biomarkers of fetal exposure to methylmercury]. Nihon Eiseigaku Zasshi (2007 Sep) 62(4):949-59

In epidemiological studies on the health effect of methylmercury (MeHg) exposure, maternal-hair mercury concentration has been used as an exposure biomarker because of its ease of collection and capability to recapture the exposure history. … The mean total mercury (T-Hg) concentration in cord blood was between 0.5 and 35.6microg/l, and the cord blood-to-maternal blood ratio of T-Hg concentrations was estimated to be approximately 1.5. MeHg concentrations in dried cord tissue did not exceed 0.4 microg/g in Japanese populations without particular exposure to MeHg. Dried cord tissue appeared to be better than wet tissue because the definition of wet weight of the umbilical cord is ambiguous. Both cord-blood and cord-tissue mercury concentrations seemed to correlate closely with maternal-hair and maternal-blood ones. Since cord mercury concentrations are a direct exposure biomarker of the fetus and the cord blood-to-maternal blood ratio of mercury differed markedly among mother-child pairs, mercury concentration in cord blood or dried cord tissue should therefore be used in assessing the possible effects of fetal exposure to MeHg on the susceptible brain. Further studies are required to clarify at which period of exposure during gestation the cord mercury concentration represents in relation to mercury concentrations in maternal segmental hair.

146. Oken E Radesky JS Wright RO Bellinger DC Amarasiriwardena CJ Kleinman KP Hu H Gillman MW Maternal fish intake during pregnancy, blood mercury levels, and child cognition at age 3 years in a US cohort. Am J Epidemiol (2008 May 15) 167(10):1171-81

The balance of contaminant risk and nutritional benefit from maternal prenatal fish consumption for child cognitive development is not known. Using data from a prospective cohort study of 341 mother-child pairs in Massachusetts enrolled in 1999-2002, the authors studied associations of maternal second-trimester fish intake and erythrocyte mercury levels with children's scores on the Peabody Picture Vocabulary Test (PPVT) and Wide Range Assessment of Visual Motor Abilities (WRAVMA) at age 3 years. Mean maternal total fish intake was 1.5 (standard deviation, 1.4) servings/week, and 40 (12%) mothers consumed >2 servings/week. Mean maternal mercury

level was 3.8 (standard deviation, 3.8) ng/g. After adjustment using multivariable linear regression, higher fish intake was associated with better child cognitive test performance, and higher mercury levels with poorer test scores. Associations strengthened with inclusion of both fish and mercury: effect estimates for fish intake of >2 servings/week versus never were 2.2 (95% confidence interval (CI): - 2.6, 7.0) for the PPVT and 6.4 (95% CI: 2.0, 10.8) for the WRAVMA; for mercury in the top decile, they were -4.5 (95% CI: -8.5, -0.4) for the PPVT and -4.6 (95% CI: -8.3, -0.9) for the WRAVMA. Fish consumption of < or =2 servings/week was not associated with a benefit. Dietary recommendations for pregnant women should incorporate the nutritional benefits as well as the risks of fish intake.

147. Dewailly E Suhas E Mou Y Dallaire R Chateau-Degat L Chansin R High fish consumption in French Polynesia and prenatal exposure to metals and nutrients. Asia Pac J Clin Nutr (2008) 17(3):461-70

French Polynesians consume high quantities of fish and are therefore exposed to seafood-related contaminants such as mercury (Hg) or lead (Pb) and nutrients such as iodine, selenium and long chain polyunsaturated fatty acids (LC-PUFAs). As the developing foetus is sensitive to contaminants and nutrients, a cross-sectional study was conducted in French Polynesia in 2005-2006 to assess prenatal exposure to contaminants and nutrients through fish consumption. Two hundred and forty one (241) delivering women originating from all islands of French Polynesia were recruited and agreed to answer questions on fish consumption and gave permission to collect umbilical cord blood for metals and nutrients analyses. All parameters were found in high concentrations in cord blood samples except for lead. Mercury concentrations averaged 64.6 nmol/L (or 13 microg/L) with values ranging from 0.25 to 240 nmol/L. Of the sample, 82.5% had Hg concentrations above the US-EPA blood guide-line of 5.8 microg/L. Tuna was the fish species which contributed the most to Hg exposure. High selenium and LC-PUFAs may counterbalance the potential risk of prenatal exposure to Hg in French Polynesia. Due to the high fish consumption of mothers, Polynesian newborns are prenatally exposed to high doses of mercury. Although selenium and omega-3 fatty acids may counteract mercury toxicity, informing pregnant women on both the mercury and nutrient content of local fish species is important.

148. Pugach S Clarkson T Prenatal mercury exposure and postnatal outcome: clinical case report and analysis. Clin Toxicol (Phila) (2009 Apr) 47(4):366-70

INTRODUCTION: It is well known that vapor emitted from metallic mercury is a potent neurotoxic agent, but little toxicological information on liquid metallic mercury itself is available, especially with respect to developmental neurotoxicity. We were unable to find any cases of parental metallic mercury administration that reveal its effect on embryogenesis and human development. CASE REPORT: Young woman who, following a suicide attempt through the intravenous injection of liquid mercury, developed extremely high blood and urine mercury levels but was able to become pregnant and deliver an apparently mature and healthy infant. ANALYSIS: To our knowledge, there were no similar cases reported in the literature. Therefore, we chose to perform a detailed analysis of this unique clinical case. We report levels of mercury in maternal, umbilical cord, and infant blood, in samples of breast milk and placental tissues. Despite high levels of mercury in blood and urine samples, no immediate adverse heath effects were observed in either mother or infant. This case may shed a new light and information on the toxicology of mercury.

149. Tang D Li TY Liu JJ Zhou ZJ Yuan T Chen YH Rauh VA Xie J Perera F Effects of prenatal exposure to coal-burning pollutants on children's development in China. Environ Health Perspect (2008 May) 116(5):674-9

BACKGROUND: Environmental pollutants such as polycyclic aromatic hydrocarbons (PAHs), lead, and mercury are released by combustion of coal and other fossil fuels. OBJECTIVES: In the present study we evaluated the association between prenatal exposure to these pollutants and child development measured by the Gesell Developmental Schedules at 2 years of age. METHODS: The study was conducted in Tongliang, Chongqing, China, where a seasonally operated coal-fired power plant was the major source of ambient PAHs and also contributed lead and mercury to the air. In a cohort of nonsmoking women and their newborns enrolled between March 2002 and June 2002, we measured levels of PAH-DNA adducts, lead, and mercury in umbilical cord blood. PAH-DNA adducts (specifically benzo[a]pyrene adducts) provided a biologically relevant measure of PAH exposure. We also obtained developmental quotients (DQs) in motor, adaptive, language, and social areas. RESULTS: Decrements in one or more DQs were significantly associated with cord blood levels of PAH-DNA adducts and lead, but not mercury. Increased adduct levels were associated with decreased motor area DQ ($p = 0.043$), language area DQ ($p = 0.059$), and average DQ ($p = 0.047$) after adjusting for cord lead level, environmental tobacco smoke, sex, gestational age, and maternal education. In the same model, high cord blood lead level was significantly associated with decreased social area DQ ($p = 0.009$) and average DQ ($p = 0.038$). CONCLUSION: The findings indicate that exposure to pollutants from the power plant adversely affected the development of children living in Tongliang; these findings have implications for environmental health policy.

150. Huel G Sahuquillo J Debotte G Oury JF Takser L Hair mercury negatively correlates with calcium pump activity in human term newborns and their mothers at delivery. Environ Health Perspect (2008 Feb) 116(2):263-7

BACKGROUND: Calcium homeostasis is a known target of several environmental toxicants including lead and mercury. OBJECTIVE: Our goal was to determine the relationship between Hg exposure and erythrocyte Ca pump activity in women at delivery and in their newborns. METHODS: We determined total Hg as well as Pb concentrations in 81 hair and blood samples obtained at delivery. Basal and calmodulin-stimulated Ca pump activity was measured in red blood cells from cord blood and maternal erythrocyte plasma membranes. RESULTS: Maternal hair Hg negatively correlates with Ca pump activity in maternal and cord blood erythrocytes. Pb and Hg both independently correlate negatively with Ca pump activity without any statistically significant interaction. After adjustment for potential confounders, Pb and Hg explain about 30% and 7% of total variance of Ca pump activity in newborns and mothers, respectively. CONCLUSION: Our findings confirm results reported in previous experimental studies and support the use of biomarkers in newborns from general population.

151. Abdelouahab N Mergler D Takser L Vanier C St-Jean M Baldwin M Spear PA Chan HM Gender differences in the effects of organochlorines, mercury, and lead on thyroid hormone levels in lakeside communities of Quebec (Canada). Environ Res (2008 Jul) 107(3):380-92

Environmental chemicals can disrupt endocrine balance and in particular thyroid hormone (TH) homeostasis. However, studies differ with respect to thyroid profile changes and gender differences are rarely examined. ….. These findings suggest that even at low concentrations, these environmental contaminants can interfere with thyroid status and effects may differ by gender.

152. Dorea JG Early mercury exposure (with ethylmercury) could include 3-day olds: is that the case in China? Environ Res (2008 Mar) 106(3):420; discussion 421-2

153. Sakamoto M Kubota M Murata K Nakai K Sonoda I Satoh H Changes in mercury concentrations of segmental maternal hair during gestation and their correlations with other biomarkers of fetal exposure to methylmercury in the Japanese population. Environ Res (2008 Feb) 106(2):270-6

> Methylmercury (MeHg) is one of the most hazardous substances that affects the fetus through fish consumption. … The findings of this study indicate that maternal hair close to the scalp at parturition and neonatal hair are useful biomarkers of fetal exposure to MeHg at parturition. In addition, the segmental maternal hair throughout gestation is essential to obtain important information on MeHg exposure during the different sensitive windows or bolus MeHg exposure during gestation.

154. Tyler CV White-Scott S Ekvall SM Abulafia L Environmental health and developmental disabilities: a life span approach. Fam Community Health (2008 Oct-Dec) 31(4):287-304

> Prenatal and childhood environmental exposures are an underrecognized primary cause of intellectual and other developmental disabilities. In addition, individuals with established disabilities are vulnerable to further harm from subsequent environmental exposures. In individuals with communicative impairment or limited ability to independently escape from hazards, these subsequent exposures, too, may occur undetected or untreated. This article introduces the subject of environmental health and developmental disabilities throughout the life span. In particular, we focus on ways that families, communities, and health professionals can prevent both primary and secondary disabilities through better awareness of common environmental health issues.

155. Jackson LW Zullo MD Goldberg JM The association between heavy metals, endometriosis and uterine myomas among premenopausal women: National Health and Nutrition Examination Survey 1999-2002. Hum Reprod (2008 Mar) 23(3):679-87

> BACKGROUND: It has been hypothesized that exposure to exogenous estrogens may be associated with endometriosis and uterine myomas. We sought to investigate the association between heavy metals which have been shown to be hormonally active and these disorders using data from the National Health and Nutrition Examination Survey, 1999-2002. …RESULTS: A dose-response association between cadmium and endometriosis was observed …. This association persisted in subanalyses: (i) limiting analysis to women diagnosed in the past 10 years and (ii) limiting analysis to women diagnosed since last pregnancy, although limited by sample size. CONCLUSIONS: These results must be interpreted with caution given the cross-sectional study design. The observed association between cadmium and endometriosis deserves further investigation in properly designed studies.

156. Al-Saleh I Coskun S Mashhour A Shinwari N El-Doush I Billedo G Jaroudi K Al-Shahrani A Al-Kabra M El Din Mohamed G Exposure to heavy metals (lead, cadmium and mercury) and its effect on the outcome of in-vitro fertilization treatment. Int J Hyg Environ Health (2008 Oct) 211(5-6):560-79

> We investigated the effect of lead, cadmium and mercury exposure on pregnancy and fertilization rate outcome among 619 Saudi women (age 19-50 years) who sought in-vitro fertilization (IVF) treatment between 2002 and 2003… We found that among various demographic, socioeconomic and environmental factors, fish consumption was positively associated with blood lead levels. These results support the hypothesis that a raised blood lead level affects infertility and intervention to reduce the lead exposure might be needed for women of reproductive age. …It should be noted that skin-lightening creams and dental amalgam were

important contributors to mercury exposure. Such finding is alarming and priority for further studies are, urgently, needed.

157. Marques RC Bernardi JV Dorea JG Bastos WR Malm O Principal component analysis and discrimination of variables associated with pre- and post-natal exposure to mercury. Int J Hyg Environ Health (2008 Oct) 211(5-6):606-14

The variance of variables associated with neurodevelopment at 180 days, pre-natal variables (Hg in placenta, blood and hair) and post- natal Hg exposure (including Thimerosal-containing vaccines, TCV) were examined in 82 exclusively breastfed infants using principal component analysis (PCA). ….. However, infant neurodevelopmental (ND) disorders linked to Thimerosal-Hg stands in need of proof, but PCA points to the possibility of identifying exposure risk variables associated with ND schedules.

158. Monrroy SX Lopez RW Roulet M Benefice E Lifestyle and mercury contamination of Amerindian populations along the Beni river (lowland Bolivia). J Environ Health (2008 Nov) 71(4):44-50

The objective of this paper was to document mercury contamination of Amerindian populations living along the Beni River in Bolivia and to examine risk factors related to their lifestyle. A cross-sectional survey was performed among 15 communities on the flood plains of the Beni River at the foothills of the Andes. … Communities accessible only by canoe were more frequently contaminated than those accessible by road. Subjects who ate at least one serving of fish per day had higher H-Hg, and families who maintained substantial fishing activity were more strongly contaminated. Contamination levels were found to be low compared with other Amazonian studies. The most strongly affected groups, however, were those which preserved a traditional way of life and were the most economically and socially disadvantaged.

159. Palkovicova L Ursinyova M Masanova V Yu Z Hertz-Picciotto I Maternal amalgam dental fillings as the source of mercury exposure in developing fetus and newborn. J Expo Sci Environ Epidemiol (2008 May) 18(3):326-31

Dental amalgam is a mercury-based filling containing approximately 50% of metallic mercury (Hg(0)). Human placenta does not represent a real barrier to the transport of Hg(0); hence, fetal exposure occurs as a result of maternal exposure to Hg, with possible subsequent neurodevelopmental disabilities in infants. … Levels of Hg in the cord blood were significantly associated with the number of maternal amalgam fillings (rho=0.46, P<0.001) and with the number of years since the last filling (rho=-0.37, P<0.001); these associations remained significant after adjustment for maternal age and education. Dental amalgam fillings in girls and women of reproductive age should be used with caution, to avoid increased prenatal Hg exposure.

160. Ausili A Gabellini M Cammarata G Fattorini D Benedetti M Pisanelli B Gorbi S Regoli F Ecotoxicological and human health risk in a petrochemical district of southern Italy. Mar Environ Res (2008 Jul) 66(1):215-7

An ecotoxicological investigation has been carried in the petrochemical district of Priolo (Sicily, Italy), one of the largest in Europe. Results indicated a severe mercury contamination in sediments sampled near a chloro-alkali plant. A clear bioavailability of this element was demonstrated in mussels Mytilus galloprovincialis (both native and translocated) and the benthic fish Mullus barbatus, which also exhibited marked genotoxic damages. The elevated mercury concentrations in marine organisms are a serious concern for human health; according to the national average fish consumption, the provisional tolerable weekly intake (PTWI) of Hg would be

easily exceeded by at least 4 to 12 fold. Such toxicological risk is of particular importance for pregnant women, being possibly involved in the elevated frequency of neonatal malformations.

161. Ramon R Ballester F Aguinagalde X Amurrio A Vioque J Lacasana M Rebagliato M Murcia M Iniguez C Fish consumption during pregnancy, prenatal mercury exposure, and anthropometric measures at birth in a prospective mother-infant cohort study in Spain. Am J Clin Nutr (2009 Oct) 90(4):1047-55

BACKGROUND: Birth size has been shown to be related to maternal fish intake, although the results are inconsistent. …RESULTS: When multivariate models were adjusted, newborns in the higher quartile of total mercury weighed 143.7 g less (95% CI: -251.8, - 35.6; P for trend = 0.02) and had higher odds of being SGA for length (odds ratio: 5.3; 95% CI: 1.2, 23.9; P from likelihood ratio test = 0.03) without a linear relation (P for trend = 0.13) compared with those in the lowest quartile. Mothers consuming >/=2 portions/wk of canned tuna had newborns who weighed more than those who consumed <1 portion/mo (P for trend = 0.03) and a lower risk of having infants who were SGA for weight (P for trend = 0.01). Consumption of > or =2 portions/wk of large oily fish was associated with a higher risk of being SGA for weight and consumption of lean fish with a lower risk of being SGA for length compared with the consumption of <1 portion/mo, but in neither case was there a linear relation (P for trend >0.05). CONCLUSIONS: The role of fish in fetal growth depends on the amount and type of fish consumed. The findings for mercury warrant further investigation in other settings.

162. Geier DA Kern JK Geier MR A prospective study of prenatal mercury exposure from maternal dental amalgams and autism severity. Acta Neurobiol Exp (Wars) (2009) 69(2):189-97

Dental amalgams containing 50% mercury (Hg) have been used in dentistry for the last 150 years, and Hg exposure during key developmental periods was associated with autism spectrum disorders (ASDs). This study examined increased Hg exposure from maternal dental amalgams during pregnancy among 100 qualifying participants born between 1990-1999 and diagnosed with DSM-IV autism (severe) or ASD (mild). Logistic regression analysis (age, gender, race, and region of residency adjusted) by quintile of maternal dental amalgams during pregnancy revealed the ratio of autism:ASD (severe:mild) were about 1 (no effect) for < or =5 amalgams and increased for > or =6 amalgams. Subjects with > or =6 amalgams were 3.2-fold significantly more likely to be diagnosed with autism (severe) in comparison to ASD (mild) than subjects with < or =5 amalgams. Dental amalgam policies should consider Hg exposure in women before and during the child- bearing age and the possibility of subsequent fetal exposure and adverse outcomes.

163. Diez S Delgado S Aguilera I Astray J Perez-Gomez B Torrent M Sunyer J Bayona JM Prenatal and early childhood exposure to mercury and methylmercury in Spain, a high-fish-consumer country. Arch Environ Contam Toxicol (2009 Apr) 56(3):615-22

Exposure to mercury, a risk factor for neurodevelopmental toxicity, was assessed in Spanish children (preschool children and newborns, n = 218) in a four-locations survey by performing mercury determination in hair. … In children, the mean THg values among frequent fish consumers (more than four times per week) were almost threefold higher compared with non-consumers (1.40 vs. 0.49 microg/g). Newborns from mothers who had intake of fish two or more times per week exhibited nearly threefold higher hair levels than those who rarely or never consumed fish (2.26 vs. 0.78 microg/g). Finally, mercury levels in hair exceeded the EPA reference dose (RfD) of 0.1 microg Hg/kg body weight per day (equivalent to 1 microg Hg/g hair) in 42% of the population studied. Overall, we conclude that levels of mercury in Spain are among the highest in the non-exposed populations probably because of the relatively high fish consumption.

164. Drum DA Are toxic biometals destroying your children's future? Biometals (2009 Oct) 22(5):697-700

Cadmium, arsenic, lead, and mercury have been linked to autism, attention deficit disorder, mental retardation and death of children. Mercury in thimerosal found in many vaccines and flu shots contributes significantly to these problems. Decomposition of the thimerosal can produce more toxic compounds, either methylethylmercury or diethylmercury, in the body. These compounds have a toxicity level similar to dimethylmercury. Within the human body, a mitochondrial disorder may release the more toxic form of mercury internally. Young children and pregnant women must minimize internal exposure to the vaccines and flu shots containing mercury.

165. Marques RC Dorea JG Bernardi JV Bastos WR Malm O Prenatal and postnatal mercury exposure, breastfeeding and neurodevelopment during the first 5 years. Cogn Behav Neurol (2009 Jun) 22(2):134-41

166. Tan SW Meiller JC Mahaffey KR The endocrine effects of mercury in humans and wildlife. Crit Rev Toxicol (2009) 39(3):228-69

Mercury (Hg) is well studied and research continues as our knowledge of its health risks increases. One expanding area of research not well emphasized to date is the endocrine effects of Hg. This review summarizes the existing literature on the effects of Hg on the endocrine system and identifies gaps in the knowledge. It focuses on the thyroid, adrenal, and reproductive systems, including the accumulation of Hg in the endocrine system, sex differences that are manifested with Hg exposure, reproductive effects in male and female animals including humans, and Hg effects on the thyroid and adrenal systems. We concluded that there are five main endocrine-related mechanisms of Hg across these systems: (a) accumulation in the endocrine system; (b) specific cytotoxicity in endocrine tissues; (c) changes in hormone concentrations; (d) interactions with sex hormones; and (e) up-regulation or down-regulation of enzymes within the steroidogenesis pathway. Recommendations for key areas of research to better understand how the endocrine effects of Hg affect human and wildlife health were developed, and include increasing the amount of basic biological information available about Hg and wildlife species, exploring the role of Hg in the presence of other stressors and chemicals, understanding sublethal and indirect effects of Hg on adverse outcomes, developing better methods to extrapolate effects across species, and understanding the effects of Hg on multiple organ systems following exposure of an animal. Greater inclusion of endocrine endpoints in epidemiological and field studies on humans and wildlife will also advance the research in this area.

167. Kruzikova K Kensova R Blahova J Harustiakova D Svobodova Z Using human hair as an indicator for exposure to mercury. Neuro Endocrinol Lett (2009) 30 Suppl 1:177-81

OBJECTIVES: Exposure to mercury, a risk factor for neuro- developmental toxicity, was evaluated in the Czech Republic by performing mercury determination using human hair as an indicator. … CONCLUSION: The results show a positive correlation between the total mercury content in human hair and the consumption of marine and freshwater fish. Hair are a very good indicator of fish consumption.

168. Crinnion WJ Tran JQ Case report: heavy metal burden presenting as Bartter syndrome. Altern Med Rev (2010 Dec) 15(4):303-10

CONTEXT: Maternal transfer of heavy metals during fetal development or lactation possibly contributed to the clinical manifestations of Bartter syndrome and developmental delay in the offspring. CASE PRESENTATION: An 11-month-old child diagnosed with **Bartter syndrome** and failure to thrive was treated concurrently for elevated metal burden while he was undergoing standard medical interventions. Treatment with body-weight doses of meso-2,3-dimercaptosuccinic acid (DMSA) reduced the body burden of lead, beryllium, copper, mercury, and cadmium at the three- and sixth-month follow-up tests. During the course of the six-month treatment, the patient gained 2.4 kg (5.2 lb) and grew approximately 9.5 cm (3.75 in). His weight shifted from significantly below the 5th percentile in weight to within the 5th percentile, and from below the 5th to within the 10th percentile for length. DISCUSSION: The child's acquisition of lead, beryllium, and copper correspond to his mother's history of stained glass assembly and occurred during fetal development or lactation, since there were no other identifiable sources that could have contributed to the heavy metal burden. Tests for known genetic mutations leading to Bartter syndrome were all negative. RELEVANCE TO CLINICAL PRACTICE: This case report highlights the potential benefit of DMSA for treatment of heavy metal body burden in infants who present with Bartter syndrome.

169. Drouillet-Pinard P Huel G Slama R Forhan A Sahuquillo J Goua V ThiÃ©baugeorges O Foliguet B Magnin G Kaminski M Cordier S Charles MA Prenatal mercury contamination: relationship with maternal seafood consumption during pregnancy and fetal growth in the 'EDEN mother- child' cohort. Br J Nutr (2010 Oct) 104(8):1096-100

170. Sakamoto M Murata K Kubota M Nakai K Satoh H Mercury and heavy metal profiles of maternal and umbilical cord RBCs in Japanese population. Ecotoxicol Environ Saf (2010 Jan) 73(1):1-6

Mercury (Hg) and other heavy metal profiles, namely, lead (Pb), arsenic (As), cadmium (Cd), and selenium (Se) were investigated in maternal and umbilical cord (cord) red blood cells (RBCs) at parturition in Japanese population. Correlation coefficients of Hg, Pb, As, Cd, and Se between maternal and cord RBCs were 0.91, 0.79, 0.89, 0.31, and 0.76, respectively, and the respective means of cord/maternal RBCs ratios were 1.63, 0.52, 0.62, 0.12, and 1.18. These results indicate that fetal exposure to these metals (excluding Cd) strongly reflected each maternal exposure level. Among these metals, the placental transfer of methylmercury (MeHg) seemed to be extremely high but that of Cd to be limited. Hg showed positive correlations with Se in maternal RBCs but not in cord RBCs, and the Se/Hg molar ratio was lower in the latter, suggesting that the protective effects of Se against MeHg are less expected in fetuses than in mothers.

171. Whitfield JB Dy V McQuilty R Zhu G Heath AC Montgomery GW Martin NG Genetic effects on toxic and essential elements in humans: arsenic, cadmium, copper, lead, mercury, selenium, and zinc in erythrocytes. Environ Health Perspect (2010 Jun) 118(6):776-82

BACKGROUND AND OBJECTIVES: An excess of toxic trace elements or a deficiency of essential ones has been implicated in many common diseases or public health problems, but little is known about causes of variation between people living within similar environments. We estimated effects of personal and socioeconomic characteristics on concentrations of arsenic (As), cadmium (Cd), copper (Cu), mercury (Hg), lead (Pb), selenium (Se), and zinc (Zn) in erythrocytes and tested for genetic effects using data from twin pairs. METHODS: We used blood samples from 2,926

adult twins living in Australia (1,925 women and 1,001 men; 30-92 years of age) and determined element concentrations in erythrocytes by inductively coupled plasma-mass spectrometry. We assessed associations between element concentrations and personal and socioeconomic characteristics, as well as the sources of genetic and environmental variation and covariation in element concentrations. We evaluated the chromosomal locations of genes affecting these characteristics by linkage analysis in 501 dizygotic twin pairs. RESULTS: Concentrations of Cu, Se, and Zn, and of As and Hg showed substantial correlations, concentrations of As and Hg due mainly to common genetic effects. Genetic linkage analysis showed significant linkage for Pb [chromosome 3, near SLC4A7 (solute carrier family 4, sodium bicarbonate cotransporter, member 7)] and suggestive linkage for Cd (chromosomes 2, 18, 20, and X), Hg (chromosome 5), Se (chromosomes 4 and 8), and Zn {chromosome 2, near SLC11A1 [solute carrier family 11 (proton-coupled divalent metal ion transporters)]}. CONCLUSIONS: Although environmental exposure is a precondition for accumulation of toxic elements, individual characteristics and genetic factors are also important. Identification of the contributory genetic polymorphisms will improve our understanding of trace and toxic element uptake and distribution mechanisms.

172. Lee BE Hong YC Park H Ha M Koo BS Chang N Roh YM Kim BN Kim YJ Kim BM Jo SJ Ha EH Interaction between GSTM1/GSTT1 polymorphism and blood mercury on birth weight. Environ Health Perspect (2010 Mar) 118(3):437-43

BACKGROUND: Mercury (Hg) is toxic to both the reproductive and nervous systems. In addition, glutathione S-transferases (GSTs), which conjugate glutathione to a variety of electrophilic compounds, are involved in the detoxification of Hg.OBJECTIVE: In this study we examined the association between prenatal exposure to Hg and birth weight as well as the influence of GST polymorphisms…..RESULTS: The geometric mean levels of Hg in the maternal blood during late pregnancy and in cord blood were 3.30 microg/L and 5.53 microg/L, respectively. For mothers with the GSTT1 null genotype, elevated Hg levels in maternal blood during late pregnancy were associated with an increased risk of lower birth weight. For mothers with both GSTM1 and GSTT1 null genotype, both maternal and cord blood Hg levels were associated with lower birth weight. CONCLUSIONS: This study suggests that the interactions of Hg with GSTM1 and GSTT1 polymorphisms play a role in reducing birth weight.

173. Lope V Pollan M Fernandez M de Leon A Gonzalez MJ Sanz JC Iriso A Perez-Gomez B Gil E Perez-Meixeira AM de Paz C Cisneros M de Santos A Asensio A Astray J Martinez M Garcia JF Lopez-Abente G Garcia-Sagredo JM Aragones N Cytogenetic status in newborns and their parents in Madrid: the BioMadrid study. Environ Mol Mutagen (2010 May) 51(4):267-77

Monitoring cytogenetic damage is frequently used to assess population exposure to environmental mutagens. … Our results show a statistically significant correlation in MNBC frequency between fathers and mothers, and between parents and newborns. Elevated blood mercury levels in fathers were associated with significantly higher MNBC frequency, compared with fathers who had normal mercury levels (RR:1.21; 95%CI:1.02-1.43). This last result suggests the need to implement greater control over populations which, by reason of their occupation or life style, are among those most exposed to this metal.

174. Chien LC Gao CS Lin HH Hair mercury concentration and fish consumption: risk and perceptions of risk among women of childbearing age. Environ Res (2010 Jan) 110(1):123-9

The purposes of this study were to assess the hair mercury concentration of women of childbearing age in Taiwan, and to calculate a hazard quotient (HQ) to evaluate the risk of fish consumption for these women. … The high hair mercury concentrations among women of

childbearing age in Taiwan are a cause for concern, due to the effect on babies' brain development. The government should provide specific information about risks and benefits of fish consumption for women to make risk-balancing decisions.

175. Benefice E Luna-Monrroy S Lopez-Rodriguez R Fishing activity, health characteristics and mercury exposure of Amerindian women living alongside the Beni River (Amazonian Bolivia). Int J Hyg Environ Health (2010 Nov) 213(6):458-64

Populations in Bolivian Amazonia are exposed to mercury contamination through fish ingestion. A group of 170 Amerindian women living along the banks of the Beni River were examined in order to detect any adverse effects on their health consistent with the toxic effects of mercury. The mercury content of the women's hair (H-Hg) was used as the bio-indicator of mercury exposure. … Significant relationships were found between fishing practices, the frequency of fish consumption and H-Hg levels with mercury contaminated women (H-Hg>5Î¼g/g) being more likely to present neurological abnormalities (paresthesia, static and dynamic imbalance, poor motor coordination) than non-contaminated women. No relationship was found between blood pressure and mercury levels. Women with higher H-Hg reported more infant deaths than did women with lower levels. A logistic regression analysis which included socio-cultural traits, fish consumption habits and health characteristics was performed in order to determine the risks of contamination. Contaminated women were more likely to belong to those communities pursuing traditional fishing activities; moreover these women tended to be younger and frailer than other. They also exhibited mild neurological abnormalities and reported more infant deaths. These findings should stimulate local communities to take preventive actions directed towards the more "traditional" and vulnerable groups of population.

176. Liu Y McDermott S Lawson A Aelion CM The relationship between mental retardation and developmental delays in children and the levels of arsenic, mercury and lead in soil samples taken near their mother's residence during pregnancy. Int J Hyg Environ Health (2010 Mar) 213(2):116-23

This study was designed to evaluate the association between lead, mercury, and arsenic in the soil near maternal residences during pregnancy and mental retardation or developmental disability (MR/DD) in children. The study was conducted using 6,048 mothers who did not move throughout their pregnancies and lived within six strips of land in South Carolina and were insured by Medicaid between January 1, 1997 and December 31, 2002. The mother child pairs were then followed until June 1, 2008, through their Medicaid reimbursement files, to identify children diagnosed with MR/DD. The soil was sampled for mercury (Hg), lead (Pb), and As based on a uniform grid, and the soil concentrations were Kriged to estimate chemical concentration at individual locations. We identified a significant relationship between MR/DD and As, and the form of the relationship was nonlinear, after controlling for other known risk factors.

177. Gerhardsson L Lundh T Metal concentrations in blood and hair in pregnant females in southern Sweden. J Environ Health (2010 Jan-Feb) 72(6):37-41

The study described here was comprised of 100 pregnant females from two prenatal care units at the cities of Hassleholm and Simrishamn in southern Sweden. It included a questionnaire as well as whole blood (total mercury, cadmium, and lead) and hair (total mercury) sampling (collection period 2002-2003). The median values of total mercury (B- Hg 0.70 microg/L; range 0.27-2.1 microg/L), cadmium (0.30 microg/L, 0.05-4.8 microg/L) and lead (11.0 microg/L, 4.2-79 microg/L) in whole blood were low in the total material, as were the hair mercury concentrations (Hair-Hg 0.22 microg/g, 0.04-0.83 microg/g). In a multiple linear regression model, B-Hg was related to the number of fish meals per week and to the number of occlusal amalgam fillings (multiple r = 0.51;

p < .001). The levels of mercury, cadmium, and lead in whole blood were lower than suggested biological reference intervals, and did not indicate risks for adverse health effects.

178. Schoeman K Tanaka T Bend JR Koren G Hair mercury levels of women of reproductive age in Ontario, Canada: implications to fetal safety and fish consumption. J Pediatr (2010 Jul) 157(1):127-31

OBJECTIVE: To study hair mercury concentrations among women of reproductive age in relation to fish intake in Ontario, Canada. …. RESULTS: There were significant correlations between fish servings and hair mercury (Spearman r=0.73, P<.0001) and between amounts of consumed mercury and hair mercury concentrations (Spearman r=0.81, P<.0001). Nearly two thirds of the Motherisk callers, all of the Japanese women, and 15% of the Canadian women of reproductive age had hair mercury above 0.3 microg/g, which was shown recently to be the lowest observable adverse effect level in a large systematic review of all perinatal studies. CONCLUSIONS: Because of very wide variability, general recommendations for a safe number of fish servings may not be sufficient to protect the fetus. Analysis of hair mercury may be warranted before pregnancy in selected groups of women consuming more than 12 ounces of fish per week, as dietary modification can decrease body burden and ensure fetal safety.

179. Jones L Parker JD Mendola P Blood lead and mercury levels in pregnant women in the United States, 2003-2008. NCHS Data Brief (2010 Dec)(52):1-8

Chemical exposure during pregnancy is potentially harmful to the developing fetus, as the placenta cannot protect against heavy metals such as lead and mercury. Cord blood mercury levels have been associated with childhood cognitive function. High levels of lead exposure during pregnancy have been associated with adverse birth outcomes and, in some studies, with lower cognitive function test scores in childhood; relatively low lead levels have recently been associated with a small risk of decreased birthweight. While intervention for pregnant women with blood lead levels greater than or equal to 5 Î¼g/dL has been recommended, no comparable recommendation for blood mercury in pregnant women has been established.This report presents geometric mean lead and mercury blood levels of pregnant women in the United States based on using the 2003-2008 National Health and Nutrition Examination Surveys (NHANES). Throughout this report, the term mean refers to the geometric mean.

180. Abdelouahab N Huel G Suvorov A Foliguet B Goua V Debotte G Sahuquillo J Charles MA Takser L Monoamine oxidase activity in placenta in relation to manganese, cadmium, lead, and mercury at delivery. Neurotoxicol Teratol (2010 Mar-Apr) 32(2):256-61

BACKGROUND: Environmental prenatal exposure to potentially neurotoxic metals poses a particular challenge with regard to the study of early toxic effects. Monoamine oxidase activity, shown to be influenced by metals in experimental studies, could be a useful biomarker in humans. OBJECTIVE: To examine the relationship between blood metal concentrations at delivery and placenta MAO activity. METHODS: The study was performed in 163 pregnancies. Maternal and cord blood samples were obtained for manganese (Mn), lead (Pb), and cadmium (Cd) determination. Mercury (Hg) was also analysed in maternal hair. Placental samples were stored immediately after expulsion and total MAO activity was measured. RESULTS: MAO activity was significantly positively correlated with maternal and cord blood Mn concentrations in subjects with high MAO activity. In subjects with low MAO activity, maternal hair Hg was negatively correlated with MAO. CONCLUSION: Our results suggest the use of placental MAO as a potential surrogate marker of Mn toxicity in the newborn and its correlation with psychomotor development should be further investigated.

181. Thomas Curtis J Chen Y Buck DJ Davis RL Chronic inorganic mercury exposure induces sex-specific changes in central TNFÎ± expression: importance in autism? Neurosci Lett (2011 Oct 17) 504(1):40-4

> Mercury is neurotoxic and increasing evidence suggests that environmental exposure to mercury may contribute to neuropathologies including Alzheimer's disease and autism spectrum disorders. Mercury is known to disrupt immunocompetence in the periphery, however, little is known about the effects of mercury on neuroimmune signaling. Mercury-induced effects on central immune function are potentially very important given that mercury exposure and neuroinflammation both are implicated in certain neuropathologies (i.e., autism). Furthermore, mounting evidence points to the involvement of glial activation in autism. Therefore, we utilized an in vivo model to assess the effects of mercury exposure on neuroimmune signaling. In prairie voles, 10 week mercury exposure (60ppm HgCl(2) in drinking water) resulted in a male-specific increase in TNFÎ± protein expression in the cerebellum and hippocampus. These findings are consistent with our previously reported male-specific mercury-induced deficits in social behavior and further support a role for heavy metals exposure in neuropathologies such as autism. Subsequent studies should further evaluate the mechanism of action and biological consequences of heavy metals exposure. Additionally, these observations highlight the potential of neuroimmune markers in male voles as biomarkers of environmental mercury toxicity.

182. Sanz JC Astray J Cisneros M de Santos A Asensio A GarcÃa-Sagredo JM GarcÃa JF Vioque J PollÃ¡n M LÃ³pez-Abente G GonzÃ¡lez MJ MartÃnez M Bohigas PA Pastor R AragonÃ©s N Mercury, lead and cadmium in human milk in relation to diet, lifestyle habits and sociodemographic variables in Madrid (Spain). Chemosphere (2011 Sep) 85(2):268-76

183. Pollack AZ Schisterman EF Goldman LR Mumford SL Albert PS Jones RL Wactawski-Wende J Cadmium, lead, and mercury in relation to reproductive hormones and anovulation in premenopausal women. Environ Health Perspect (2011 Aug) 119(8):1156-61

> …CONCLUSIONS: Our findings support the hypothesis that environmentally relevant levels of metals are associated with modest changes in reproductive hormone levels in healthy, premenopausal women.

184. Ramon R Murcia M Aguinagalde X Amurrio A Llop S Ibarluzea J Lertxundi A Alvarez-Pedrerol M Casas M Vioque J Sunyer J Tardon A Martinez-Arguelles B Ballester F Prenatal mercury exposure in a multicenter cohort study in Spain. Environ Int (2011 Apr) 37(3):597-604

> …CONCLUSION: A high proportion of newborns had elevated concentrations of cord blood T-Hg according to the current US-EPA reference dose (5.8Î¼g/L for methylmercury). Mercury concentrations were related to maternal fish consumption, with large oily fish being the main contributor.

185. MiklavÄ iÄ A Cuderman P Mazej D Snoj Tratnik J Krsnik M PlaninÅ¡ek P Osredkar J Horvat M Biomarkers of low-level mercury exposure through fish consumption in pregnant and lactating Slovenian women. Environ Res (2011 Nov) 111(8):1201-7

> In order to assess the mercury exposure of pregnant and lactating women in Slovenia, levels of total mercury (THg) and methylmercury (MeHg) were determined in hair, cord blood and breast milk. In addition, the frequency of fish consumption was estimated, because fish is generally the main pathway for human exposure to MeHg… In conclusion, THg levels in cord blood, THg levels in hair and MeHg levels in cord blood are suitable biomarkers of low- level Hg exposure through fish consumption. Compared to cord blood, hair samples are easy to collect, store and analyse.

186. Wells EM Jarrett JM Lin YH Caldwell KL Hibbeln JR Apelberg BJ Herbstman J Halden RU Witter FR Goldman LR Body burdens of mercury, lead, selenium and copper among Baltimore newborns. Environ Res (2011 Apr) 111(3):411-7

Umbilical cord blood or serum concentrations of mercury, lead, selenium and copper were measured with inductively coupled plasma mass spectrometry in a population of 300 infants born in Baltimore, Maryland. Geometric mean values were 1.37 Î¼g/L (95% confidence interval: 1.27, 1.48) for mercury; 0.66 Î¼g/dL (95% CI: 0.61, 0.71) for lead; and 38.62 Î¼g/dL (95% CI: 36.73, 40.61) for copper. Mean selenium was 70.10 Î¼g/L (95% CI: 68.69, 70.52). Mercury, selenium and copper levels were within exposure ranges reported among similar populations, whereas the distribution of lead levels was lower than prior reports; only one infant had a cord blood lead above 10 Î¼g/dL. Levels of selenium were significantly correlated with concentrations of lead (Spearman's Ï =0.20) and copper (Spearman's Ï =0.51). Multivariable analyses identified a number of factors associated with one of more of these exposures. These included: increase in maternal age (increased lead); Asian mothers (increased mercury and lead, decreased selenium and copper); higher umbilical cord serum n-3 fatty acids (increased mercury, selenium and copper), mothers using Medicaid (increased lead); increasing gestational age (increased copper); increasing birthweight (increased selenium); older neighborhood housing stock (increased lead and selenium); and maternal smoking (increased lead). This work provides additional information about contemporary prenatal element exposures and can help identify groups at risk of atypical exposures.

187. Wang S Li B Zhang M Xing D Jia Y Wei C Bioaccumulation and trophic transfer of mercury in a food web from a large, shallow, hypereutrophic lake (Lake Taihu) in China. Environ Sci Pollut Res Int (2011 Aug) 19(7):2820-31

PURPOSE: Due to the fast development of industry and the overuse of agrichemicals in past decades, Lake Taihu, an important source of aquatic products for Eastern China, has simultaneously suffered mercury (Hg) contamination and eutrophication. The objectives of this study are to understand Hg transfer in the food web in this eutrophic, shallow lake and to evaluate the exposure risk of Hg through fish consumption…. Health risk of exposure to Hg by consumption of fish for local residents is relatively low in the Lake Taihu area. Dilution of Hg levels in the phytoplankton induced by eutrophication is a possible factor inhibiting accumulation of MeHg in fish in eutrophic Lake Taihu.

188. Valent F Pisa F Mariuz M Horvat M Gibicar D Fajon V Mazej D Daris F Barbone F [Fetal and perinatal exposure to mercury and selenium: baseline evaluation of a cohort of children in Friuli Venezia Giulia, Italy]. Epidemiol Prev (2011 Jan-Feb) 35(1):33-42

OBJECTIVE: neurotoxicity of prenatal exposure to high concentrations of mercury (Hg) is well known; however, the doseresponse relationship at low exposure levels has not been quantified yet. This article illustrates the measurement of prenatal exposure to Hg and the pathway of exposure through the diet in Friuli Venezia Giulia, Italy…..RESULTS: in general, Hg levels in hair and milk were positively associated with the consumption of fish from the lagoon of Grado and Marano. However, they were low in comparison with those of other fish-eating populations and below theWHO alert limits, likely because of the small consumption of fish among pregnant women, estimated from the FFQ. The concentration of Se in milk was also smaller than that reported in other international studies.CONCLUSION: in Friuli Venezia Giulia, fetal and perinatal Hg exposure is low. The children of the cohort will be followed- up at school age to measure possible neurodevelopmental effects of such low exposures to Hg.

189.Jackson LW Howards PP Wactawski-Wende J Schisterman EF The association between cadmium, lead and mercury blood levels and reproductive hormones among healthy, premenopausal women. Hum Reprod (2011 Oct) 26(10):2887-95

BACKGROUND: Cadmium, lead and mercury have been identified in human follicular fluid and ovarian tissue, and have been associated with adverse reproductive outcomes in epidemiologic studies; however, few studies have examined the relationship between blood metal levels and reproductive hormones….RESULTS: Median (interquartile range) cadmium, lead and mercury levels were 0.30 Âµg/l (0.19, 0.43), 0.87 Âµg/dl (0.68, 1.20) and 1.10 Âµg/l (0.58, 2.10), respectively. Each 1 Âµg/l increase in cadmium levels was associated with a 21% [95% confidence interval (CI): -2.9, 49.9] increase in early follicular phase E(2) levels after adjusting for age, race/ethnicity, lead and mercury. This association decreased when restricted to never smokers (10%; 95% CI: -19.5, 51.3). Cadmium was also associated with a non-significant 9% (95% CI: -0.2, 19.9), or 2.7 day, increase in cycle length among never smokers. No associations were observed between lead or mercury and the outcomes in adjusted analyses.CONCLUSIONS: Further evaluation of the association between cadmium, E(2) and cycle length is warranted, taking into consideration cigarette smoke and its multiple components.

190.Al-Saleh I Shinwari N Mashhour A Mohamed Gel D Rabah A Heavy metals (lead, cadmium and mercury) in maternal, cord blood and placenta of healthy women. Int J Hyg Environ Health (2011 Mar) 214(2):79-101

Lead, cadmium and mercury were measured in placental tissue, umbilical cord and maternal blood samples of 1578 women who delivered at the Al-Kharj King Khalid Hospital between 2005 and 2006. The aim of this study was to evaluate the status of heavy metal exposure in mothers and their newborns and to identify predictors of maternal exposure. Lead was detected in all cord and maternal blood and in 96% of placental tissues. Only in 0.89% and 0.83% of cord and maternal blood samples were the levels of lead above the CDC threshold limit of 10 Î¼g/dl. Maternal blood lead was also higher (2.3%) than the German Reference value in women of 7 Î¼g/dl. Approximately 9.3% of women had a placental lead above the 95th percentile in the range of 0.83-78 Î¼g/g dry wt., a level of possible developmental toxicity. Cadmium was detected in 94.8% and 97.9% of cord and maternal blood samples respectively, though only five newborns had a cadmium level above the OSHA threshold limit of 5 Î¼g/l. Comparing our results to the newly revised German Reference value for nonsmokers, 48.6% of mothers had blood cadmium levels >1.0 Î¼g/l. We found as well that 25% of women had placental cadmium in the >75th percentile, in the range of 0.048-4.36 Î¼g/g dry wt., which is likely to affect fetal growth and development. Of the maternal and cord blood samples, 11.2% and 13%, respectively, had mercury levels >5.8 Î¼g/l, which is the EPA reference dose. Nearly 49% of women had mercury levels >2.0 Î¼g/l, the German Reference value for those who consume fish 3 times a month. Around 50% of the mothers had placental mercury in the range of 0.031-13.0 Î¼g/g dry wt. Regression analyses indicated that the levels of metals in the blood and placenta were influenced by several factors.

191.Hansen S Nieboer E Sandanger TM Wilsgaard T Thomassen Y Veyhe AS Odland JÃ˜ Changes in maternal blood concentrations of selected essential and toxic elements during and after pregnancy. J Environ Monit (2011 Aug) 13(8):2143-52

The objective of this study was to investigate changes in the levels of toxic and essential elements in maternal blood during pregnancy and subsequently. … In a multivariable analysis of the P1 data, fish consumption was a robust positive predictor for Hg ($p < 0.02$), As ($p < 0.01$) and Se (p â‰¤ 0.001) blood concentrations, multivitamin intake for Se ($p < 0.001$), and parity for Co ($p <$

0.002); age reached significance only for Hg ($p < 0.001$). An inverse association was observed between parity and Hg ($p < 0.05$). For the other elements, predictor patterns were not evident.

192. Mieiro CL Pacheco M Duarte AC Pereira ME Fish consumption and risk of contamination by mercury---considerations on the definition of edible parts based on the case study of European sea bass. Mar Pollut Bull (2011 Dec) 62(12):2850-3

In the present study, the risk to humans by consuming European sea bass (Dicentrarchus labrax), captured at three sites along a Hg contamination gradient, was evaluated by comparing muscle and kidney total Hg (T-Hg) levels with the European regulations for marketed fish. Moreover, T-Hg and organic Hg (O-Hg) levels in muscle were compared with the Provisional Tolerable Weekly Intake (PTWI) and the Reference Dose (RfD). Although T-Hg levels in muscle were below the European value allowable for marketed fish, kidney's levels were higher than the set value, stressing the importance of redefining the concept of edible tissue and which tissues should be considered. Mercury weekly ingestion in the contaminated areas was higher than the PTWI, and O-Hg daily ingestion rates were higher than the RfD in all sampling sites. Thus, populations consuming sea bass from the contaminated sites may be at risk, with particular relevance for children and pregnant women.

193. Cace IB Milardovic A Prpic I Krajina R Petrovic O Vukelic P Spiric Z Horvat M Mazej D Snoj J Relationship between the prenatal exposure to low-level of mercury and the size of a newborn's cerebellum. Med Hypotheses (2011 Apr) 76(4):514-6

Exposure to methylmercury at any stage of central nervous system development could induce alterations and result in severe congenital abnormalities. Total mercury level in maternal hair during pregnancy correlates well with blood levels of methylmercury and with total mercury levels in fetal brain. … Two dimensions of cerebellum in the sagital-medial plane have been measured: maximum height and width starting from the roof of the fourth chamber. Majority of mothers had hair mercury levels lower than 1 Î¼g/g (N = 107). Mean value was 0.88 Î¼g/g (SD 1.24), ranging from 0.02 to 8.71 Î¼g/g. There was no significant difference between the two groups when it comes to the width of cerebellum (Mann-Whitney test: Z = 1471; p = 0.141). However, comparison related to the length of cerebellum shows statistically significant smaller cerebellum in newborns whose mother had hair mercury levels higher than 1 Î¼g/g (Mann-Whitney test: Z = 2329; p = 0.019). Our results lead to a conclusion that prenatal exposure to, what we consider to be, **low-levels of methylmercury does influence fetal brain development detected as decreased size of newborn's cerebellum**. …

194. Sanders AP Flood K Chiang S Herring AH Wolf L Fry RC Towards prenatal biomonitoring in North Carolina: assessing arsenic, cadmium, mercury, and lead levels in pregnant women. PLoS One (2012) 7(3):e31354

Exposure to toxic metals during the prenatal period carries the potential for adverse developmental effects to the fetus, yet such exposure remains largely unmonitored in the United States. The aim of this study was to assess maternal exposure to four toxic metals (arsenic (As), cadmium (Cd), mercury (Hg), and lead (Pb)) in a cohort of pregnant women in North Carolina. …A large fraction of the blood samples showed detectable levels for each of the four metals. Specifically, As (65.7%), Cd (57.3%), Hg (63.8%), and Pb (100%) were detected in blood samples. Moreover, compared with adult females participating in the Fourth National Report on Human Exposure to Environmental Chemicals and guidelines for pregnant women, some women in the sample population exceeded benchmark levels of Cd, Hg, and Pb. Evidence from this pilot study indicates that pregnant women in North Carolina are exposed to As, Cd, Hg, and Pb and suggests

that factors related to maternal county of residence and race may impact maternal exposure levels. As increased levels of one or more of these metals in utero have been associated with detrimental developmental and reproductive outcomes, further study is clearly warranted to establish the impacts to newborns.

195. Cho GJ Park HT Shin JH Hur JY Kim SH Lee KW Kim T The relationship between blood mercury level and osteoporosis in postmenopausal women. Menopause (2012 May) 19(5):576-81

OBJECTIVE: Postmenopausal women have a higher prevalence of osteoporosis compared with premenopausal women. Postmenopause status has been found to be an independent risk factor for osteoporosis. Several studies have reported that heavy metals, including lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As), have detrimental effects on bone. The aim of this study was to evaluate the association among heavy metals, including Pb, Hg, Cd, and As, bone mineral density, and osteoporosis in postmenopausal Korean women.METHODS: We conducted a cross-sectional study of 481 postmenopausal women, all of whom were enrolled in the Korean National Health and Nutrition Examination Survey in 2008. Bone mineral density was measured using dual-energy x-ray absorptiometry. Blood Pb, Hg, and Cd and urinary As levels were measured.RESULTS: Postmenopausal women with higher blood Hg levels were more likely to be younger and have higher vitamin D levels, fish consumption, and prevalence of osteoporosis. On multivariate logistic regression analysis, postmenopausal women with blood Hg levels in the fourth quartile had a 0.36-fold decreased risk of having osteoporosis compared with those with levels in the first quartile, after adjustments for age, body mass index, alcohol intake, smoking history, exercise, use of oral contraceptive pills, hormone therapy, intake of caloric energy and calcium, fish consumption, and vitamin D level. However, there was no association between other heavy metals and osteoporosis.CONCLUSIONS: High blood Hg levels were associated with a lower risk of having osteoporosis in postmenopausal women. Because biomarkers of all four metals measured in this study reflect recent exposures, further studies are necessary to clarify the association of osteoporosis with the level of heavy metals in biomarkers for long-term exposure such as hair or fingernail.

196. Llop S Guxens M Murcia M Lertxundi A Ramon R RiaÃ±o I Rebagliato M Ibarluzea J Tardon A Sunyer J Ballester F Prenatal exposure to mercury and infant neurodevelopment in a multicenter cohort in Spain: study of potential modifiers. Am J Epidemiol (2012 Mar 1) 175(5):451-65

Vulnerability of the central nervous system to mercury is increased during early development. This study aimed to evaluate whether cord blood total mercury levels may have a negative effect on both mental and psychomotor development in a maternal-birth cohort from moderate- high fish consumption areas. Study subjects were 1,683 child participants in the INMA (Environment and Childhood) Project from 4 areas of Spain between 2003 and 2010. Cord blood total mercury levels were analyzed by atomic absorption spectrometry. Infant neurodevelopment was assessed around age 14 months by the Bayley Scales of Infant Development. Sociodemographic, lifestyle, and dietary information was obtained by questionnaire during pregnancy. The geometric mean of total mercury levels was 8.4 Î¼g/L (95% confidence interval (CI): 8.1, 8.7). In multivariate analysis, a doubling in total mercury levels did not show an association with mental (Î² = 0.1, 95% CI: -0.68, 0.88) or psychomotor (Î² = -0.05, 95% CI: -0.79, 0.68) developmental delay; **however, stratified findings by sex suggest a negative association between prenatal exposure to total mercury and psychomotor development among female infants** (Î² = -1.09, 95% CI: -2.21, 0.03), although follow-up is required to confirm these results.

197.Sagiv SK Thurston SW Bellinger DC Amarasiriwardena C Korrick SA Prenatal exposure to mercury and fish consumption during pregnancy and attention-deficit/hyperactivity disorder-related behavior in children. Arch Pediatr Adolesc Med (2012 Dec) 166(12):1123-31

OBJECTIVE: To investigate the association of prenatal mercury exposure and fish intake with attention-deficit/hyperactivity disorder (ADHD)-related behavior. METHODS: For a population-based prospective birth cohort recruited in New Bedford, Massachusetts (1993-1998), we analyzed data for children examined at age 8 years with peripartum maternal hair mercury measures (n = 421) or maternal report of fish consumption during pregnancy (n = 515). Inattentive and impulsive/hyperactive behaviors were assessed using a teacher rating scale and neuropsychological testing. RESULTS: The median maternal hair mercury level was 0.45 Î¼g/g (range, 0.03-5.14 Î¼g/g), and 52% of mothers consumed more than 2 fish servings weekly. In multivariable regression models, mercury exposure was associated with inattention and impulsivity/hyperactivity; some outcomes had an apparent threshold with associations at 1 Î¼g/g or greater of mercury. For example, at 1 Î¼g/g or greater, the adjusted risk ratios for mild/markedly atypical inattentive and impulsive/hyperactive behaviors were 1.4 (95% CI, 1.0-1.8) and 1.7 (95% CI, 1.2-2.4), respectively, for an interquartile range (0.5 Î¼g/g) mercury increase; there was no confounding by fish consumption. For neuropsychological assessments, mercury and behavior associations were detected primarily for boys. There was a protective association for fish consumption (>2 servings per week) with ADHD-related behaviors, particularly impulsive/hyperactive behaviors (relative risk = 0.4; 95% CI, 0.2-0.6). CONCLUSIONS: Low-level prenatal mercury exposure is **associated with a greater risk of ADHD-related behaviors,** and fish consumption during pregnancy is protective of these behaviors. These findings underscore the difficulties of balancing the benefits of fish intake with the detriments of low-level mercury exposure in developing dietary recommendations in pregnancy.

198.Moreno MA Advice for patients. Exposure to mercury and consumption of fish during pregnancy: a confusing picture. Arch Pediatr Adolesc Med (2012 Dec) 166(12):1188

199.Barghi M Behrooz RD Esmaili-Sari A Ghasempouri SM Mercury exposure assessment in Iranian pregnant women's hair with respect to diet, amalgam filling, and lactation. Biol Trace Elem Res (2012 Sep) 148(3):292-301

Our aim for carrying out this study was to estimate the levels of mercury in the hair of pregnant women and its association with fish consumption and amalgam fillings. From November 2007 to January 2008, 100 hair samples were collected randomly from three groups of pregnant women: Ahvaz in the south of Iran, Noushahr in the north, and the countryside of Noushahr. Significant differences were found in these three groups of pregnant women's samples (p>0.05). The mean mercury level in women's hair was found to be 0.37 Î¼g/g (range, 0.11- 3.57 Î¼g/g). Only in 2 % of collected hair samples did the total mercury (THg) level exceed the United States Environmental Protection Agency-recommended 1.0 Î¼g/g. In addition, there was a positive correlation of THg content in Ahvaz group's samples with respect to fish consumption (r=0.41, p=0.02) and a negative correlation of THg content in those who consumed vegetables and fruit. The level of education also played an indicating factor in this group. Moreover, significant association was found between the residence time and Hg concentration of women's hair samples collected from Noushahr (p>0.05). Similarly, the same correlations were found between hair mercury levels and the time since the first filling, number of dental fillings, pregnancy interval, and lactating period.

200. Buck Louis GM Sundaram R Schisterman EF Sweeney AM Lynch CD Gore-Langton RE Chen Z Kim S Caldwell KL Barr DB Heavy metals and couple fecundity, the LIFE Study. Chemosphere (2012 Jun) 87(11):1201-7

The effect of heavy metals at environmentally relevant concentrations on couple fecundity has received limited study despite ubiquitous exposure. In 2005-2009, couples (n=501) desiring pregnancy and discontinuing contraception were recruited and asked to complete interviews and to provide blood specimens for the quantification of cadmium (Î¼g L(-1)), lead (Î¼g dL(-1)) and mercury (Î¼g L(-1)) using inductively coupled plasma-mass spectrometry. Couples completed daily journals on lifestyle and intercourse along with menstruation and pregnancy testing for women. Couples were followed for 12 months or until pregnant. Fecundability odds ratios (FORs) and 95% confidence intervals (CIs) were estimated adjusting for age, body mass index, cotinine, and serum lipids in relation to female then male exposures. FORs <1 denote a longer time to pregnancy. In adjusted models, reduced FORs were observed for both female cadmium (0.78; 95% CI 0.63- 0.97) and male lead (0.85; 95% CI 0.73-0.98) concentrations. When jointly modeling couples' exposures, only male lead concentration significantly reduced the FOR (0.82; 95% CI 0.68, 0.97), though the FOR remained <1 for female cadmium (0.80; 95% CI 0.64, 1.00). This prospective couple based cohort with longitudinal capture of time to pregnancy is suggestive of cadmium and lead's reproductive toxicity at environmentally relevant concentrations.

201. Sakamoto M Chan HM Domingo JL Kubota M Murata K Changes in body burden of mercury, lead, arsenic, cadmium and selenium in infants during early lactation in comparison with placental transfer. Ecotoxicol Environ Saf (2012 Oct) 84:179-84

The developing brains of both fetuses and infants are susceptible to environmental contaminants. However, the contribution of breast- feeding to the element body burden in infants remains unclear. The main objective of this study was to investigate the changes in body burden of elements such as methylmercury, lead, arsenic, cadmium, and selenium in infants during a 3-month breast-feeding period compared with placental transfer of the elements. Element concentrations were measured in maternal and umbilical cord (fetus) red blood cells (RBCs) at parturition and in infant RBCs at 3 months. Most of the mercury in RBCs is in the methyl form, and the total mercury concentration in RBCs reflects methylmercury exposure. The mercury level in cord RBCs was approximately 1.5 times higher than that in mothers, while in infants, it declined by approximately 60% after 3- months' breast-feeding. The cord selenium level was similar to the maternal level, but declined approximately 75% after 3-months' breast-feeding in infants. Lead and arsenic concentrations in cord RBCs were about 60% of the maternal levels, and remained constant until the 3- month study period. The cadmium level in cord RBCs was about 20% of that in maternal RBCs, and remained almost constant until the end of the 3-month study period. In conclusion, although pregnant women should pay attention to avoid high methylmercury exposure, element exposure through breast-feeding does not pose any great concern in this population.

202. Kern JK, Geier DA, Audhya T, King PG, Sykes LK, Geier MR. **Evidence of parallels between mercury intoxication and the brain pathology in autism.** Acta Neurobiol Exp (Wars). 2012;72(2):113-53.

Abstract; The purpose of this review is to examine the parallels between the effects mercury intoxication on the brain and the brain pathology found in autism spectrum disorder (ASD). This review finds evidence of many parallels between the two, including: (1) microtubule degeneration, specifically large, long-range axon degeneration with subsequent abortive axonal sprouting (short, thin axons); (2) dentritic overgrowth; (3) neuroinflammation; (4) microglial/astrocytic activation; (5) brain immune response activation; (6) elevated glial fibrillary acidic protein; (7) oxidative stress and lipid

peroxidation; (8) decreased reduced glutathione levels and elevated oxidized glutathione; (9) mitochondrial dysfunction; (10) disruption in calcium homeostasis and signaling; (11) inhibition of glutamic acid decarboxylase (GAD) activity; (12) disruption of GABAergic and glutamatergic homeostasis; (13) inhibition of IGF-1 and methionine synthase activity; (14) impairment in methylation; (15) vascular endothelial cell dysfunction and pathological changes of the blood vessels; (16) decreased cerebral/cerebellar blood flow; (17) increased amyloid precursor protein; (18) loss of granule and Purkinje neurons in the cerebellum; (19) increased pro-inflammatory cytokine levels in the brain (TNF-α, IFN-γ, IL-1β, IL-8); and (20) aberrant nuclear factor kappa-light-chain-enhancer of activated B cells (NF-kappaB). This review also discusses the ability of mercury to potentiate and work synergistically with other toxins and pathogens in a way that may contribute to the brain pathology in ASD. The evidence suggests that mercury may be either causal or contributory in the brain pathology in ASD, possibly working synergistically with other toxic compounds or pathogens to produce the brain pathology observed in those diagnosed with an ASD.

203. Kim Y Lee BK Associations of blood lead, cadmium, and mercury with estimated glomerular filtration rate in the Korean general population: analysis of 2008-2010 Korean National Health and Nutrition Examination Survey data. Environ Res (2012 Oct) 118:124-9

INTRODUCTION: The objective of this study was to evaluate associations between blood lead, cadmium, and mercury levels with estimated glomerular filtration rate in a general population of South Korean adults…. DISCUSSION: In this large, representative sample of South Korean adults, elevated blood lead level was consistently associated with lower eGFR levels and with the prevalence of reduced eGFR even in blood lead levels below 10 Î¼g/dL. In conclusion, elevated blood lead level was associated with lower eGFR in a Korean general population, supporting the role of lead as a risk factor for chronic kidney disease.

204. Liu YR He JZ Zhang LM Zheng YM Effects of long-term fertilization on the diversity of bacterial mercuric reductase gene in a Chinese upland soil. J Basic Microbiol (2012 Feb) 52(1):35-42

205. DÃ³rea JG Marques RC Isejima C Neurodevelopment of Amazonian infants: antenatal and postnatal exposure to methyl- and ethylmercury. J Biomed Biotechnol (2012) 2012:132876

Neurodevelopment as Gesell development scores (GDSs) in relation to mercury exposure in infants (<6 months of age) of one urban center and two rural villages, respectively, of fisherman and cassiterite miners. … Conclusion. In nurslings whose mothers are exposed to different levels of fish-MeHg (HHg), a higher score of neurological development at six months was negatively associated with exposure to additional TCV-EtHg. Results should be interpreted with caution because of unaccounted variables.

206. Geer LA Persad MD Palmer CD Steuerwald AJ Dalloul M Abulafia O Parsons PJ Assessment of prenatal mercury exposure in a predominately Caribbean immigrant community in Brooklyn, NY. J Environ Monit (2012 Mar) 14(3):1035-43

Prenatal mercury exposure and its fetotoxic effects may be of particular concern in urban immigrant communities as a result of possible contributing cultural factors. The most common source of exposure in these communities is ingestion of fish and shellfish contaminated with methylmercury. Other sources of exposure may occur in ritualistic practices associated with Hispanic and Caribbean-based religions. This study 1) assessed total mercury levels in both random urine specimens from pregnant women, and in cord blood; and 2) examined

environmental sources of exposure from a convenience sample in a predominantly Caribbean immigrant population in Brooklyn, New York. …Findings may help target interventions in this population, which might include appropriate fish selection and consumption frequency during pregnancy, and safe handling of mercury-containing products in the home.

207. Cunha LR Costa TH Caldas ED Mercury concentration in breast milk and infant exposure assessment during the first 90Â days of lactation in a midwestern region of Brazil.: Biol Trace Elem Res (2013 Jan) 151(1):30-7

Breast milk samples collected from 18 nursing mothers between the 15th and 90th day of lactation were digested in nitric acid in a microwave, and total mercury (THg) levels were quantified by atomic fluorescence spectrometry. …Although this study showed that **mercury intake by infants during lactation may exceed the toxicologically safe exposure level (PTWI**), we nevertheless believe that the benefits of lactation for both the mother and the infant outweigh the eventual risks that this exposure may represent.

208. Jain RB Effect of pregnancy on the levels of blood cadmium, lead, and mercury for females aged 17-39 years old: data from National Health and Nutrition Examination Survey 2003-2010. J Toxicol Environ Health A (2013) 76(1):58-69

Data from the National Health and Nutrition Examination survey for the years 2003-2010 were used (n = 4700) to evaluate the effect of age, parity, body mass index (BMI), race/ethnicity, pregnancy, iron (Fe) storage status, smoking status, and fish/shellfish consumption on the levels of blood cadmium (Cd), lead (Pb), and total mercury (Hg)for females aged 17-39 years old. Regression analysis was used to fit models for each of the three metals. For all three metals, age was positively and BMI was negatively associated with levels of these metals in blood. Smokers had statistically significantly higher levels of Cd and Pb irrespective of race/ethnicity and Fe storage status as compared to nonsmokers. Novel to this study, pregnancy was found to be associated with significantly lower levels of Cd, Pb, and Hg irrespective of race/ethnicity and Fe storage status as compared to nonpregnant females. It is conceivable that pregnancy may thus accelerate clearance of these metals from blood. Fish/shellfish consumption was associated with higher levels of Hg but not with Cd levels.

ANIMAL STUDIES 1990-2012

1. Furness RW Lewis SA Mills JA Mercury levels in the plumage of red-billed gulls Larus novaehollandiae scopulinus of known sex and age. Environ Pollut (1990) 63(1):33-9

   ... Analysis of total mercury in the feather samples showed that levels were independent of sex and age in adults. Mean fresh weight concentration in adult body feathers was 2.4 microg g(-1). ...Mercury levels in chick feathers were about 80% of levels in adult feathers.

2. Cagiano R De Salvia MA Renna G Tortella E Braghiroli D Parenti C Zanoli P Baraldi M Annau Z Cuomo V Evidence that exposure to methyl mercury during gestation induces behavioral and neurochemical changes in offspring of rats. Neurotoxicol Teratol (1990 Jan-Feb) 12(1):23-8

   ...At day 1 of postnatal life the levels of MMC in whole brain of exposed pups were found to be about 100 times higher than those of saline-exposed rats... From these data, we tentatively suggest that a high level of MMC induces a transient phenomenon of disuse-supersensitivity of the dopaminergic system. Moreover, further evidence that acute MMC exposure during prenatal life might induce permanent disturbances in learning and memory which could be partially related to a reduced functional activity of the glutamatergic system is provided.

3. Ivanitskaia NF [Evaluation of combined effects of ionizing radiation and mercury on the reproductive function of animals]Otsenka sochetannogo deistviia ioniziruiushchego izlucheniia i rtuti na reproduktivnuiu funktsiiu zhivotnykh.: Gig Sanit (1991 Dec)(12):48-51

   Reduction of spermatogenesis and enzymatic activity due to single or combined action of ionizing radiation and mercury was noted. The total biological effects seemed to be close to the cumulative influence of environmental factors.

4. Sundberg J Oskarsson A Bergman K Milk transfer of inorganic mercury to suckling rats. Interaction with selenite. Biol Trace Elem Res (1991 Jan) 28(1):27-38

   ... There was a linear relationship between mercury concentrations in dam's plasma and milk. The level of mercury in milk was approximately 25% of the level in plasma. ...Mercury concentration in milk was linearly correlated to the levels in kidney, liver, and brain in the suckling offspring after 3 d exposure to mercury via milk. Selenite treatment of rats, 1.3 micrograms Se/g diet for 5 mo, resulted in increased transport of mercury to milk, probably because of increased plasma levels of mercury. However, selenite treatment of the dams did not cause any increased tissue levels of mercury in the suckling offspring.

5. Sundberg J Oskarsson A Albanus L Methylmercury exposure during lactation: milk concentration and tissue uptake of mercury in the neonatal rat. Bull Environ Contam Toxicol (1991 Feb) 46(2):255-62
6. Wester PW Histopathological effects of environmental pollutants beta-HCH and methyl mercury on reproductive organs in freshwater fish. Comp Biochem Physiol C (1991) 100(1-2):237-9

   From various environmental pollutants studied so far, specific effects on the reproductive system of small fish species Poecilia reticulata (guppy) and Oryzias latipes (medaka) were noted in the case of beta-hexachlorocyclohexane (induction of vitellogenesis and hermaphroditism, both indicative of estrogenic activity; 32 micrograms/l) and methyl mercury (impaired spermatogenesis; 1.8 micrograms/l). The latter effect was attributed to a disturbance of mitosis.

7. Lindstrom H Luthman J Oskarsson A Sundberg J Olson L Effects of long-term treatment with methyl mercury on the developing rat brain. Environ Res (1991 Dec) 56(2):158-69
8. ... In cerebellum the NA levels were increased (117% of controls, P = 0.008), whereas in other regions analyzed NA and DA levels were unchanged. ... However, the results indicate that effects may occur in specific transmitter-identified systems, such as the NA input to cerebellum.
9. Schmidt GH Ibrahim NM Abdallah MD Long-term effects of heavy metals in food on developmental stages of Aiolopus thalassinus (Saltatoria: Acrididae). Arch Environ Contam Toxicol (1992 Oct) 23(3):375-82

    Newly hatched F1 nymphs of Aiolopus thalassinus (Fabr.) were fed on food treated with various concentrations of HgCl2, CdCl2, and PbCl2 until the end of adult life. Toxicological observations were followed in the F1 generation and in the F2 generation derived from the heavy metal-loaded F1 parents. The highest concentration of the heavy metal caused 100% mortality of the F1 adults within four weeks. The nymphal duration of the F1 and F2 generations was significantly prolonged after Hg and Cd exposure, but the F1 of the group treated with lead was not affected. The fresh body weight of adults was significantly reduced in the F1 generation of most treatments and in the resulting untreated F2. The lifespan of the F1 adults was shortened. In the F2 generation, although the lifespan was somewhat longer, generally it was still shorter than that of the control adults. The mean egg number laid by F1 adults fed on food contaminated with Hg or Cd was decreased. This decrease was more pronounced in the case of Cd than Hg. In the females fed on food treated with Pb the reduction of the number of egg pods was not remarkable. The hatchability of the eggs laid by F1 females was significantly reduced as compared to the control. The viability of the eggs laid by F2 adults was somewhat decreased due to either a reduced number of egg pods or to a lower rate of hatchability, especially in the case of Cd. The treated adults frequently displayed weakness in their legs, difficulties in walking, tremors, and nervous movements

9a Nielsen JB Andersen O Transplacental passage and fetal deposition of mercury after low- level exposure to methylmercury--effect of seleno-L-methionine. J Trace Elem Electrolytes Health Dis (1992 Dec) 6(4):227-32

Previous experimental studies on transplacental passage and possible fetotoxicity of methylmercury have almost exclusively used a single dosage or 2-4 repeated doses of mercury on specific days during gestation and often used at relatively high dose levels. In previous studies, selenium supplementation considerably increased the concentration of mercury in the blood of offspring after maternal exposure of rats to methylmercury, whereas whole-body retention and organ deposition of mercury in mice were unaffected. The present study in mice, which involved exposure for 5 weeks to a low dose of methylmercury in the drinking water (1 nmol/ml) before and during pregnancy, demonstrates that mercury is deposited in offspring both in utero and during lactation, and that transplacentally absorbed mercury is not, or only very slowly, excreted. Seleno-L-methionine increased the deposition of mercury in offspring, but the effect was due to slightly higher deposition in the dams. Selenomethionine significantly reduced the kidney deposition of mercury in offspring, whereas liver deposition of mercury was unaffected. These results indicate that interactions between organo-selenium compounds and methylmercury orally administered at low doses is of less importance than previously believed on the basis of experiments with higher doses of selenite injected or supplemented to the diet.

10. Bernard AM Collette C Lauwerys R Renal effects of in utero exposure to mercuric chloride in rats. Arch Toxicol (1992) 66(7):508-13

    .. Mercuric chloride was injected s.c. to rats at the dose of 1 mg/kg during the last 8 gestational days or the whole pregnancy. Both mothers and newborns developed a transient renal dysfunction resulting in an increased urinary excretion of beta 2-microglobulin and albumin. In mothers and their female offspring, these effects were completely reversible and did not influence the subsequent evolution of the renal function. In the male offspring, however, transitory changes in protein excretion were again observed a few months later, concomitantly with an enhanced accumulation of alpha 2u-globulin in the kidney. ...The barrier role of the placenta is not sufficient to prevent the occurrence of renal effects in the offspring of rats treated with inorganic mercury during pregnancy.

11. Castagna A Sinatra F Zafarana S [Effect of various heavy metals on the ATP content of spermatozoa from Arbacia lixula L.--activity of mercury]Effetti di alcuni metalli pesanti sul contenuto di ATP di spermatozoi di Arbacia lixula L.--azione de mercurio. Boll Soc Ital Biol Sper (1992 Mar) 68(3):151-8

    ... The results clearly show that ATP levels are strongly affected by mercury concentrations, already three hours after the beginning of treatment. We propose the use of ATP determination in sea urchin sperm as a bioassay, because they, even more than eggs and developmental stages, readily suffer the environmental stresses.

12. Ornaghi F Ferrini S Prati M Giavini E The protective effects of N-acetyl-L-cysteine against methyl mercury embryotoxicity in mice. Fundam Appl Toxicol (1993 May) 20(4):437-45

    In the last experiment the treatment with NAC (400 mg/kg i.v., during the period of organogenesis) drastically reduced the severe embryolethality induced by MMC (6 mg/kg/day po) administered during the same period of time

13. Sanchez DJ Gomez M Llobet JM Domingo JL Effects of meso-2,3-dimercaptosuccinic acid (DMSA) on methyl mercury- induced teratogenesis in mice. Ecotoxicol Environ Saf (1993 Aug) 26(1):33-9

    Methyl mercury has been reported to be embryotoxic and teratogenic in numerous systems such as fish, birds, and mammals. meso-2,3- Dimercaptosuccinic acid (DMSA) has been useful for prevention and treatment of mercury poisoning. In this study, the protective activity of DMSA on methyl mercury-induced embryo/fetotoxicity was evaluated in mice. ... Oral administration of MMC resulted in a high rate of resorptions and dead fetuses as well as a reduced fetal body weight. Moreover, cleft palate (46.9%) and various developmental variations were found in the positive control group. ...According to these results, DMSA offers encouragement with regard to its therapeutic potential for pregnant women exposed to methyl mercury.

14. Danielsson BR Fredriksson A Dahlgren L Gardlund AT Olsson L Dencker L Archer T Behavioural effects of prenatal metallic mercury inhalation exposure in rats. Neurotoxicol Teratol (1993 Nov-Dec) 15(6):391-6

    The effects of administration by inhalation of metallic mercury vapour (Hg0) to pregnant rats, approximately corresponding to doses of 0.2 mg Hg0/kg/day (high dose) or 0.07 mg Hg0/kg/day (low dose), on the developmental and behavioural repertoire of the offspring were studied. ... Tests of spontaneous motor activity showed that the Hg0-treated offspring were hypoactive at 3 months of age but hyperactive at 14 months. In spatial learning tasks the prenatally exposed offspring showed retarded acquisition in the radial arm maze but no differences in circular swim maze. A simple test of learning, habituation to a novel environment (activity chambers), indicated

a reduced ability to adapt. These data suggest that prenatal exposure to Hg0 vapour results in similar behaviour changes in the offspring as reported for methylmercury.

15. Yoshida M Watanabe C Satoh H Kishimoto T Yamamura Y Milk transfer and tissue uptake of mercury in suckling offspring after exposure of lactating maternal guinea pigs to inorganic or methylmercury. Arch Toxicol (1994) 68(3):174-8

    ... There was a strong correlation between milk and plasma T-Hg concentrations in HgCl2 treated dams. In the milk of MeHg-treated dams, the plasma MeHg concentrations correlated better than did the plasma T-Hg concentrations. In the offspring, regardless of the chemical forms of Hg given to the dams, the highest Hg concentrations were found in the kidney, followed by the liver and the brain. Brain Hg concentrations were, however, significantly higher in the offspring of MeHg-treated dams than in those of HgCl2-treated dams. ...These facts indicate that the two chemical forms of Hg were transferred to the offspring via the breast milk and were distributed differently, depending on the chemical form, to the offspring's tissues.

16. Warfvinge K Hua J Logdberg B Mercury distribution in cortical areas and fiber systems of the neonatal and maternal adult cerebrum after exposure of pregnant squirrel monkeys to mercury vapor. Environ Res (1994 Nov) 67(2):196-208

    Pregnant squirrel monkeys were exposed 5 days/week to mercury vapor at a concentration of 0.5 mg Hg/m3 air for 7 hr/day, or at 1 mg Hg/m3 air for 4 or 7 hr/day. The calculated total mercury absorption ranged between 0.8 and 5.4 mg (range of daily absorption 0.04-0.07 mg). The mercury concentration in the cerebral occipital lobe of the offspring ranged between 0.20 and 0.70 microgram/g tissue, and in the mothers between 0.8 and 2.58 micrograms/g tissue. Mapping of the distribution of mercury in the neocortical layers of the maternal brains revealed that the pyramidal cells contained more visualized mercury than the other neurons. In addition, the mapping disclosed that the deeper the pyramidal cells were situated the more mercury they contained. In the offspring brains, no laminar distribution pattern was found. In the hippocampal formation, the pyramidal cells again contained more mercury than the other neurons. By contrast, the stratum granulosa of the dentate gyrus was always devoid of visualized mercury. The claustrum and the amygdaloid complex always contained mercury. In the fiber systems, the offspring brains contained more mercury than the adult brains. Mercury was found in both glial cells and neurons both in the cortical areas and in the fiber systems.

17. Tsai CL Jang TH Wang LH Effects of mercury on serotonin concentration in the brain of tilapia, Oreochromis mossambicus. Neurosci Lett (1995 Jan 30) 184(3):208-11

    In order to know the effect of mercury pollution on the serotonergic system of fish, serotonin concentrations in a discrete brain region of tilapia, Oreochromis mossambicus, were examined. ... After exposure to 0.015 and 0.03 ppm HgCl2 for 6 months beginning 7 days posthatching, male sample fish showed a significantly dose-dependent decrease in serotonin concentration in the hypothalamus. ... These results suggest that exposure to HgCl2 results in an attenuated development of the serotonergic system in the hypothalamus of fish.

18. Facemire CF Gross TS Guillette LJ Guillette LJ Jr Reproductive impairment in the Florida panther: nature or nurture Environ Health Perspect (1995 May) 103 Suppl 4:79-86
    a. ... Thus, regardless of the effects of inbreeding, current evidence seems to indicate that environmental contaminants may be a major factor contributing to reproductive impairment in the Florida panther population.

19. Maretta M Marettova E Skrobanek P Ledec M Effect of mercury on the seminiferous epithelium of the fowl testis. Acta Vet Hung (1995) 43(1):153-61

    ... Treatment with 30 ppm Hg resulted in hypospermia, occurrence of abnormally maturing spermatozoa, reduction of the volume of semen, and decrease in the number of spermatozoa. The dose of 5 ppm Hg only resulted in the appearance of abnormally developing cells and decreased sperm motility. The addition of Se maintained spermatogenesis and the values of semen on the control level.

20. Lundholm CE Effects of methyl mercury at different dose regimes on eggshell formation and some biochemical characteristics of the eggshell gland mucosa of the domestic fowl. Comp Biochem Physiol C Pharmacol Toxicol Endocrinol (1995 Jan) 110(1):23-8

    Eggshell formation and egg production in domestic fowl were studied following the administration of methyl mercury ... A daily oral dose of 5 mg of methyl mercury for 6 consecutive days induced significant eggshell thinning and deformation and inhibited egg production...

21. Kajiwara Y Yasutake A Adachi T Hirayama K Methylmercury transport across the placenta via neutral amino acid carrier. Arch Toxicol (1996) 70(5):310-4

    Methylmercury (MeHg) penetrates the placental barrier to affect developing fetuses in the uterus. ... MeHg was found to be rapidly transported to the fetal blood in a time- and dose-dependent manner, and predominantly distributed in the blood cells there. ...

22. Pribilincova J Marettova E Kosucky J Maretta M The effect of phenyl mercury on reproductive performance in laying hens. Acta Vet Hung (1996) 44(3):377-87

    The effect of phenyl mercury with and without selenium on the egg production of laying hens and on the fertility, hatchability and properties of eggs was studied. ... After two months, egg production decreased by 8.18% and 7.74% in hens fed 30 ppm Hg, and 30 ppm Hg + 4 ppm Se, respectively. Egg weight decreased in all experimental groups. In comparison to the controls, these results were highly significant ($P < 0.01$) in hens fed 30 ppm Hg and 30 ppm Hg + 4 ppm Se and significant ($P < 0.05$) between hens fed 5 ppm Hg and 30 ppm Hg. ... Both egg-shell thickness and weight decreased in all experimental groups. ...Residual mercury levels in egg yolk greatly surpassed the level found in the egg white: the highest values were measured in the group fed 30 ppm Hg. The addition of selenium had a protective effect upon residual Hg deposits in the yolk, but not in the egg-white.

23. Gilbert SG Rice DC Burbacher TM Fixed interval/fixed ratio performance in adult monkeys exposed in utero to methylmercury. Neurotoxicol Teratol (1996 Sep-Oct) 18(5):539-46

    ... In the present study, monkeys (Macaca fascicularis) were exposed in utero to methylmercury (MeHg). Maternal doses of MeHg of 50, 70, or 90 micrograms/kg b.wt./day resulted in infant blood mercury levels at birth ranging from 1.04 to 2.45 ppm. ... Post hoc t- tests revealed a significant difference in quarter-life of treated male and female monkeys and a marginal difference between treated and control males. The FI run rate of the male monkeys was significantly greater than that of the female monkeys whereas the FR run rate of the males was marginally greater. These results indicate that there may be a differential effect of MeHg on male and female monkeys, which could be interpreted as an effect on temporal discrimination.

24. Fredriksson A Dencker L Archer T Danielsson BR Prenatal coexposure to metallic mercury vapour and methylmercury produce interactive behavioural changes in adult rats. Neurotoxicol Teratol (1996 Mar-Apr) 18(2):129-34

...Offspring of dams exposed to Hg degrees showed hyperactivity in the motor activity test chambers over all three parameters: locomotion, rearing and total activity; this effect was potentiated in the animals of the MeHg + Hg degrees group. In the swim maze test, the MeHg + Hg degrees and Hg degrees groups evidenced longer latencies to reach a submerged platform, which they had learned to mount the day before, compared to either the control or MeHg groups. In the modified, enclosed radial arm maze, both the MeHg + Hg degrees and Hg degrees groups showed more ambulations and rearings in the activity test prior to the learning test. During the learning trial, the same groups (i.e., MeHg + Hg degrees and Hg degrees) showed longer latencies and made more errors in acquiring all eight pellets. Generally, the results indicate that prenatal exposure to Hg degrees causes alterations to both spontaneous and learned behaviours, suggesting some deficit in adaptive functions. Coexposure to MeHg, which by itself did not alter these functions at the dose given in this study, served to significantly aggravate the changes.

25. Aschner M Lorscheider FL Cowan KS Conklin DR Vimy MJ Lash LH Metallothionein induction in fetal rat brain and neonatal primary astrocyte cultures by in utero exposure to elemental mercury vapor (Hg0). Brain Res (1997 Dec 5) 778(1):222-32

Brain metallothionein (MT) protein and mRNA levels were determined in the fetal rat following in utero (gestational days 7-21) exposure to elemental mercury vapor (Hg0; 300 microg Hg/m3; 4 h/day). Total RNA was probed on Northern blots with [alpha-32P]dCTP-labeled synthetic cDNA probes specific for rat MT isoform mRNAs. The probes for MT-I and MT-II mRNA hybridized to a single band of approximately 550 and 450 nucleotides, respectively. Expression of whole brain MT-I mRNA in full-term fetal rats (day 21) was significantly increased ($P < 0.03$) by in utero exposure to Hg0 compared to nonexposed controls. This corresponded to a 14-fold increase ($P < 0.001$) in fetal brain Hg concentration after in utero Hg0 exposure. In addition, astrocytes from both control and in utero Hg0-exposed fetuses were isolated, and neonatal primary astrocyte cultures were established and maintained in vitro for up to 3 weeks without additional experimental intervention. Astrocyte monolayers derived from in utero Hg0-exposed fetuses consistently expressed increased abundance of MT-I mRNA transcripts after 1, 2, and 3 weeks in culture ($P < 0.03$, $P < 0.01$, and $P < 0.03$, respectively) compared with controls. The abundance of astrocyte MT-II mRNA was unchanged at 1 and 2 weeks in culture, but was significantly increased at 3 weeks in cultures derived from brains of Hg0-exposed fetuses ($P < 0.04$). Consistent with the increase in MT mRNA, an increase in astrocytic levels of MT proteins was noted by Western blot analysis and MT-immunoreactivity. These studies suggest that in utero exposure to Hg0 induces brain MT gene expression, and that MT mRNAs and their respective proteins are useful quantitative biochemical markers of intrauterine exposure to Hg0, a potentially cytotoxic challenge to astrocytes in the developing brain. It is concluded that induction of MT by fetal/neonatal astrocytes represents an attempt by these glial cells to protect against Hg cytotoxicity in maintaining cerebral homeostasis.

26. Ma T Yang B Gillespie A Carlson EJ Epstein CJ Verkman AS Generation and phenotype of a transgenic knockout mouse lacking the mercurial-insensitive water channel aquaporin-4. J Clin Invest (1997 Sep 1) 100(5):957-62

Aquaporin-4 (AQP4) is a mercurial-insensitive, water-selective channel that is expressed in astroglia and basolateral plasma membranes of epithelia in the kidney collecting duct, airways,

stomach, and colon. A targeting vector for homologous recombination was constructed using a 7-kb SacI AQP4 genomic fragment in which part of the exon 1 coding sequence was deleted. Analysis of 164 live births from AQP4[+/-] matings showed 41 [+/+], 83 [+/-], and 40 [-/-] genotypes. The [-/-] mice expressed small amounts of a truncated AQP4 transcript and lacked detectable AQP4 protein by immunoblot analysis and immunocytochemistry. Water permeability in an AQP4-enriched brain vesicle fraction in [+/+] mice was high and mercurial insensitive, and was decreased by 14-fold in [-/-] mice. AQP4 deletion did not affect growth or tissue morphology at the light microscopic level. Northern blot analysis showed that tissue-specific expression of AQPs 1, 2, 3, and 5 was not affected by AQP4 deletion. Maximum urine osmolality after a 36-h water deprivation was (in mosM, n = 15) [+/+] 3,342+/-209, [+/-] 3, 225+/-167, and [-/-] 2,616+/-229 ($P < 0.025$), whereas urine osmolalities before water deprivation did not differ among the genotypes. Rotorod analysis of 35- 38-d-old mice revealed no differences in neuromuscular function (performance time in s, n = 8): [+/+] 297+/-25, [+/-] 322+/-28, [-/-] 288+/-37. These results indicate that AQP4 deletion in CD1 mice has little or no effect on development, survival, growth, and neuromuscular function, but produces a small defect in urinary concentrating ability consistent with its expression in the medullary collecting duct.

27. Dansereau M Lariviere N Du Tremblay D Belanger D Reproductive performance of two generations of female semidomesticated mink fed diets containing organic mercury contaminated freshwater fish. Arch Environ Contam Toxicol (1999 Feb) 36(2):221-6

    Semidomesticated female mink (Mustela vison) were fed daily diets containing 0.1 ppm, 0.5 ppm, and 1.0 ppm of total mercury. ...The proportion of females giving birth was low for all groups, except for the G1 females fed the 0.1 ppm diet. There was an inverse relationship between whelping proportion and exposure group, but was not statistically significant. There was evidence that kits were exposed to mercury both in utero and/or during lactation as indicated by the presence of mercury in their livers.

28. Szasz A Barna B Szupera Z De Visscher G Galbacs Z Kirsch-Volders M Szente M Chronic low-dose maternal exposure to methylmercury enhances epileptogenicity in developing rats. Int J Dev Neurosci (1999 Nov) 17(7):733-42

    Effects of continuous low-dose maternal methylmercury intoxication on the induction and propagation of ictal epileptiform activity induced by 3-aminopyridine, were investigated on the neocortex of 4-weeks-old offspring rats. Epileptogenicity was significantly increased in offspring of mercury-treated animals compared to those of controls, characterized by more frequent occurrence of periodic ictal activity, a facilitated propagation of epileptiform discharges and a strong tendency to generalization... the amplitude of seizure discharges was significantly smaller in treated animals than in controls. We conclude, that the synaptic and membrane mechanisms responsible for initiation and propagation of paroxysmal activity were probably facilitated, while the efficacy of cortical inhibition, in preventing initiation and spread of epileptiform discharges was reduced by mercury treatment in the developing nervous system. The smaller amplitude of paroxysmal discharges could be a sign of a remarkable loss of cortical neurons.

29. Chakrabarti SK Bai C Effects of protein-deficient nutrition during rat pregnancy and development on developmental hindlimb crossing due to methylmercury intoxication. Arch Toxicol (2000 Jul) 74(4-5):196-202

    Pregnant rats were fed either a control (20% protein) or low (3.5%) protein diet during gestation and lactation. The pups were separated from their mothers on postnatal day 21, and were given the same diet as their corresponding mothers. The groups of pups from each diet group were

treated on either postnatal day 21 or postnatal day 60 with 7.5 mg methylmercury chloride (MeHgCl) per kg b.w. once daily by gavage for 10 consecutive days, and the development of ataxia (hind- limb crossing) was monitored. The offspring from mothers on the protein-deficient diet were found to be more sensitive to MeHg- induced ataxia than those on the protein-sufficient diet. The former accumulated more mercury in different brain regions than the latter. The rates of protein synthesis in different brain regions of the offspring fed the protein-deficient diet were significantly reduced compared with the rates in those fed the protein-sufficient diet. However, MeHg treatment did not significantly modify the rates of such protein synthesis further in protein-deficient rats. Thus, a significantly much higher inhibition of the intrinsic rates of protein synthesis in different brain regions due to severe protein deficiency, as observed in this study, may be partly responsible for the increased susceptibility of developing rats fed a protein-deficient diet to MeHg-induced ataxia, or hindlimb crossing, although other factor(s) might also be involved.

30. Barna B Szasz A Gajda Z Galbacs Z Kirsch-Volders M Szente M Effects of chronic, intrauterine organic and inorganic mercury intoxication on the epileptogenicity of developing rat. Cent Eur J Public Health (2000 Jul) 8 Suppl:73-5
31. Warfvinge K Mercury distribution in the neonatal and adult cerebellum after mercury vapor exposure of pregnant squirrel monkeys. Environ Res (2000 Jun) 83(2):93-101

    The objectives of the study were (1) to map the detailed localization of mercury in the monkey cerebellum after mercury vapour exposure; (2) to investigate whether there is any difference in mercury distribution between neonatal and adult cerebellum after mercury vapor exposure; (3) to investigate the ability of mercury to accumulate in the cerebellum years after the end of exposure. Pregnant squirrel monkeys were exposed 5 days/week to mercury vapor at a concentration of 0.5 mg Hg/m(3) air 4 or 7 h/day or 1 mg Hg/m(3) air for 4 or 7 h/day. Mercury concentration in the offspring and maternal brains was examined by cold vapor, flameless atomic absorption spectrophotometry. Mercury distribution was examined by processing cerebellar sections for autometallographic (AMG) silver enhancement. Mercury concentration in the offspring cerebral occipital pole ranged between 0.20 and 0.70 microg Hg/g tissue, and in the maternal between 0.80 and 2.58 microg/Hg tissue in animals killed immediately after the end of exposure. AMG revealed that the external granule cell layer of offspring cerebellar tissue contained small amounts of mercury. The molecular layer contained mercury in some of the mercury-exposed monkeys. In the Purkinje cell layer, the Bergmann glial cells together with the Purkinje cells contained mercury. The granule cells and the Golgi cells contained small amounts of mercury. The astrocytes of the medullary layer, identified by immunohistochemistry, contained considerable amounts of mercury, but the cerebellar nuclei accumulated the highest amounts of mercury. No correlation was found between cellular accumulation and maturity of the brain; that is, the cellular localization of mercury did not differ between adult and neonatal brain, except for the amount of visualized mercury. This pattern corresponded well to the mercury concentrations found in the cerebral occipital pole. The differences found in mercury accumulation were instead considered to be dose- related. The results demonstrate that the distribution of mercury in the cerebellum after mercury vapor exposure is similar to the distribution pattern obtained after methyl mercury exposure and that mercury is trapped in the cerebellum over a long period of time.

32. Warfvinge K Bruun A Mercury distribution in the squirrel monkey retina after in Utero exposure to mercury vapor. Environ Res (2000 Jun) 83(2):102-9

Pregnant squirrel monkeys were exposed to mercury vapor during approximately 2/3 of a pregnancy, at a concentration of 0.5 or 1 mg Hg/m(3) air for 4 or 7 h a day, 5 days a week. The offspring were sacrificed at different ages (gestational week 16 to 5 years). The eyes were enucleated and horizontal sections of the retina, comprising the optic disc and the fovea, were processed for autometallographic (AMG) silver enhancement. The AMG mercury distribution was mapped using light and epipolarization microscopy. In young offspring (16-week-old fetus to 3 days old), mercury was detected mainly in the optic nerve, retinal pigment epithelium, inner plexiform layer, vessel walls, and ganglion cells. Three and a half months later, the amount of visualized mercury had decreased in all areas except for the retinal pigment epithelium. In adult monkeys that had survived for 2 to 5 years, only a faint AMG staining was seen in the retinal pigment epithelium, the optic nerve, and in some vessel walls. In conclusion, in offspring sacrificed in utero or shortly after birth, the structures accumulating mercury were the same as those which accumulate mercury following direct exposure through the lungs, as reported previously (K. Warfvinge and A. Bruun, 1996, Toxicology 107, 189-200), although the amount of AMG staining was less in transplacental animals. This demonstrates that inorganic mercury penetrates the blood-retina barrier. In monkeys that had survived 3 to 5 years, only tiny amounts of mercury were detected, which is in contrast to findings from direct exposure, in which large amounts were still found 3 years after exposure. This may suggest that the elimination process in the retina is more efficient in young animals, but a possible adverse effect of mercury on retinal development cannot be ruled out.

33. Kim CY Nakai K Kasanuma Y Satoh H Comparison of neurobehavioral changes in three inbred strains of mice prenatally exposed to methylmercury. Neurotoxicol Teratol (2000 May-Jun) 22(3):397-403

Pregnant mice of three inbred strains (BALB/c, C57BL/6J, C57BL/6Cr) were orally given methylmercury (MMC; 3 x 3 mg/kg body weight) or the equivalent volume of phosphate-buffered saline during days 12-14 of gestation and allowed to deliver..... This result indicated that the prenatal exposure to MMC impaired the performance in the Morris water maze differently among the strains. This study provides a basis for evaluating strain- specific neurobehavioral changes when the widely used three inbred strains of mice are chronically exposed to MMC.

34. Orisakwe OE Afonne OJ Nwobodo E Asomugha L Dioka CE Low-dose mercury induces testicular damage protected by zinc in mice. Eur J Obstet Gynecol Reprod Biol (2001 Mar) 95(1):92-6

OBJECTIVES: This investigation was set out to determine whether mercury at a very low dose (4ppm) induces testicular damage on murine testis, and if so whether the toxic effects of mercury could be prevented by zinc. ... RESULTS: Both zinc and mercury significantly ($p<0.05$) decreased the absolute and relative testicular weights, with mercury producing the highest reduction in weight. Mercury reduced significantly ($p<0.05$) the epididymal sperm number, while zinc and mercury/zinc produced statistically same effect with control on the sperm number. Histological study showed that mercury at the concentration employed produced remarkable degenerative lesions on the testes, as the zinc-treated group showed a normal morphology. Majority of the animals in the mercury/zinc-treated group exhibited complete or partial protection as evidenced by the morphology of the seminiferous tubules. CONCLUSION: Zinc prevents mercury-induced testicular damage in mouse. These findings highlight the risks exposure to inorganic mercury might pose to male reproduction of mice, and suggests possible therapy with zinc. Study in humans is therefore advocated.

35. Scheuhammer AM Perrault JA Bond DE Mercury, methylmercury, and selenium concentrations in eggs of common loons (Gavia immer) from Canada. Environ Monit Assess (2001 Nov) 72(1):79-94

    Concentrations of Hg and Se were determined for a total of 125 Common Loon (Gavia immer) eggs collected from lakes in Alberta, Saskatchewan, Ontario, Quebec, New Brunswick and Nova Scotia, Canada between 1972 and 1997. ...In this subset of eggs, the relationship between organic (methyl) Hg and Se was significant (r = 0.538, p = 0.007) while that found between inorganic Hg and Se in the same eggs was not significant (r = 0.353, p = 0.091). This relationship was unexpected and was contrary to relationships established for organic and inorganic Hg vs. Se in adult loon liver and kidney tissue (Scheuhammer et al., 1998b).

36. Fekete SG Bersenyi A Kadar I Glavits R Koncz J Zoldag L Study of soil-plant (potato and beetroot)-animal cycle of nutritive and hazardous minerals in a rabbit model. Acta Vet Hung (2001) 49(3):301-10

    Potato and beetroot were grown on soils previously treated with heavy metal salts. Each particular microelement had a high concentration in both potato and beetroot [cadmium (Cd) 3.7 and 55.4, lead (Pb) 8.1 and 3.0, and mercury (Hg) 5.8 and 6.8 mg/kg dry matter, respectively]. In a metabolic balance trial 16 New Zealand White rabbits were fed 50 grams of basal diet and potato or beetroot ad libitum. The apparent digestibility of major nutrients and the accumulation of the microelements in different organs were investigated. Both potato and beetroot samples of high Pb and Hg content had the significantly ($p < 0.05$) lowest digestibility of organic matter and nitrogen-free extract. The Cd ingested from both potato and beetroot accumulated in the kidneys and liver (2.85 and 1.48 as well as 0.459 and 0.265 mg/kg, respectively). All the microelements (Cd, Pb and Hg) accumulated in the testicles (0.196, 0.32 and 0.199 mg/kg, respectively), reducing the rate of spermatogenesis. The tissue retention of heavy metals depends not only on the element itself, but also upon the 'carrier' feedstuff.

37. Rumbold DG Niemczyk SL Fink LE Chandrasekhar T Harkanson B Laine KA Mercury in eggs and feathers of great egrets (Ardea albus) from the Florida Everglades. Arch Environ Contam Toxicol (2001 Nov) 41(4):501-7

    Great egret (Ardea albus) eggs and nestling feathers were collected for total mercury (THg) and methylmercury (MeHg) analysis from two colonies in the Florida Everglades in 1999 and 2000. THg was present in all eggs at a mean concentration of 0.39 +/- 0.19 microg/g fresh weight (n = 33, range = 0.08-0.86 microg/g). ....

38. Wall VD Alberts JJ Moore DJ Newell SY Pattanayek M Pennings SC The effect of mercury and PCBs on organisms from lower trophic levels of a Georgia salt marsh. Arch Environ Contam Toxicol (2001 Jan) 40(1):10-7

    We examined several indicators of salt marsh function, focusing on primary producers, microbes, and grass shrimp..... Fungal biomass was related to methylmercury concentrations, but the direction of the relationship differed between wholly dead shoots (positive) and partially dead shoots (negative). S. alterniflora POD was positively related to methylmercury concentrations. S. alterniflora A(net) and E were negatively related to elevation and salinity, respectively. Despite high levels of contamination at the LCP site, our results provided only suggestive evidence for impacts on organisms at lower trophic levels.

39. Zanoli P Cannazza G Baraldi M Prenatal exposure to methyl mercury in rats: focus on changes in kynurenine pathway. Brain Res Bull (2001 May 15) 55(2):235-8

    Previous studies showed learning and memory deficits following prenatal exposure to methyl mercury (MMC) in rats. Considering the described dysfunction in several neurotransmission systems after MMC exposure, one can surmise that changes in the kynurenine pathway could also be involved in an altered brain functional development. .... These results suggest that an imbalance in the kynurenine pathway could be involved in the toxic effects induced by MMC on brain development.

40. Latif MA Bodaly RA Johnston TA Fudge RJ Effects of environmental and maternally derived methylmercury on the embryonic and larval stages of walleye (Stizostedion vitreum). Environ Pollut (2001) 111(1):139-48

    The effects of environmental and maternally derived methylmercury (MeHg) on the embryonic and larval stages of walleye (Stizostedion vitreum) were investigated using eggs collected during two successive spawning seasons. Eggs were collected from fish in a mercury (Hg)- polluted environment (Clay Lake, Ontario, Canada), and from fish in two relatively pristine lakes (Lakes Manitoba and Winnipeg, in the province of Manitoba). Both bioaccumulation of Hg into muscle and its mobilization into eggs was significantly higher in Clay Lake females. Maternal muscle MeHg concentration was positively correlated with female length and egg MeHg was positively correlated with muscle MeHg concentration in all three populations. Hatching success of eggs from all three stocks declined significantly with increasing waterborne MeHg (0.1-7.8 ng l-1). Hatching success was not significantly affected by egg MeHg concentration. Embryonic heart rate declined with increasing waterborne MeHg concentration, but larval growth was not affected. Occurrence of larval deformities was negatively correlated with size of female, but was not significantly correlated with MeHg in either eggs or water. Larval MeHg was positively correlated with the concentrations of MeHg in eggs demonstrating transmission of MeHg from females. Uptake of ambient MeHg was higher in larvae exposed to higher waterborne MeHg concentrations.

41. Oliveira RB Malm O Guimaraes JR Distribution of methylmercury and inorganic mercury in neonate hamsters dosed with methylmercury during fetal life. Environ Res (2001 May) 86(1):73-9

    The study of the effects of methylmercury (MeHg) contamination has intensified since the MeHg outbreaks in Japan and Iraq. However, most of these studies used high doses of MeHg to obtain its most severe effects. This work identified the MeHg targets in neonate hamsters after administration of two different single oral doses of radiolabeled methylmercury chloride (Me203HgCl) to two groups of pregnant hamsters. The low-dose group received 0.05 microg of 203Hg as Me203HgCl per gram of body weight and the radioactivity was 6.6x10(3) Bq. The high-dose group received 0.55 microg of 203Hg as Me203HgCl per gram of body weight with 2x104 Bq. In the first day of life, the brain was the organ with the highest Me203Hg concentration, followed by the liver, kidneys, and intestines. However, these values of Me203Hg decreased at different rates in all organs until 12 days of life, whereas total 203Hg in the body did not change during the same period. This suggests an age-dependent Me203Hg body distribution instead of an elimination of Me203Hg from the body.

42. Reynolds KD Rainwater TR Scollon EJ Sathe SS Adair BM Dixon KR Cobb GP McMurry ST Accumulation of DDT and mercury in prothonotary warblers (Protonotaria citrea) foraging in a heterogeneously contaminated environment. Environ Toxicol Chem (2001 Dec) 20(12):2903-9

    Foraging areas of adult prothonotary warblers (Protonotaria citrea) were determined using standard radiotelemetry techniques...Mean concentration of DDE was greater in eggs than all other tissues, with individual samples ranging from 0.24 to 8.12 microgram/kg. In general, concentrations of DDT in soil were effective in describing the variation of contaminants in adipose samples. Concentrations of mercury in soils accounted for 78% of the variation in kidney samples. ...

43. Pamphlett R Kum-Jew S Mercury vapor uptake into the nervous system of developing mice. Neurotoxicol Teratol (2001 Mar-Apr) 23(2):191-6

    The localisation of mercury in the developing nervous system following mercury vapor (Hg(0)) exposure is not clear. We therefore looked for mercury in the mouse nervous system following fetal or neonatal exposure to Hg(0). Mice were exposed to 50 or 500 microg/m(3) Hg(0) for 4 h a day for 5 days in late pregnancy, and pups sacrificed on postnatal day (P)1 or P40. Neonatal mice were exposed to 500 microg/m(3) Hg(0) for 2 h between P1 and P23, and were sacrificed 2 days later or at P40. Paraffin sections of the nervous system were stained with autometallography to detect inorganic mercury. No mercury was seen in the nervous system of pups after fetal exposure to the 50 microg/m(3) Hg(0) dose rate. After fetal exposure to the 500 microg/m(3) Hg(0) dose rate, mercury was seen in nervous system blood vessels and sensory ganglia. No mercury was seen in the nervous system after neonatal exposure to 500 microg/m(3) Hg(0) for 2 h between P1 and P10. From this exposure at P11 onwards, mercury was detected in motor neurons. The lack of stainable mercury in early developing central neurons suggests that the fetal and neonatal nervous systems are somehow protected from Hg(0) uptake.

44. Stern S Cox C Cernichiari E Balys M Weiss B Perinatal and lifetime exposure to methylmercury in the mouse: blood and brain concentrations of mercury to 26 months of age. Neurotoxicology (2001 Aug) 22(4):467-77

    Chronic, low-level exposures to environmental toxicants, because they often begin prenatally and then persist throughout the individual's lifetime, pose challenging issues to risk assessment. ...Samples were obtained on PND 4 and 21, and then at the end of months 14 and 26. On PND 4, brain and blood levels closely reflected maternal dosing. In all groups, concentrations fell sharply from PND 4 to 21, but to a greater extent in the perinatal groups. Blood levels in the 1 ppm lifetime group remained unchanged between months 14 and 26, but brain levels rose modestly. In the 3 ppm lifetime group, both brain and blood levels rose significantly between months 14 and 26, suggesting an interaction between dose and age.

45. Belles M Albina ML Sanchez DJ Corbella J Domingo JL Interactions in developmental toxicology: effects of concurrent exposure to lead, organic mercury, and arsenic in pregnant mice. Arch Environ Contam Toxicol (2002 Jan) 42(1):93-8

    The development toxicity of lead nitrate (25 mg/kg, SC), methylmercury chloride (12.5 mg/kg, PO), and sodium arsenite (6 mg/kg, SC) was assessed in CD1 mice following administration on gestation day 10 of these chemicals separately or in their binary and ternary combinations. ...With regard to developmental toxicity, the most relevant effects (decreased fetal weight, cleft palate) corresponded to the Hg-treated groups. It is in agreement with the finding that in all experimental groups the levels of Pb and As in whole fetuses were under their respective

detection limits. In general terms, the present data suggests that at the current doses, the interactive effects of Pb and As on Hg-induced developmental toxicity were not greater than additive. In contrast, exposure of pregnant mice to Pb and As at doses that were practically nontoxic to dams, concurrently with organic Hg at a toxic dose, caused supra-additive interactions in maternal toxicity.

46. Sakamoto M Kakita A Wakabayashi K Takahashi H Nakano A Akagi H Evaluation of changes in methylmercury accumulation in the developing rat brain and its effects: a study with consecutive and moderate dose exposure throughout gestation and lactation periods. Brain Res (2002 Sep 13) 949(1-2):51-9

    Methylmercury (MeHg) can be transferred to the fetus through the placenta and to newborn offspring through breast milk. The higher mercury (Hg) accumulation and susceptibility to toxicity in the fetus than in the mother during the gestation period is well known. However, the contribution of MeHg exposure through breast milk to the brain Hg concentration in offspring is not clear. The purposes of this study were to evaluate the changes in Hg concentration in the brain of offspring and its effects on the developing rat brain, based on consecutive and moderate doses of MeHg throughout gestation and lactation. Adult female rats were given a diet containing 5 ppm Hg (as MeHg) for 8 weeks. The administration level was thought not to cause adverse effects in adult rats. The rats were then mated and subsequently given the same diet throughout gestation and after parturition. The newborn offspring were placed with the mothers until postnatal day 30. The offspring were exposed to MeHg throughout their intrauterine life through the placenta, and during the postnatal developing phase via contaminated milk. Furthermore, they were given the same diet containing MeHg for 2 months following weaning. On the day of parturition, the concentration of Hg in the brains of newborns was 1.4 times higher than that in the mothers. During the suckling period the concentration in the brain of the offspring rapidly declined to 1/5 of that at birth, suggesting that MeHg transport by milk was limited while the brain and body volumes increased rapidly. The concentration increased gradually again after the offspring started the contaminated diet. In behavioral tests performed at 5 and 6 weeks of age, MeHg-exposed rats showed a significant deficit in motor coordination in the rotarod test and a learning disability in the passive avoidance response test, compared with controls. Histopathologically, focal cerebellar dysplasia, including the heterotopic location of Purkinje cells and granule cells, was observed. These abnormalities may be induced by the effect of highly accumulated MeHg in the brain during the gestation period. Thus, although offspring are subjected to consecutive and moderate dose MeHg exposure throughout both the gestation and suckling periods, the risk is especially high during gestation but may decrease during lactation.

47. Henny CJ Hill EF Hoffman DJ Spalding MG Grove RA Nineteenth century mercury: hazard to wading birds and cormorants of the Carson River, Nevada. Ecotoxicology (2002 Aug) 11(4):213-31

    ... Immune deficiencies and neurological impairment of fledglings may affect survivability when confronted with the stresses of learning to forage and the ability to complete their first migration.

48. Penedo de Pinho A Davee Guimaraes JR Martins AS Costa PA Olavo G Valentin J Total mercury in muscle tissue of five shark species from Brazilian offshore waters: effects of feeding habit, sex, and length. Environ Res (2002 Jul) 89(3):250-8

    ... These results indicate that feeding habits influence total mercury level in sharks. ... Although mercury levels were generally higher in males than in females for all species (with the exception of S. mitsukurii), a statistically significant correlation was observed only for M. canis.

49. Tatara CP Mulvey M Newman MC Genetic and demographic responses of mercury-exposed mosquitofish (Gambusia holbrooki) populations: temporal stability and reproductive components of fitness. Environ Toxicol Chem (2002 Oct) 21(10):2191-7

    ...Mercury-exposed female mosquitofish had a lower probability of being gravid than control females (p = 0.001). Mercury-exposed females also had lower fecundity (total number of eggs and embryos) than control females (p = 0.036). Unlike the results of the more intense mercury exposures in the single generation study, no strong evidence was found that Gpi-2 genotype influenced fecundity or the probability of being gravid in both control and mercury-exposed females. ...

50. Aditya AK Chattopadhyay S Mitra S Effect of mercury and methyl parathion on the ovaries of Labeo rohita (Ham). J Environ Biol (2002 Jan) 23(1):61-4

    ... It was found that the significant decrease in RNA/DNA ratio occurs after 9 and 30 days of exposure for mercury and 30 days for methyl parathion. ... In some cases loss of metachromasia is correlated with the fall in RNA/DNA ratio. Some other abnormalities like fall in stage II: stage I oocyte ratio and necrosis was also observed.

51. Brambila E Liu J Morgan DL Beliles RP Waalkes MP Effect of mercury vapor exposure on metallothionein and glutathione s- transferase gene expression in the kidney of nonpregnant, pregnant, and neonatal rats. J Toxicol Environ Health A (2002 Sep 13) 65(17):1273-88

    Elemental mercury (Hg(0)) is a ubiquitous toxic pollutant. Exposure to Hg(0) vapor typically is by inhalation, and the kidney is the primary target organ. Glutathione (GSH) and metallothionein (MT) appear to mitigate mercury toxicity.....Hg(0) vapor exposure produced renal accumulation of mercury in nonpregnant, pregnant, and neonatal rats. However, the transplacentally exposed neonates accumulated approximately 1000-fold less mercury than adults. Hg(0) vapor exposure produced a time-dependent increase in renal MT protein in nonpregnant and pregnant rats, but not in neonatal rats. ... Activation of these genes could be part of a defensive response directed at decreasing renal mercury toxicity, and may help divert the metal away from the fetus.

52. Szasz A Barna B Gajda Z Galbacs G Kirsch-Volders M Szente M Effects of continuous low-dose exposure to organic and inorganic mercury during development on epileptogenicity in rats. Neurotoxicology (2002 Jul) 23(2):197-206

    The effects of chronic, low-dose fetal and lactational organic (MeHgCl) and inorganic (HgCl2) mercury intoxication on epileptogenicity were investigated and compared in rats. The main observations after both mercury treatments were a facilitated seizure expression and propagation evoked by 4-aminopyridine (4-AP). The seizure susceptibility of the offspring seemed to be in a parallel relation to the mercury concentration in the cortical tissue, which was significantly higher in treated animals as compared to the controls. While MeHgCl enhanced the number of ictal periods, HgCl2 facilitated the duration of seizure discharges in younger animals. HgCl2 intoxication seemed to be more permanent than MeHgCl. Changes in the summated ictal activity--which is an indication of epileptogenicity--were observed in the opposite directions in the two treated groups with increasing age. The amplitudes of seizure discharges were smaller in both mercury-treated groups than in the controls, which could be a consequence of a depressed proliferation of neurons or enhanced cell death in the neocortex. In summary, we observed that adult rats exposed to organic or inorganic mercury chemicals during their embryonic life, are more prone to epilepsy than control rats given only 4-AP.

53. Siah A Pellerin J Amiard JC Pelletier E Viglino L Delayed gametogenesis and progesterone levels in soft-shell clams (Mya arenaria) in relation to in situ contamination to organotins and heavy metals in the St. Lawrence River (Canada). Comp Biochem Physiol C Toxicol Pharmacol (2003 Jun) 135(2):145-56

There is a growing awareness that contaminants in the aquatic environment may alter steroid hormone levels and affect the reproductive success of the invertebrates. .... Sites that had intermediate levels of contaminants exhibited intermediate responses of hormones and sexual maturation stages. It is therefore suggested that TBT, DBT are endocrine disruptors in clams.

54. Massanyi P Tataruch F Slameka J Toman R Jurik R Accumulation of lead, cadmium, and mercury in liver and kidney of the brown hare (Lepus europaeus) in relation to the season, age, and sex in the West Slovakian Lowland. J Environ Sci Health A Tox Hazard Subst Environ Eng (2003 Jul) 38(7):1299-309

Concentrations of lead, cadmium, and mercury in liver and kidneys of brown hares in relation to season, age, and sex were investigated....In mercury, we report significantly higher ($p < 0.001$) median concentrations in liver (0.023 mg kg(-1)) as well as in kidney (0.068 mg kg(-1)) in winter period in comparison with all other observed periods. In relation to age the concentrations in lead and mercury in liver and kidney were very similar, without significant differences. In cadmium we report significantly higher concentrations in the liver as well as kidney in adult animals (0.154 and 1.521 mg kg(-1)) in comparison with juvenile animals (0.048 and 0.582 mg kg(-1), respectively). In comparison of the female and male brown hares we found significantly higher ($p < 0.05$) median concentration of lead in the liver of males (0.216 mg kg(-1)) than in females (0.127 mg kg(- 1)) and the level of cadmium is significantly higher ($p < 0.001$) in females (1.464 mg kg(-1) than in male brown hares (1.384 mg kg(-1)).

55. Vicente E Boer M Leite M Silva M Tramontina F Porciuncula L Dalmaz C Goncalves CA Cerebrospinal fluid S100B increases reversibly in neonates of methyl mercury-intoxicated pregnant rats. Neurotoxicology (2004 Sep) 25(5):771-7

Methylmercury (MeHg), an organic methylated form of mercury, is one of the most hazardous environmental pollutants. MeHg is a potent neurotoxin, particularly during brain development. Neurotoxicity- induced by MeHg in prenatal age can cause mental disorders, cerebral palsy and seizures. We investigated cerebrospinal fluid (CSF) and brain tissue contents of S100B, a calcium binding protein produced and secreted by astrocytes, which has trophic and toxic activity on neurons depending on concentration. .... Hippocampal tissue demonstrated increased S100B (and reduction in glial fibrillary acidic protein) immediately after birth, but not later. No changes in the S100B content were observed in cerebellum and cerebral cortex. No changes were observed in the spatial learning of these rats at adult age. These specific and reversible changes in the hippocampus could be related to the cognitive and epileptic disorders attributed to MeHg. Our results further indicate the glial involvement in the MeHg- induced neurotoxicity. The increment of CSF S100B in neonates exposed to MeHg reinforces the view that increased S100B is related to damage in the nervous system and that S100B could be a marker for MeHg-neurotoxicity. ...

56. Al-Saleh I Shinwari N El-Doush I Billedo G Al-Amodi M Khogali F Comparison of mercury levels in various tissues of albino and pigmented mice treated with two different brands of mercury skin-lightening creams. Biometals (2004 Apr) 17(2):167-75

The use of mercury containing skin-lightening creams are becoming increasingly popular among dark-skinned women. The long-term use of certain brands may cause serious health effects over

the years. In the present study, we investigated the dermal absorption of mercury and its accumulation in the tissues of albino and pigmented mice treated with two brands of mercury containing skin-lightening creams for a period of one months at different intervals. ... the study indicated that mercury was readily absorbed through the skin of both albino and pigmented mice as evidenced with its accumulation in the brain, kidney and liver tissues where the kidney had the highest mercury content and brain had the lowest (it P < 0.0001). .... Results of this study stresses the potential harm of these mercury containing skin-lightening creams regardless of their mercury contents especially for women who apply these creams frequently or for extended periods. Permanent nephrological or/and neurological deficits may occur if the damage is severe and diagnosis and treatment are delayed.

57. Ramirez-Perez T Sarma SS Nandini S Effects of mercury on the life table demography of the rotifer Brachionus calyciflorus Pallas (Rotifera). Ecotoxicology (2004 Aug) 13(6):535-44

    Mercury is highly toxic to a variety of aquatic organisms including zooplankton. The functioning of freshwater ecosystems can be altered if rotifers, being a natural food link between phytoplankton and fish larvae, are contaminated by mercuric compounds. ....Regardless of mercury concentration in the medium, gross and net reproductive values varied from 10 to 33 and 4 to 19 offspring female(-1). The longest generation time (about 9 days) of B. calyciflorus was obtained at 1.5 x 10(6) cells ml(-1) food density in control, while the shortest was 5 days at low food level and high (0.005 mg l(-1)) mercury concentration in the medium. Depending on the food level and heavy metal concentration in the medium, the rate of population growth (r) varied from 0.32 to 0.62 d(-1). In general, higher food level resulted in higher r. Except generation time, all other derived variables were significantly influenced by food level and the heavy metal concentration in the medium.

58. Frederick PC Hylton B Heath JA Spalding MG A historical record of mercury contamination in Southern Florida (USA) as inferred from avian feather tissue. Environ Toxicol Chem (2004 Jun) 23(6):1474-8

    During the late 1980s, the upper trophic-level biota of the Everglades (FL, USA) was recognized as being highly contaminated with mercury (Hg). However, the timing and pattern of that increase is poorly known, and no information is available about mercury contamination in Everglades wildlife prior to 1974. We measured methylmercury concentrations in feathers of white ibises (n = 33), great egrets (n = 7), anhingas (n = 21), and great blue herons (n = 12) from museum specimens collected from 1910 through 1980 and combined them with more recent feather samples collected from live birds (1985-2000, n = 98, 37, 49, and 7, respectively). We found no evidence of contamination of museum samples with inorganic mercuric preservatives (0.01-0.28% of total Hg in feathers). All species showed relatively low concentrations of mercury through the 1970s (<5 microl/L dry wt for anhingas, ibises, and egrets, <10 microl/L for herons). Samples from all species taken during the 1990s showed a large and significant increase (4-5X) in MeHg concentration. This evidence suggests that most of the increase in Hg deposition during the 20th century in south Florida occurred during the last two to three decades, which is consistent with information about local source deposition. Contamination levels prior to the 1970s appear to have been associated with normal reproduction in these birds, suggesting partial evidence for a threshold of reproductive impairment.

59. Heinz GH Hoffman DJ Mercury accumulation and loss in mallard eggs. Environ Toxicol Chem (2004 Jan) 23(1):222-4

    Female mallards (Anas platyrhynchos) were fed diets containing 5, 10, or 20 ppm mercury as methylmercury chloride. One egg was collected from each bird before the start of the mercury

diets and 15 eggs were collected from each bird while it was being fed mercury. The mercury diets were then replaced by uncontaminated diets, and each female was allowed to lay 29 more eggs. Mercury levels in eggs rose to about 7, 18, and 35 ppm wet-weight in females fed 5, 10, or 20 ppm mercury, respectively. Mercury levels fell to about 0.16, 0.80, and 1.7 ppm in the last egg laid by birds that had earlier been fed 5, 10, or 20 ppm mercury, respectively. Higher concentrations of mercury were found in egg albumen than in yolk, and between 95 and 100% of the mercury in the eggs was in the form of methylmercury.

60. Khan AT Atkinson A Graham TC Thompson SJ Ali S Shireen KF Effects of inorganic mercury on reproductive performance of mice. Food Chem Toxicol (2004 Apr) 42(4):571-7

    Effects of mercuric chloride (MC) on the reproductive performance of mice were evaluated. ... Fertility and survival indices were significantly reduced in the treated groups. Exposure of mice to MC did not affect their litter size. ...in MC treated females, ovary weights were significantly different from the control. There were no histomorphologic or clinical pathology effects induced by MC. These results suggested that oral exposure to 0.25-1.00 mg/kg/day of MC produced adverse effects on the reproductive performance of mice in the absence of overt mercury toxicity.

61. Burgess NM Evers DC Kaplan JD Mercury and other contaminants in common loons breeding in Atlantic Canada. Ecotoxicology (2005 Mar) 14(1-2):241-52

    Common loons (Gavia immer) were studied to assess the biomagnification of persistent contaminants in lake ecosystems in Atlantic Canada. ...Of adult loons at Kejimkujik, 92% had blood mercury levels > 4 microg/g (wet wt), which have been associated with impaired reproduction, elevated corticosterone levels, asymmetry in plumage development, and altered breeding behavior in loons there and elsewhere.

62. Henny CJ Kaiser JL Packard HA Grove RA Taft MR Assessing mercury exposure and effects to American dippers in headwater streams near mining sites. Ecotoxicology (2005 Oct) 14(7):709-25

    To evaluate mercury (Hg) exposure and possible adverse effects of Hg on American dipper (Cinclus mexicanus) reproduction, we collected eggs and nestling feathers and the larval/nymph form of three Orders of aquatic macroinvertebrates (Ephemeroptera, Plecoptera and Trichoptera = EPT) important in their diet from three major headwater tributaries of the upper Willamette River, Oregon in 2002. The Coast Fork Willamette River is contaminated with Hg due to historical cinnabar (HgS) mining at the Black Butte Mine; the Row River is affected by past gold-mining operations located within the Bohemia Mining District, where Hg was used in the amalgamation process to recover gold; and the Middle Fork Willamette River is the reference area with no known mining. Methyl mercury (MeHg) concentrations (geometric mean) in composite EPT larvae (111.9 ng/g dry weight [dw] or 19.8 ng/g wet weight [ww]), dipper eggs (38.5 ng/g ww) and nestling feathers (1158 ng/g ww) collected from the Coast Fork Willamette were significantly higher than MeHg concentrations in EPT and dipper samples from other streams. ...Birds feeding almost exclusively on fish (e.g., osprey [Pandion haliaetus]) and usually found further downstream from the headwaters would not be adequately represented by dippers given the higher MeHg concentrations in fish resulting from biomagnification, compared to lower trophic level invertebrates.

63. Tavares PC Monteiro LR Lopes RJ Pereira ME Duarte AC Furness RW Variation of mercury contamination in chicks of little Tern Sterna albifrons in southwest Europe: brood, age, and colony related effects. Bull Environ Contam Toxicol (2005 Jan) 74(1):177-83

64. Milosevic M Petrovic S Demajo M Horvat A Effects of metal ions on plasma membrane Mg2+-atpase in rat uterus and ovaries. Ann N Y Acad Sci (2005 Jun) 1048:445-8

    The in vitro effects of cadmium and mercury were investigated on the Mg(2+)-ATPase activity of plasma membranes from the rat ovary and uterus. ATP hydrolyzing activities were significant and dose- dependent-inhibited in both plasma membrane preparations by both metals. According to the IC(50) and apparent K(i), Cd(2+) was most potent in the ovary, while Hg(2+) was most potent in the uterus. In ovaries and uterus, Cd(2+) inhibits competitively, while Hg(2+) inhibits noncompetitively in both organs. The observed inhibition was a consequence of direct action of the chosen metal ions on the enzyme protein and by decreasing ATP hydrolysis, Hg(2+) and Cd(2+) may affect mammalian fertility.

65. Toschik PC Rattner BA McGowan PC Christman MC Carter DB Hale RC Matson CW Ottinger MA Effects of contaminant exposure on reproductive success of ospreys (Pandion haliaetus) nesting in Delaware River and Bay, USA. Environ Toxicol Chem (2005 Mar) 24(3):617-28

    Despite serious water-quality problems and pollutant loading and retention, Delaware River and Bay (USA) provide important wildlife habitat. In 2002, we conducted a comprehensive evaluation of contaminant exposure and reproduction of ospreys (Pandion haliaetus) breeding in Delaware River and Bay.... Several perfluorinated compounds and PBDEs were detected in eggs at concentrations approaching 1 microg/g wet weight. These findings provide evidence that contaminants continue to be a significant stressor on osprey productivity in the northern Delaware River and Bay.

66. Papp A Nagymajtenyi L Vezer T Subchronic mercury treatment of rats in different phases of ontogenesis: functional effects on the central and peripheral nervous system. Food Chem Toxicol (2005 Jan) 43(1):77-85

    Electrophysiological changes caused by inorganic mercury administration during the pre- and/or postnatal development were studied. ....The rats' spontaneous and evoked electrophysiological activity underwent dose- and treatment-dependent changes following the treatment (increased frequency of spontaneous activity, lengthened latencies and duration of evoked potentials, lower conduction velocity of the peripheral nerve, etc.). In the same rats, however, the treatment failed to cause major signs of general intoxication. The results emphasize the functional neurotoxic risk arising from the continuous presence of inorganic mercury in the human environment, and point to possible use of early functional changes for monitoring the effects of mercury.

67. Sindhe VR Kulkarni RS Fecundity of the freshwater fish, Notopterus notopterus (Pallas) in natural and heavy metal contaminated water. J Environ Biol (2005 Apr) 26(2):287-90

    The knowledge of fecundity of fish from a specific aquatic body is extremely important in the successful management and exploitation of its fishery. In the present investigation the fecundity of the freshwater fish, Notopterus notopterus was studied in fish collected from a natural aquatic body (Sirnoor nala) near Gulbarga and also in fish exposed to some heavy metal contamination (HgCl2, CdCl2 and their combination) at sublethal concentration for 15 days in the laboratory. ... The fish, N. notopterus has bigger oocytes and are few in number. Studies in the fish exposed to heavy metals indicate that significant reduction in these parameters after exposure to heavy metals at sublethal concentration was noticed. The fecundity has straight line relationship with total length, body weight, ovary length and ovary weight in control fish which did not alter after heavy metal exposure. This study provides the viability of species in only specific environment.

68. Day JJ Reed MN Newland MC Neuromotor deficits and mercury concentrations in rats exposed to methyl mercury and fish oil. Neurotoxicol Teratol (2005 Jul-Aug) 27(4):629-41

    It has been suggested that docosahexaenoic acid (DHA) or other n-3 polyunsaturated fatty acids (PUFAs) may prevent or ameliorate methyl mercury's neurotoxicity. ... Forelimb grip strength declined with age for all groups, but the decline was greatest for those exposed chronically to 400 microg/kg/day of methyl mercury. This high-dose group also displayed hind limb crossing, gait disorders, and diminished running wheel activity. Dietary n-3 fatty acids did not influence these effects. Chronic exposure to 400 microg/kg/day of methyl mercury resulted in blood and brain concentrations of about 70 and 10 ppm, respectively, approximately 50-fold higher than concentrations seen in rats exposed to 40 microg/kg/day. Rats that became ill and died before the experiment ended had higher concentrations of mercury than their cohorts who survived to the end. Organic mercury was highly correlated with total mercury in these rats but inorganic mercury remained approximately constant. Some deaths were due to urolithiasis (kidney or bladder stones) associated with a dietary contaminant and that was eventually fatal to 22% of the females in the colony. Neurobehavioral effects are reported on rats that did not become ill.

69. Webb MA Feist GW Fitzpatrick MS Foster EP Schreck CB Plumlee M Wong C Gundersen DT Mercury concentrations in gonad, liver, and muscle of white sturgeon Acipenser transmontanus in the lower Columbia River. Arch Environ Contam Toxicol (2006 Apr) 50(3):443-51

    This study determined the partitioning of total mercury in liver, gonad, and cheek muscle of white sturgeon (Acipenser transmonatus) in the lower Columbia River. The relationship between tissue mercury concentrations and various physiologic parameters was assessed. .... Mean tissue mercury concentrations were higher in muscle compared with liver and gonad at all sampling locations, except Bonneville Reservoir where mean liver mercury content was the highest tissue concentration observed in the study. Significant negative correlations between plasma androgens (T and KT) and muscle mercury content and plasma E2 and liver mercury content were found. A significant positive linear relationship between white sturgeon age and liver mercury concentrations was evident. Significant negative correlations between CF and relative weight and gonad and liver mercury content were found. In addition, immature male sturgeon with increased gonad mercury content had decreased GSIs. These results suggest that mercury, in the form of methylmercury, may have an effect on the reproductive potential of white sturgeon.

70. Morgan DL Price HC Fernando R Chanda SM O'Connor RW Barone SS Herr DW Beliles RP Gestational mercury vapor exposure and diet contribute to mercury accumulation in neonatal rats. Environ Health Perspect (2006 May) 114(5):735-9

    Exposure of pregnant Long-Evans rats to elemental mercury (Hg0) vapor resulted in a significant accumulation of Hg in tissues of neonates. Because elevated Hg in neonatal tissues may adversely affect growth and development, we were interested in how rapidly Hg was eliminated from neonatal tissues. ...Before weaning, the Hg levels in neonatal tissues were proportional to maternal exposure concentrations and were highest in kidney followed by liver and then brain. There was no elimination of Hg between birth and weaning, indicating that neonates were exposed continuously to elevated levels of Hg during postpartum growth and development. Consumption of milk from exposed dams resulted in a slight increase in kidney Hg concentration during this period. Unexpectedly, neonatal Hg accumulation increased rapidly after weaning. Increased Hg was measured in both control and exposed neonates and was attributed to consumption of NIH-07 diet containing trace levels of Hg. By PND90, tissue Hg levels equilibrated at concentrations similar to those in unexposed adult Long-Evans rats fed the same diet. These

data indicate that dietary exposure to trace amounts of Hg can result in a significantly greater accumulation of Hg in neonates than gestational exposure to high concentrations of Hg0 vapor.

71. Mohapatra SP Nikolova I Mitchell A Managing mercury in the great lakes: an analytical review of abatement policies. J Environ Manage (2007 Apr) 83(1):80-92

    Mercury, a toxic metal known to have several deleterious affects on human health, has been one of the principal contaminants of concern in the Great Lakes basin. There are numerous anthropogenic sources of mercury to the Great Lakes area. Combustion of coal, smelting of non ferrous metals, and incineration of municipal and medical waste are major sources of mercury emissions in the region. In addition to North American anthropogenic emissions, global atmospheric emissions also significantly contribute to the deposition of mercury in the Great Lakes basin. Both the USA and Canada have agreed to reduce human exposure to mercury in the Great Lakes basin and have significantly curtailed mercury load to this region through individual and joint efforts. However, many important mercury sources, such as coal-fired power plants, still exist in the vicinity of the Great Lakes. More serious actions to drastically reduce mercury sources by employing alternative energy sources, restricting mercury trade and banning various mercury containing consumer products, such as dental amalgam are as essential as cleaning up the historical deposits of mercury in the basin. A strong political will and mass momentum are crucial for efficient mercury management. International cooperation is equally important.

72. Chen MH Chen CY Chang SK Huang SW Total and organic mercury concentrations in the white muscles of swordfish (Xiphias gladius) from the Indian and Atlantic oceans. Food Addit Contam (2007 Sep) 24(9):969-75

    A total of 226 swordfish samples collected from Taiwanese fishing vessels in the Indian and Atlantic oceans were examined for total mercury (THg) and organic Hg (OHg). Analysis of 56 pooled white muscle samples showed that THg and OHg concentrations ranged from 0.056 to 3.97 (1.3 +/- 0.97) and from 0.043 to 3.92 (1.01 +/- 0.82) microg g(-1) flesh mass, respectively. These values were similar to those from various previous studies during the past three decades. THg and OHg were significantly linearly correlated with fork length (FL, cm) of the fish from Indian and Atlantic oceans; however, there was no significant OHg%-FL relationship. OHg and THg also were significantly correlated. Fishes with FL < or = 140 cm met the methyl Hg (meHg) regulatory standard set by the European Commission Decision (meHg < or = 1.0); and fish with FL < or = 211 cm met the Taiwanese Food and Hygiene Standard (meHg < or = 2.0). Weekly swordfish consumption rates and amounts are recommended accordingly.

73. Weis P Ashley JT Contaminants in fish of the Hackensack Meadowlands, New Jersey: size, sex, and seasonal relationships as related to health risks. Arch Environ Contam Toxicol (2007 Jan) 52(1):80-9

    The trace metal content and related safety (health risk) of Hackensack River fish were assessed within the Hackensack Meadowlands of New Jersey, USA. E...Of the eight elements analyzed, the one that accumulates to the point of being a health risk in white perch is mercury (Hg). Relationships between mercury concentrations and size and with collection season were observed; correlation with lipid content, total polychlorinated biphenyl (PCB) content, or collection site were very weak. Only 18% of the Hg was methylated in October (n = 8), whereas June and July fish (n = 12) had 100% methylation of Hg. White perch should not be considered edible because the Hg level exceeded the 51one meal per month51 action level of 0.47 microg/g wet weight (ppm) in 32% of our catch and 2.5% exceeded the 51no consumption at all51 level of 1 microg/g. The larger fish represent greater risk for Hg. Furthermore, the warmer months, when more recreational fishing takes place, might present greater risk. A more significant reason for

avoiding white perch is the PCB contamination because 40% of these fish exceeded the US Food and Drug Administration (FDA) action level of 2000 ng/g for PCBs and all white perch exceeded the US Environmental Protection Agency cancer/health guideline (49 ng/g) of no more than one meal/month. In fact, nearly all were 10 times that advisory level. There were differences between male and female white perch PCB levels, with nearly all of those above the US FDA action level being male. Forage fish (mummichogs and Atlantic silversides) were similarly analyzed, but no correlations were found with any other parameters. The relationship of collection site to contaminants cannot be demonstrated because sufficient numbers of game fish could not be collected at many sites at all seasons.

74. Heckel PF Keener TC Sex differences noted in mercury bioaccumulation in Magicicada cassini. Chemosphere (2007 Aug) 69(1):79-81

    This study focuses on quantitative differences in mercury bioaccumulation based on the sex of the specimen. The species of interest is an herbivorous, terrestrial insect. Male and female periodical cicadas (genus: Magicicada) analyzed using combustion atomic absorption spectrophotometry exhibit different levels of mercury bioaccumulation. The concentration of mercury in Magicicada cassini males was significantly higher than the concentration in females of the same species.

75. Kojadinovic J Potier M Le Corre M Cosson RP Bustamante P Bioaccumulation of trace elements in pelagic fish from the Western Indian Ocean. Environ Pollut (2007 Mar) 146(2):548-66

    Trace elements were analyzed in fish of commercial interest to determine their importance in marine systems of the Western Indian Ocean and their bioaccumulation patterns. The results are equivalent or lower than levels reported in ichthyofauna worldwide. Certain values of muscular Cd, Hg, Pb and Zn were, however, above thresholds for human consumption. Levels varied among tissues, species and fish length, but were seldom influenced by the nutritional condition of the fish, its gender and its reproductive status. Correlations between hepatic Hg and Se levels in Swordfish (r2=0.747) and Yellowfin Tunas (r2=0.226), and among metallothionein linking metals imply the existence of detoxification processes in these species. Level differences between fish from the Mozambique Channel and Reunion Island reflect differences of diets rather than differences of elemental availability in both environments.

76. Sanchez-Chardi A Lopez-Fuster MJ Nadal J Bioaccumulation of lead, mercury, and cadmium in the greater white- toothed shrew, Crocidura russula, from the Ebro Delta (NE Spain): sex- and age-dependent variation. Environ Pollut (2007 Jan) 145(1):7-14

    We quantified bioaccumulation of lead, mercury, and cadmium in bones from 105 greater white-toothed shrews (Crocidura russula) collected at the Ebro Delta, a polluted area, and the Medas Islands, a control site. Lead and mercury levels varied with site, age, and sex, although statistical significances depended on each factor. Globally, shrews from the polluted area exhibited significantly higher concentrations of Pb and Hg. Increment of Pb with age was particularly remarkable in wetland animals and was interpreted in relation to human activities, namely hunting. Unlike males, females from the Ebro Delta maintained low Hg levels, which were associated with gestation and lactation. Cadmium levels did not differ between sites, sexes, or ages. This study provides the first data on heavy metals in mammals from this wetland and suggests that C. russula is a good bioindicator of metal pollution. We concluded that sex and age may represent an important source of variation in the bioaccumulation of these metals in wild populations.

76b Franco JL Braga Hde C Nunes AK Ribas CM Stringari J Silva AP Garcia Pomblum SC Moro AM Bohrer D Santos AR Dafre AL Farina M Lactational exposure to inorganic mercury: evidence of neurotoxic effects. Neurotoxicol Teratol (2007 May-Jun) 29(3):360-7

> This study examined the effects of inorganic mercury (mercuric chloride - HgCl2) exposure exclusively through maternal milk on biochemical parameters related to oxidative stress (glutathione and thiobarbituric acid reactive substances levels, glutathione peroxidase and glutathione reductase activities) in the cerebellum of weanling mice. These parameters were also evaluated in the cerebellum of mothers, which were subjected to intraperitoneal injections of HgCl2 (0, 0.5 and 1.5 mg/kg, once a day) during the lactational period. Considering the relationship between cerebellar function and motor activity, the presence of motor impairment was also evaluated in the offspring exposed to HgCl2 during lactation. After treatments (at weaning), pups lactationally exposed to inorganic mercury showed high levels of mercury in the cerebellar tissue, as well as significant impairment in motor performance in the rotarod task and decreased locomotor activity in the open field. Offspring and dams did not show changes in cerebellar glutathione levels or glutathione peroxidase activity. In pups, lactational exposure to inorganic mercury significantly increased cerebellar lipoperoxidation, as well as the activity of cerebellar glutathione reductase. However, these phenomena were not observed in dams. These results indicate that inorganic mercury exposure through maternal milk is capable of inducing biochemical changes in the cerebellum of weanling mice, as well as motor deficit and these phenomena appear to be related to the pro-oxidative properties of inorganic mercury.

77. Coccini T Randine G Castoldi AF Acerbi D Manzo L Methylmercury interaction with lymphocyte cholinergic muscarinic receptors in developing rats. Environ Res (2007 Feb) 103(2):229-37

> Cerebral cholinergic muscarinic receptors (MR) have been suggested as one of the sensitive biochemical endpoints of the central nervous system altered by developmental exposure to the widespread seafood contaminant methylmercury (MeHg). In adult rats, MeHg has been shown to alter MR binding both in the brain and lymphocytes, supporting the use of MR in blood cells as a surrogate marker of CNS changes. The effects of MeHg have been evaluated on rat lymphocyte MR binding (using [3H]QNB as specific muscarinic ligand) in vivo (after perinatal exposure) and in vitro. ... The finding that the MR binding is a target for the effects of MeHg in peripheral blood cells is in accordance with our previous data in brain ... The similarity of MeHg IC50 binding data between human and rat in peripheral tissues suggests the possible application of such biomarker to humans exposed to environmental chemicals.

78. Falluel-Morel A Sokolowski K Sisti HM Zhou X Shors TJ Dicicco-Bloom E Developmental mercury exposure elicits acute hippocampal cell death, reductions in neurogenesis, and severe learning deficits during puberty. J Neurochem (2007 Dec) 103(5):1968-81

> Normal brain development requires coordinated regulation of several processes including proliferation, differentiation, and cell death. Multiple factors from endogenous and exogenous sources interact to elicit positive as well as negative regulation of these processes. In particular, the perinatal rat brain is highly vulnerable to specific developmental insults that produce later cognitive abnormalities. We used this model to examine the developmental effects of an exogenous factor of great concern, methylmercury (MeHg). Seven-day-old rats received a single injection of MeHg (5 microg/gbw). MeHg inhibited DNA synthesis by 44% and reduced levels of cyclins D1, D3, and E at 24 h in the hippocampus, but not the cerebellum. Toxicity was associated acutely with caspase-dependent programmed cell death. MeHg exposure led to reductions in hippocampal size (21%) and cell numbers 2 weeks later, especially in the granule cell layer (16%) and hilus (50%) of the dentate gyrus defined stereologically, suggesting that neurons might be

particularly vulnerable. Consistent with this, perinatal exposure led to profound deficits in juvenile hippocampal- dependent learning during training on a spatial navigation task. In aggregate, these studies indicate that exposure to one dose of MeHg during the perinatal period acutely induces apoptotic cell death, which results in later deficits in hippocampal structure and function.

79. Pierce GJ Santos MB Murphy S Learmonth JA Zuur AF Rogan E Bustamante P Caurant F Lahaye V Ridoux V Zegers BN Mets A Addink M Smeenk C Jauniaux T Law RJ Dabin W Lopez A Alonso Farre JM Gonzalez AF Guerra A Garcia-Hartmann M Reid RJ Moffat CF Lockyer C Boon JP Bioaccumulation of persistent organic pollutants in female common dolphins (Delphinus delphis) and harbour porpoises (Phocoena phocoena) from western European seas: geographical trends, causal factors and effects on reproduction and mortality. Environ Pollut (2008 May) 153(2):401-15

    Concentrations of polychlorinated biphenyls (PCBs) in blubber of female common dolphins and harbour porpoises from the Atlantic coast of Europe were frequently above the threshold at which effects on reproduction could be expected, in 40% and 47% of cases respectively. This rose to 74% for porpoises from the southern North Sea. PCB concentrations were also high in southern North Sea fish. The average pregnancy rate recorded in porpoises (42%) in the study area was lower than in the western Atlantic but that in common dolphins (25%) was similar to that of the western Atlantic population. Porpoises that died from disease or parasitic infection had higher concentrations of persistent organic pollutants (POPs) than animals dying from other causes. Few of the common dolphins sampled had died from disease or parasitic infection. POP profiles in common dolphin blubber were related to individual feeding history while those in porpoises were more strongly related to condition.

80. Su L Wang M Yin ST Wang HL Chen L Sun LG Ruan DY The interaction of selenium and mercury in the accumulations and oxidative stress of rat tissues. Ecotoxicol Environ Saf (2008 Jul) 70(3):483-9

    This study evaluates the interaction of selenium (Se) and mercury (Hg) in the accumulations and oxidative stress of rat tissues. ...Results showed that Hg was deposited mainly in kidney. Se could decrease Hg content in kidney but increase it in blood and liver. Hg decreased GSH and SOD and increased MDA levels in most detected tissues, while Se took on a counteraction effect in same tissues. This study suggests that interactions of Se and Hg affect their accumulation and Se may antagonize Hg-induced inhibition on organic activities.

81. Yang J Kunito T Anan Y Tanabe S Miyazaki N Subcellular distribution of trace elements in kidney of a mother- fetus pair of Dall's porpoises (Phocoenoides dalli). Chemosphere (2008 Jan) 70(7):1203-10

    Total and subcellular renal Zn, Cu, Se, Mn, V, Hg, Cd and Ag were determined by a mother-fetus pair of Dall's porpoises (Phocoenoides dalli). All element concentrations in the maternal individual were higher than those in the fetal individual. Most of total renal elements studied were present in the cytosol of both animals. In maternal cytosol, Mn, Hg and Ag were present in high molecular weight substances (HMW); Se was in low molecular weight substances (LMW); Zn, Cu, and Cd were in metallothionein (MT), mostly; and the distribution of V in percentage among the three renal cytosolic fractions was similar. In fetal cytosol, Zn, Mn, Hg, V, Cd, and Ag were present in HMW, Cu was present in MT, mostly. In contrast, Se was observed mostly in both LMW and HMW. MT isoforms were characterized. Three obvious peaks in retention time were found in either the maternal or fetal MT. The highest elemental ion intensities were in the 7.8min peak for the mother, and in the 4.3min peak for the fetus, respectively, implying that different MT

isoforms may be closely associated with elemental accumulation between maternal and fetal renal cytosols.

82. Hill EF Henny CJ Grove RA Mercury and drought along the lower Carson River, Nevada: II. Snowy egret and black-crowned night-heron reproduction on Lahontan Reservoir, 1997--2006. Ecotoxicology (2008 Feb) 17(2):117-31

    Mercury concentrations in the floodplain of the Carson River Basin in northwestern Nevada are some of the highest ever reported in a natural system. Thus, a portion of the basin including Lahontan Reservoir was placed on the U.S. Environmental Protection Agency's Natural Priorities List for research and cleanup. ... A putative biological effect threshold of 2.0 microg THg/g in whole blood for young of both species was evaluated, which was frequently exceeded, but with no evidence, while still in the colony, of an association with direct mortality. An evaluation of physiological associations with blood residues and post-fledging survival will be presented in future reports in this series.

83. Evers DC Savoy LJ DeSorbo CR Yates DE Hanson W Taylor KM Siegel LS Cooley JH Bank MS Major A Munney K Mower BF Vogel HS Schoch N Pokras M Goodale MW Fair J Adverse effects from environmental mercury loads on breeding common loons. Ecotoxicology (2008 Feb) 17(2):69-81

    Anthropogenic inputs of mercury (Hg) into the environment have significantly increased in the past century. Concurrently, the availability of methylmercury (MeHg) in aquatic systems has increased to levels posing risks to ecological and human health. We use the common loon (Gavia immer) as an upper trophic level bioindicator of aquatic Hg toxicity in freshwater lakes. ... Mercury body burdens in adult loons increased an average of 8.4% per year. Increasing Hg body burdens reduced the number of fledged chicks per territorial pair, with highest risk loons producing 41% fewer fledged young than our reference group. Our multiple endpoints establish adverse effect thresholds for adult loons at 3.0 ug/g (wet weight) in blood and 40.0 ug/g (fresh weight) in feathers. Mercury contamination in parts of Maine and New Hampshire is a driving stressor for creating breeding population sinks

84. Brasso RL Cristol DA Effects of mercury exposure on the reproductive success of tree swallows (Tachycineta bicolor). Ecotoxicology (2008 Feb) 17(2):133-41

    An experimental tree swallow population was established in the headwaters of the Shenandoah River, Virginia, USA to assess the accumulation and effects of mercury contamination on birds that eat emergent aquatic insects. One tributary, the South River, was contaminated with mercury before 1950. Reproductive success of swallows nesting within 50 m of this river was compared to that of three uncontaminated reference tributaries in 2005 and 2006. Female swallows on the contaminated stretch of river had significantly elevated blood and feather total mercury (blood: 3.56 +/- 2.41 ppm ww vs. 0.17 +/- 0.15 ppm reference; feather: 13.55 +/- 6.94 ppm vs. 2.34 +/- 0.87 ppm reference), possibly the highest ever reported for an insectivorous songbird. Insects collected by the swallows to be fed to nestlings averaged 0.97 +/- 1.11 ppm dw total mercury, significantly higher than on reference sites. Swallows in the contaminated area produced fewer fledglings than those in reference areas. The effect of mercury contamination on productivity was detectable only for young females in the contaminated area that were breeding for the first time in 2006, a segment of the population that may already have been stressed by inexperience. Tree swallows served as practical and effective biomonitors for mercury levels and effects and have great potential as proxy biomonitors for more logistically challenging birds such as loons or eagles.

85. Somers CM Valdes EV Kjoss VA Vaillancourt AL Quinn JS Influence of a contaminated fish diet on germline expanded-simple- tandem-repeat mutation frequency in mice. Environ Mol Mutagen (2008 Apr) 49(3):238-48

    Herring gulls (Larus argentatus) in polluted areas on the North American Great Lakes were previously shown to have elevated germline mutation frequencies at minisatellite DNA loci. Airborne or dietary contaminants likely caused induced mutations, but the importance of each exposure type was unknown. Follow-up experiments with lab mice determined that air pollution significantly induced germline mutations; however, an evaluation of mutations induced by the diet of herring gulls has not yet been conducted. ..... Our findings suggest that a contaminated fish diet may contribute to the elevated germline mutation frequencies observed previously in gulls at this site, but air pollution is likely a more important route of exposure.

86. Pilones K Tatum A Gavalchin J Gestational exposure to mercury leads to persistent changes in T-cell phenotype and function in adult DBF1 mice. J Immunotoxicol (2009 Sep) 6(3):161-70

    Previously, we showed that in utero exposure to mercury induced phenotypic changes in fetal immune cells. Here, we sought to determine whether the effects of in utero exposure on immune cells persisted in the adult. ... The results of our study revealed that exposure of the developing immune system to relatively low levels of inorganic mercury could lead to persistent alterations in adult immune cell phenotypes and functions. These changes could pose a relevant health risk, if they contribute to impaired responses to pathogens and/or an increased risk for the development of atopy, asthma or possibly autoimmune diseases.

87. Orct T Lazarus M Jurasovic J Blanusa M Piasek M Kostial K Influence of selenium dose on mercury distribution and retention in suckling rats. J Appl Toxicol (2009 Oct) 29(7):585-9

    It is well known that metal-metal interactions in the body are age- dependent. We studied the influence of increasing selenium (Se) doses on mercury (Hg) distribution and retention in the postnatal period in Hg-exposed suckling rats. ... Results showed that in all samples Se concentrations rose almost proportionally to the dose of Se given to pups. Mercury concentration in organs, plasma and urine decreased with higher oral doses of Se. However, Hg concentration in erythrocytes increased with increasing Se dose. There was evidently a redistribution of Hg from plasma to erythrocytes at higher ratio of Se:Hg. Approximately equimolar doses of Se and Hg are necessary to produce maximum uptake of Hg by plasma and liver and minimum retention of Hg in the kidney and erythrocytes.

88. De La Rosa D Lima L Olivares-Rieumont S Graham DW Enriquez I Diaz O Bastias JM Munoz O Assessment of total mercury levels in Clarias gariepinus from the Sagua la Grande River, Cuba. Bull Environ Contam Toxicol (2009 Jan) 82(1):101-5

    Total mercury levels (Thg) were quantified in Clarias gariepinus captured from the Sagua la Grande River (Cuba) in the vicinity of an active chlor-alkali plant, and relationships among place of capture; fish size, weight, and sex; and THg levels were assessed. THg levels ranged from 67 to 375 ng/g ww in collected fish, never exceeding the Cuban recommended maximum limit for fish consumption of 500 ng/g ww. No significant correlation was observed between mercury levels and fish allometric characteristics ($p < 0.05$); however, levels were significantly higher in fish captured below the chlor-alkali facility, suggesting a connection between mercury bioaccumulation and plant discharges.

89. Lanszki J Orosz E Sugar L Metal levels in tissues of Eurasian otters (Lutra lutra) from Hungary: variation with sex, age, condition and location. Chemosphere (2009 Feb) 74(5):741-3

Liver samples of Eurasian otters from various parts of Hungary were analysed for mercury, copper, zinc, lead and cadmium. Only zinc concentration was significantly higher in females. Higher mercury and cadmium concentrations in adults and higher zinc values in immature otters were measured. Accumulation of mercury, copper and zinc in tissues increased with the declining condition of animals. Mercury and copper were detected with higher values in samples from large rivers.

90. Burger J Gochfeld M Jeitner C Burke S Volz CD Snigaroff R Snigaroff D Shukla T Shukla S Mercury and other metals in eggs and feathers of glaucous-winged gulls (Larus glaucescens) in the Aleutians. Environ Monit Assess (2009 May) 152(1-4):179-94

    Levels of mercury and other contaminants should be lower in birds nesting on isolated oceanic islands and at high latitudes without any local or regional sources of contamination, compared to more urban and industrialized temperate regions. We examined concentrations of arsenic, cadmium, chromium, lead, manganese, mercury and selenium in the eggs, and the feathers of fledgling and adult glaucous-winged gulls (Larus glaucescens) nesting in breeding colonies on Adak, Amchitka, and Kiska Islands in the Aleutian Chain of Alaska in the Bering Sea/North Pacific. ..... levels of mercury in some gull eggs are within a range suggesting that several eggs should not be eaten in one day by sensitive humans.

91. Badzinski SS Flint PL Gorman KB Petrie SA Relationships between hepatic trace element concentrations, reproductive status, and body condition of female greater scaup. Environ Pollut (2009 Jun) 157(6):1886-93

    We collected female greater scaup (Aythya marila) on the Yukon- Kuskokwim Delta, Alaska during two breeding seasons to determine if concentrations of 18 trace elements in livers and eggs were elevated and if hepatic concentrations correlated with body condition or affected reproductive status. Fifty-six percent, 5%, and 42% of females, respectively, had elevated hepatic cadmium (Cd: >3 microg g(- 1) dry weight [dw]), mercury (Hg: >3 microg g(-1) dw), and selenium (Se: >10 microg g(-1) dw). Somatic protein and lipid reserves were not correlated with hepatic Cd or Hg, but there was a weak negative correlation between protein and Se. Hepatic Cd, Hg, and Se were similar in females that had and had not initiated egg production. In a sample of six eggs, 33% and 100%, respectively, contained Se and Hg, but concentrations were below embryotoxicity thresholds.

92. Gertz E Study reveals new mercury risks for fish and birds. Environ Sci Technol (2009 Dec 15) 43(24):9048-9

93. Ackerman JT Eagles-Smith CA Integrating toxicity risk in bird eggs and chicks: using chick down feathers to estimate mercury concentrations in eggs.Environ Sci Technol (2009 Mar 15) 43(6):2166-72

    The concentration of mercury (Hg) in eggs that causes reduced hatching success is regarded as a critical end point for Hg toxicity in birds.. Our results demonstrate the utility of using down feathers of chicks < or =10 days of age to nonlethally predict Hg in eggs and thus provide the ability to develop exposure thresholds for eggs that incorporate in ovo Hg's effects on both egg hatchability and subsequent chick mortality.

94. Gariboldi JC Bryan AL Jagoe CH Annual and regional variation in mercury concentrations in wood stork nestlings. Environ Toxicol Chem (2001 Jul) 20(7):1551-6

Mercury concentrations were measured in blood, down, and feathers from approximately 300 wood stork nestlings in one South Carolina, USA, and four Georgia, USA, colonies from 1996 to 1999. Coastal nestlings generally had lower mercury concentrations than those from inland colonies. Inter-year differences were also apparent, particularly for coastal colonies, where nestling mercury concentrations were higher in 1998 than in 1997 or 1999. In 1998, a wet winter followed by a dry spring and summer produced ideal freshwater foraging conditions and mercury concentrations in coastal nestlings were higher than during the two dry years. There was little inter-year variation in mercury concentrations in nestlings from inland colonies, as parent storks from these colonies forage exclusively in freshwater habitats regardless of rainfall patterns. These results suggest that greater risk of mercury exposure to nestlings is associated with use of freshwater foraging habitats.

95. Crump KL Trudeau VL Mercury-induced reproductive impairment in fish. Environ Toxicol Chem (2009 May) 28(5):895-907

    Mercury is a potent neurotoxin, and increasing levels have led to concern for human and wildlife health in many regions of the world. During the past three decades, studies in fish have examined the effects of sublethal mercury exposure on a range of endpoints within the reproductive axis. Mercury studies have varied from highly concentrated aqueous exposures to ecologically relevant dietary exposures using levels comparable to those currently found in the environment. ...The evidence presented suggests that the inhibitory effects of mercury on reproduction occur at multiple sites within the reproductive axis, including the hypothalamus, pituitary, and gonads. Accumulation of mercury in the fish brain has resulted in reduced neurosecretory material, hypothalamic neuron degeneration, and alterations in parameters of monoaminergic neurotransmission. At the level of the pituitary, mercury exposure has reduced and/or inactivated gonadotropin-secreting cells. Finally, studies have examined the effects of mercury on the reproductive organs and demonstrated a range of effects, including reductions in gonad size, circulating reproductive steroids, gamete production, and spawning success. Despite some variation between studies, there appears to be sufficient evidence from laboratory studies to link exposure to mercury with reproductive impairment in many fish species. Currently, the mechanisms underlying these effects are unknown; however, several physiological and cellular mechanisms are proposed within this review.

96. Conover MR Vest JL Selenium and mercury concentrations in California gulls breeding on the Great Salt Lake, Utah, USA. Environ Toxicol Chem (2009 Feb) 28(2):324-9

    We examined selenium (Se) and mercury (Hg) concentrations in adult California gulls (Larus californicus) nesting on the Great Salt Lake, Utah, USA, during 2006 and 2007. ...

97. Zarnescu O Tracing the accumulation and effects of mercury uptake in the previtellogenic ovary of crucian carp, Carassius auratus gibelio by autometallography and caspase-3 immunohistochemistry. Histol Histopathol (2009 Feb) 24(2):141-8

    The aims of the present study were to apply the AMG technique for localization of mercury at the light and electron microscopic level in the ovary of crucian carp after exposure to mercuric chloride and to find out if this heavy metal induces expression of caspase-3. Depending on the stage of ovarian follicle development, two patterns of mercury accumulation have been found in previtellogenic ovary of crucian carp. The first mercury accumulation pattern has been found in the early previtellogenic oocyte without zona radiata. In these oocytes, mercury accumulates into an ooplasmic region that seems to correspond to the Balbiani body (32-65 microm oocyte diameter), throughout the cytoplasm (84-116 microm oocyte diameter) and in the cortical

cytoplasm (approximately 180 microm oocyte diameter). The second mercury accumulation pattern has been found in the late previtellogenic oocyte with cortical alveoli (229-330 microm oocyte diameter). Ultrastructural observations have shown grains of silver-enhanced mercury inside coated vesicles, the cortical lysosome-like bodies or multivesicular bodies and cortical alveoli. Immunohistochemistry reaction for caspase-3 was positive in nuclei of the early previtellogenic oocyte and Balbiani body.

98. Olivero-Verbel J Caballero-Gallardo K Torres-Fuentes N Assessment of mercury in muscle of fish from Cartagena Bay, a tropical estuary at the north of Colombia. Int J Environ Health Res (2009 Oct) 19(5):343-55

    Fish belonging to several trophic levels from Cartagena Bay, a tropical estuary, were collected and analyzed for total mercury (T- Hg) concentrations in muscle. ... Although results suggest fish from the bay pose a low health threat for humans in terms of Hg exposure, vulnerable groups such as pregnant women, should avoid eating large size carnivorous species. Knowledge about species with low Hg content should be widespread within fishing communities, guaranteeing adequate nutrition by including fish in the diet and reducing the risk of Hg poisoning.

99. Nigam R Linshy VN Kurtarkar SR Saraswat R Effects of sudden stress due to heavy metal mercury on benthic foraminifer Rosalina leei: laboratory culture experiment. Mar Pollut Bull (2009) 59(8-12):362-8

    Laboratory culture experiments were carried out to understand the response of benthic foraminifer Rosalina leei to gradual as well as sudden addition of heavy metal mercury into the media. When mercury was added suddenly, specimens did not show any change in morphology during the initial 40 days. However, later on, out of all the specimens subjected to mercury concentrations up to 150 ng/l, 75% developed deformities, whereas all the specimens subjected to 150-275 ng/l Hg concentrations, had deformed chambers. All specimens kept at 300 ng/l Hg concentration died within 20 days. In addition to this, irregularities were also observed in the rate of reproduction, number of juveniles produced and the survival rate of the juveniles. Where as in an earlier experiment where Hg concentration was increased gradually, irregularities in the newly added chambers were noticed only in case of specimens subjected to very high (180 ng/l) Hg concentration. However, during this experiment, growth was found to be inversely proportional to the mercury concentration.

100. Ramos R Gonzalez-Solis J Forero MG Moreno R Gomez-Diaz E Ruiz X Hobson KA The influence of breeding colony and sex on mercury, selenium and lead levels and carbon and nitrogen stable isotope signatures in summer and winter feathers of Calonectris shearwaters. Oecologia (2009 Mar) 159(2):345-54

    Contamination in marine foodwebs is nowadays of great environmental concern owing to the increasing levels of pollution in marine ecosystems from different anthropogenic sources. Seabirds can be used as indicators of regional contaminant patterns across large temporal and spatial scales. We analysed Hg, Se and Pb levels as well as stable isotope ratios of C(13C/12C, delta13C) and N(15N/14N, delta15N) in breeding- and winter-season feathers on males and females of two related shearwater species, providing information on spatiotemporal patterns of contaminants as well as the influence of the trophic ecology of these seabirds on contaminant levels. During the breeding season, Se and Pb concentrations were highest at the Cape Verde archipelago, showing no differences among the other colonies or between the sexes. However, Hg levels varied among colonies, being highest in the Mediterranean, probably resulting from the larger emissions and fallout of this pollutant in Europe. Feathers grown during breeding also

showed sexual differences in Hg concentrations and delta13C. Differences in Hg concentration between sexes are mainly due to egg-laying decontamination in females. In contrast, differences in Hg among colonies are probably related to differences in trophic ecology, as indicated by delta13C and delta15N measurements. Contaminant concentrations in winter-grown feathers did not show any relationship with stable isotope values but were affected by contaminant loads associated with the breeding season. These findings suggest that the interpretation of contaminant levels of migratory species from feathers moulted out of the breeding season should be made with caution because those values could reflect exposures to contaminants acquired during the breeding season. We conclude that factors other than feeding ecology may play an important role in the interpretation of contaminant levels and their annual dynamics at several spatial scales. Consideration of the relevant temporal context provided by isotopic signatures and contaminant concentrations is important in deciphering contaminant information based on various tissues.

101. Kolesarova A Roychoudhury S Slivkova J Sirotkin A Capcarova M Massanyi P In vitro study on the effects of lead and mercury on porcine ovarian granulosa cells. J Environ Sci Health A Tox Hazard Subst Environ Eng (2010) 45(3):320-31

The heavy metals lead (Pb) and mercury (Hg) pose potential risks to sustainability of environment and thus to our future generations. General objective of this in vitro study was to examine the secretory activity of porcine ovarian granulosa cells after Pb and Hg administration and to outline the potential intracellular mediators of its effects... These results indicate that Pb can affect the pathway of proliferation and apoptosis of porcine ovarian granulosa cells through intracellular substances such as cyclin B1 and caspase-3. On the other hand, the P(4) release by ovarian granulosa cells of pregnant gilts was stimulated by experimental Pb administration at doses of 0.25 mg/mL and 0.063 mg/mL and experimental Hg administration at doses 0.25 mg/mL and 0.083 mg/mL. P(4) release by ovarian cells of pregnant gilts was not influenced by a combinatory dose of FSH (1.0 ng/mL) + Pb (0.083 mg/mL) + Hg (0.083 mg/mL) but it was inhibited by experimental administration of FSH (10 ng/mL) + Pb (0.25 ng/mL) + Hg (0.25 ng/mL). Possible involvement of heavy metals - Pb and Hg and pituitary hormone FSH, in the regulation of P(4) release by porcine ovarian granulosa cells of pregnant gilts was noted. Data obtained from in vitro studies suggest the dose dependent association of heavy metals administration with the hormonal release by porcine ovarian granulosa cells. This association also depended on pregnancy of the gilts.

102. Liu YR Zheng YM Zhang LM Luan YX He JZ Effects of mercury on reproduction, avoidance, and heat shock protein gene expression of the soil springtail Folsomia candida. Environ Toxicol Chem (2010 Mar) 29(3):654-9

Based on the Cambisols of Beijing (used as agricultural soils), toxicity tests were conducted to investigate the effects of mercury (Hg) on reproduction and avoidance of Folsomia candida (Hexapoda: Collembola), as well as the transcriptional responses of the hsp70 gene, under different Hg concentrations and at different exposure times. Results showed that the hsp70 gene of the springtail was the most sensitive parameter to soil Hg stress, with a half-maximal effective concentration (EC50) of 0.42 mg/kg. The EC50 values based on reproduction and avoidance tests were 9.29 and 3.88 mg/kg, respectively. The expression level of the hsp70 gene was significantly up-regulated when soil Hg concentration was over 0.25 mg/kg (lowest-observed-effect concentration [LOEC]). In addition, responses of this gene expression were strongly induced after 48 h exposure under 1 mg/kg soil Hg, which probably was due to the fast and sensitive response of the gene transcription to Hg stress. Thus, the results suggested that the responses of the hsp70

gene and individual-level effects (reproduction and avoidance) could be integrated to provide helpful information for environmental monitoring and assessment of contaminated soils.

103. Fathallah S Medhioub MN Medhioub A Kraiem MM Toxicity of Hg, Cu and Zn on early developmental stages of the European clam (Ruditapes decussatus) with potential application in marine water quality assessment. Environ Monit Assess (2010 Dec) 171(1-4):661-9

The toxicity of mercury, zinc and copper on sperm viability, fertilisation and embryogenesis of Ruditapes decussatus was examined. Cu did not affect sperm viability at all the concentrations tested. Conversely, the Zn and Hg significantly (P<0.01) reduced sperm viability only at the highest concentration (respectively 512 and 256 Î¼g/l). Cu caused a significant decrease (p<0.05) of less than 6% in the fertilisation rate at 128 Î¼g/l and Zn of up to 13% at 64 Î¼g/l. Hg significantly (p<0.01) inhibited fertilisation at concentrations as low as 32 Î¼g/l. The median effective concentrations (EC50) reducing rates of embryogenesis by 50% were 21.1 Î¼g Hg/l (0.1 Î¼M), 46.3 Î¼g Cu/l (0.72 Î¼M) and 43.4 Î¼g Zn/l. Therefore, Hg is up to seven times more toxic than Cu (on a molar basis). Ecotoxicity of mercury on larvae survival was also assessed in this work. Result showed a significant (p<0.05) reduction of survival after exposure to 4 and 12 Î¼g/l of Hg. The fertilisation rate and embryogenesis were the most sensitive endpoints, although the latter is more advisable for routine assessment of seawater quality because of its greater sensibility.

104. Dietrich GJ Dietrich M Kowalski RK Dobosz S Karol H Demianowicz W Glogowski J Exposure of rainbow trout milt to mercury and cadmium alters sperm motility parameters and reproductive success. Aquat Toxicol (2010 May 10) 97(4):277-84

In the current work, seminal plasma was used for the first time as an incubation medium for monitoring short-time exposure effects of sublethal concentrations of mercury and cadmium ions on rainbow trout sperm. Sperm motility parameters (CASA) and hatching rates were used as gamete quality markers. Additionally live/dead sperm viability test and comet assay of DNA fragmentation were performed. We demonstrated that computer-assisted sperm motility analysis (CASA) may serve as a predictor of reproductive success, when milt contaminated with heavy metals is used. Results presented in this study demonstrate that mercury ions altered sperm motility characteristics at 1-10 mg Hg2+/l and 10 mg Cd2+/l and hatching rates at 10 mg Hg2+/l and 10 mg Cd2+/l after 4h of exposure. Although mercury ions affected sperm motility parameters immediately after dilution with milt as well as at 4h of exposure, no differences in sperm motility parameters were found between intact and mercury- treated milt after 24h of exposure. Our results suggest that rainbow trout seminal plasma has a protective role against the toxic effects of mercury ions of rainbow trout sperm motility.

105. Curtis JT Hood AN Chen Y Cobb GP Wallace DR Chronic metals ingestion by prairie voles produces sex-specific deficits in social behavior: an animal model of autism. Behav Brain Res (2010 Nov 12) 213(1):42-9

We examined the effects of chronic metals ingestion on social behavior in the normally highly social prairie vole to test the hypothesis that metals may interact with central dopamine systems to produce the social withdrawal characteristic of autism. Relative to water-treated controls, 10 weeks of chronic ingestion of either Hg(++) or Cd(++) via drinking water significantly reduced social contact by male voles when they were given a choice between isolation or contact with an unfamiliar same-sex conspecific. The effects of metals ingestion were specific to males: no effects of metals exposure were seen in females. Metals ingestion did not alter behavior of males allowed to choose between isolation or their familiar cage-mates, rather than strangers. We also

examined the possibility that metals ingestion affects central dopamine functioning by testing the voles' locomotor responses to peripheral administration of amphetamine. As with the social behavior, we found a sex-specific effect of metals on amphetamine responses. Males that consumed Hg(++) did not increase their locomotor activity in response to amphetamine, whereas similarly treated females and males that ingested only water significantly increased their locomotor activities. Thus, an ecologically relevant stimulus, metals ingestion, produced two of the hallmark characteristics of autism - social avoidance and a male-oriented bias. These results suggest that metals exposure may contribute to the development of autism, possibly by interacting with central dopamine function, and support the use of prairie voles as a model organism in which to study autism.

106. Ishitobi H Stern S Thurston SW Zareba G Langdon M Gelein R Weiss B Organic and inorganic mercury in neonatal rat brain after prenatal exposure to methylmercury and mercury vapor. Environ Health Perspect (2010 Feb) 118(2):242-8

BACKGROUND: Many populations are exposed to multiple species of mercury (Hg), predominantly organic Hg as methylmercury (MeHg) from fish, and inorganic Hg as Hg vapor from dental amalgams. Most of our knowledge of the neurotoxicity of Hg is based on research devoted to studying only one form at a time, mostly MeHg. ... RESULTS: ....MeHg dose was the primary determinant of both organic and inorganic brain Hg levels. For both outcomes, we also found significant interactions between MeHg and Hg vapor exposure. These interactions were driven by the fact that among animals not exposed to MeHg, animals exposed to Hg vapor had significantly greater organic and inorganic brain Hg levels than did unexposed animals. CONCLUSION: This interaction, heretofore not reported, suggests that coexposure to MeHg and Hg vapor at levels relevant to human exposure might elevate neurotoxic risks.

107. Schmidt C Salmon as transport vectors for mercury. Environ Sci Technol (2010 Jan 1) 44(1):11
    a. Some of the mercury adult salmon import to freshwater systems from the ocean goes back out to sea again with their offspring.

108. Brasso RL Abdel Latif MK Cristol DA Relationship between laying sequence and mercury concentration in tree swallow eggs. Environ Toxicol Chem (2010 May) 29(5):1155-9

When female birds lay eggs, some of their body burden of mercury is eliminated into each egg, potentially leading to declining mercury across the clutch. However, there was no decline in mercury with laying sequence in clutches of tree swallow (Tachycineta bicolor) eggs at a mercury-contaminated site, presumably due to daily replenishment of mercury in females during laying. Sampling just one egg from the nest provided an accurate measure of clutch mercury contamination.

109. Wu Q He K Liu P Li Y Wang D Association of oxidative stress with the formation of reproductive toxicity from mercury exposure on hermaphrodite nematode Caenorhabditis elegans. Environ Toxicol Pharmacol (2011 Sep) 32(2):175-84

Here we selected HgCl(2) to investigate the mechanism of Hg toxicity on reproduction in hermaphrodite nematodes. Accompanied with decrease of brood size, Hg exposure caused severe deficits in egg number in uterus, egg laying and reproductive structures, including gonad arms and vulva, and formation of protruding phenotype for vulva. Meanwhile, Hg exposure induced severe stress response and oxidative damage in gonad and vulva. ... Moreover, Hg exposure increased expression of clk-2 and isp-1 genes, whose mutations decrease ROS production, and decreased expression of mev-1 and gas-1 genes, whose mutations increase ROS

production. Thus, oxidative stress may be essential for the induction of reproductive deficits in Hg exposed hermaphrodite nematodes.

110. Spencer SH Shutler D O'Brien MS Correlates of mercury in female river otters (Lontra canadensis) from Nova Scotia, Canada. Environ Toxicol Chem (2011 Aug) 30(8):1879-84

Mercury (Hg) can reach toxic concentrations in aquatic habitats, sometimes as a consequence of human activity. Mercury can have deleterious effects, particularly in piscivorous mammals in which it bioaccumulates. Furs from trapper-provided female otter (Lontra canadensis) carcasses in Nova Scotia were analyzed for total Hg. ...Because we found no evidence of reduced reproductive potential from greater Hg concentrations, the low proportion of juveniles suggests that Hg reduced juvenile survival, although our evidence is circumstantial.

111. Habran S Debier C Crocker DE Houser DS Das K Blood dynamics of mercury and selenium in northern elephant seals during the lactation period. Environ Pollut (2011 Oct) 159(10):2523-9

The effects of reproduction and maternal investment (i.e., milk transfer) on trace element levels remain poorly understood in marine mammals. We examined the blood dynamics of mercury (Hg) and selenium (Se) during lactation in the northern elephant seal (Mirounga angustirostris), a top predator from the North Pacific Ocean. Total Hg and Se levels were measured in whole blood and milk of 10 mother- pup pairs on days 5 and 22 of lactation. Both Hg and Se were transferred to offspring through the milk. Results suggested that the maternal transfer of Se was prominent during lactation, whereas the Hg transfer was larger during gestation. The lactation period affected Hg and Se levels in the blood of elephant seal mothers and pups. Physiological processes and their relationship to body condition should be considered carefully when interpreting trace element levels in the framework of biomonitoring.

112. Hallinger KK Cristol DA The role of weather in mediating the effect of mercury exposure on reproductive success in tree swallows. Ecotoxicology (2011 Aug) 20(6):1368-77

Mercury is a heavy metal that has contaminated countless ecosystems throughout the world. A large body of literature has documented reproductive, physiological, and behavioral impairments associated with mercury exposure in laboratory settings, but whether and how such effects are manifest in free-living populations remains poorly understood. The purpose of this study was to evaluate whether tree swallow (Tachycineta bicolor) breeding success at a site with high mercury exposure varied with ambient temperature or precipitation at various points in the breeding cycle. Tree swallows nesting along the South River had significantly elevated blood total mercury (mean Â± SE: 3.03 Â± 0.15 Î¼g/g) compared to swallows breeding on reference sites (mean Â± SE: 0.16 Â± 0.005 Î¼g/g). These high levels of mercury were associated with reduced hatching and fledging success, and contaminated birds produced approximately one less fledgling per nest than their reference counterparts. The magnitude of this difference was weather-dependent: unusually high ambient temperatures encountered early in the nestling period were associated with reduced reproductive output in contaminated, but not in reference, birds. In contrast, little effect of mercury on success of nestlings was observed when temperatures were cooler, and precipitation also had no detectable interaction with mercury. These results provide insight into mechanisms underlying reproductive effects of mercury. In addition, these findings underscore the importance of considering variable environmental conditions when assessing effects of contaminants on free-living wildlife. In particular, projections about the effects of global climate change on ecotoxicological impacts must take into account the kinds of weather-mediated effect demonstrated here.

113. Pittman HT Bowerman WW Grim LH Grubb TG Bridges WC Using nestling feathers to assess spatial and temporal concentrations of mercury in bald eagles at Voyageurs National Park, Minnesota, USA. Ecotoxicology (2011 Oct) 20(7):1626-35

> Bald eagles (Haliaeetus leucocephalus) have been utilized as a biosentinel of aquatic ecosystem health in the Great Lakes Region since the early 1960s. ...Mercury is an environmental pollutant with both natural and anthropogenic sources, and negatively affects many species of wildlife. In a previous study, geometric mean concentrations of Hg in feathers of nestling bald eagles were greater at VNP (20 mg/kg Dry Weight (DW)) than in nestling feathers from other Great Lakes subpopulations (7 mg/kg DW), for the period 1985- 1989. .... Although Hg concentrations in feathers of nestlings greatly declined after the change in water level management in 1999 and are lower than 1989 concentrations, recent samples suggest a gradual increase. Continued monitoring of nestling feather concentrations will be essential to assess this increase, to determine the source of Hg, to determine if there are changes to methylation potential, and to evaluate and optimize water level management.

114. Escobar-SÃ¡nchez O GalvÃ¡n-MagaÃ±a F RosÃles-MartÃnez R Biomagnification of mercury and selenium in blue shark Prionace glauca from the Pacific Ocean off Mexico. Biol Trace Elem Res (2011 Dec) 144(1-3):550-9

> The aim of this study was to determine the biomagnification of mercury through the principal prey of the blue shark, Prionace glauca, off the western coast of Baja California Sur, Mexico, as well as the relationship between mercury and selenium in blue sharks. High levels of mercury were found in shark muscle tissues (1.39â€‰Â±â€‰1.58Â Î¼g/g wet weight); these values are above the allowed 1.0Â Î¼g/g for human consumption. The mercury to selenium molar ratio was 1:0.2. We found a low correlation between mercury bioaccumulation and shark size. Juveniles have lower concentrations of mercury than adults. ...

115. Hatef A Alavi SM Butts IA Policar T Linhart O Mechanism of action of mercury on sperm morphology, adenosine triphosphate content, and motility in Perca fluviatilis (Percidae; Teleostei). Environ Toxicol Chem (2011 Apr) 30(4):905-14

> The main objectives of the present study were to investigate the performance of mercury chloride (HgCl2) on sperm function and structure, identify sites of action of HgCl2 , and investigate the mechanism of action of HgCl2 on fish (Perca fluviatilis L.) spermatozoa.
>
> Adenosine-5'-triphosphate content of sperm was significantly lower in an IM containing HgCl2 greater than 3â€‰ÂµM compared with those of the control (no HgCl2) and lower HgCl2 concentrations. Damage to the plasma membrane and axoneme were observed in sperm incubated in an IM containing HgCl2 compared with the control, when HgCl2 concentration and incubation time increased. In conclusion, HgCl2 acts on sperm through disruption of function of the plasma membrane, axoneme, and ATP content.

116. Perrault J Wyneken J Thompson LJ Johnson C Miller DL Why are hatching and emergence success low? Mercury and selenium concentrations in nesting leatherback sea turtles (Dermochelys coriacea) and their young in Florida. Mar Pollut Bull (2011 Aug) 62(8):1671-82

> Leatherback sea turtles (Dermochelys coriacea) have low hatching and emergence success compared to other sea turtle species. Postmortem examinations of hatchlings showed degeneration of heart and skeletal muscle that was similar to that found in other neonates with selenium deficient mothers. Selenium deficiency can result from elevated concentrations of bodily mercury. Ingested mercury is detoxified by the liver through mercury-selenium compound

formation. In animals persistently exposed to mercury, the liver's ability to detoxify this element may decrease, especially if dietary selenium is insufficient. We measured mercury and selenium concentrations in nesting female leatherbacks and their hatchlings from Florida and compared the levels to hatching and emergence success. Both liver selenium and the liver selenium-to-mercury ratio positively correlated with leatherback hatching and emergence success. This study provides the first evidence for the roles of mercury and selenium in explaining low reproductive success in a globally imperiled species, the leatherback sea turtle.

117. Huang CF Hsu CJ Liu SH Lin-Shiau SY Exposure to low dose of cinnabar (a naturally occurring mercuric sulfide (HgS)) caused neurotoxicological effects in offspring mice. J Biomed Biotechnol (2012) 2012:254582

Cinnabar, a naturally occurring mercuric sulfide (HgS), has long been used in Chinese mineral medicine for more than 2000 years. Although mercury is well-known for its toxicity, whether cinnabar induces neurotoxicity, especially in infants and children, is unknown. The purpose of this study was to explore the neurotoxic effects of low- dose of cinnabar (10 mg/kg/day) on developing mice. The results revealed neurobehavioral defects in F1-C-Cin group, which were associated with Hg accumulation, increased NO(x) levels in whole blood, and Na(+)/K(+)-ATPase activities in brain tissues. F1- and F2- Cin-V groups were found to increase brain Hg contents and prominent neurobehavioral defects compared with F1-C-V group, suggesting that the fetal brain was more susceptible to irreversible effects for cinnabar-induced damage. Moreover, F1- and F2-Cin-Cin groups had severely neurobehavioral dysfunctions, closely correlated with the further alteration of NO(x) levels and Na(+)/K(+)-ATPase activities than F1- and F2-C-Cin groups. Effects in F2-Cin-Cin group were more significant than those in F1-Cin-Cin group. In conclusion, this study demonstrates that exposure to low-dose of cinnabar during the perinatal and developmental stages results in irreversible and severe injuries of the neurotoxicity in offspring, and NO(x) and Na(+)/K(+)- ATPase activities may exist potential and useful biomarkers for neurotoxicity-induced by low-doses of mercuric compounds.

118. Assefa S Curtis JT Sethi S Davis RL Chen Y Kaul R Inorganic mercury exposure in prairie voles (Microtus ochrogaster) alters the expression of toll-like receptor 4 and activates inflammatory pathways in the liver in a sex-specific manner. Hum Exp Toxicol (2012 Apr) 31(4):376-86

Environmental exposure to mercury can cause a number of adverse effects in humans including the disruption of endocrine function that may result in sex-specific effects. The present study was designed to characterize sex-specific effects of chronic inorganic mercury exposure on toll-like receptor (TLR) 2 and TLR4 and inflammatory signaling in the liver of prairie voles (Microtus ochrogaster). Following 10 weeks of exposure to mercury via drinking water, effects on protein expression levels of TLR2 and TLR4 and the downstream p38 mitogen-activated protein kinase (p38 MAPK) and nuclear factor-kappa (NF-ÎºB) signaling pathways were assessed. Using immunoblot analysis, we found that mercury exposure significantly enhanced the expression of TLR4 and activated p38 MAPK and NF-ÎºB pathways in vole livers. This is the first report indicating that TLR4 may serve as a sensor for chronic mercury exposure in the liver. Further, compared to females, mercury-treated male voles exhibited significant increases in activated p38 MAPK and a greater extent of liver damage. Together, these findings establish sex-specific liver immunomodulation and cellular signaling following chronic inorganic mercury exposure. Furthermore, this study also supports the use of voles as biomarkers of environmental mercury contamination and offers a promising in vivo tool to test various therapeutic strategies for mercury detoxification.

119. Oliveira CS Oliveira VA Ineu RP Moraes-Silva L Pereira ME Biochemical parameters of pregnant rats and their offspring exposed to different doses of inorganic mercury in drinking water.Food Chem Toxicol (2012 Jul) 50(7):2382-7

> This work investigated the effects of low and high doses of inorganic mercury in drinking water on biochemical parameters of pregnant rats and their offspring. Female Wistar rats were treated during pregnancy with 0, 0.2, 0.5, 10 or 50 Î¼g Hg(2+)/mL as HgCl(2). Rats were euthanized on day 20 of pregnancy. Pregnant rats presented a decrease in total water intake in all doses of mercury tested. At high doses, a decrease in the total food intake and in body weight gain was observed. Pregnant rats exposed to 50 Î¼g Hg(2+)/mL presented an increase in kidney relative weight. Mercury exposure did not change serum urea and creatinine levels in any of the doses tested. Moreover, mercury exposure did not change porphobilinogen synthase activity of kidney, liver and placenta from pregnant rats in any of the doses tested, whereas fetuses of pregnant rats exposed to 50 Î¼g Hg(2+)/mL presented an increase in the hepatic porphobilinogen synthase activity. In general, pregnant rats presented alterations due to HgCl(2) exposure in drinking water. However, only the dose 50 Î¼g Hg(2+)/mL appeared to be enough to cross the blood-placenta barrier, since at this dose the fetuses presented change in the porphobilinogen synthase activity.

120. Elahi M Esmaili-Sari A Bahramifar N Total mercury levels in selected tissues of some marine crustaceans from Persian Gulf, Iran: variations related to length, weight and sex. Bull Environ Contam Toxicol (2012 Jan) 88(1)

> Much of the variation in trace metal tissue concentrations in marine invertebrates has been attributed to the variety in individual organism size, age and sex. This study assessed the relationship between total mercury (Hg) concentrations in edible tissue, exoskeleton and viscera with length, weight and gender for 69 samples of crustaceans, ...Significantly higher Hg levels (pÂ <Â 0.01) were found in female P. semisulcatus than in males (muscle and viscera), but no gender differences were found for the other two species.

121. Bryan CE Davis WC McFee WE Neumann CA Schulte J Bossart GD Christopher SJ Influence of mercury and selenium chemistries on the progression of cardiomyopathy in pygmy sperm whales, Kogia breviceps. Chemosphere (2012 Oct) 89(5):556-62

> More than half of pygmy sperm whales (Kogia breviceps) that strand exhibit signs of cardiomyopathy (CMP). Many factors may contribute to the development of idiopathic CMP in K. breviceps, including genetics, infectious agents, contaminants, biotoxins, and dietary intake (e.g. selenium, mercury, and pro-oxidants). This study assessed trace elements in K. breviceps at various stages of CMP progression using fresh frozen liver and heart samples collected from individuals that stranded along US Atlantic and Gulf coasts between 1993 and 2007. ... Cardiomyopathy was only observed in adult pygmy sperm whales, predominantly in male animals. Both Hg:Se molar ratios and overall protein oxidation were greater in males than females and increased with progression of CMP.

122. Robinson SA Lajeunesse MJ Forbes MR Sex differences in mercury contamination of birds: testing multiple hypotheses with meta-analysis. Environ Sci Technol (2012 Jul 3) 46(13):7094-101

> The sex of a bird can, in principle, affect exposure and accumulation of mercury. One conventional explanation for sex differences in mercury burden suggests female birds should have lower concentrations than conspecific males, because breeding females can depurate methylmercury to their eggs. However, sex differences in body burden of mercury among birds

are not consistent. We used meta-analysis to synthesize 123 male-female comparisons of mercury burden from 50 studies. For breeding birds, males had higher concentrations of mercury than did females, supporting egg depuration as a mechanism. However, the percentage of female body mass represented by a clutch did not significantly predict the magnitude of the sex difference in mercury contamination, as predicted. Furthermore, whether species were semialtrical or altrical versus semiprecocial or precocial also did not explain sex differences in mercury burden. Foraging guild of a species did explain near significant variation in sex differences in mercury burden where piscivores and invertivores showed significant sex differences, but sex differences were not detected for carnivores, herbivores, insectivores, and omnivores. The magnitude and direction of sexual size dimorphism did not explain variation in sex differences in mercury burden among breeding birds. We reveal targeted research directions on mechanisms for sex differences in mercury and confirm that sex is important to consider for environmental risk assessments based on breeding birds.

123. Ertan AK Ivankovic S Schmid W Carcinogenic effects of oxides of lead, nickel, cadmium and mercury after prenatal administration to BD-IX rats. Libri Oncol (201992) 21(3):141-6

Carcinogenic effects of metal oxides of low solubility, namely Pb3O4 NiO, CdO and HgO, were investigated after prenatal exposure to BD-IX rats. The spontaneous overall tumor incidence in untreated controls was 3.7%, while an incidence of 23% was observed in the offspring of mothers orally treated with metal oxides. Especially malignant tumors of the kidney (adenocarcinomas) and the female genital tract (squamous cell carcinoma of the vagina and carcinoma of the ovaries) were seen in higher frequency.

124. Yoshida M Watanabe C Honda A Satoh M Yasutake A Emergence of delayed behavioral effects in offspring mice exposed to low levels of mercury vapor during the lactation period. J Toxicol Sci (2013) 38(1):1-6

This study examined the emergence of delayed behavioral effects in offspring mice exposed to low levels of mercury vapor (Hg(0)) during the lactation period. Female offspring of mice were repeatedly exposed to Hg(0) at 0.057 mg/m(3), similar to the current threshold value (TLV), for 24 hr until the 20(th) day postpartum. The behavioral effects were evaluated with locomotor activity in the open field (OPF), learning activity in the passive avoidance response (PA) and spatial learning ability in the Morris water maze (MM) at the ages of 3 and 15 months. Hg(0)-exposed mice did not differ from controls in the three behavioral measurements at 3 months of age, and no neurobehavioral effects were observed. On the other hand, the mice exhibited significantly more central locomotion in the OPF task when tested at 15 months of age, but no abnormality in other behavioral performance. Immediately after postnatal exposure, the brain mercury concentration of offspring was about 150 times that of the control, in which the concentrations were approximately 0.4 Âμg/g. The results indicate that mice exposed to Hg(0) at concentrations around TLV during the developing period resulted in the emergence of delayed behavioral effects at a later stage in life.