Vascular materials: Predicting Design Evolution

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Mechanical Engineering at Duke University : Distinguished Professor

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バージョン：

Keynote Speaker

Short Biography

Adrian Bejan is J. A. Jones Distinguished Professor of Mechanical Engineering at Duke University who is the recipient of the Benjamin Franklin Medal for "Thermodynamics and Constructal theory", which predicts natural design and its evolution in engineering, scientific, and social systems". He earned all his degrees from the Massachusetts Institute of Technology: B.S. (1971, Honors Course), M.S. (1972, Honors Course) and Ph.D. (1975). He was Fellow of the Miller Institute for Basic Research in Science, University of California Berkeley (1976-1978). Since 1989 he is the J.A. Jones Distinguished Professor at Duke University.

Prof. Bejan's research is in applied physics, thermodynamics, theoretical biology, and design and evolution everywhere in nature, bio, and non-bio. He created original methods of theory, modeling, analysis, and design, which today are associated with his name: entropy generation minimization, scale analysis, intersection of asymptotes, heatlines, constructal law, and evolutionary design everywhere in nature, bio and non-bio.

He is the author of 30 books and 700 peer-refereed journal articles. His total citations in Google Scholar passed 84,000 with the h-index of 107. According to the 2019 'citations impact' world rankings, he is 9th among all Engineering authors in the world, all disciplines.

He was awarded 18 honorary doctorates from universities in 11 countries, for example, Swiss Federal Institute of Technology (ETH Zurich), University of Rome I "La Sapienza", National Institute of Applied Sciences (INSA) Lyon, and University of Pretoria. He is a member of the Academies of Europe, Mexico, Turkey, Romania, and Moldova.

Adrian Bejan's books are used worldwide (in multiple editions), for example:

- **Advanced Engineering Thermodynamics**, 4th Ed, Wiley 2016.
- **Convection Heat Transfer**, 4th Ed, Wiley 2013.
- **Convection in Porous Media**, 5th Ed, Springer 2017.
- **Shape and Structure**, from Engineering to Nature, Cambridge U. P. 2000.
- **Design in Nature**, Doubleday 2012, two translations.
- **The Physics of Life**, St. Martin's Press, 2016, six translations.
- **Freedom and Evolution**, Springer Nature, 2020, two translations.
- **Time and Beauty**, World Scientific, 2022.
- **Heat Transfer**: Evolution, Design and Performance, Wiley, 2022

Vascular materials: Predicting Design Evolution

His lecture, entitled: Vascular materials: Predicting Design Evolution, will focus on one of his major contributions: evolutionary design illustrated in the case of multiscale vasculature, a methodology that can be used generally to predict the evolution toward flow access, miniaturization, high density of heat transfer, and the scaling up (or down) of an existing design.

Abstract

Porous materials are usually thought of as amorphous mixtures of two or more things, solids, fluids, and voids. The research field started that way, and so did my own activity in it. Along the way, I was drawn to the part of nature (the physics) that was missing from the amorphous view: the structure, flow, configuration, drawing (design), purpose, and evolution.

The lecture is pictorial. It begins with defining the terms, because words have meaning: vascular, design, evolution, and prediction (theory). Next, the lecture shows that vascular (tree shaped) architectures flow more easily than parallel channels with only one length scale (the wall to wall spacing). Transport across channels is facilitated when the spacing is such that the channel flow length matches the entrance (developing) length of the flow.

The tendency to evolve with freedom toward flow configurations that provide greater access is universal in nature, bio, and non-bio. This tendency is the *Constructal Law*, which empowers us to predict the evolution toward flow access, miniaturization, high density of heat transfer, and the scaling up (or down) of an existing design.

Multiscale vasculatures occur naturally because they flow more easily than their counterparts with a few length scales. The future of evolutionary design everywhere points toward vascular, hierarchical flow architectures that will continue to morph with freedom and directionality.