RESEARCH CLUSTER V: Evolutionary Materials

Cluster Co-Leaders: Alfred Crosby and Duncan Irschick

Cluster V research centers on a philosophical strategy that combines observation from natural variation and evolution with knowledge of physics, chemistry, engineering, materials science, medical science and computational science to address materials challenges for general societal benefit.

Overview While the concept of biomimicry is widespread, it is often employed by directly mimicking biological structures without necessarily considering the broader evolutionary context. Organismal design is complex and never perfect, and direct mimicry is therefore self-limiting and often misguided. Evolutionary materials research is based on the idea that understanding evolutionary variation is critical for developing novel bio-inspired materials. For example, the shape of airplane wings is inspired by bird wings, yet planes lack feathers, and while some bird wings are built for gliding and lift, others are better suited for speed and maneuverability. Evolutionary materials researchers integrate principles revealed by biological investigations and take advantage of variation among species in structure and material properties to create “hybrid” materials that offer high performance while circumventing weaknesses.

Dynamic Cluster: This dynamic cluster provides access to experts in Evolutionary Biology, Materials Science, Medical Science and Physics and encourages the flow of information in multidisciplinary directions. Cluster researchers will not only share with industry the results of their research, but also industry representatives are encouraged to share with cluster researchers their real world problems. Three research themes of particular interest are: 1) Prosthetics: With the goal of ensuring the utmost comfort to prosthetic users, cluster researchers will construct a novel prosthetic built with advanced materials to enable pain-free repositioning or removal, breathability for extended wear, and chemical flexibility to allow sensitivities to be addressed with ease. Such materials will impact many technologies, such as hair prosthetics, bandages, limb prosthetics, as well as wearable sensors; 2) Protective Materials/Environmental Materials: The group seeks to develop easy-to-use protective materials that provide comprehensive protection against chemical and biological irritants, and 3) Sustainable Habitats: Recognizing that human shelter is needed in many parts of the world, the center will develop a robust system that is easily transported, assembled, and disassembled for reuse. These structures will be based on biological design, require minimal tools for construction, yet use reusable materials.

Available Resources: Adhesion characterization instrumentation; ultra-thin film mechanical property measurement; optical profilometry; 3D printing; cavitation rheology; contact mechanical characterization; 140 core, multi-node Linux computing cluster; generation of nonparametric 3D models of biological structures; finite element analysis; statistical analyses of size, shape and variation in 1D, 2D and 3D space; biological specimens representing a diverse array of vertebrates; detailed knowledge of vertebrate anatomy and evolution; acquisition of fresh human skin; enrollment of human subjects.

Cluster Participants

Alfred J. Crosby, Professor, Polymer Science & Engineering. Research group focuses on gaining fundamental knowledge of structure-property-performance relationships, across an extensive size scale range, in order to create new, nature-inspired materials.

Duncan J Irschick, Professor, Biology. Lab examines both functional morphology and how natural structures and behaviors inspire novel technologies in animals from lizards, sharks, spiders to mammals.

R. Craig Albertson, Associate Professor, Biology. Focus lies at the intersection of genes, development and evolution in integrating studies in laboratory and evolutionary models to address fundamental questions related to the evolution of complex morphologies.

Elizabeth Dumont, Professor, Biology. Lab studies the evolution of animal form and function from many different perspectives including natural environments to document behaviors, and linking those functions to anatomical form through detailed biomechanical studies.

Gregory M. Grason, Associate Professor, Polymer Science & Engineering. Group studies theories of mesostructured soft matter assemblies by integrating and applying statistical mechanics, continuum elasticity and geometry to model frustrated order in flexible assemblies.

John E. Harris, MD, Assistant Professor, Dermatology at UMass Medical School. A practicing board-certified dermatologist and physician-scientist with a research interest in skin function, both in animal models and human tissue.

Ryan C. Hayward, Professor, Polymer Science & Engineering. Group studies soft, responsive, and nanostructured materials. Emphasis is placed on bioinspired design including reconfigurable 3D forms shaped by processes that mimic natural morphogenetic strategies.

Sarwat Hussain, MD, FRCR, FACR, Professor, Radiology at UMass Medical School and Division Chief, Global Radiology. Research interests include simulation and collaboration with non-medical scientist in developing new methods of training and education.

Jae-Hwang Lee, Assistant Professor, Mechanical & Industrial Engineering. Group focuses on the mechanical, optical, and thermal behaviors of metallic, polymeric, and biological microstructures using projectile impact testing, direct laser writing and infrared radiometry.

Maureen Lynch, Assistant Professor Mechanical & Industrial Engineering. Lab focuses on mechanical regulation of cancer in the skeleton, specifically through development of novel platform systems that apply cyclic mechanical forces to in vivo and in vitro 3D culture.

Christian D. Santangelo, Associate Professor, Physics. Group uses geometrical principles to understand the behavior of soft and biological materials. Through collaborations with experimentalists, they leverage this understanding to develop tools to design new functional materials.

Contact Information

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