

# Preface

Biologically inspired design is a promising paradigm for design innovation as well as sustainable design. The scientific challenge now is to transform it into a repeatable and scalable methodology. This requires addressing several big challenges, including the following four: the first and foremost of course is to use the paradigm to address increasing numbers of real problems that translate into real products in the market. A second challenge is to document the best practices of successful applications of the paradigm and develop a theory of biologically inspired design. A third challenge is to develop computational methods and tools that can make biologically inspired design repeatable and scalable. A fourth challenge is to educate new generations of would-be-designers in the paradigm of biologically inspired design. These four challenges are interconnected and build on one another: success at one likely will spur success at others.

This volume brings together a dozen chapters that together address all four of the above challenges at least to some degree, while emphasizing computational methods and tools for biologically inspired design. We are pleased to bring together these articles by some of the leading researchers and practitioners of biologically inspired design into a single volume.

[Chapter 1](#) provides a brief review of two workshops sponsored by the United States National Science Foundation (NSF). These workshops served as the initial catalysis and formation of this book. Taken together, the two workshops brought together some 50 researchers in biologically inspired design, helped establish a stronger sense of research community, and led to the formulation of a research agenda outlined in the chapter.

[Chapter 2](#) by Jon-Michael Deldin and Megan Schuknecht describe AskNature, Biomimicry 3.8 Institute's publicly available webportal that provides a functionally indexed database of biological design strategies and systems. Insofar as we know, this is the first scholarly article describing AskNature in detail, and thus adds an important piece to the growing literature on biologically inspired design.

In [Chap. 3](#), Li Shu and Hyunmin Cheong describe a natural language approach to finding biological analogies and applying them to design problems. They review a decade long research program on developing the natural language approach to biologically inspired design, and also provide several examples of its application.

In [Chap. 4](#), Jacquelyn Nagel presents an engineering-to-biology thesaurus, along with several examples of its use in addressing design problems. This kind of thesaurus can be a very useful tool for designers in finding biological analogies to their design problems.

Nagel, McAdams, and Stone in [Chap. 5](#) describe the big picture of their several years of research on biologically inspired design. In particular, they present their information-processing theory of biologically inspired design, and illustrate it with several examples. They also describe a suite of tools that match several tasks in the process theory.

Goel, Swaroop Vattam, Bryan Wiltgen, and Michael Helms in [Chap. 6](#) present their information-processing theory of biologically inspired design. They also compare their theory with similar theories such as Design Spiral and BioTRIZ, and examine what makes biologically inspired design different from other paradigms.

In [Chap. 7](#), Jeannette Yen, Helms, Goel, Craig Tovey, and Marc Weissburg describe the evolution of a college-level interdisciplinary course on biologically inspired design. Their chapter reviews many lessons from teaching the course for several years. These lessons should be useful for potential teachers of similar courses.

In [Chap. 8](#), Amaresh Chakrabarti focuses on analogical transfer from biology to engineering. He proposes guidelines for supporting this analogical transfer and describes an interactive tool that implements the guidelines. Comparative studies indicate that use of the tool increases the number of transferred designs.

Julie Linsey and Vimal Viswanathan in [Chap. 9](#) study the cognitive challenges in biologically inspired design, focusing on design fixation. They describe several heuristics for addressing the challenges, including fixation. These heuristics should be useful for designing interactive tools for supporting biologically inspired design.

In [Chap. 10](#), Wojciech Bejgerowski, John Gerdes, James Hopkins, Lengfeng Lee, Madusudanan Sathia Narayanan, Frank Mendel, Venkat Krovi, and Satyandra Gupta focus on bioinspired robotics. Building on several years of research, they present case studies ranging from bird-inspired robots to snake-inspired robots. They also describe a process by which biological features are selected and simplified for application using existing technologies for robot construction.

Julian Vincent in [Chap. 11](#) specifies a need for identifying design principles that may help produce good technical designs without requiring biological expertise. He proposes four such principles derived from TRIZ: local quality, merging, dynamics, and prior cushioning. He calls for identification of design principles, especially those pertaining to information and material.

Frank Fish and John Beneski in [Chap. 12](#) analyze the limits of design by evolution in biology and design by analogy in biologically inspired design. They argue that biological designs are not necessarily optimal with respect to any specific function. They advocate focusing on biological features that outperform currently available technologies for incorporation into technical designs.

We are grateful to Janine Benyus for writing the Foreword to this volume. Her work at Biomimicry 3.8 has long inspired the biomimicry movement, including our own efforts.

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We also thank the Springer publishing company, and especially Grace Quinn at Springer, for working with us on the preparation of this volume. We can only hope that scholars and practitioners of biologically inspired design, as well as design teachers and students more generally, will find this volume useful.

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