# STUDENT TRAVEL FELLOWSHIP APPLICATION

**Title of Project:** Microbial Oxidation of Hg(0): Its Effect on Hg Stable Isotope Fractionation and Methylmercury Production

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Project Description:

Neurotoxic methylmercury (MeHg) has been formed from the inorganic mercury (Hg) wastes discharged into the headwaters of East Fork Poplar Creek (EFPC) in Oak Ridge, Tennessee [1-4]. High concentrations of Hg persist in both EFPC sediments and watershed soils. Thus, understanding the processes and mechanisms that lead to Hg methylation along the flow path of EFPC is critical to predicting the impacts of the contamination and designing effective remediation strategies in the Oak Ridge Reservation (ORR). Sediment samples taken from different locations along the flow path of EFPC reveal a Hg stable isotope signature that is unexplainable by current knowledge. Under the leadership of PI Dr. Tamar Barkay and co-PIs Drs. Nathan Yee, John Reinfelder, and Tom Johnson, we hypothesize that the isotope signature of the Hg could be explained by the oxidation of Hg by bacteria. Therefore, our objectives are (1) to determine if bacteria can oxidize Hg(0), (2) to determine if bacteria can methylate Hg when provided with Hg(0) as their sole Hg source, and (3) to measure the stable isotope signature of Hg oxidation.

Research Results:

1) I have examined the Hg(0) oxidation activity for a wide range of phylogenetically and environmentally diverse anaerobic bacteria. My results have revealed that the ability to oxidize Hg(0) is widespread among anaerobic bacteria. The bacterium that I have studied in the most detail, *Desulfovibrio desulfuricans* ND132, can oxidize Hg at a rapid rate when provided with a constant source of Hg(0). I have confirmed that the oxidation state of this Hg is Hg(II) by X-ray absorption spectroscopy (XAS) at the Advanced Photon Source (APS). More detailed analyses of XAS spectra have also revealed that the cell-associated Hg is bound to thiol functional groups.
2) I have found that bacteria can methylate Hg when provided with Hg(0) as their sole Hg source. Exposure of *D. desulfuricans* ND132 to Hg(0) resulted in the formation of up to 50 µg/L of MeHg in 1 day. To accurately predict the sources of MeHg that enter aquatic food webs, our findings advise the incorporation of anaerobic oxidation and methylation of Hg(0) into current Hg biogeochemical models.
3) I am investigating the effect of microbial Hg(0) oxidation on Hg stable isotope fractionation. Collaborative work on the Hg stable isotope signature of Hg(0) oxidation is ongoing, as I prepare samples at Rutgers University and send them to the University of Illinois at Urbana-Champaign (Tom Johnson's lab) for analysis. If the expected isotope effect does in fact occur during biological Hg(0) oxidation, where the light isotopes of Hg(0) preferentially oxidize and produce isotopically light Hg in sediments, we can potentially explain the observed isotope signature in EFPC sediments.

Presentations and publications:

- Colombo M, Barkay T, Reinfelder J, and Yee N. Microbial Uptake and Methylation of Dissolved Elemental Mercury, Goldschmidt Conference, Prague, August 2011
- Colombo M, Ha J, Reinfelder J, Barkay T, and Yee N. Production of methylmercury from Hg(0), *Nature Geoscience*, submitted
- Colombo M, Ha J, Reinfelder J, Barkay T, and Yee N. Microbial production of methylmercury from Hg(0), Goldschmidt Conference, Montreal, June 2012

[1] Campbell *et al.* (1998) *Environ. Toxicol. Chem.* **17**, 1191-1198. [2] Southworth *et al.* (1995) *Chemosphere* **30** 779-787. [3] Southworth *et al.* (2000) *Environ. Monit. Assess.* **63**, 481-494. [4] Southworth *et al.* (2002) *Chemosphere* **49** 455-460.