MOST SIGNIFICANT CONTRIBUTIONS

I- February 2006 – Present: As molecular biologist and microbiologist, I joined the interdisciplinary team at the NanoRobotics Laboratory at École Polytechnique de Montréal. I have concentrated my effort at providing solutions through the use of bio-components such as the integration of special bacteria as bio-actuators in applications where technological constraints do not permit the development of specific important functions such as controllable micro- or nano-self-propulsion systems for critical applications such as tumor targeting for enhanced therapeutic effect in cancer therapy. My complementary expertise has been important during this period. Indeed, my scientific contribution has enabled the team to reach the majors milestones aimed at investigating the exploitation and integration of biological components and their potentials for critical applications. At the present time, our group integrates magnetotactic bacteria (MTB) with their molecular motors as a means of self-propulsion or bio-actuation for nanorobots or other micro-scale entities. More specifically, our group exploited the property of the chain of magnetic single domain nanoparticles (50-100 nm in size) called magnetosomes, embedded in each MTB and acting as a navigational compass inside each bacterium combined with the very effective thrust provided by the molecular motor of the bacteria. I have studied and investigated the different options for the control of these microorganisms in order to provide a suitable interface between a computing platform and these bacterial systems.

Several projects relied on my work performed during this period, such as but not limited to MRI tumor targeting enhancement with magnetotactic bacterial carriers, the implementation of novel microsystems capable of fast detection of pathogens, mass-scale and low cost micro-assembly, new techniques for lab-on-a-chip and micro-total-analysis systems, etc (1, 2, 6-13).

II- May 2003 to February 2006: I was involved in postdoctoral research concerning the directed evolution of a dioxygenase to create enzymes exhibiting higher turnover rate of reaction or modified regiospecificity toward different polychlorobiphenyl (PCB) congener. Our specific goals over these years were: 1- To engineer the biphenyl dioxygenase (BPDO), to enhance its degrading potential toward PCBs and other chlorinated persistent pollutants such as chlorodibenzofurans and DDT using directed evolution approaches; 2- To elucidate the mechanism by which enzymes can change their substrate specificity and regiospecificity toward substrate analogs; 3- To express these engineered enzymes in plants in order to design novel remediation processes based on plant-microbe interactions. I have contributed to various aspects of that project including:

- Genetic Engineering, through site directed mutagenesis, saturation mutagenesis or DNA shuffling to obtain evolved BphA (biphenyl dioxygenase).
- High throughput screening to detect desired variants of biphenyl dioxygenase.
- Development of enzymatic assays to monitor biphenyl dioxygenase activity.
- Analysis of metabolites using GC-MC.
- Purification of the metabolites by HPLC and their identification by NMR.
- Optimization of expression conditions and purification of different biphenyl dixigenases for crystallography and analyze of their three dimensional structures.
- Expression of biphenyl dioxygenase complex (BphAE, BphG and bphF) in transgenic plants and development of protocols to assess their activities.

The results of this postdoctoral research were published in three significant publications (3, 4, 5). I should emphasize that **ref. 4 was chosen to make the cover page** of the July 2005 issue of Chemistry

and Biology and it was also chosen to be the subject of a preview article in the same issue (BucKel, W. On the road to bioremediation of dioxin. Chem. Biol. 12, 723-724, 2005).

III- List of Contributions:

- **Journal Papers**

1. Sylvain Martel, **Mahmood Mohammadi**, Ouajdi Felfoul, Zhao Lu, and Pierre Pouponneau, "Flagellated magnetotactic bacteria as controlled MRI-trackable propulsion and steering systems for medical nanorobots operating in the human microvasculature," *International Journal of Robotics Research (IJRR)*, Special edition on current state of the art and future challenges in nanorobotics, (Accepted for publication, July 2008).
2. Sylvain Martel, Ouajdi Felfoul, Jean-Baptiste Mathieu, Arnaud Chanu, Samer Tamaz, **Mahmood Mohammadi**, Martin Mankiewicz and Nasr Tabatabaei, "MRI-based Medical Nanorobotic Platform for the Control of Magnetic Nanoparticles and Flagellated Bacteria for Target Interventions in Human Capillaries," *International Journal of Robotics Research (IJRR)*, Special Issue on Medical Robotics (submitted Feb. 2008, in review).
3. **Mohammadi M,** Chalavi V, Laliberté J. F, Sylvestre M. 2007, "Expression of BPDO complex (BphAE, BphG and bphF) in transgenic Plants," *Biotechnol & Bioeng*, 97(3): 496-505
4. **Mohammadi M** and Sylvestre M. 2005**,** "Resolving the profile of metabolites generated during oxidation of Dibenzofuran and Chlorodibenzofurans by the Biphenyl catabolic pathway enzymes," *Chem Biol*, 12: 835-846.
   Comment in: *Chem Biol.* 2005 Jul: 12(7):723-4.
5. Barriault D, Lepine F, **Mohammadi M**, Milot S, Leberre N, Sylvestre M. 2004, "Revisiting the regiospecificity of Burkholderia xenovorans LB400 Biphenyl Dioxygenase toward 2,2'-Dichlorobiphenyl and 2,3,2',3'-Tetrachlorobiphenyl," *J. Biol. Chem*. 279(46): 47489-47496.

- **Reviewed Proceedings**

6. Sylvain Martel, Walder André, **Mahmood Mohammadi**, and Zhao Lu, "Towards Swarms of Communication-enable and Intelligent Sensotaxis-based Bacterial Microrobots Capable of Collective Tasks in an Aqueous Medium, " *The 2009 IEEE International Conference on Robotics and Automation (ICRA2009)(in* in review).

7. Sylvain Martel and **Mahmood Mohammadi**, "Controllable Bacterial Actuators for Nanorobots, " *Actuator 2008, the 11th International Conference on New Actuators & 5th International Exhibition on Smart Actuators and Drive systems*, Bremen, Germany, June 9-11, 2008.
8. Sylvain Martel, Ouajdi Felfoul, **Mahmood Mohammadi,** and Jean-Baptiste Mathieu, "Interventional Procedure Based on Nanorobots Propelled and Steered by Flagellated Magnetotactic Bacteria for Direct Targeting of Tumors in the Human Body," *30th Annual International IEEE EMBS Conference*, Vancouver, British Columbia, Canada, August 20-24, 2008.
9. Sylvain Martel, **Mahmood Mohammadi,** Martin Mankiewicz, Charles C. Tremblay, and Zhao Lu, "Implementation of a Bacterial Microfactory," 6*th International Workshop on Microfactories***,** Evanston, IL, USA, October 5-7, 2008.

10. Sylvain Martel, Ouajdi Felfoul and **Mahmood Mohammadi**, "Flagellated Bacterial Nanorobots for Medical Interventions in the Human Body," *IEEE International Conference on Biomedical Robotics and Biomechatronics, Scottsdale, Arizona*, USA, October 19-22, 2008.
11. Ouajdi Felfoul, **Mahmood Mohammadi** and Sylvain Martel, "Magnetic Resonance Imaging of Fe3O4 Nanoparticles Embedded in Living Magnetotactic Bacteria for Potential Use as Carriers for In Vivo Applications," *29th IEEE EMBS Annual International Conference*, Lyon, France, August 23 - 26, 2007.
12. Martin Mankiewicz, **Mahmood Mohammadi** and Sylvain Martel, "Motion Tracking and Analysis System for Magnetotactic Bacteria," *International Symposium on Optomechatronic Technologies*, Lausanne, Suisse, October 8-10, 2007.
13. Sylvain Martel and **Mahmood Mohammadi, "**High thoughput controlled bacterial transport using geometrical fluidic microchannels or 3D microfibers structures," *The 11th International Conference on Miniaturized Systems for Chemistry and Life Sciences (µTAS)*, Paris, France, October 7 – 11, 2007.