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Preface

This Special Issue honors Professor Marc André Meyers for his contributions to biological and bioinspired materials on the occasion of his 70th birthday. It is a collection of 17 papers written by highly respected colleagues and friends of Professor Meyers, as well as by some of his former students. Marc's work in the research area of biological and bioinspired materials was initiated in 2000, after he had established himself firmly as a leading scholar in the field of mechanical behavior of materials, co-authoring three books and a large number of research papers, helping to define the field of dynamic behavior of materials. However, the kernel for his interest in biomaterials stems from much earlier, a fortuitous event that took place in 1967, half a century ago. Accompanying his father on a partridge hunting trip in the north of his home state of Minas Gerais, he rested in a forest after several hours of walking through the savannah-like *cerrado*. There, laying on the ground, he observed intently a toucan flying overhead, gracefully balancing a massive beak with the necessity of flight. He looked at the ground, always alert for snakes, and discovered the skeleton of a toucan. Picking up its skull, he realized how light it was. He bent and twisted it and was impressed by its stiffness. This was a Eureka moment and he understood instantly that the beak's design minimized weight while maximizing strength. A second one came in New Mexico, also in a hunting trip. Walking through the bush, Marc collected the trunk of a dead cholla cactus and peeled it, revealing an intricate structure that maximizes stiffness with a minimum of material. He keeps this faithfully on his mantelpiece and realized recently that significant efforts are being invested in generating bioinspired beams using these principles.

Marc's interest in biological materials owes a great deal to the encouragement provided by Richard Skalak, his mentor in the Institute for Mechanics and Materials. Starting in 1997, the first systematic effort by Marc Meyers and coworkers on biological materials focused on the abalone shell; they identified the critical mechanisms of toughening and growth. These early pioneering studies were followed by a number of investigations which resulted in the publication of a significant number of papers. The two biological materials that initiated his interest and propelled his actions are shown in Figure below as reference markers.

In the past twenty years, Marc has studied a cornucopia of biological materials, aided by a cohort of enthusiastic students and competent colleagues. They are listed below, with the student that spearheaded each effort, which in all cases was a truly collaborative undertaking.

Toucan and hornbill beaks: Matt Schneider and Yasuaki Seki
Abalone and conch shell studies: Reiner Menig, Albert Lin, Maribel Lopez
Asian mussel shell (Saxidomus): Wen Yang
Crab exoskeleton: Po-Yu Chen
Carp and coelacanth scales: Haocheng Quan
Arapaimas scales: Y. S. Lin
Alligator gar scales: Vincent Sherman
Boxfish: Steven Naleway
Seahorse: Michael Porter
Pangolin scales and whale baleen: Bin Wang
Turtle, alligator, and armadillo osteoderms: Iren Chen
Rabbit skin: Vincent Sherman
Pig skin: Andrei Pissarenko
Titanium implants: Glaucio Serra, Liliane Morais
Egg shells: Eric Hahn
Human, horse, and boar hair: Daniel Yu
Bird feathers: Tarah Sullivan
Dragonfish teeth and additive manufacturing: Audrey Velasco

In each of these studies, the structure-properties approach was applied, using the modern arsenal of testing, characterization, and analysis methods developed by materials scientists and engineers. These studies are revealing novel relationships and characteristics not heretofore explored by biologists and are significantly enhancing our knowledge.

Not content with studying these individual materials, Marc has continued to apply the method of René Decartes (in the *Discours de la Méthode*), whose essential precepts are:

1. Never accept anything for true which one clearly knows to be such;
2. Divide each problem into as many parts as are necessary; study each part as if the ones do not exist: this the *analysis* stage of research.
3. In ascending order, go from the simplest to the most complex.
4. Periodically assemble your knowledge in as complete and thorough a manner as possible. This is the *synthesis*.

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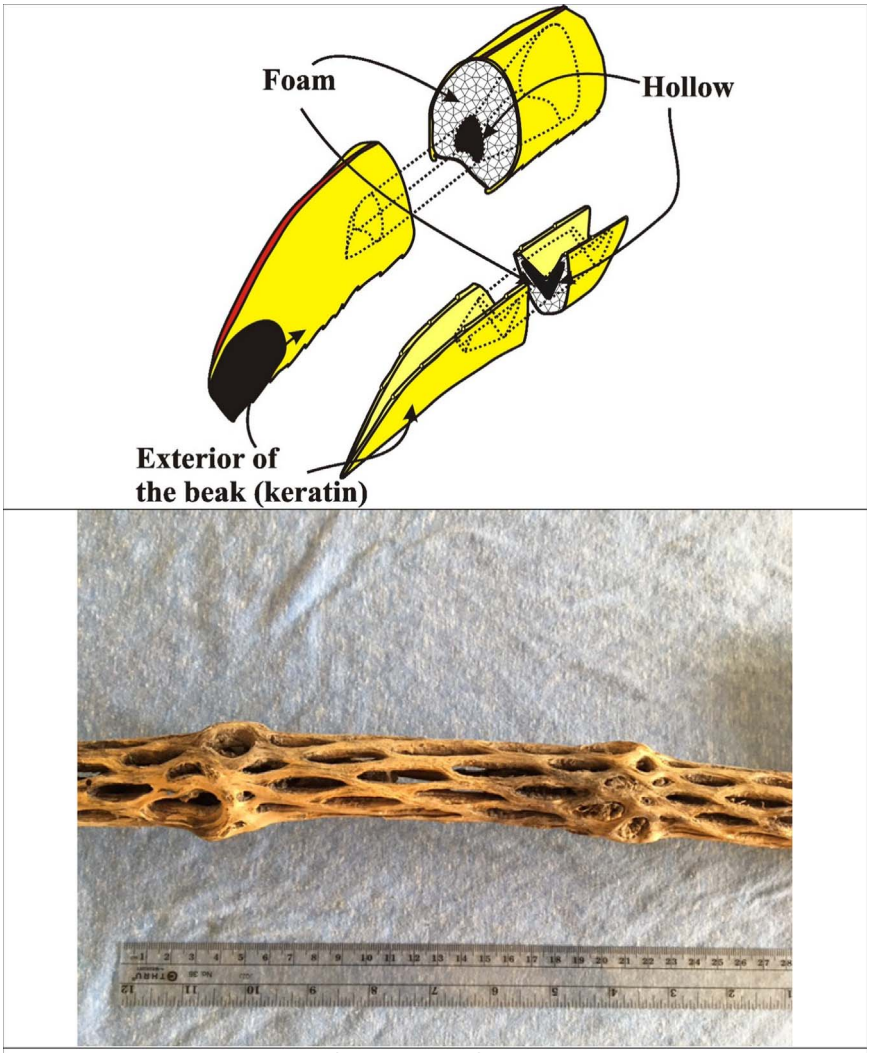
This has led to frequent and major reviews, published in Progress in Materials Science, Advanced Materials, JOM, JMBBM, MSEC, Materials Today, and to the book "Biological Materials Science" with Po-Yu Chen, published in 2014 by Cambridge University Press. In this endeavor, he has established, with his students and colleagues at UCSD and other institutions, a methodology for the study of biological materials laying the foundation for bioinspired designs that have transformative potential. This body of knowledge comprises close to twenty doctoral dissertations, several of which are still in progress. Of significance is the emergence of the concept of common structural design elements shared by many species and resulting from convergent or parallel evolution.

With a great admiration of Marc's professional contributions to materials science and engineering and of his devotion to engineering education, we look forward to many more years of his creative work, professional service, and genuine and supportive relationships to his colleagues and friends throughout the world.

1. Marc André Meyers – Bibliographical Sketch

Marc A. Meyers is Distinguished Professor of Materials Science at the University of California, San Diego. His research field is the mechanical behavior of materials. Within this field, he has focused on three areas: dynamic behavior of materials, nanocrystalline materials, and biological materials. In the dynamic behavior of materials, the unifying theme is the high rate at which events occur. He initiated this work in 1972 and has dedicated forty-five uninterrupted years to it, unifying it by emphasizing the physical and chemical phenomena. This has been defined in his now classic book "Dynamic Behavior of Materials" (1994, translated into Chinese), cited 2500 times. His honors include Fellow of TMS, APS, and ASM, as well as awards in the US (APS Shock Compression Award, ASM Charles Barrett, Albert White, and Albert Sauveur Awards, TMS Morris Cohen and Educator (Weertman) Awards, Acta Materials and Society Award, SMD/TMS Distinguished Engineer/Scientist and Service Awards), Europe (Humboldt, DGM Heyn, and DYMAT Rinehart Awards), and China (Lee Hsung Award). He was co-founder of the Center for Explosives Technology Research, New Mexico Tech, and of the EXPLOMET conference series (1980–2000). He is also the co-author of "Mechanical Metallurgy", "Mechanical Behavior of Materials" (both translated into Chinese), "Biological Materials Science", and approximately 440 research papers. He is corresponding member of the Brazilian Academy of Sciences, and of the Institute Grand Ducal (Luxembourg). In 2014 and 2015 he followed the celebrated 1914 Roosevelt-Rondon Scientific Expedition of Amazon on horseback and completed the kayak descent of the River of Doubt. He also writes fiction, and is the author of "Mayan Mars", "Chechnya Jihad", "A Dama e o Luxemburguês" (translated into French as "D'amour et d'acier"), and "Yanomami".



Lightweight structures that have fascinated Prof. Meyers and have inspired his studies in biological materials: (a) toucan beak with cellular core covered by keratin shell; (b) Hollow Cholla cactus trunk consisting of weaved wood fibers. Both structures maximize the stiffness/weight ratio.

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