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Biological materials science: An emerging art

Introduction

Artists often find inspiration in nature. Think of paintings of landscapes, birds, and people. Many subjects of art are from the natural world. So pervasive is nature in art that colours are often named after their naturally occurring namesakes: burnt sienna, cobalt blue, bone white. Take for example the glasswork of Dale Chihuly (1941-), a glass artist from Washington state. The 6th Biological Materials Science Symposium was held in Seattle at the Washington State Convention Center, which had on display outside the meeting rooms several Chihuly glassworks.[1] Fig. 1, depicts two such works in the collection which embody the spirit of biological materials science: nature, and a multidisciplinary quality. Chihuly is inspired by nature, but is a master in understanding how to manipulate technical materials to create beautiful thought provoking art. His end product is artwork but he too must have knowledge of materials science to get there!

Chihuly's inspiration and explanations of his work relate glass to water, and the shapes of his Seaforms to ridged shells, with added strength due to shape factor. The names of the colours of glass used in Chihuly's work also include inspiration from nature. Pale tabac: (tabac: French for tobacco) a faint and light brown colour; raven: a dark yet lustrous black with hints of deep blue and purple; oxblood: a deep red the colour of blood; and tangerine: the bright and zesty orange colour of the fruit with same name.

Scientists and Engineers also follow suit with regard to being inspired by nature. We look to nature for solutions to problems, or even for new ideas. In fact, we take the challenge a step further and try to imitate nature through our creation of technology: airplanes imitate the gliding flight of birds and insects; Velcro imitates the attachment mechanism of plant burrs; paints now mimic the superhydrophobic and self cleaning nature of the Lotus leaf. Biological Materials Science is a field based on nature, and discovering the scientific connections between many phenomena and biological processes is indeed an art. The field is wide, and rooted in many disciplines that are related through chemistry, physics, and biology. As engineers we cannot learn all of biology, so we need to form interdisciplinary collaborations to be successful, and this is one of the aims and strengths of our symposium. Each nesting basket in Fig. 1 can be thought to represent a different discipline with the field of biological materials science, and the all encompassing basket is the knowledge stored in the natural world. The art in the field is to determine how to relate, connect, and integrate knowledge so that it can easily flow from one discipline (basket) to another whilst also providing the ability for creation of new technology to help society.

What is next on the horizon for biological materials science? This special issue will give you some idea of the future and art with topics ranging from the growth of abalone shells to the characterization of articular cartilage.

Fig. 1. (left) Tangerine basket set with raven lip wrap; (right) Pale tabac basket set with oxblood lip wrap. Artwork: Washington State Convention Center Collection, Seattle, WA (2002): Baskets, Macchia, Persians, and a Seaform Set (Glass); Dale Chihuly. Photos: John A. Nychka.

[1] Convention Center Collection (2002): Baskets, Macchia, Persians, and a Seaform Set; Glass; Dale Chihuly.

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Symposium Details

The 6th Symposium on Biological Materials Science was held February 14–18, 2010 in Seattle, Washington, at the 139th Annual Meeting & Exhibition of The Minerals, Metals & Materials Society. The Biological Materials Science symposium was started in 2005[2] in an effort to expand the ever growing multidisciplinary field of materials science to include biology. Materials science was founded on physics, chemistry, and engineering; biology is a complex and rich arena in which to play and adapt the concepts and tools of the materials science toolbox. A major goal of the Biological Materials Science Symposium is to bring people together from diverse backgrounds to initiate discussions and interdisciplinary collaborations in the realm of biological materials. Our abilities to study, understand, and mimic nature are becoming more and more advanced, and through interdisciplinary study we continue to diffuse the boundaries between scientific disciplines, and some might say to even discover the sometimes hidden art in nature. The cover images attest to the beauty hidden in nature, and even in technical materials.

Biological materials science spans a great many disciplines and encompasses naturally occurring biological materials, biomaterials (materials intended for integration with biological systems), and bioinspired and biomimetic materials (structures, behaviour, and processing strategies taken from natural materials). Sessions held within the symposium were planned to accommodate the wide range of topics within biological materials science:

- Bio-inspired Materials Design and Processing I: Macromolecular Concepts and Applications
- Bio-inspired Materials Design and Processing II: Bioceramics and Biomineralization
- Mechanical Behavior of Biological Materials I: Nature-inspired Materials
- Mechanical Behavior of Biological Materials II: Hard Tissues and their Replacement Materials
- Mechanical Behavior of Biological Materials III: Soft Tissues and Materials
- Surface Engineering: Biomimetics and Biological Applications
- Computational Materials Science

Many excellent presentations were given throughout the symposium, most notably the keynote presentations. Professor Mehmet Sarikaya (University of Washington) talked about "*From Materials Science to Medicine Using Genetically Engineered Peptides*". Professor Sarikaya's talk and others from his group enlightened the audience as to how functional biological entities can be *engineered* to effect molecular signalers, erectors, and assemblers in medicine.

Professor Robert O. Ritchie's (University of California Berkeley) keynote presentation was part of The Institute of Metals/Robert Franklin Mehl Award, and his topic was *"Nature-Inspired Structural Materials"*. Dr. Ritchie's talk was inspiring and at a high technical level - qualities that demonstrate the field of biological materials science is not a passing fancy.

Professor Michelle Dickinson's (University of Auckland) talk regarding nanoindentation on the leg bones of anesthetized race horses. The exposure of new ideas was fantastic at the meeting, and it is clear that researches in the field are very creative and searching for new ways to explore materials in the biological realm. We won't soon forget Professor Marc Meyers' (University of California, San Diego) opening of a small cardboard box during his talk to reveal a stuffed piranha!

The Biomaterials Committee highly prizes the inclusion of students in the symposium both in attendance and in poster and oral presentations. The committee has sought extramural funding though the National Science Foundation (NSF) and the Army Research Office (ARO) for several years in order to offer travel stipends and poster awards to students. The organizing committee greatly acknowledges the continued financial support from the NSF and the ARO which has helped us to maintain and grow our future community through inclusion of a younger generation of scientists and engineers. In 2010 we managed to provide student stipends to 21 students to help defray the costs of travel to the conference.

Moreover, the Sunday evening of the conference we also held a student poster competition. While the quality and enthusiasm of all participants was high, the judges selected the following excellent presentations for awards:

Graduate Student Poster Awards:

1st place

"Wetting and Corollary Biocompatibility of Laser Synthetic Surface Micro-Textures for Bone Tissue Engineering,"

Sameer Paital, The University of Tennessee, Knoxville; co-authors: Yuling Yang, Zheng Cao, Wei He, Claus Daniel, Narendra B. Dahotre

2nd place

"Electro-Thermally Polarized Hydroxyapatite (HAp) Ceramics: Influence of MgO, ZnO, and SrO Dopants,"

Subhadip Bodhak, Washington State University; co-authors: Susmita Bose and Amit Bandyopadhyay

3rd place

"Tissue Development in Arabidopsis: 3D Shape Analysis for Detection of Cell Type,"

Begum Gulsoy, Carnegie Mellon University; co-authors: Fatma Uyar, Jean Christophe Palauqui, Marc De Graef, Anthony Rollett

Undergraduate Student Poster Award:

1st place

"Resorbable Tricalcium Phosphates for Bone Tissue Engineering: Influence of SrO Doping,"

Kenneth DeVoe, Washington State University; co-authors: Shashwat Banerjee, Amit Bandyopadhyay, and Susmita Bose

You will notice that when leafing through this special issue that one of the contributions was made by the award winning student Subhadip Bodhak, who is now currently a JSPS Post Doctoral Fellow at NIMS in Japan.

Special Issue Details

From the vast array of topics presented at the symposium we also had many diverse manuscript submissions. Through the peer-review process the accepted papers were divided into five main topic areas, and ordered therein:

Biological Materials
Biomaterials for Hard Tissues
Mechanics of Biomaterials and Tissue
Characterization of Soft Tissues
Metallic Biomaterials

[2] The first symposium was organized by Professor Roger J. Narayan at MS&T in 2005, and he has been a steady driving force and supporter of the symposia held at MS&T and TMS ever since. The name should look familiar - Professor Narayan is Editor-in-Chief of Materials Science and Engineering C!

In reading the issue you may find that the emerging biological materials science field has significant materials science and engineering roots, biology roots, computation roots, characterization roots, soft matter roots, and like a tree the field continues to develop roots and grow in many directions. We hope you find an area to which you may be able to contribute, or develop, in future symposia.

Summary

Nature has many mysteries and many solutions to problems. In some cases there are many solutions to the same general problem, for example the need of birds to fly. One has to be careful when assessing a particular perceived problem; when we extend the general problem of birds needing to fly we can consider the Ostrich, the Kiwi, and Penguin. Not all birds need to fly. The art of discovery from the natural world lies in our ability to prevent blind assumption: we cannot assume we know all the design elements, constraints, or processes in place for a particular application in nature – we may not even know the original problem. However, through careful study, discussion, and critical, analytical, and creative thinking we can use our discipline specific tools to synthesize our collected and nested knowledge to better our understanding and physical well being.

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