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fold between placentae, while GST pi levels varied 4 fold. GST pi activity and levels were only modestly correlated ($r = 0.359$, $p < 0.01$). The variant GSTP1 allele val105 did not appear to significantly affect GST pi levels or activity, in contrast to reports in other tissues. Interestingly, activity and levels of GST pi were higher in placentae with the GST mu 'null' genotype, especially for mother-baby pairs concordant for GSTM1 null genotype and GSTP1 ile105 ($p < 0.05$). Additionally, maternal serum folate positively correlated with GST pi levels in placentae, but this correlation was seen only in GST mu 'null' mothers ($\rho = 0.552$, $p = 0.009$). The research on this border population of Mexican women provides valuable data which indicate that placental genotype and phenotype may affect detoxification processes in the maternal-fetal environment.

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1263 PREDICTING GC/MS TEQ FROM XDS-CALUX[®] DETERMINATIONS OF DIOXIN CONTAMINATION IN SOIL

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The XDS-CALUX[®] bioassay is a recombinant cell bioassay designed to rapidly evaluate the level of polychlorinated dioxin-like contaminants (i.e., PCDDs, PCDFs and PCBs) present in sample extracts. Combined with our patented sample processing system, which reduces contributions from Ah receptor agonists that are not dioxin-like, the XDS-CALUX[®] bioassay can be used to estimate dioxin TEQ for environmental samples. A US EPA/Battelle cross validation SITE study was recently completed that compared the TEQ estimates for 209 samples as determined by both the XDS-CALUX[®] screening method and high resolution GC/MS analysis of chlorinated dioxins/furans and PCBs. We used this data to develop a mathematical model that could predict GC/MS TEQ results from CALUX bioassay data to improve the comparability of the two methods. A statistical model was generated using a generalized estimating equation that accounts for the correlation due to replicates using a base 10 logarithm transformation of the two variables; GC/MS TEQ and XDS-CALUX[®]-TEQ. Modeling the data we derived the following equation:

$$\text{LOG (GC/MS)} = 0.6093 * \text{LOG (CALUX)} + 0.0584 * [\text{LOG (CALUX)}]^2$$

This equation can be used to transform XDS-CALUX[®]-TEQ to predict GC/MS derived TEQ. The model generated with the EPA SITE data was tested using 49 soil and 18 ash determinations of XDS-CALUX[®]-TEQ and GC/MS TEQ data from a second double-blind study. The model did a good job of predicting GC/MS TEQ based on XDS-CALUX[®]-TEQ data. This modeling exercise demonstrates how values of GC/MS TEQ can be predicted from XDS-CALUX[®] bioassay data for dioxin-like contaminants in ash and soil samples. Supported by NIEHS SBIR grant ES08372-02 and Superfund Basic Research Grant ES04699.

1264 DNA-PROTEIN CROSSLINKS AS A POTENTIAL BIOMONITOR OF HEXAVALENT CHROMIUM EXPOSURE IN RAINBOW TROUT

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Hexavalent chromium (Cr6+) is found ubiquitously in many industrial waterways, as a result of mining, leather, steel, chrome plating and dye industries. Cr6+ has been demonstrated to cause DNA-protein crosslink (DPX) formation in developing sea urchin embryos, yet little is known about vertebrate aquatic wildlife. Fish erythrocytes are nucleated and represent a convenient tissue for studying DNA damage in vivo. Using an SDS/KCl precipitation technique, we attempted to determine if Cr6+ causes DPXs in erythrocytes of live trout at exposure levels which may be environmentally relevant. Fingerling trout (2-4") were exposed to increasing [Cr6+] for 4 days at 15°C. Dose dependent increases in DPXs were found at concentrations above 1 ppm, with 44, 116 ($p < 0.05$), and 140% ($p < 0.01$) above control levels at 1, 2 and 4 ppm, respectively. Next, fingerlings were exposed to 2 ppm Cr6+ in tank water for up to 21 days at 15°C. Significant, time-dependent elevations in DPXs were observed in Cr6+ treated trout with 44, 92 and 201% increases above control DPX levels at 4, 7 and 21 days of exposure, respectively ($p < 0.05$). Effect of body size on Cr6+-induced DPXs studied with four size groups of juvenile trout (2-4", 4-6", 6-8" and 8-10"), housed together in a 55 gallon tank. Trout were exposed with an initial 2 ppm dose at time zero, and subsequent additions of 1 ppm at 24, 48 and 72 hours (total of 5 ppm Cr6+ over 4 days). Statistically significant increases in DPXs (greater than 200% above controls) were observed in all Cr6+ treated size groups, as would be expected. However, there was no statistical difference between DPX levels of any of the size groups of fish ($p > 0.05$, one-way ANOVA, with

Bonferroni post-test). Although the significance of DPXs to fish health is not well understood, this assay may provide a useful, non-lethal tool to detect low level Cr6+ exposure of freshwater fish in their natural habitats.

1265 COMPARISON OF NICKEL-INDUCED DNA-PROTEIN CROSSLINKS IN SEVERAL FRESHWATER FISH SPECIES AFTER ACUTE EXPOSURE

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DNA-protein crosslinks (DPXs) have been demonstrated in cultured mammalian cells and suggested to be a stable biomarker for exposure to several carcinogenic heavy metals. Divalent nickel (Ni2+) has been reported as an industrial pollutant in sediments of many major waterways worldwide. Ni2+ toxicity to freshwater fish is well known, yet standard biological tools to monitor low level exposure are lacking. Using an SDS/KCl precipitation technique, we examined the potential for DPX formation in Rainbow trout erythrocytes cultured in vitro with increasing [Ni2+], as well as in several freshwater species of fish exposed to 15 ppm in tank water. Statistically significant ($p < 0.05$) increases in DPX occurred were detected in isolated erythrocytes cultured for 24 hrs at 20°C with 50, 100, 250 and 500 mM Ni2+ exhibited 63, 115, 150 and 282% elevations in DPXs above control values (2.41% of DNA in DPX fraction). Several freshwater fish species (2-4" juveniles) were exposed to 15 ppm Ni2+ for 4 days at 15°C, at which time blood samples were taken from the gills. Erythrocytes from hybrid bluegill exhibited the highest level of DPXs with 237% ($p < 0.01$) above control values, while erythrocytes from Rainbow trout and channel catfish contained 124% ($p < 0.05$) and 82% ($p < 0.05$) higher DPX levels than controls, respectively. When exposed to 15 ppm Ni2+ for 4 days, then removed from water containing Ni2+ for 7 days, DPXs remained elevated at 66% higher levels ($p < 0.05$) than control values. DPX formation has been demonstrated in several fish species exposed to waterborne nickel at 15 ppm, of which bluegill appear to be the most sensitive. In addition, it appears Ni2+ induced DPXs are unstable over time, but may be detectable for up to several weeks after acute exposure. Work is in progress to determine if channel catfish exposed to Ni2+ containing sediment can accumulate DPX under chronic exposure conditions.

1266 PERSISTENCE OF DNA-PROTEIN CROSSLINKS IN ERYTHROCYTES OF CHANNEL CATFISH AFTER ACUTE HEXAVALENT CHROMIUM EXPOSURE

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DNA-protein crosslinks (DPXs) have been used previously as a potential biomarker for occupational exposure to a hexavalent chromium (Cr6+), under a variety of exposure scenarios. Cr6+ is found ubiquitously in many industrial waterways, causing considerable concern about human health and environmental impact. The accumulation of Cr6+ in river sediments has raised issues about possible of toxicity to fish species feeding in such areas. To be useful as an environmental biomarker, adducts such as DPXs must be biologically stable for some time after chemical exposure. It has been shown recently that Cr6+ induced DPXs are repaired in mammalian cells, yet no information exists about their formation and stability in fish under controlled conditions. We have addressed this issue by exposing juvenile channel catfish (2-4") to Cr6+ at 2 ppm in tank water for up to 15 days, and removing some fish from the tank and placing them back in purified water alone. DPXs in erythrocytes from exposed catfish were monitored over this time period to determine their biologic stability. Catfish exposed for 4, 7, 10 and 15 days accumulated significantly higher levels of DPXs above time zero and day 15 controls, with 48, 73, 119 and 801% elevations, respectively ($p < 0.05$). When catfish were exposed to Cr6+ for 10 days, then placed in purified water (no Cr6+), DPXs continued to increase to over the next 5 days to 419% above 15 day controls. This represents a 250% increase above levels seen at day 10 (when removed from Cr6+). This suggests that DPX formation may occur for a significant period of time after initial uptake of Cr6+. It may be that Cr6+ is reduced intracellularly and sequestered as Cr3+ adducts on the DNA alone, subsequent reaction with chromatin proteins would form additional DPXs. Available data suggest that DPXs are biologically stable and detectable for several weeks.

1267 DIETARY HEXAVALENT CHROMIUM EXPOSURE CAUSES DNA-PROTEIN CROSSLINK FORMATION IN ERYTHROCYTES OF LARGEMOUTH BASS

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Hexavalent chromium (Cr6+) is known to cause DNA-protein crosslink (DPX) formation in cell lines and in liver cells of rats exposed by drinking water. This project was designed to determine if DPXs could accumulate in minnows following water-