

Biomedical Engineering Inspired by Nature: Biomimetics

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In biomimetics, one studies how nature, building atom by atom, i.e., through bottom-up manufacturing, through eons of evolution of life, developed materials, structures, processes and intelligence to inspire and improve the engineering and design of artificial materials, man-made structures and processes (e.g., software). Human manufacturing technology works in the opposite direction, i.e., it builds top-down; in most current manufacturing we tend to start with larger building blocks and use stiff materials (e.g., Si or stainless steel), whereas nature prefers small building blocks and mostly soft, low Young's modulus materials (e.g., muscle or skin). Throughout history, biomimetics has been attempted but often with less-than-satisfactory results. Bird flight, for example, did not lead to aircraft, but mathematical expressions from aerodynamics did. As a consequence, from the middle of the eighteenth century to about 30 years ago, engineers were tempted to engineer around nature's obstacles rather than be inspired by nature itself. Today though, in fields ranging from artificial intelligence to MEMS, NEMS and smart materials, the perceived advantages of bottom-up designs and manufacturing are convincing many scientists to research natural, biomimetic approaches and manufacturing methods. In this lecture we sample examples of biomimetics in design, materials and engineering.

Biography:

Marc Madou earned his doctorate degree at the University of Ghent in Belgium in the Solid State Physics lab of Professor Dekeyser (1978). After his studies he joined the Department of Materials Science of Dr. S. Roy Morrison at SRI International, Menlo Park, California, USA, as a visiting scientist. The research focused on liquid junction solar cells. In 1981 he returned to the University of Ghent, Belgium, to become an Assistant Professor working with Professor Gomes. He rejoined SRI in 1982 to work briefly on batteries with Dr. Michael McKubre. In 1983 he founded SRI's Microsensor Department in The Physical Electronics Laboratory. In 1989 he wrote his first science book (Chemical Sensing with Solid State Devices, Academic Press) and founded Teknekron Sensor Development Corporation (TSDC) one of the first MEMS/BIOMEMS companies (MEMS = microelectromechanical systems) in the Silicon Valley. Out of that very creative group came early work and patents on MEMS based responsive drug delivery systems, micromachined switches planar zirconia-based oxygen sensors, SOI based micro- mirrors, AFM tips, fast electrochemical oxygen and CO sensors and solid state pH electrodes. From the original TSDC team, people like Dr. Fariborz Maseeh (founder of IntelliSense (now Corning-IntelliSense)) and Dr. Armand Neukermans (founder of Xros (acquired by Nortel)) emerged as some of the most successful MEMS entrepreneurs yet. In 1992 he became a Visiting Miller Professor at University of California Berkeley and a NASA Ames Associate. Here, working with Professor Richard White, his interests shifted to polymer actuators and carbon based MEMS structures (C-MEMS) and he started writing "Fundamentals of Microfabrication" (CRC Press, 1997). In 1997 he accepted an Endowed Chair professorship

(Center for Materials Research Scholar) at the Ohio State University's Materials Science and Engineering Department combined with an appointment in the Chemistry Department. While at OSU, he started a fruitful and ongoing collaboration with Drs. Daunert and Bachas from the University of Kentucky, a husband and wife team, skilled in genetic engineering of proteins and biomimetic sensing strategies. Combining their biomimetic sensing chemistries with compact disc based fluidic platforms and novel in vivo drug delivery vehicles, a long list of papers and a few new start-ups resulted. Missing California and more and more intrigued with nanotechnology he joined Nanogen, Inc. in 2001 as Vice President of Research and Development. Their work focused on active DNA arrays and their integration in fluidic platforms. In July 2002, he accepted the position of Chancellor's Professor at UC Irvine in the Department of Mechanical and Aerospace Engineering, with a joint appointment in the Department of Biomedical Engineering. The Second Edition of Fundamentals of Microfabrication (CRC press) appeared early 2002 and has become a well accepted textbook in the MEMS field.