MECHANICAL ENGINEERING DEPARTMENT
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Host: Joachim V.R. Heberlein
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Joint seminar with Departments of Chemistry, Chemical Engineering and Materials Science, and Mechanical Engineering

Bear Bones and Ferrous Wheels: When Might Nature be Worth Copying?

by

Steven Vogel
James B. Duke Professor
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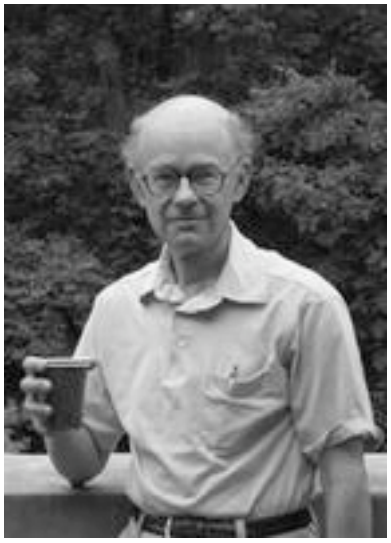
Wednesday, November 16, 2005
4:00 p.m.
2-650 Moos Tower
A reception will follow in the Dale Shephard Room of the Campus Club

ABSTRACT — Three points. (1) Ignore engineer-bashing claims that we humans have invented little. A remarkable number of our best bits of technology don't occur elsewhere in the living world. (2) Never mind assertions that we've often copied nature—few purported examples survive close scrutiny. Most cases of coincident designs just reflect basic physical imperatives. (3) Still, some cases of biomimetics have worked, the earthy contexts of human and natural technologies differ little, and we seem to be moving toward materials and designs that are closer to nature's. So we might just get some useful guidance from the past as we look to organisms for adoptable technology.



BIO — Steven Vogel is James B. Duke Professor in the Department of Biology at Duke University. He joined the Duke faculty in 1966, after receiving his doctorate at Harvard. While a biologist by training and inclination, he looks at mechanical factors behind the designs of organisms, in particular at their fluid dynamic devices. He has, for instance, considered the aerodynamics of especially small insects, convective cooling of broad leaves in near-still air and at drag minimization of the same leaves in storm-level winds, ways in which organisms from sponges to burrowing rodents use velocity gradients to induce flows through themselves or their domiciles, and ways in which organisms such as squid and whales use flow-induced pressures to re-expand their mantle and oral cavities. In addition he has written articles for a variety of popular magazines as well as several books. The latter include a textbook on biological fluid dynamics (*Life in Moving Fluids*), a more general book on biomechanics (*Life's Devices*), and a less academic book on circulatory systems (*Vital Circuits*). Two books explore the intersections of biomechanics, human technology, and human culture—*Cats' Paws and Catapults* compares the mechanical technologies of humans and of nature, while *Prime Mover* looks at how the performance of muscle as an engine has shaped human history and prehistory. And he has recently published an undergraduate textbook, *Comparative Biomechanics*.

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The Donaldson Lecture Series

On interdisciplinary topics in Chemistry, Chemical Engineering Materials Science and Mechanical Engineering sponsored by the Donaldson Company

November 15-16, 2005

STEVEN VOGEL

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Lecture 1: "*From Flower Stems to Feather Shafts: Twisting in the Wind Without Getting Bent Out of Shape"*
Date: Tuesday, November 15, 2005
Time: 1:25 pm
Place: B75 Amundson Hall, East Bank Campus

We usually regard low torsional stiffness as something to be avoided or offset in our structures, and insufficient stiffness has made big trouble for some airplanes, bridges, and buildings. Nature, though, goes in for less rigid structures than we humans build--she designs more often to a criterion of adequate strength rather than stiffness. As a result, in her world solid and fluid mechanics don't stay obligingly distinct--fluid forces change structural shapes that then encounter different fluid forces. Many of Nature's beams and columns seem deliberately designed to have low torsional stiffness relative to their flexural stiffness, a feature put to use in flows. For instance, low torsional stiffness permits insect wings and bird feathers to twist as needed to maintain appropriate angles of attack and permits leaves to minimize their drag in high winds by reconfiguring and clustering. A look at what Nature does might impel us toward designs where shape change under load amounts to virtuous reconfiguration rather than pathological deformation.