

# Electromagnetic Probes of Biological Molecular Motors (2005) and Low-Frequency Dielectric Spectroscopy of Martian Soil Samples (2004)

by John H. Miller, Jr.

**T**HE AIMS OF THESE ONGOING ISSO-FUNDED PROJECTS ARE to (1) study the electromagnetic properties of active enzyme complexes in live organisms and (2) investigate Martian soil simulants and live cell suspensions using low-frequency dielectric spectroscopy and related techniques. Our studies have focused on both linear (dielectric) and nonlinear (harmonic) responses and include studies of whole cells, extracted organelles, such as mitochondria and chloroplasts, and whole organisms. Continuance of these studies has been aided by a Postdoctoral Aerospace Fellowship (PDAF) awarded to Dr. David Warmflash. Results are discussed in a companion report titled: "Martian Soil Biosensors Based on Dielectric Spectroscopy." (p. 21) New resulting publications have benefited from both the previous mini-grant, as well as the ongoing PDAF program and are thus also listed here for convenience.

## Publications

- Sanabria, Hugo, John H. Miller, Jr., Andreas Mershin, Richard F. Luduena, Alexandre A. Kolomenski, Hans A. Schuessler, and Dimitri V. Nanopoulos, "Impedance Spectroscopy of  $\alpha$ - $\beta$  Tubulin Heterodimer Suspensions," *Biophys. J.* 90 (2006): 4644-50.
- Nawarathna, D., J. R. Claycomb, G. Cardenas, J. Gardner, D. Warmflash, J. H. Miller, Jr., and W. R. Widger, "Harmonic Generation by Yeast Cells in Response to Low-Frequency Electric Fields," *Physical Review E* 73 (2006): 051914-1-6.
- Claycomb, James R. and John H. Miller, Jr., "Superconducting and High-Permeability Shields Modeled for Biomagnetism and Nondestructive Testing," *IEEE Trans. on Magnetics* 42 (2006): 1694-1702.
- Sanabria, Hugo and John H. Miller, Jr., "Relaxation Processes Due to the Electrode-Electrolyte Interface in Ionic Solutions," *Physical Review E* 74 (2006): 051505-1-9.
- Mershin, Andreas, Hugo Sanabria, John H. Miller, Dharmakeerthna Nawarathna, Efthymios M. C. Skoulakis, Nikolaos E. Mavromatos, Alexandre A. Kolomenskii, Hans A. Schuessler, Richard F. Luduena, and Dimitri V. Nanopoulos, "Towards Experimental Tests of Quantum Effects in Cytoskeletal Proteins," Chapter 4 of *The Emerging Physics of Consciousness*, Ed. Jack A. Tuszynski. The Frontiers Collection. Springer Berlin Heidelberg, 2006, pp. 95-170. (*Invited book chapter.*)

## Presentations

- Nawarathna, D., J. Gardner, G. Cardenas, J. R. Claycomb, J. H. Miller, Jr., and W. R. Widger. "Electromagnetic Probing of Mitochondria and Chloroplasts Reveals Unique Harmonics Due to Specific Components of the Electron Transport

Chain," Biophysical Society 50th Annual Meeting, Salt Lake City, UT, Feb. 18-22, 2006.

- Nawarathna, D., J. Gardner, G. Cardenas, D. Warmflash, J. Miller, W. Widger, and J. Claycomb. "Nonlinear Electromagnetic Responses of Active Molecular Motors in Live Cells and Organelles," *Bull. Am. Phys. Soc.* 51.200 (2006), March Meeting of the American Physical Society, Session B29, Focus Session on Microorganism Motility, Baltimore, MD, March 13-17, 2006.
- Vajrala, Vijayanand, James Claycomb, and John H. Miller, Jr., "Analytical Model of Induced Transmembrane Potentials in Cells and Organelles," *Bull. Am. Phys. Soc.* 51, 1524 (2006), March Meeting of the American Physical Society, Session Y26, Focus Session on the Physics of Physiological Systems, Baltimore, MD, March 13-17, 2006.
- Miller, J. H., Jr., D. Warmflash, D. Nawarathna, J. Gardner, G. Cardenas, and W. R. Widger, "Low-Frequency Electromagnetic Probes of Live Organisms," Session on Biogeophysics, 2006 Joint Assembly between the American Geophysical Union, Geochemical Society, Microbeam Analysis Society, Mineralogical Society of America, Society of Exploration Geophysicists, and Unión Geofísica Mexicana, Baltimore, MD, May 23-26, 2006. (*Invited Talk.*)

## Funding and Proposals

- Miller, J. H., Jr. "Dielectric Spectroscopy of Chemical and Biological Systems," Robert A. Welch Foundation, June 1, 2004-May 31, 2007. \$165,000.
- Miller, J. H. Miller, Jr., PI, W. R. Widger, Co-I. Dale J. Hamilton, MD, and Richard J. Robbins, MD, of Methodist Hospital. "Noninvasive Sensors of Metabolic Activity," NIH, Bioengineering Approaches to Energy Balance and Obesity (R21), \$150,000/yr for three years. (*Direct costs.*)
- Miller, J. H., Jr., PI. "Nonlinear Impedance Spectroscopy of Chemical and Biological Systems," Robert A. Welch Foundation, renewal of E-1221, \$60,000/year for three years. (*Direct costs.*)

## Planned submissions

- NIH (R01), United Mitochondrial Disease Foundation and American Diabetes Assoc. Marin Laughlin, an NIDDK program director in NIH, and others in NIBIB and NHLBI have expressed considerable interest in our ideas for detecting mitochondrial function.