Speakers and Chairpersons – Abstracts and Bios

Eric Amis

College of Polymer Science and Polymer Engineering, University of Akron

Bio: Eric J. Amis has responsibilities as Vice Provost for Research at the University of Akron and as Dean of the College of Polymer Science and Polymer Engineering. He has a special interest in research engagement with industry.

Dr. Amis came to UA in 2014 from United Technologies Research Center, where he was Director of Physical Sciences since 2009. He led a team of 140 scientists and engineers responsible for research and development in advanced manufacturing, materials and chemical sciences, structural integrity, applied physics, and measurement science. In addition, he was responsible for developing external partnerships aligned with UTC strategies in advanced manufacturing.

Prior to UTRC, Amis spent 15 years in leadership roles at the National Institute of Standards and Technology (NIST) for the Materials Science and Engineering Laboratory, including 10 years in the Polymers Division. Before NIST, he was on the faculty in chemistry at the University of Southern California for 11 years. His Ph.D. in chemistry is from the University of Wisconsin-Madison and B.S. from Willamette University.

Dr. Amis is a member of the Connecticut Academy of Science and Engineering and a Fellow of the American Chemical Society, the Materials Research Society, the American Physical Society, and the Polymeric Materials Science and Engineering Division of the American Chemical Society. He has served as chair of the Division of Polymer Physics of the APS and of the Polymer Chemistry Division of the ACS, and he was Editorin-Chief of the Journal of Polymer Science: Physics for 11 years. His research interests are combinatorial and high-throughput methods for functional polymers or biomaterials, direct write and additive manufacturing, nanomaterial characterization, gels and networks, polyelectrolytes, and soft matter physics. He has 150 peer-reviewed publications and 56 H-index.

The University of Akron is the region's most influential public research university, contributing to the resurgence of the local economy and providing a workforce highly trained in a full range of undergraduate and graduate majors. With its career-focused and experiential learning UA defines a polytechnic approach to education. Its internationally renowned College of Polymer Science and Polymer Engineering, which has one of the largest concentrations of polymer expertise anywhere, draws top students and distinguished partners from around the world. The wealth of expertise at UA has helped establish Northeastern Ohio as "Polymer Valley."

Mark Avsec

Benesch, Friedlander, Coplan & Aronoff LLP

The Synergistic Relationship Between Biomimicry and 3D Printing

Abstract: Nature has been called the ultimate 3D printer. This talk will explore why a 3D printer and the right materials will likely result in the most efficient and elegant parts and products that the world has ever seen: parts and products that mimic nature's strategies and designs.

Bio: Mark E. Avsec is a partner and Vice-Chair of the Innovations, Information Technology & Intellectual Property (3iP) Practice Group of Benesch, Friedlander, Coplan & Aronoff, LLP. He leads Benesch's 3D Printing Legal Team.

A copyright, trademark, and media lawyer by trade, and a litigator and business attorney, Mr. Avsec focuses his practice on "old" and "new" media issues, consumer products, technotainment (including music and other entertainment-related technology licensing matters), and general mobile commerce.

Mr. Avsec provides general legal support to various types of museums, technology and software companies, consumer products companies, and media, music, film, creative content, and content distribution companies. His practice focuses on complex technology licensing deals involving creative content, 3D-printing industry related counseling, copyright, trademark, and trade dress litigation, copyright and trademark prosecution, fair use and rights of publicity/privacy counseling, celebrity endorsements, and an expertise in privacy and data security compliance. Before becoming a lawyer,

Mr. Avsec earned a living as a studio musician, producer and songwriter, writing over 500 songs and producing or performing on more than 35 albums for, among other artists, Carlos Santana ("Angel Love"), Bon Jovi ("She Don't Know Me"), Donnie Iris ("Ah! Leah!" and "Love Is Like A Rock"), Mason Ruffner ("Gypsy Blood") and Wild Cherry ("Play That Funky Music, White Boy"). Mr. Avsec regularly teaches and is a frequent speaker on 3D printing and intellectual property topics. He serves as an Adjunct Law Professor at Case Western Reserve University School of Law since 2003. He is also a faculty member at the Great Lakes Sports and Entertainment Academy, a joint program of Case Western Reserve University School of Law and Cleveland-Marshall College of Law, Cleveland State University, where he has taught since 2012. He has participated as a faculty member for the Federal Judicial Center and the Berkeley Center for Law & Technology where he has presented on copyright law basics and infringement analysis to federal judges with Professors David Nimmer and Peter Menell at the University of California, Berkeley, Boalt School of Law.

Mr. Avsec has served the Cleveland community in the past as a chairperson of The Volunteer Lawyers for the Arts section of The Cleveland Bar Association, a member of the Board of Trustees of the Contemporary Youth Orchestra, and a member of the Cleveland Foundation's Rock and Roll Hall of Fame Foundation Scholarship Fund Selection Committee. Mr. Avsec is currently a member of ASCAP, the Dean's Visiting Committee of Cleveland State University's College of Liberal Arts and Social Sciences, and the Board of Trustees of the Cleveland Metropolitan Bar Association. He was recently appointed by Cuyahoga County Executive Armond Budish to serve on the Cuyahoga Arts & Culture's Board of Trustees. Mr. Avsec earned his B.A. summa cum laude in 1992 and his J.D. magna cum laude in 1994 from Cleveland State University. He is a ranked lawyer in Chambers USA 2015 and Chambers USA 2016, and has been named an Ohio "Super Lawyer" for Intellectual Property multiple times. He is a member of the Leadership Cleveland Class of 2014. In conjunction with Cleveland State University's 50th anniversary, he was named one of Cleveland State University's most fascinating alumni.

Yoseph Bar-Cohen
Jet Propulsion Laboratory, California Institute of Technology

Planetary Exploration Using Biologically Inspired Technologies

Abstract: A key objective of the NASA's solar system exploration of planetary bodies is the search for preserved bio-signatures and habitable regions. In support of this objective, various biomimetic approaches having a range of technology readiness levels (TRL) are being investigated. The efforts include artificial nose that was tested on the International Space Station, a biomimetic optical sensor for real-time measurement of aircraft wing deflection, artificial muscles as actuators, parallel processing algorithms, as well as snake-like robotic device that can be articulated to traverse through narrow openings and passages to conduct maintenance and inspection functions. The development of electroactive polymers (EAP), also known as artificial muscles, is at version TRLs but they are still far from being used to actuate flight hardware. In 1999, in an effort to promote rapid development of EAP worldwide, the author posed an arm wrestling challenge [http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/EAP-armwrestling.htm].

At his lab, the author has a task focused on deep drilling using piezoelectric actuation and the developed drill is called Auto-Gopher. The drill is biologically inspired by the gopher method of digging holes and underground tunnels. It requires relatively pre-load making it effective at low gravity environments and is piezoelectric actuation makes it applicable for operating at extremely include low or high pressures and temperatures.

To explore future directions for the field of biomimetics, the author will cover in his paper also the topic of humanlike robots as the ultimate challenge. While for many years such robots were considered a science fiction, they are increasingly becoming an engineering reality and they are able to perform impressive functions and tasks. In 2012, DARPA posed a Robotic Challenge to produce such robots that operate in disaster scenarios that would make society more resilient. Another significant development in this field is the fact that major US corporations have entered into the race to produce commercial humanlike robots. As a result, one can expect significant advances in the coming years.

Bio: Dr. Bar-Cohen is a physicist specializing in electroactive materials/mechanisms and ultrasonic NDE. He has extensive experience initiating and leading multidisciplinary tasks while partnering with experts from the academia, industry and other R&D organizations. His efforts and leadership led to the development of novel ultrasonic drill, multi-radiation ferrosource, piezoelectric motors, piezoelectric pump, ultrasonic NDE methods, real time sensing, geophysical probing techniques, haptic interfaces, electroactive polymer actuators (artificial muscles), and high power ultrasonic techniques.

Nikolaus Correll
University of Colorado Boulder

Material-integrated Intelligence for Robot Autonomy

Abstract: Advances in miniature electronics, distributed algorithms and manufacturing technology have enabled a new generation of smart composites that tightly integrate sensing, actuation, computation and communication. Such “robotic materials” are inspired by multi-functional natural structures such as the skin of the cuttlefish that can change its color and patterning, bird wings that can change their shape, or the human skin that provides tactile sensing at high dynamic range. I will describe a series of recent results that best illustrate the benefits of material integrated computation: high-bandwidth sensing for texture recognition and localization in artificial skins, distributed optimization for controlling shape change, distributed classification for recognizing gestures drawn onto a modular facade, and feedback control of soft robotic actuators. I will then describe current challenges in robotic grasping and manipulation, and demonstrate how robotic materials can provide critical sensing and control during a series of manipulation tasks with applications to warehouse automation, manufacturing and lab automation.

Bio: Nikolaus Correll is an Assistant Professor in Computer Science at the University of Colorado at Boulder with courtesy appointments in Aerospace, Electrical and Materials Engineering. Nikolaus obtained a degree in Electrical Engineering from ETH Zurich in 2003 with visits at Lund Tekniska Hogskola, Sweden, and Caltech, and earned a PhD in Computer Science from EPFL in Lausanne, Switzerland in 2007. He did a post-doc at MIT CSAIL from 2007-2009. Nikolaus is the recipient of a 2012 NSF CAREER award and a 2012 NASA Early Career Faculty Fellowship. He has received multiple best paper awards at international conferences including DARS (2006, 2012) and SAB (2008).

Haibo Dong

University of Virginia

Aerodynamic Role and Low Dimensional Analysis of Wing Surface Morphology in Bio-inspired Flapping Flight

Abstract: Surface morphing in flapping wings is a hallmark of insect/bird flight. In current work, the role of dynamic wing morphing of free flying hummingbird and dragonfly on the aerodynamic performance is computationally studied using an in-house immersed-boundary-method based N-S equation solver. A 3D image-based surface reconstruction method is firstly used to obtain the kinematics and deformation of hummingbird wings from high-quality high-speed videos. The observed wing surface morphing is highly complex and a number of modeling methods including singular vector decomposition (SVD) are used to obtain the fundamental kinematical modes with distinct motion features. Their aerodynamic roles are then investigated by conducting high-fidelity flow simulations for flow visualization and performance evaluation. The results show that the chord-wise deformation modes play key roles in the attachment of leading-edge vortex, thus modulate the unsteady flows and improve the performance of the flapping wings.

Bio: Professor Dong obtained a Ph.D. degree in Aerospace Engineering from UCLA. In 2006, he joined the Wright State University as an Assistant Professor in the Department of Mechanical and Materials Engineering, where he received the Presidential Early Career Achievement award in 2010 and was promoted to tenured Associate Professor by 2011. In that year, he also received NSF Faculty Early Career Development (CAREER) award and Excellence in Teaching award from Southwest Ohio Council for Higher Education (SOCHE). In August 2012, he joined the Department of Mechanical & Aerospace Engineering at the University of Virginia as Associate Professor.

Rebecca Eagle-Malone

University of Akron

Biomimicry in our Backyard

Bio: Rebecca, mother of 3 children, explored both urban and rural landscapes in Stark and Carroll Counties while growing up. After graduation, she eventually spent time living in Oklahoma, Virginia, and Connecticut. In every location, she found interesting natural features unique to that particular region. From all these adventures blossomed an intrigue of ecosystems and how each one sustains itself on local and available resources—each component working for survival , yet interworking as a whole to serve the ecosystem as a whole. Upon returning to Ohio in 2010, Rebecca took that intrigue to The University of Akron to complete a degree in Biology. Finding a love of plants and trees, specifically, developed out of a seasonal job (or two!) with Cleveland Metroparks Natural Resource's Plant Community Assessment Program. She believes that plants and soil hold many properties that have often been overlooked to solve problems we are currently facing on the planet and intends to do as much as she can to bring about an awareness of Botany Biomimicry. Currently, she is sponsored by Cleveland Metroparks Zoo as an educator of biomimicry within the Conservation Science Education Department.

Russell Eberhart

Indiana University, Purdue University

Swarm Intelligence and Extended Analog Computing

Abstract: This presentation reviews the basic attributes of extended analog computers (EACs), and the development of EAC applications using swarm intelligence. An EAC is a continuous ‐ valued, implicitly parallel, reconfigurable processor that operates within a framework of a continuous distributed computational model. Is a paradigm (example) of the concept of natural computing. The EAC is enabled to accomplish useful tasks with structures that are configured (not programmed). An EAC has no RAM, no ROM, no program, and no clock. Configuration can be accomplished using evolutionary algorithms such as particle swarm optimization. Examples of EAC implementations and configurations are presented. Future research and development includes replacing programmed microprocessors, and the implementation of fully integrated analog/digital computers.

Bio: Russell C. Eberhart, an American electrical engineer, best known as the co-developer of particle swarm optimization concept (with James Kennedy (social psychologist)). He is emeritus professor of Electrical and Computer Engineering, and adjunct professor of Biomedical Engineering at the Purdue School of Engineering and Technology, Indiana University Purdue University Indianapolis (IUPUI). Fellow of the IEEE. Fellow of the American Institute for Medical and Biological Engineering. He earned a Ph.D. in electrical engineering from Kansas State University in 1972. And he was Associate Editor of IEEE Transactions on Evolutionary Computation and Past president of IEEE Neural Networks Council.

Marjan Eggermont
University of Calgary

Zygote Quarterly, an Open-source Bio-inspired Design Journal

Abstract: Zygote Quarterly (zqjournal.org) is an open-source bio-inspired design journal. ZQ's mission is to establish a credible educational platform showcasing the nexus of science and design in the field of biologically inspired design, using case studies, news and articles that are exemplary in their impact on the field, rigorous in their methodology, and relevant to today's reader. In this talk I will discuss how using the application and tools articles could help students and professionals learn about biomimicry, I will give overview of several articles currently available, and I will discuss our recent research into the 3D modelling of insect gears and the potential for application. I will also discuss my work in biomimicry and education since 2004.

Bio: Marjan Eggermont grew up in The Netherlands and immigrated to Canada in 1986. She has a B.A., a B.F.A. and M.F.A. from the University of Calgary and is currently working on a PhD in Computational Media Design, a collaboration between art, design and computer science. Marjan is Associate Dean (Student Affairs) and a faculty member at the University of Calgary in the Mechanical and Manufacturing department of the Schulich School of Engineering. Marjan's innovative work has gained her recognition, including being named in 2003, one of the 20 most influential artists in Calgary by the Calgary Artwalk Society and as one of 45 international artists featured in "Printmaking at the Edge" by Richard Noyce (2006). She recently completed a large installation piece for the new EEEL Building (Energy, Environmental, Experiential Learning Building) at the University of Calgary which is jointly financed by the U of C Alumni Association, The Students Union and the graduating class of 2010 as the first ever legacy gift to the campus.

Barbara Esker
NASA Headquarters

ARMD Overview and Interest in Biomimicry

Bio: Barbara Esker is the Deputy Director, Advanced Air Vehicles Program, NASA HQ. As deputy director in close partnership with the director, Ms. Esker is responsible for the overall planning, management and evaluation of the mission directorate's efforts to develop tools, technologies, and concepts that enable new generations of civil aircraft that are safer, more energy efficient, and that have a smaller environmental footprint. The AAV program works to achieve major leaps in the performance of subsonic fixed-wing and vertical lift air vehicles to meet growing long-term civil aviation needs, in the concept of low-boom supersonic flight, and in sustaining hypersonic competency for national needs. Since September 2009, Ms. Esker had served as the deputy director for the Fundamental Aeronautics Program under the NASA Aeronautics Research Mission Directorate at NASA Headquarters in Washington, DC. In 2010, Ms. Esker received a NASA Exceptional Service Medal for sustained excellence and innovation in program management. She has also received three agency-level recognitions, six team achievement awards, 27 individual contribution awards, the Glenn Federal Women's Program Award and has completed OPM's Women's Executive Leadership Program. Ms. Esker holds bachelor's and master's of science degrees in mechanical engineering from the University of Akron and a certificate in engineering management from Case Western Reserve University.

Anamarija Frankić
UNIZD & Biomimicry New England

Green Harbors Project® and Biomimicry LivingLabs®

Abstract: The dynamics of coupled human-natural systems, and our capacity to manage and protect both, requires training of environmental professionals in new ways. The complexities of coupled systems demand innovative scientists and professionals with new knowledge and expanded capacity to implement novel strategies and sustainable solutions. Biomimicry LivingLabs® is a 'common sense' program designed to foster transdisciplinary learning by providing a direct response to local community needs for green infrastructure technologies that will support both human and ecological services and functions in urban harbors (e.g. green cement, green piers, floating salt marshes and shellfish beds, living shorelines). Our three key goals are to: 1) educate and inspire a new generation of environmental problem solvers; 2) bring feasible and resilient solutions to local community, and 3) engage industry and businesses in applying science and innovative green technologies in restoring our urban coastal areas. As part of the Green Harbors Project, our LivingLabs have been initiated at diverse sites as a response to local community needs: Nantucket Island, Boston Harbor, Wellfleet, Orleans, Cohasset and Gloucester Harbors, and at the University of Zadar, Croatia. At each site the Livinglabs approach is uniquely and organically designed to integrate practical learning and innovation with professional development, entrepreneurial skill development, and team building that inspires and implements holistic solutions to environmental and social challenges specific for each place. The implementation of the best practices developed by LivingLabs in their surrounding communities will serve as a teaching tool for communities worldwide, as they create their own livinglabs, which can be used as local centers/expos of innovation for applied science, technology, engineering, design and art. Our projects include integrated approach to restore three keystone costal habitats: salt marshes, oyster reefs and eel grass beds. How can we learn from these systems and work with them to bring back lost ecological services in urban harbors? These efforts will spread ideas, experiences, and technologies to communities who may otherwise not have access to such resources (addressing social and environmental justice is the key driving force n our LivingLabs). For this purpose we designed the free open online course "Coasts & Communities" that is sharing our experiences, solutions and challenges. All our projects and reports are available on line at www.umb.edu/ghp

Bio: Dr. Anamarija Frankić is a founding director of the Green Harbors Project®, and the Biomimicry LivingLabs®, a research faculty at UMass Boston and University of Zadar, Croatia. She is a Biomimicry, Fulbright and Sea Grant Knauss Fellow, in 2014 she founded the Biomimicry New England. Her educational background in biology, ecology, limnology and marine science, guided her interdisciplinary restoration research and management work in coastal, marine and fresh water ecosystems, nationally and internationally. Her work is about integrating human services with ecological services and functions in our built environments to support resiliency and sustainability. She initiated and established the 'livinglabs' for applied science education and research where students, local communities and businesses are able to 'learn and teach by doing' biomimicry, applying nature's wisdom for resilient today and tomorrow; her premise is that 'the environment sets the limits for sustainable development'.

Amir Gandomi
Michigan State University

Evolutionary Computation for Real-World Optimization Problems

Abstract: Evolutionary Computation (EC) has been widely used during the last two decades and has remained a highly-researched topic, especially for complex real-world optimization problems. Evolutionary optimization methods are inspired from biological systems or nature in general. The efficiency of EC is due to their significant ability to imitate the best features of nature which have evolved by natural selection over millions of years. The main theme of this presentation is about nature-inspired optimization techniques and their application to engineering optimization problems. At first, applied EC in optimization field will be presented, and then some nature-inspired algorithms will be explained such as Krill Herd and Interior Search Algorithms which I proposed recently. Then, some of my studies on applications of these algorithms on complex and nonlinear engineering problems will be presented. Additionally, optimization results of large-scale structures (e.g. tower structures) using BIC will be illustrated which show the applicability of BIC for real-world problems. It will also be explained how such algorithms have been adopted to the real-world problems and how their advantages over the classical optimization problems are used in action.

Ashok Goel
Georgia Institute of Technology

Cognitive Challenges of Biologically Inspired Design

Abstract: The paradigm of biologically inspired design espouses the use of biological systems as analogues for inspiring the design of technological systems as well as standards for evaluating system designs. Over the last generation, this paradigm has transformed into a design movement as evidenced by a rapid proliferation of educational programs and courses in biologically inspired design. Yet, our understanding of the biologically inspired design paradigm remains modest. We have been studying biologically inspired design practice for almost a decade. During this time, we have conducted in situ studies and developed information-processing theories of biologically inspired design. We have also developed a digital library of case studies of biologically inspired design, as well as a suite of computational techniques and tools for supporting its practice. In this talk, I will summarize this decade long research in terms of the fundamental cognitive challenges of biologically inspired design. I will posit that these cognitive challenges may provide the core principles for organizing both pedagogy and practice of biologically inspired design.

Bio: Ashok K. Goel is a Professor of Computer Science and Cognitive Science in the School of Interactive Computing at Georgia Institute of Technology in Atlanta, USA. He is Director of the School's Design & Intelligence Laboratory, a Co-Director of the Institute’s Center for Biologically Inspired Design, and a Fellow of Brook Byers Institute for Sustainable Systems. He is also President of The Biomimicry Institute’s Board of Directors, and a Founding Member of the BID Think Tank. His TEDx talk in 2012 <http://www.youtube.com/watch?v=wiRDQ4hr9i8> summarizes some of his research on biologically inspired design. An interactive tool for supporting some aspects of biologically inspired design developed by his laboratory is available at <http://dilab.cc.gatech.edu/dane/>.

Acknowledgements: This research represents joint work since 2006 with several Georgia Tech colleagues including Swaroop Vattam, Michael Helms, Bryan Wiltgen, and Jeannette Yen. It has been supported by several grants from NSF over the years.

Petra Gruber
University of Akron

A Biomimetic Approach to Architecture and Design

Abstract: In recent years, the method of biomimetics has successfully contributed to innovations in different fields of technology, and also in architectural design the approch is increasingly applied.
Past projects in the field of biomimetic architectural design include workshops on space exploration as well as terrestrial applications focusing on building facades, and the development of experimental approaches to transfer a biological paradigms into an architectural and artistic dimension. The talk will present an overview of recent projects carried out in international interdisciplinary teams, together with a discussion on methodologies, tools, and challenges encountered.

Bio: Dr. Petra Gruber is an architect with a strong interest in inter- and transdisciplinary design. Apart from her professional work as an architect, she holds a Ph.D. in Biomimetics in Architecture from the Vienna University of Technology in Austria. She also collaborated as a research fellow at the Centre for Biomimetics at The University of Reading, UK. She taught Biomimetics in Energy Systems at the University of Applied Sciences in Villach, Austria, and held lectures and workshops at universities worldwide. As a visiting professor for Architectural Design and Building Science, she set up a master's program in Advanced Architectural Design at the Addis Ababa University in Ethiopia. Her research spans from projects for the European Space Agency on lunar base design informed by folding principles from nature to arts-based research on the translation of growth principles from nature into proto-architectural spatial solutions. Dr. Gruber is based at the Myers School of Arts and the Department of Biology for the Biomimicry Research and Innovation Center or BRIC.

Stephen Howe

University of Akron

Fossil Doesn’t Equal Failure

Bio: Stephen is beginning his second year in the Biomimicry PhD fellowship at the University of Akron. He received his bachelors of science in biology focusing on ecology evolution and natural history from Westmont College in Santa Barbara California. As an avid swimmer and scuba diver, his love of water was naturally paired with an affinity for fish, cetaceans, and other aquatic organisms. He has also harbored a passion for dinosaurs since his youth, including their extant descendants, birds. His research focuses on aspects of flight and swimming kinematics and he hopes to apply it towards improving autonomous and remotely operated swimming and flying vehicles.

Rashmi Jha
University of Cincinnati

An Artificial Brain Mechanism to Develop a Learning Paradigm for Robots

Abstract: The navigation problem in unmanned vehicles consists of three parts, viz., localization, obstacle avoidance, and path planning. Localization can be achieved using a GPS outdoors, but for indoor environments, or areas which are cluttered, some sort of alternate localization method is required. The challenges associated with obstacle avoidance and path planning are the reasons behind autonomous navigation of robots still being a developing area. Most of the applications involving path planning and navigation include search, rescue, surveillance, and tracking of targets, and HazMat spills etc. These tasks become much easier and safer if the robot can be automated. For indoor environments, there is no localization data available, such as GPS, thus creating a challenge to localize obstacles and avoid them. Humans and animals have long been solving the navigation problem intuitively using their brains. The human brain is a remarkable learning machine that uses neurons connected via synapses to learn the environment and then exploit this learning when presented with the similar situation. This motivated us to study the brain learning mechanism that will be able to solve numerous complex problems. This can be done by developing an algorithm that makes use of the concept of spiking neurons connected together in synaptic array to implement the learning mechanism. We have a unique opportunity to implement this on robots, since we have already built a memristive device that mimics the synapse of the human brain and can be used to implement the rules of Spike Timing Dependent Plasticity (STDP). According to STDP, synaptic weights between two neurons are increased if presynaptic spike occurs before the postsynaptic spike, thus establishing a causal correlation between spiking times of the two neurons. On the other hand, if the postsynaptic spike occurs before the presynaptic spike, the synaptic weight between the neurons is decreased. We are working towards developing a novel solution for implementing learning using resistive memory devices. This will enable us to invent an artificial brain mechanism that can learn by observing the environment and take actions to achieve a required goal. We aim to implement this learning scheme on a robot by integrating it with the resistive memory device that can mimic the synapse of the human brain. Through this work, we hope to achieve the unsupervised learning mechanism applied to robots. This will solve a myriad of problems especially in the area of navigation and path planning. The present hindrances in this area include the lack of knowledge of the environment, thus proving it difficult to achieve a robust navigation technique. This learning mechanism may prove to be the answer to this problem. We are working to achieve two aims through this study: 1. Development and interfacing: Firstly, we wanted to interface the learning scheme with a model of the resistive memory device that we have already developed. This memory device is a cross bar array of resistors that can change their resistance based on an applied voltage signal. These resistance states can store the information about the association of sensor and actuator neurons. We have simulated the mathematical model of the learning scheme and are extending it to the hardware now. 2. Implementation: We are working now to integrate our learning method with the real hardware. Once we have interfaced and tuned the algorithm with the hardware, we will attempt to implement this interface on a robot consisting of different sensors in an attempt to solve the navigation problem. We plan to make the robot completely autonomous such that all information coming from the sensors are processed on-board to plan an optimized path. The beauty of this learning scheme is in its scalability, thus making it versatile enough to be implemented on any kind of robot with any type of sensors.

Marc Kirschenbaum

John Carroll University

Mimicking Bio-mimicry: What Can We Learn From a Swarm of Humans?

Abstract: In The Social Conquest of Earth, E. O. Wilson enumerates the evolutionary advantages of eusocial species. His argument is compelling and gives examples from African driver ants, leafcutter ants, and Formosan bees. By some measurements, humans are the most successful such species. Humans are the only eusocial group that also has highly developed individual cognitive skills. So what happens when a group of humans are given tasks to solve that require emergence – a typical characteristic of swarms – and individual intelligence? The first benefit is that swarm algorithms can be quickly prototyped and tested, avoiding both complex software simulations and long development times. This talk will focus on another potential benefit: exploring the phase transition or hybrid process between individual and group intelligence and asks the question what can a swarm of intelligent agents do?

Bio:

Prof. Marc Kirschenbaum

Professor of Mathematics & Computer Science

Degrees: B.A., University of Cincinnati; M.S., Ph.D., The Ohio State University

Expertise: Swarm and Artificial Intelligence, Logic Programming, Computer Science Education, Singularity Theory

Paul Kladitis

University of Dayton Research Institute

Multifunctional Structures and Materials: the Ultimate Biomimicry

Abstract: Usually when people think of biomimicry, they equate biomimicry to copying gross natural behavior or function at the system level. For example flying like a bird flies, swimming like a fish swims, sticking to a surface like a gecko, locomotion like an insect, and the list goes on. While this thinking is in fact biomimicry, and perhaps the most glamorous aspect, this may also be the most superficial aspect of the concept of biomimicry. At the most fundamental level, all natural living things are designed with structures that perform more than one function besides a purely structural role: i.e. multifunctional. From hair to skeleton, every structure has more than one important function. The multifunctionality found in every part is most likely the fundamental design principle that allows an autonomous living organism to be optimum in size, weight, and power (SWaP). Furthermore, biological structures seem to be made from materials that enable the multifunctionalities. It can be argued that multifunctional structures and supporting materials of which the bio-realm is constructed are the necessary foundation for the more glamorous overall system-level behavior observed. If this is so, why don't multifunctional materials and structures have a more prominent emphasis in man-made designs? Some reasons relate to design complexity, maintainability requirements, cost, manufacturability, and short term gain.

Bio: Dr. Paul Kladitis has over 21 years of developmental engineering and leadership experience in various roles for the United States government and industry including program management; basic, advanced, and applied research and development; and installed system and flight developmental and operational test and evaluation. He is currently the leader of the Multifunctional Products Group in the Multi-Scale Composites and Polymers Division at the University of Dayton Research Institute, Dayton, OH. Dr. Kladitis' experience in innovating new nanotechnologies was recognized by appointment to national committees under the National Nanotechnology Initiative (NNI), Washington D.C. He has also served as the Chair of the Dayton, Ohio Section of the IEEE Executive Committee. He is a Lieutenant Colonel, USAF, Retired. He has published 44 technical papers and holds 4 patents. He holds a Ph.D. in mechanical engineering, B.S. and M.S. in electrical engineering, and a Master of Military Operational Art and Science

Craig Kundrot
NASA Headquarters

Application of Biomimicry to NASA Engineering Problems

Abstract: The application of biomimicry to NASA engineering problems presents many challenges. Recognition of the deep differences in design principles between traditional human-engineered systems and biological systems helps overcome these challenges. It also helps identify new areas for applying biomimicry. Examples of current and potential applications of biomimicry to NASA problems show how biological principles are being currently being used and how they could be extended to support NASA's Journey to Mars.

Bio: Dr. Craig Kundrot is in the Office of the Chief Scientist at NASA where he leads the coordination of life science research in astrobiology, human research, planetary protection and space biology within NASA and with other organizations. Dr. Kundrot was previously the Deputy Chief Scientist for NASA's Human Research Program where he served as the first Mission Scientist for HRP's Twins Study and, as IRB Chair, helped formulate NASA's genetic research policy for astronauts. A graduate of Northwestern and Yale Universities, Dr. Kundrot is an erstwhile x-ray crystallographer who studied protein and RNA structure and function.

Lyndsey McMillon-Brown
Yale University / NASA Glenn Research Center

Light-trapping in Polymer Solar Cells by Processing with Nanostructured Diatomaceous Earth

Abstract: We demonstrate the use of fossilized diatoms (diatomaceous earth) as light traps in regioregular poly(3-hexylthiophene) (P3HT) and fullerene derivative [6,6]-phenyl-C60-butyric acid methyl ester (PC60BM) polymer solar cells. Diatoms, the most common type of phytoplankton found in nature, are optimized for the photosynthesis process through millions of years of adaptive evolution. We suggest that their frustules (outer porous silica cell wall) possess remarkable hierarchical micro-/nano-scaled features suitable for solar energy harvesting. Here we establish the preparation of dispersing the diatomaceous earth throughout the P3HT/PCBM active layer with characterization by absorption and I-V measurement. We find that the location of the diatomaceous earth is critical for increasing light absorption and scattering. Our numerical simulations are in good agreement with the absorption spectra. We show that through the addition of diatomaceous earth, we can achieve the same power conversion efficiencies of standard thickness cells with active layers that are 46% thinner. We observe that the 30% power conversion enhancement of these devices is mainly due to increases of the short circuit current; we are likely observing an optical enhancement.

Rajesh Naik
Air Force Research Laboratory, Wright-Patterson Air Force Base

Creating Functional Biomimetic Materials

Abstract: The unique and diverse functions of biomaterials provide many opportunities in developing concepts, as well as new classes of materials and devices. The knowledge gained in understanding how biological materials are constructed and function has enabled the design of bioinspired/derived functional materials with tailored properties for optics, sensing, catalysis and electronics. We have employed experimental and computational approaches to understand structure-function relationships for the development of biomimetic materials, tailoring interfacial properties features and fabricating functional materials for the development of photonic ad electronic devices based on these biomimetic materials will be discussed. In this talk, I will highlight our efforts on using our fundamental understanding of biomolecular interactions, factors that influence bio-nanomaterials interactions and demonstrate the fabrication of biomimetic materials for sensing, catalysis and decontamination applications.

Bio: Dr. Rajesh R. Naik, a member of the Senior Executive Service, is the Chief Scientist of the 711th Human Performance Wing of the Air Force Research Laboratory, Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio. He is the primary science and technology adviser to the wing commander. In this position he provides technical vision and strategy for the wing's science and technology plans. He also leads research efforts in biomimetic materials and sensors. Dr. Naik joined AFRL in 1999 as a visiting scientist and became a federal employee in 2004, where he was assigned the position of Biotechnology Group Leader. In 2007 he was appointed the technology adviser for biotechnology in the Nanostructure and Biological Materials Branch. Dr. Naik also served as the Chair for AFRL's Bio-X Strategic Technology Team from 2008 to 2011. Scientifically, Dr. Naik has research interests in the areas of bionanotechnology and biomimetics, with focus on biosensing, bioelectronics, nanostructured materials, and protein engineering. He has published over 210 peer-reviewed articles, several book chapters and has 10 awarded patents. He is also active in numerous technical communities.

Peter Niewiarowski
University of Akron

Gecko Adhesion: An Exploration of Bibliometric Pattern and Biomimetic Process

Abstract: People have been interested in how geckos stick for millennia, but the bulk of the scientific literature establishing the form, function and performance of the gecko system has largely emerged over just the past 15 years. Literature from this last 1.5 decades now includes hundreds, if not thousands of studies coming from and leading in many directions, ranging from questions about the significance of adhesion in the ecology and evolution of geckos all the way to development of biologically inspired synthetics. Using bibliometric approaches, we explore the gecko adhesion literature to identify if and how particular foundational work is related to advancing fronts of research activity. We also look for evidence that might link fundamental research trends to existing or emerging applications found in patent databases. Finally, we consider state of the art and gaps in knowledge about gecko-inspired adhesion as they inform biomimicry as an innovation process.

Bio: Prof. Peter H. Niewiarowski is a professor in the Biology Department and Principal Investigator of the Biomimicry Research and Innovation Center (BRIC) at the University of Akron. He is the Director of the Biomimicry Fellowship program. His current research includes several broad areas in ecology and evolution. He has active projects in population biology (spotted salamanders), physiological ecology and life history variation (fence lizards), and evolutionary biology/bio-inspired design (geckos). The thread which has always tied these seemingly disparate activities together is a firm foundation in evolutionary theory and analysis. Although he is active (publishing papers, seeking funding and mentoring students) in all of the areas mentioned above, he is focusing much of his energy on new work with geckos, in collaboration with a colleague in Polymer Science (Ali Dhinojwala). Prof. Dhinojwala's lab was one of the first to produce a synthetic version of the gecko adhesive system with performance capabilities equaling or exceeding natural toepads. His collaboration with Dr. Dhinojwala is one of many examples of faculty collaborations within the new Integrated Bioscience PhD program (IB).

John Nottingham

Nottingham Spirk

Real World Examples of How Biomimetic Principles are being Utilized in the Product Design Process

Abstract: I will be presenting real world examples of how biomimetic principles are being utilized in the product design process. At the Nottingham Spirk Innovation Center, we are organized organically and have a vertically integrated process that we call Vertical Innovation. We use biomimetic concepts in our process starting with human insights, creative sessions to produce product concepts, nature-centured design, engineering, prototyping, packaging and commercialization, all utilizing biomimicry. Specific case studies will demonstrate the natural references via graphics and video.

Bio: John Nottingham is the co-founder and Co-President of Nottingham Spirk, a leading business innovation firm with over 1,000 commercialized patents. The Nottingham Spirk "Vertical Innovation" process has helped client / partner companies earn over $50 billion in combined sales. The NS innovation team has co-created such award winning innovations as SpinBrush, the largest selling powered toothbrush line; Swiffer Sweeper Vac, the largest selling floor care appliance; Scott's Snap Spreader System; dozens of Dirt Devil/Hoover products; Sherwin-Williams Twist & Pour, named one of the Top 10 Package Innovations of the Decade; DualSaw; Medtronic CardioInsight EC Vue, the first non-invasive electrocardiographic mapping system; and ViewRay, the first MRI guided radiation therapy device.

John has presented numerous times on the subject of breakthrough innovation, and has shared speaker platforms with Neil Armstrong, Colin Powell and Clayton Christensen, author of The Innovator's Dilemma.

John serves on the Cleveland Clinic Board of Trustees, CWRU Technology Commercialization Visiting Committee, CWRU Think[box] Advisory Board, boards of Global Center for Health Innovation, Great Lakes Biomimicry, Cleveland Institute of Art and University Circle Inc., as well as several private equity company boards of directors.

Douglas Paige

Cleveland Institute of Art

Biomimicry: A Multidisciplinary Design Process

Abstract: Biomimicry, at its core, bridges knowledge and processes from many disciplines: Biology, design, engineering and business. A synthesis of observational research, abstract thinking and problem solving skills, with a vast library from the natural world can reveal new pathways of exploration for old problems. Case studies demonstrate the process with tangible, physical solutions, along with process and system level problems.

Bio: Doug Paige, an Associate Professor of Industrial Design at The Cleveland Institute of Art and Certified Biomimicry Professional, has been incorporating nature's lessons into sustainable design and design research methods. He has been introduced biomimicry to the design curriculum at CIA, built collaboration with the University of Akron's Integrated Biosciences to bring biology and design together in joint campus projects, and worked with Biomimicry 3.8, to teach their B-Specialist program.

In addition to teaching, Doug has been incorporating biomimicry methodologies into research projects with the Cuyahoga river bulkheads, paddle sports performance and sports safety protective gear. Doug holds a BFA in industrial Design from the Cleveland institute of Art and an MS in Biomimicry from Arizona State University.

Daniel Palmer

John Carroll University

Mimicking Bio-mimicry: What Can We Learn From a Swarm of Humans?

Abstract: In The Social Conquest of Earth, E. O. Wilson enumerates the evolutionary advantages of eusocial species. His argument is compelling and gives examples from African driver ants, leafcutter ants, and Formosan bees. By some measurements, humans are the most successful such species. Humans are the only eusocial group that also has highly developed individual cognitive skills. So what happens when a group of humans are given tasks to solve that require emergence – a typical characteristic of swarms – and individual intelligence? The first benefit is that swarm algorithms can be quickly prototyped and tested, avoiding both complex software simulations and long development times. This talk will focus on another potential benefit: exploring the phase transition or hybrid process between individual and group intelligence and asks the question what can a swarm of intelligent agents do?

Bio:

Prof. Daniel W. Palmer

Professor of Mathematics & Computer Science

Degrees: B.S., State University of New York at Albany; M.S., Ph.D., University of North Carolina at Chapel Hill

Expertise: Swarm Intelligence, Decentralized algorithms, Parallel Programming, Programming Languages, Computer Science Education, Cellular Automata

Shashank Priya
Virginia Polytechnic Institute & State University

Jellyfish Node and Colonies

Abstract: A biomimetic robot inspired by Cyanea capillata, termed as "Cyro", was developed to meet the functional demands of underwater surveillance in defense and civilian applications. The swimming kinematics of the C. capillata were analyzed after extracting the required kinematics from the in situ video. A discrete model of the exumbrella was developed and used to analyze the kinematics. Cyro was designed to mimic the morphology and swimming mechanism of the natural counterpart. The full vehicle measures 170 cm in diameter and has a total mass of 76 kg. Cyro reached the water surface untethered and autonomously from a depth of 182 cm in five actuation cycles. It achieved an average velocity of 8.47 cm/s while consuming an average power of 70 W. Steady state velocity during Cyro's swimming test was not reached but the measured performance during its last swim cycle resulted in a cost of transport of 10.9 J/kg·m and total efficiency of 3%. It was observed that a passive flexible margin or flap, drastically increases the performance of the robotic jellyfish (Robojelly). The effects of flap length and geometry on Robojelly were analyzed using PIV. The flap was defined as the bell section which is located between the flexion point and bell margin. The flexion point was established as the location where the bell undergoes a significant change in compliance and therefore in slope. The flap was analyzed in terms of its kinematics and hydrodynamic contribution. An outer trajectory is achieved by the flap margin during contraction while an inner trajectory is achieved during relaxation. The flap kinematics was found to be replicable using a passive flexible structure. Flaps of constant cross-section and varying lengths were put on the robotic vehicle to conduct a systematic parametric study. Robojelly's swimming performance was tested with and without a flap. This revealed a thrust increase 1340% with the addition of a flap. Velocity field measurements were performed using planar Time Resolved Digital Particle Image Velocimetry (TRDPIV) to analyze the change in vortex structures as a function of flap length. To prolong the life of bio-inspired autonomous underwater vehicles (AUVs) inspiration is taken from the constant feeding and energy generation achieved by Rhizostomeae. From this study, still in progress, we hope to obtain a representation of how the additional parts meant for feeding affect things like drag force and streamlining. This will begin a large design of experiments to balance the negative effects the structures have on vehicle performance and the positive effect they have on feeding efficiency. Determining the probability of capture given a specific induced flow is a multistep process and determining the static bulk flow characteristics (i.e. separation, boundary layer, and velocity at the margin) is the first step. Future work would include generating a robotic swimming model to run further dynamic experiments to resolve the fluid physics of feeding. Acknowledgements: This research was sponsored by Office of Naval Research through MURI program. The author would like to thank the whole MURI team for their input and suggestions on various aspects of this research.

Bio: Shashank Priya is currently Robert E Hord Jr. Professor in department of mechanical engineering and Turner Fellow in college of engineering. His research is focused in the areas related to multifunctional materials, energy and bio-inspired systems. He has published over 300). He is currently serving as the chief editor of journal "Energy Harvesting and Systems", editorial board member of journal integrated ferroelectrics and advisory board member of journal of dielectrics. He is also serving as the member of the Honorary Chair Committee for the International Workshop on Piezoelectric Materials and Applications (IWPMA). Shashank has received several awards including: Alumni award for excellence in Research 2014, Fellow American Ceramic Society 2013, Turner Fellowship 2012, Dean's Research Excellence Award 2011, and AFOSR Young Investigator Award.

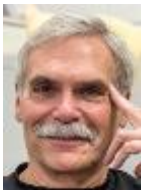
Roger Quinn

Case Western Reserve University

Animals as Models for Robot Mobility and Autonomy: Crawling, Walking, Running, Climbing, and Flying

Abstract: We incorporate neuromechanical principles of locomotion and autonomy into robot designs. The goals are to develop useful mobile robots and to use robot models to help us better understand animal neurobiology and mechanics. Many examples will be presented. A robot that captures the leg designs important for animal locomotion could be extremely agile and therefore suitable for many missions. However, before a robot with the intricate leg designs and controlled with the agility and energy efficiency of an animal can be deployed some technical issues must be solved. Therefore, we are using two complementary approaches to develop mobile robots. Using the direct approach we have developed a series of robots that model animals. For control of robots with multi-segmented legs, we are developing continuous time biological neural networks based upon the neurobiology of insects and vertebrates and applyin them to a praying mantis robot, a dog robot and a bipedal simulation. In the second approach the fundamental principles of insect locomotion are applied using existing technologies and in a simplified manner. Their motor control is also simplified and the agility of these vehicles makes them suitable for applications in the near term. Versions have run on rugged terrain, climbed obstacles and climbed glass walls. This abstracted approach has also been used to develop a small vehicle called MALV (micro air and land vehicle) that flies, lands and crawls. Animals have compliant joints and structures for various reasons including impact absorption and stability: MALV's compliant running gear permits it to crawl away from hard landings. As another example, our softworm robots are structurally compliant and crawl via continuous peristaltic waves. Robots with a human in the loop for low-level control decisions are limited in their movements in complex terrain because of sparse sensory information. Robot autonomy is essential for their agility. Insect neurobiology and behavioral experiments are being used to develop decision making strategies and preliminary brain models.

Bio: Roger D. Quinn is an Arthur P. Armington Professor of Engineering at Case Western Reserve University. He joined the Mechanical and Aerospace Engineering department in 1986 after receiving a Ph.D. (1985) from Virginia Tech and a M.S. (1983) and B.S. (1980) from the University of Akron. He has directed the CWRU Biologically Inspired Robotics Complex since its inception in 1990. His research, in collaboration with biologists, is devoted to the development of robots and control strategies based upon biological principles. Dozens of robots have been developed to either improve robot performance with biological principles or model animal systems. He has authored more than 200 publications and a dozen patents on practical devices resulting from his work. His biology-engineering collaborative work on behavior based distributed control, robot autonomy, human-machine interfacing, soft robots, and neural control systems have each earned awards.



Frank Rosenzweig

Georgia Institute of Technology

Sweet are the Uses of Adversity: Insights into Adaptation and Speciation using Experimental Evolution

Abstract: Experimental evolution under selection dates back to the dawn of modern genetics, where it helped to shape our understanding of allele and chromosome dynamics in populations under selection. Modern experimental evolution, coupled with genomic analyses, promises to transform our view of the adaptive process and the mechanisms by which major evolutionary transitions have occurred and are occurring. For example, we can now directly probe into the mechanisms underlying antagonistic pleiotropy, the origin and fate of new genes, multicellularity, and the emergence of simple community structure. We will discuss recent insights into these phenomena afforded by experiments in which we analyze the evolutionary process in real time using Bakers yeast, Chlamydomonas and E. coli.

Bio: The goal of my research is to enlarge our understanding of the ecological and evolutionary forces that promote and preserve genetic variation. My approach to this goal has been to study how genetic variation is integrated at the level of cellular physiology to produce differences in fitness. For my graduate work, I demonstrated that metabolic control theory inadequately explained the effects of overexpressing glycolytic genes having both catalytic and regulatory function. As a postdoctoral fellow I showed that cross-feeding interactions among microbes preserved unexpected levels of genetic polymorphism in simple, constant environments. As a faculty researcher, my group has studied adaptation in the field, exploring how alternative terminal accepting processes such as iron, sulfur and arsenic respiration structure microbial communities in freshwater sediments, controlling therein the speciation and mobility of diverse metals. We have also continued to study adaptation in the lab. There, by seizing on advances in genomic analysis we have helped develop experimental evolution as a tool to better understand the connection between genetic variation and organismal fitness. With our collaborators we carried out what is now regarded as foundational work in evolutionary genomics (Ferea et al. 1999), we have used experimental evolution to gain new insights into mutualism (Kinnersley et al. 2014), fitness trade-offs (Wenger et al. 2011), and genome evolution in chronic infections (Warren et al. 2011), starving cells, and in newly-formed hybrid species (Dunn et al. 2013). Recently, we pioneered methods for isolating mRNA from immobilized microbial cultures, and reported on the transcriptional profile of yeast whose reproduction is uncoupled from metabolism by encapsulating them in a semisolid matrix of alginate (Nagarajan et al. 2014).

Lynn Rothschild
NASA Ames Research Center

Synthetic Biology as an Enabling Technology for Space Exploration

Abstract: Human exploration off planet is severely limited by the cost of launching materials into space and by re-supply. Thus materials brought from Earth must be light, stable and reliable at destination. Using traditional approaches, a lunar or Mars base would require either transporting a hefty store of metals or heavy manufacturing equipment and construction materials for in situ extraction; both would severely limit any other mission objectives. Long-term human space presence requires periodic replenishment, adding a massive cost overhead. Even robotic missions often sacrifice science goals for heavy radiation and thermal protection. Biology has the potential to solve these problems because life can replicate and repair itself, and perform a wide variety of chemical reactions including making food, fuel and materials. Synthetic biology enhances and expands life's evolved repertoire. Using organisms as feedstock, additive manufacturing through bioprinting will make possible the dream of producing bespoke tools, food, smart fabrics and even replacement organs on demand. This new approach and the resulting novel products will enable human exploration and settlement on Mars, while providing new manufacturing approaches for life on Earth.

Bio: Dr. Lynn Rothschild has helped found astrobiology and synthetic biology at NASA. Her research focuses on how microbes have evolved in the context of the physical environment, both here and potentially elsewhere. Field sites range from Australia to Africa to the Andes, off Earth on balloons and in orbit. Rothschild has brought her expertise in extremophiles and evolutionary biology to the field of synthetic biology, demonstrating how synthetic biology can enhance NASA's missions. Since 2011 she has been the faculty advisor of the Stanford-Brown award-winning iGEM team. Rothschild is a Fellow of the Linnean Society of London and the Explorers Club, and winner of the Isaac Asimov Award and Horace Mann Medal.

Konrad Rykaczewski
Arizona State University

Cacti, Kale, Aphids, and Airplane De-icing Poison Dart Frogs

Abstract: Frost and ice can have negative impact on travel and variety of industrial processes. Since current chemical, mechanical and thermal anti-icing methods can be expensive and environmentally unfriendly, development of alternative passive methods is highly desired. In this case, nature is the source of the problem but can also offer inspiration for its potential solutions. For example, water-repelling and non-adhesive characteristics of the lotus leaf and the pitcher plant have inspired the design of anti-icing superhydrophobic and lubricant impregnated surfaces. In this talk I will introduce fundamental mechanisms that govern ice and frost formation, and show how these inherently restrict functionality of the fully passive anti-icing coatings to a narrow range of conditions. To resolve this challenge my group has recently developed an alternative anti-icing surface that responds to icing by releasing an antifreeze liquid that was stored within inner “dermis” layer hidden underneath a porous superhydrophobic “epidermis” layer. The “on demand” antifreeze release mechanism is analogous to the way poison dart frogs release toxin from glands in their dermis through pores in their epidermis in response to sensed danger. By repelling water drops like normal superhydrophobic coatings and releasing the antifreeze only in response to icing/frosting, our coating dramatically outperforms other types of anti-icing surfaces, while reducing antifreeze use by 2 to 8-fold as compared to current industrial practices. I will briefly discuss the intricate heat and mass transport mechanisms behind this process and prospects for translation of this technology into industrial applications. Lastly, I will discuss our latest work on age-dependent wettability of cacti and physical mechanism underlying the aphids’ ability to resist being washed off from superhydrophobic kale.

Bio: Konrad Rykaczewski is an assistant professor at School for Engineering of Matter, Transport and Energy at Arizona State University. He received his BS (2005), MS (2007) and PhD (2009) in mechanical engineering from the Georgia Institute of Technology. Prior to his appointment at ASU, he was a research scientist at Massachusetts Institute of Technology and National Research Council postdoctoral fellow at National Institute of Standards and Technology. He has co-authored over 50 journal publications and is currently pursing research on fundamentals nano/microscale thermofluidic and interfacial phenomena, novel in situ and cryogenic electron and ion beam microscopy methods, and nanoengineering of biomimetic functional surfaces with special wettability for various applications.

Nita Sahai

University of Akron

From Geochemistry to Biogeochemistry: The Origins of Life

Abstract: The self-assembly of organic molecules and the emergence of primitive "protocells" on Earth occurred at ~ 4.4 - 3.5 Ga (Giga-annum or billion years ago), as the geological environment cooled to allow these molecules to be stable. The commonly-accepted essential components of life include a cell membrane, metabolism and a heritable, evolvable information system (genes). In the present study, we focused on whether the minerals and rocks present on early Earth would help or hinder the formation of protocell membranes. We found that the minerals examined here promote the rate of membrane formation. Interestingly, a positive correlation was identified between the membrane formation rates and the fundamental chemical-physical-structural properties of these minerals. This correlation allows us to extrapolate our results to other minerals, which are not included in the present study, if their fundamental chemical-physical-structural properties are known. Thus, the potential for protocell membrane stability could be predicted for solid worlds of known mineralogy such as the Moon, Mars, the solid satellites of Jupiter and Saturn, as well as for other extra-terrestrial worlds as their mineralogy becomes known.

Bio: Prof. Nita Sahai has been at the University of Akron since August 2011. Prior to this, she was a Professor in the Department of Geoscience, University of Wisconsin-Madison for 11 years. She earned her Ph.D. at Johns Hopkins University, Baltimore.

Kenneth Sandhage
Purdue University

Materials Alchemy: Changing the Chemistries but not Shapes of 3-D Biogenic and Synthetic Structures

Abstract: Nature provides impressive examples of organisms capable of generating complex 3-D rigid structures under gentle ambient conditions with a high degree of control of morphology over a range of length scales. Although such hierarchical control of structure exceeds common man-made patterning methods, the range of chemistries (particularly inorganic chemistries) utilized by such organisms to generate rigid 3-D structures pales in comparison to the rich variety of synthetically-derived materials. While future genetic modifications of such organisms may allow for the biological syntheses of structures with a wider range of chemistries, an alternative and more immediately-accessible strategy is to utilize synthetic approaches to alter the chemistries, but not the morphologies, of biogenic structures. For example, gas/solid reactions may be used, under appropriate conditions, to transform bio-inorganic structures into positive 3-D replicas comprised of new functional inorganic materials. Layer-by-layer wet chemical coating strategies may be used to generate highly-conformal coatings on bio-organic or bio-inorganic templates that, upon removal of the underlying template, yield negative replica structures with overall shapes and fine surface features inherited from the starting templates. In this presentation, the conversion of biogenic and synthetic silica-based structures (diatom silica microshells, self-assembled silica templates, microlithographically-patterned silica-bearing structures) into replicas comprised of new functional porous inorganic materials via the use of gas/solid reactions will be discussed. The conversion of bio-organic templates (e.g., pollen, butterfly scales) into functional oxides via an automated layer-by-layer surface sol-gel process will also be described. Such integration of biological or synthetic self-assembly with synthetic chemical tailoring can yield attractive 3-D structures for a variety of catalytic, optical, sensor, energy, and other applications. By analogy to the medieval concept of alchemy (conversion of common materials into more precious ones), such shape-preserving chemical transformation of readily-formed structures into new functional materials may be considered to be a modern type of materials alchemy.

Bio: Dr. Kenneth H. Sandhage is the Reilly Professor of Materials Engineering. He received a B.S. (1981) in Metallurgical Engineering with highest distinction from Purdue University and a Ph.D. (1986) in Ceramics from the Massachusetts Institute of Technology. After working for 5 years in industry (as a Senior Scientist at both Corning, Inc. and American Superconductor Corp.), he joined the Materials Science & Engineering Dept. at Ohio State University. In 2003, he moved to the School of Materials Science & Engineering at the Georgia Institute of Technology, where he was the B. Mifflin Hood Professor. In the fall of 2015, Dr. Sandhage joined the School of Materials Engineering at Purdue. The Sandhage group has pioneered the development of novel shape-preserving, reaction-based processes for generating materials with tailored chemistries and macro-to-nanoscale structures for energy, environmental, transportation, defense, and medical applications.

John Sankovic
NASA Glenn Research Center

NASA GRC Innovation and Biomimicry

Bio: Dr. John M. Sankovic serves as the Director of the Office of Technology Incubation and Innovation at the National Aeronautics and Space Administration's John H. Glenn Research Center in Cleveland, Ohio. Dr. Sankovic was appointed to the position and to the Senior Executive Service in September 2014. In his current role he oversees discretionary investments in technology, technology transfer and licensing, promoting and protecting the center's intellectual property portfolio and identifying infusion opportunities. Dr. Sankovic also serves as the Center Chief Technologist. He joined NASA in June of 1987 as a co-op engineering student working on turbine engine compressors and has had a distinguished NASA career serving in various technical, supervisory and mid-level program/project management positions of increasing responsibility across a variety of Glenn competencies. Prior to his current position Dr. Sankovic served as the Chief of the Space Operations Project Office managing work assigned to Glenn in the areas of electric power, space communications, human health and physical sciences. Dr. Sankovic earned his bachelor's and master's degrees in mechanical engineering from The University of Akron, his Master of Business Administration from Cleveland State University, and his master's and doctorate in biomedical engineering from Case Western Reserve University. He is a certified Project Management Professional by the Project Management Institute. Dr. Sankovic is a registered professional engineer in the State of Ohio with distinction by the Ohio Society of Professional Engineers for highest achievement on both licensure examinations. He is the recipient of numerous awards including the NASA Outstanding Leadership Medal, five agency group achievement awards, and an R&D100 technology innovation award. Dr. Sankovic has authored or co-authored over 70 technical publications in topics ranging from space propulsion and power to fluid mechanics and biomedical sciences.

John Senko
University of Akron

Responses of Microbial Communities in "Non-extreme" Settings to the Imposition of Physicochemically "Extreme" Conditions

Abstract: We have characterized two settings in which microbial communities in previously "non-extreme" physicochemical settings have been subjected to physicochemically extreme conditions. This work includes determining the response of pristine soil to intrusion of coalmine-derived acid mine drainage (AMD), and characterization of microbial communities associated with flue gas desulfurization units (FGDs). AMD emerges from abandoned mines and contains high concentrations of sulfate, Fe(II) and other metals, and low pH (≤3.5). Upon incubation of pristine soil (with associated microbial community) with AMD for 24 d, we observed the development of microbial communities that were similar to sediments that had been exposed to AMD for approximately 20 years, and included phylotypes attributable to several lineages of acidophilic, Fe-metabolizing bacteria. FGDs are large reaction tanks in which coal combustion exhaust (flue gas) is passed through slurries composed of fresh water and crushed limestone. These systems operate at high temperatures (60 °C) with high dissolved solids concentrations (e.g. hundreds of mM SO42- and Cl-). Characterization of microbial communities associated with several FGD units revealed microbial communities that were dominated by phylotypes attributable to thermophilic Hydrogenophilus sp., though they retained components of "non-extreme" freshwater communities. These results indicate that extremophilic microorganisms persist under "non-extreme" conditions, perhaps for long periods of time. This observation raises the question of whether these organisms persist in a state of slowed (or no) metabolism, or if they may continue to metabolize in physicochemically "extreme" microenvironments. Ongoing work is focused on how these persistent extremophiles may continue to metabolize in otherwise non-extreme conditions, and how they respond to resumption of extreme conditions.

Bio: Dr. John M. Senko is Associate Professor in the Department of Geosciences at the University of Akron. His research specialties include geomicrobiology, environmental biogeochemistry, and environmental microbiology. The Senko group studies how microorganisms influence the prevailing chemical conditions of a variety of "natural" and man-made systems. They are particularly interested in how the ecology, physiology, and in-situ activity of these microorganisms influence the fate of environmental contaminants. They are also interested in how microbial communities respond (in terms of community structure and activity) to physicochemical changes in their environment. Work in the Senko group currently focuses on microbially mediated redox transformations of iron and sulfur species in acid mine drainage (AMD)-impacted systems, microbially-influenced corrosion, and microbial processes associated with flue gas "scrubbers" at coal-fired electric power plants.

Vikram Shyam
NASA Glenn Research Center

Aerospace Biomimicry and Other Cool Things

Abstract: Biomimicry, one of the hottest design philosophies of the day, has revolutionized the world we live in. We will explore NASA's biomimicry vision in the context of emerging fields like synthetic biology, artificial evolution, hybrid manufacturing and big data analytics. We then look to our distant past to learn how pterosaurs, stegosaurs and graptolites could help insure our sustained and healthy existence on Earth and beyond. Glenn's excursions into biomimicry will be highlighted with a focus on the technologies and collaborations that are needed today to achieve our vision of a future that is truly out of this world.

Bio: Vikram Shyam is a propulsion flow dynamicist in the Turbomachinery and Turboelectric Systems branch at the NASA Glenn Research Center in Cleveland, Ohio. He received his PhD in Aerospace Engineering from The Ohio State University in December 2009. Vikram leads NASA GRC's turbine technology development to reduce fuel burn and emissions for future generation aircraft engines. He is the founder and lead of NASA GRC's biomimicry group (Virtual Institute for Bio-inspired Exploration) that applies nature's principles to solve technical and institutional challenges at GRC. Vikram and fellow collaborators are studying the application of harbor seal morphology to wind turbine struts and gas turbine blades, probes, sensors and other objects that are subject to vortex induced vibrations or variable operating conditions. Other research areas and interests include energy harvesting, multifunctional structures, development of new concepts for in-space exploration, long range planning and STEM education. Vikram was recently awarded the Presidential Early Career Award for Scientists and Engineers (PECASE). He has received NASA's Early Career Achievement medal, the NASA Group Achievement award as a member of the GRC Creativity and Innovation (C&I) team, and the ASEI young engineer award.

Mrityunjay Singh
Ohio Aerospace Institute

Biomorphic Ceramics from Lignocellulosic Template

Abstract: Biomorphic materials inspired by biological concepts of microstructural design and optimized properties have attracted a lot of attention in recent years. It has been demonstrated that natural bio-structures can offer extremely attractive and efficient approach for manufacturing of biomorphic ceramics for a wide variety of engineering and functional applications. Among them, wood is a hierarchical cellular solid with varying degree of structure ordering in three dimensions, adaptive to different load situations, and shows combination of structural and functional characteristics. Wood has been known to be one of the best and most intricate engineering materials created by nature and known to mankind. In this presentation, principles and approaches of conversion of cellulose derived preforms into oxide and non-oxide ceramics will be presented. The final materials mimic the initial cellulose template structure at various hierarchical levels. In addition, potential applications of these materials will also be discussed.

Bio: Dr. Mrityunjay Singh is Chief Scientist at Ohio Aerospace Institute, Cleveland, Ohio. He is also the President of the American Ceramic Society, Governor of Acta Materialia, Inc., and Academician of the World Academy of Ceramics, Italy, where he currently serves as Vice President of the International Advisory Board of the academy. The recipient of more than 65 national and international awards and prizes including numerous honorary doctorates and memberships worldwide, Dr. Singh is editor or co-editor of 50 books/proceedings; 7 special journal volumes; author or co-author of 14 book chapters; and more than 275 papers in various journals and proceedings. He has delivered numerous keynote and plenary presentations in international conferences, forums, and workshops, and serves on the advisory boards and committees of more than fifteen prestigious international journals and technical publications.

Alyssa Stark

University of Louisville

Wet and Dry Biological Adhesives in Complex Environments: Learning from Ants and Geckos

Abstract: In adhesion science, commercial products suffer from a multitude of problems, including reusability, reliability and attachment in complex, variable environments. In the natural world however, biological organisms possess a variety of attachment mechanisms that seem to easily overcome these challenges. For instance, a gecko routinely clings to surfaces that are rough, dirty and wet. Likewise, ants attach and detach from similar substrates over and over as they carry out their daily activities. Each attachment mechanism is different, yet both attain reliable, reusable attachment in conditions that often thwart our best attempts at synthetic design. Here I will explore several environments where the dry adhesive system of the gecko and the wet adhesive system of the ant maintain function, despite challenging conditions such as substrate roughness, surface water and superheated surfaces (55°C). Using these examples, I will outline ideas and current progress of bio-inspired designs based on these two biological attachment mechanisms.

Bio: Dr. Alyssa Stark is currently a postdoctoral associate at the University of Louisville in the Department of Biology. Her interest is in the intersection of biology and material science, focusing on the structure and function of biological organisms and how we can use these for bio-inspired design. Currently she works on the adhesive systems of ants and geckos. Her work studying how geckos stick to wet surfaces has been highlighted by The Discovery Channel, National Geographic and the Huffington Post, among others.

Bill Sullivan

FLEXcon

Collaboration, Biomimicry and Success Stories

Abstract: An overview is provided of FLEXcon's biomimicry capabilities and examples of calibration which have resulted in commercial success and new product developments. FLEXcon works with technology companies and universities to bring their biomimicry structures and chemistries to commercial availability using the company's collaborative processes. Bill will provide insights on the application advancements within the manufacturing industry. FLEXcon, an innovator in adhesive coating and laminating with locations throughout the U.S. and other countries, has been involved with the science of biomimicry for the past 10 plus years.

Bio: Bill Sullivan is Vice President, Performance Products for Spencer, MA-based FLEXcon, Inc., and oversees a Business Team (Performance Products) that is responsible for the development, marketing and commercialization of high performance adhesives, functional coatings, film castings and the creation of functional microstructures. Author of nationally published articles primarily on FLEXcon's success in helping in the creation of Sharklet®, a functional microstructure which prevents the growth of bacteria through its microscopic design capabilities, his expertise is in assisting start-up companies and enterprises with bringing their concepts and ideas to commercial reality.

Brian Trease

University of Toledo

A Stochastic, Swarm-based Control Law for Emergent-system-level Area Coverage by Robots

Abstract: This work proposes a stochastic, swarm-based control law for providing system-level area coverage by robots. In the first half of the work, the performance of a decentralized, ant-inspired, virtual pheromone-based method of area coverage was investigated with variation of the important parameters of rate of pheromone diffusion, rate of pheromone evaporation, and introduced noise. The agents continuously deposited a virtual pheromone, which repulsed other agents away from areas that had already been covered, and then diffused and evaporated over time. Agents' motion was a balance of moving away from the pheromone gradient and Brownian motion, where introduced noise controlled the relative influence of each. Although this type of control scheme has been studied in literature, the interdependent sensitivity to these parameters has not been investigated. It was shown that the most influential of these parameters is the introduced noise.

Part of this investigation included devising appropriate performance metrics, which were selected to measure the rate, exhaustivity, and frequency of area coverage. After optimal values for diffusion, evaporation, and noise were obtained, these values were used in the second half of this work. The investigation was then expanded to study the effect of using gradient following in combination with Lévy flight, which takes variable path lengths from a power-law distribution, instead of from a normal distribution. The Lévy foraging hypothesis proposes that as resources become scarce, organisms foraging for food begin using a Lévy flight type of random walk, instead of Brownian motion. Lévy flight had been shown to be effective in robot search, but had not yet been applied to area coverage. The problem of area coverage can be posed as a special case of search where instead of seeking discrete objects, the agents seek information, a continuous quantity, which can be acquired by moving through an area. More information can be gained by exploring areas that have never been previously visited. It was shown that this combination of gradient following and Lévy flight provides superior area coverage and pop-up threat detection. This type of distributed area coverage, inspired by biological swarms and observed foraging patterns, has potential to be used for many diverse applications including: planetary exploration, harmful-algae bloom mitigation, and fighting wildfires.

Bio: Dr. Brian Trease is an Assistant Professor of Mechanical Engineering at the University of Toledo, where he is director of the 3MDL (Mechanism, Mobility, & Multifunctional Design Lab). Dr. Trease previously spent eight years at NASA JPL, conducting research on mobility in granular media and developing technology with compliant mechanisms, deployable structures, and origami-inspired engineering. At UT, he continues to study deployable structures for space and solar power. He is also leading research in the area of swarm-based robotics for environmental monitoring and clean-up, with a specific focus on marine surface robotics for harmful algae bloom mitigation.

J. Scott Turner
SUNY College of Environmental Science & Forestry

What's So Inspiring About Life? Physiomimetics, Adaptation and Persistence of Life in Novel Environments

Abstract: Biomimicry is based upon an optimistic and idealistic understanding of nature and its evolution. It presumes that natural selection has produced an abundance of ingenious solutions for the many problems of life, including those of human existence. It presumes further that humans can live more sustainably and harmoniously within nature if only we can apply these solutions to our own lives.

This idealistic picture runs quite contrary to the Darwinian logic that supposedly produced these wonderful solutions. Life is often wasteful, extinction is the norm, competition is vigorous and "sustainability" often equates with stagnation. By what logic does this lead to living nature as an inspiration?

There is a logic to biomimicry, although the logic is not Darwinian, as is commonly supposed. It is, rather, Lamarckian and Bernardian (after the great 19th century physiologist Claude Bernard). That is to say, the logic of biomimicry is physiological, homeostatic, process-oriented, adaptationist and driven by striving of dynamically unstable living systems to persist. This is the only sound basis for a logic of biomimciry, or what may be called physiomimetics. It also underscores how far we are far from realizing it in practice, and I will outline why. The logic of physiomimetics also leads to a contrarian picture of the nature of adaptation and how living systems persist in novel, and even harsh, environments.

Bio: J. Scott Turner has contributed to the theory of collective intelligence through his fieldwork on the South African species of termite Macrotermes michaelseni, suggesting the architectural complexity and sophistication of their mounds as an instance of his theory of the extended organism. His theory was reviewed in a range of journals, including Perspectives in Biology and Medicine, the New York Times Book Review, EMBO Reports, and American Scientist. Working at the interface between physiology, evolution and design led Turner to formulate the idea of the Extended Organism, reviewed in a range of journals, including Nature. Turner's current research focuses on the emergence of super-organismal structure and function in mound-building termites of southern Africa (Macrotermes). His extended organism idea was inspired by his work on termite mounds that clarified how the mound functions as an external lung for respiratory gas exchange for the colony as a whole. His prior work on the thermal capacity of incubated birds' eggs showed that an egg with an embryo and an incubating parent function not as two separate organisms but as a coupled physiological unit. Prof. Turner is an adviser to the Microbes Mind Forum and Professor of Biology at the State University of New York College of Environmental Science and Forestry (SUNY-ESF) in Syracuse, New York. Under a grant from the Templeton Foundation, he has been a visiting scholar at Cambridge University, writing his third book, currently titled "Biology's Second Law: Evolution, Purpose and Desire", which builds the case that evolution operates through the complementary principles of Darwinian natural selection (biology's "First Law") coupled to homeostasis (biology's "Second Law").

Thomas Tyrrell

Great Lakes Biomimicry

Bio: A serial entrepreneur, Mr. Tyrrell was responsible for the start-up or restart of a dozen companies and organizations, achieving revenues of $250K to $1.5B. Currently, he is CEO and Founder of Great Lakes Biomimicry, whose mission is to create conditions for educationally driven sustainable regional economic development through place-based innovation inspired by nature. He is also Chairman and Co-Founder of Segmint, Inc., an award-winning provider of data analytics driven marketing technology.

Mr. Tyrrell served on five college boards, accumulating nearly 60 years of total service, including 21 years as Trustee and 16 years as Academic Affairs Committee Chair at Baldwin Wallace University. He is committed to regionalism, having served on NEO economic development boards including NorTech, Lorain County Community College's GLIDE Innovation Fund, the Youngstown Business Incubator and the University of Akron ArchAngels. Mr. Tyrrell was founding chair of Business Volunteers Unlimited and co-founder of venture catalyst Glengary LLC.

A strong advocate of regional environmental initiatives, his involvements include chairing the Ohio & Erie Heritage Canalway restoration project, founding chairman of the Conservancy of the Cuyahoga Valley National Park's Trails Forever initiative, and trustee of the Cleveland Zoological Society.

Mr. Tyrrell was a regional award winner and national finalist of E&Y's Entrepreneur of the Year award; received an Esquire Magazine Register Award for Business and Industry; appeared in Who's Who in America; and, was named one of 30 Difference Makers in Crain's Cleveland Business' 30th Anniversary issue. He received his BA from Elmhurst College and was awarded an Honorary Doctorate of Laws from Baldwin Wallace University.

Harvey Webster

Cleveland Museum of Natural History

Bio: Harvey Webster is the director of wildlife resources at the Cleveland Museum of Natural History. He oversees educational programs and the museum's Ralph Perkins Wildlife Center. Harvey is also a nationally known conservationist, currently coordinating Smart Light/Safe Flight Ohio, an effort to have skyscrapers turn off their lights at night to deter birds from striking the buildings during spring and autumn migrations.

Webster, a native of Kirtland, OH, has practically been a lifer at the museum. He joined the professional staff of the museum in 1974. Among his accomplishments, Webster helped jump-start the remarkable recovery of once-endangered bald eagles. The museum was the first institution in the world to successfully breed the eagles by artificial insemination and introduce the resulting eaglets to wild nests.

Zhiqiang Wu
Wright State University

Bio-inspired Radiofrequency Steganography via Linear Chirp Radar Signals

Abstract: The chirp signal is one of the first bio-in¬spired signals commonly used in RF applications where the term chirp is a reference to the chirping sound made by birds. It has since been rec¬ognized that birds communicate through such chirping sounds to attract other birds of the same species, to transmit an alarm for specific threats, and so on. However, birds of a different species, or sometime even birds in a different social group within a species, are unable to connect a specif¬ic meaning to certain calls — they will simply hear a bird chirping. Inspired by such, this article provides a tutorial on a novel RF steganography scheme to conceal digital communication in lin¬ear chirp radar signals. We first provide a review of the linear chirp signal and existing communi¬cation systems using chirp waveforms. Next we discuss how to implement the RF steganogra¬phy and hide digitally modulated communication information inside a linear chirp radar signal to prevent an enemy from detecting the existence of such hidden information. A new modulation called reduced phase shift keying is employed to make the modulated chirp waveform almost iden¬tical to the unmodulated chirp signal. Further¬more, variable symbol durations are employed to eliminate cyclostationary features that might otherwise be exploited by an enemy to detect the existence of the hidden information.

Bio: Dr. Zhiqiang Wu received the B.S. degree from Beijing University of Posts and Telecommunications, Beijing, China, in 1993, the M.S. degree from Peking University, Beijing, in 1996, and the Ph.D. degree from Colorado State University, Fort Collins, in 2002, all in electrical engineering. He had worked as assistant professor at Department of Electrical Engineering of West Virginia University Institute of Technology from 2003 to 2005. He joined the Department of Electrical Engineering of Wright State University in 2005 where he currently serves as full professor.

Wei Zhang

Cleveland State University

How Seal Whiskers Suppress Vortex Structures: Effects of Phase Shift Angle

Abstract: Certain seal species' whiskers have been reported to be capable of reducing vortex induced vibration and drag force, which is attributed to the peculiar three-dimensional morphology of the whisker surface. The whisker can be described as a loft through elliptic cross sections of varying major and minor axes along the whisker axis. The plane of the major and minor axis of the ellipses also changes its orientation with respect to the axis, resulting in undulating leading and trailing edges. While the effects of the dominant parameters of whisker morphology have been studied, this work focuses on the role of the phase shift angle (i.e., the angle between the elliptic cross sections and the whisker axis) on the vortex development in the wake. CT scan data of multiple seal whisker samples indicates the phase shift angle varies in a wide range, which was previously ignored. Several scaled-up whisker models are examined in the wind tunnel, concentrating on how flow structure responds to the phase shift angle of constant values (0, 5, 15 degree) and of a random distribution in a preset range. Knowledge of the influence of these morphology parameters can provide insights to design whisker-like underwater flow sensors and geometries that effectively reduce drag.

Bio: Dr. Wei Zhang earned her Ph.D. in Mechanical Engineering (specialty: Fluid Engineering and Thermo-physics) from Xi'an Jiaotong University, Xi'an, China. Prior to joining CSU, Dr. Zhang has conducted research on a wide variety of topics ranging from large-scale systems such as atmospheric turbulence, tornado vortex dynamics and wind-blown sand saltation (two-phase flows), to small-scale laminar-turbulent transition over the airfoil of micro air vehicles. Her research interests are: 1) development of non-intrusive laser and imaging based thermal/fluid measurement techniques, and 2) applications of these techniques to understand governing mechanism of complicated thermal/fluid and energy systems in nature and in industry. Dr Zhang's current focus include turbulent flows over heterogeneous earth surface, wind-farm wake modeling, and utility-scale wind farms' impact on local/global micrometeorology and the environment.

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