



PROFESSOR JOHN COATES

Department of Plant and Microbial Biology
University of California at Berkeley
USA

John D. Coates is a Professor of Microbiology at University of California, Berkeley. He also holds a joint appointment as a Geological Scientist Faculty in the Earth Sciences Division at the Lawrence Berkeley National Laboratories and is co-director of the Energy Biosciences Institute Microbial Enhanced Hydrocarbon Recovery (MEHR) program. He is co-founder and Board Member of BioInsite LLC a company geared towards the use of microorganisms for solutions to environmental contaminant problems. He obtained an Honors B.Sc. in Biotechnology in 1986 from Dublin City University, Ireland and his Ph.D. in Microbiology in 1991 from University College Galway, Ireland. His major area of interest is geomicrobiology applied to environmental problems. Specific interests include diverse forms of anaerobic microbial metabolism such as microbial perchlorate reduction, microbial iron oxidation and reduction, and microbial humic substances redox cycles. Other interests include alternative renewable energies, bioremediation of toxic metals, radionuclides, and organics. He has won several awards for research and mentorship including the 1998 Oak Ridge Ralph E. Powe Young Faculty Enhancement Award, the 2001 DOD SERDP Program Project of the Year award, and the 2002 SIUC College of Science Researcher of the Year Award. He has given more than 100 invited presentations at national and international meetings. He has authored and co-authored more than 90 peer-reviewed publications and book chapters. He has published one book and has 9 patent submissions based on technologies developed in his lab several of which are in commercial application. He sits on the editorial boards of the journals Applied and Environmental Microbiology, and Applied Microbiology and Biotechnology. He is an editorial scientist for the Faculty 1000 review database and is a member of the American Society for Microbiology, the American Chemical Society, the American Geophysical Union, and the International Humic Substances Society. In addition to his traditional teaching at UC Berkeley, Dr. Coates is continuously involved in various outreach programs supporting education of high school and community college students. He has mentored several high school students and science projects in his laboratory and was the recent recipient of the University of California Berkeley Summer Research Opportunity Program Recognition award for mentorship.

ABSTRACT

“Microbial Perchlorate Reduction - A Rocket Fueled Metabolism”

Perchlorate, an oxyanion of chlorine is now recognized as a widespread ion in environmental systems. Because of the potential health complications associated with prolonged exposure, perchlorate was added to the EPA’s Contaminant Candidate List in 1998. Subsequent remediation efforts have led to the recognition of microbial reduction as the preferential strategy to remove perchlorate. Although originally assumed to be a coincidental reaction of nitrate respiring organisms

now it is known that specialized microorganisms have evolved that can grow by the anaerobic reductive dissimilation of perchlorate into innocuous chloride. More than forty of these organisms are now in pure culture and this number is rapidly increasing all the time. Since 1996 concerted efforts have resulted in significant advances in our understanding of the microbiology, biochemistry, and genetics of microorganisms capable of reductively transforming perchlorate into innocuous chloride. The recent completion of the whole-genome sequence of the perchlorate-reducer, *Dechloromonas aromatica*, offers further insight into the evolution and regulation of this unique metabolism. Perchlorate-reducing microorganisms have been isolated from a broad diversity of environments including both pristine and contaminated soils and sediments. Although originally unexpected due to the supposed limited natural abundance of perchlorate, recent geochemical studies have indicated that natural perchlorate is far more prevalent than originally perceived. In addition, the diverse metabolic capabilities of these microorganisms could also account for their presence in environments where perchlorate is not found. Phenotypic characterization revealed that the known dissimilatory perchlorate-reducing bacteria (DPRB) exhibit a broad range of metabolic capabilities including the oxidation of hydrogen, simple organic acids and alcohols, aromatic hydrocarbons, hexoses, reduced humic substances, both soluble and insoluble ferrous iron, electrically charged cathodes, hydrogen sulfide, and elemental sulfur. All of the known DPRB are facultatively anaerobic or microaerophilic which is reasonable in light of the fact that molecular oxygen is produced as a transient intermediate of the microbial reduction of perchlorate. Some, but not all, DPRB alternatively respire nitrate. To date, all microorganisms capable of perchlorate reduction can alternatively use chlorate, however, the same is not necessarily true of chlorate-reducing bacteria and there are now several chlorate-reducing microorganisms in pure culture that are incapable of the reductive respiration of perchlorate. DPRB are ubiquitous, dependent on molybdenum for their metabolism, and the presence of oxygen and nitrate negatively regulate perchlorate reduction. All DPRB are members of the proteobacteria, a phylum that is believed to have evolved 2.5 – 2.8 Ga. However, molecular evidence suggests that perchlorate reduction is the result of horizontal transferred genetic events and it may not have originated in the proteobacteria phylum. This is supported by evolutionary analysis of the genes specifically involved in the metabolism, the perchlorate reductase and the cytochrome oxidase, both of which are belonged to protein families that may have been prevalent in the last universal common ancestor 4.25 – 4.29 Ga.

The field of microbial perchlorate reduction has clearly advanced significantly in a very short period from a poorly understood metabolism to a burgeoning scientific field of discovery. Over the last 10 yrs we have gained a much greater appreciation of the microbiology, biochemistry and genetic systems involved and this has led directly to the development of successful treatment technologies for contaminated environments. Overall, the future is promising; however, research in this field is still in its infancy. Little is known of the evolutionary timeline of this metabolism. From a biogeochemical perspective, a better understanding of how perchlorate is formed in the natural environment and what geochemical conditions are required for its formation might give some insight into this. From a microbial perspective, it will be important to look for this metabolism in more extreme environments such as hypersaline or hyperthermophilic to obtain DPRB isolates across a broader phylogeny to establish a broad-base molecular chronometer. This will also allow for the development of more robust technologies for the treatment of extreme waste streams contaminated with this pervasive compound.