

Department of Aerospace Engineering Sciences
& Department of Computer Science
K. D. Wood Colloquium

Mory Gharib

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Lessons for Bio-Inspired Design: Fluid Dynamics of Embryonic Heart

Nature has shown us that some hearts do not require valves to achieve unidirectional flow. In its earliest stages, the vertebrate heart consists of a primitive tube that drives blood through a simple vascular network nourishing tissues and other developing organ systems. Traditional developmental dogma states that valveless, unidirectional pumping in biological systems occurs by peristalsis. However, our *in vivo* studies of embryonic Zebrafish heart (Nature 2003) where we mapped the movement of both the myocardial cells in the developing heart tube wall as well as the flow of blood through the tube contradicts the notion of peristalsis as a pumping mechanism in the valveless embryonic heart. Instead, we have discovered an intriguing wave reflection process based on impedance mismatches at the boundaries of the heart tube (Science 2006). From these observations we have developed a physio-mathematical model that proposes an elastic wave resonance mechanism (JFM 2006) of the heart tube as the more likely pumping mechanism. In this model fewer cells are required to actively contract in order to maintain the pumping action than are necessary in a peristaltic mechanism.

Inspired by this design, we have succeeded in constructing a series of mechanical counterparts to this biological pump on a range of size scale including scales comparable to that of embryonic zebrafish heart (e.g. ~400 microns). This new generation of biologically-inspired pumps functions on both the micro- and macro-scale and do not possess valves or blades. These advantages offer exciting new potentials for use in applications where delicate transport of blood, drugs or other biological fluids are desired. Also, in this lecture, we will discuss some of our recent experimental observations that may teach us how to grow biological micro valves.

Wednesday, April 15, 2009
DLC Bechtel Collaboratory
12:00 noon

Biography

Mory Gharib is a Hans W. Liepmann Professor of Aeronautics and Professor of Bio-Inspired Engineering at the California Institute of Technology. He received his B.S. degree in Mechanical Engineering from Tehran University (1975) and then pursued his graduate studies at Syracuse University (M.S., 1978, Aerospace and Mechanical Engineering) and Caltech (Ph.D., 1983, Aeronautics). After two years as a senior scientist at the Jet Propulsion Laboratory (NASA/CIT), he joined the faculty of the Applied Mechanics and Engineering Sciences Department at UCSD in 1985. He became a full professor of fluid mechanics in 1992 and, in January 1993, he joined Caltech as a professor of aeronautics. Dr. Gharib's research interests have included Free surface flows, Vortex dynamics, Micro-Fluidics, advanced Flow Diagnostic systems such as Micro Laser Doppler Velocimetry, and digital image velocimetry. His research activities in the area of biomechanics includes Bio-propulsion, Heart valve dynamics and valveless pumps.

Dr. Gharib's honors and affiliations include: Fellow, American association for the advancement of science (AAAS), Fellow, American Physical Society (APS), Fellow, American Society of Mechanical Engineering (ASME), Distinguished Israel Pollak Lectureship Award, 2005, Sackler Scholar in Bioengineering, University of Tel Aviv, Watson Lecturer, Caltech, 1997 & 2002, Editor, *Experiments in Fluids* (1995-2003), Associate Editor, *Journal of Fluid Engineering*, ASME (1992--1995), Executive Committee Member, American Physical Society (1992--1995), Award for Excellence, Visualized Image (Artistic Section), 1995, Visualization Society of Japan, Award for Excellence, Visualized Image (Technical Section), 1995, Visualization Society of Japan, Flow Visualization Award, American Physical Society, 1983, 1987, 1989, 1993, 1994, 2000, 2004. He has received 5 new technology recognition awards from NASA in the fields of advanced laser imaging and nanotechnology. For his 3-D imaging camera system, he has received R&D Magazine's "R&D 100 innovation award" for one of the best invention of the year 2008. Dr. Gharib holds more than 20 U.S. Patents.