GRADUATE STUDY *at*

RICE

GRADUATE STUDY IN BIOCHEMISTRY & CELL BIOLOGY

RICE UNIVERSITY

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Rice University is a small, elite university that is a member institution of the world's largest medical center, the Texas Medical Center, in the heart of Houston, Texas. Our location provides a unique setting for our highly individualized educational training and professional development programs within an environment rich in inter-institutional seminars, conferences, courses, and collaborations.

The Department of Biochemistry & Cell Biology participates in several specialized research programs, including the Houston Area Molecular Biophysics Program, the Gulf Coast Consortia, and the Rice Institute of Bioscience and Bioengineering. State-of-the-art research and computing facilities are available for BCB graduate students, and annual external grant income is more than $8 million. BCB graduate students receive fully funded research fellowships that include a full tuition waiver and an annual stipend.

THE PROGRAM

The department strives to provide rigorous graduate training tailored to the scientific background and individual needs of each student. Our program is designed to build a strong foundation in modern biochemistry and cell biology, coupled with the development of critical thought and independence, to ensure competitive preparation for a future research career. While we do accept students who have already earned their master's degrees, our program is designed to be a five-year program from the bachelor's degree to the doctorate.

Formal course work is developed through consultation between the student and an advisory committee of faculty members. All incoming students' curricula are structured to achieve competence in modern biochemistry, biophysical chemistry and molecular and cellular biology. Course requirements after the first year are more related to the students' research interests and include participation in seminar programs to present accomplishments in the laboratory.

Students select a research advisor before the end of their first year. Final selection of an advisor is made following discussions with individual faculty and "rotations" within their laboratories. Every effort is made to facilitate an early entry into thesis research. Each student has

GRADUATE STUDY IN BIOCHEMISTRY & CELL BIOLOGY AT A GLANCE

Degrees awarded: Ph.D.
Fields of study: Biochemistry, biophysics, cell biology, computational biology, developmental biology, metabolic engineering, microbiology, molecular genetics, neurobiology, plant biology, signal transduction, structural biology, systems biology
Faculty working with students: 31
Students: 49
Number of applicants in 2013: 252
Number of new graduate students in fall 2012: 9
Stipend for fall of 2013: $28,000 per year
Degree requirements for admission: B.A. or B.S. in biochemistry, biology, chemistry, bioengineering, chemical engineering, physics or equivalent
Doctorates awarded in 2012: 11

a progress review committee composed of three faculty members who follow and advise the student throughout his or her career, conduct annual reviews of research progress independent of the formal research advisor, and ensure a productive and harmonious training environment. Graduate students also have the opportunity to participate in the BCB Higher Education Teaching and Mentoring Certificate Program.

After the second semester of their second year, students complete an examination for admission to candidacy for the Ph.D. This exam consists of a written research proposal in the student's specific field. The proposal is similar to a grant application and is defended orally before the progress review committee and thesis advisor. On completion of the thesis research, the final oral examination on the thesis is a formal, public presentation of the completed body of work. The exam is divided into a seminar presentation followed by a question-and-answer session with the thesis committee.

FACULTY/CURRENT RESEARCH

Bonnie Bartel. Ralph and Dorothy Loony Professor. B.A. (1983) Bethel College, North Newton, Kansas; Ph.D. (1990) Massachusetts Institute of Technology. bartel@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=1

Major Research Interests

We are using genetic, cell biological, and biochemical approaches in *Arabidopsis thaliana* to elucidate fundamentals aspects of plant biology, including auxin regulation the roles and biogenesis of peroxisomes. Auxin promotes cell expansion, division, and differentiation, thereby regulating a plethora of developmental events and environmental responses. We found that the auxin precursor indole-3-butryic acid (IBA) is converted to the active auxin indole-3-acetic acid (IAA) in peroxisomes, which motivated our study of the biogenesis, function, and dynamics this vital organelle. Peroxisomes compartmentalize certain metabolic reactions, thereby protecting the cytosol from oxidative damage. We are isolating mutants defective in enzymes catalyzing IBA-to-IAA conversion and mutants defective in biogenesis of peroxisomes, which house these enzymes. These mutants are revealing new peroxisome import components, unanticipated interdependencies among peroxisome biogenesis factors, and pathways for degrading peroxisome matrix proteins during organelle remodeling. We have uncovered multiple intriguing examples in which *Arabidopsis peroxisomes* closely resemble mammalian peroxisomes, suggesting that our studies can provide insights into human peroxisome biogenesis disorders.

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Kathleen M. Beckingham. Professor. B.A. (1967) Girton College, University of Cambridge; M.A. (1968), Ph.D. (1972) University of Cambridge. kate@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=359

Major Research Interests

1. The "astronaut" genes and their roles in gravity sensing and other behaviors in Drosophila. Using the model organism *Drosophila melanogaster*, we performed a genetic screen to identify genes with roles in sensing gravity. This work identified several new genes that were named in honor of space pioneers such as Yuri Gagarin, Jim Lovell and John Glenn. Further studies of these genes have revealed their roles in other behavioral and developmental processes. Current work is focused on gene jim lovell, which has roles in many behavioral processes such as male courtship and responses to food. *2. Biological applications of carbon nanotubes.* Single walled carbon nanotubes are recently identified carbon structures with novel properties that can be harnessed for applications within biology. We are collaborating with the Weisman laboratory at Rice to develop SWCNT-based immunoprobes that take advantage of the unique infrared fluorescence of SWCNTs. These probes will have valuable applications in research and medical diagnosis, including improved cancer detection. *3. Calcium signaling in the model organism Drosophila.* Calcium signaling underlies much of the complex regulation seen in multicellular organisms. This regulation is mediated by the action of numerous calcium "sensor' proteins. We are investigating the roles of calcium sensor proteins in *Drosophila* because of the great potential for deep in vivo analysis offered by this model organism. Current studies are focused on a novel testis-specific calcium sensor protein we have identified and named Androcam.

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George N. Bennett. E. Dell Butcher Professor. B.S. (1968) University of Nebraska, Ph.D. (1974) Purdue University. gbennett@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=457

Major Research Interests

The laboratory focuses on genetic engineering of metabolic pathways of microbes for production of biofuels and chemicals. In order to construct an effective biocatalyst and carry out effective modification of the metabolic pattern of cells, knowledge of the native regulatory processes, enzymes and pathways of the microbe must be understood. We study the responses of bacteria to stresses either encountered in nature or in an industrial fermentor, such as pH, oxygen limitation or salt concentration. Other areas of research involve *Clostridium acetobutylicum,* where we seek to understand and manipulate genes related to butanol production. Efforts also are under way to study the genetic and biochemical basis of biodegradation of nitroaromatic and other hazardous compounds by this soil bacterium. Development of novel DNA technology for assembling gene constructs and introducing multiple chromosomal changes to enhance microbial genetic engineering via "synthetic biology" is also an ongoing project.

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Matthew Bennett. Assistant Professor. B.S. (2000) Georgia Tech, Ph.D. (2006) Georgia Tech. http://biochem.rice.edu/facultydetail.aspx?riceid=526587

Major Research Interests

Our research generally spans the boundary between experimental and theoretical molecular systems biology. In particular, we are interested in the dynamics of gene regulation — from small-scale interactions such as transcription and translation to the large-scale dynamics of gene regulatory networks. We use a hybrid experimental and computational approach to uncover the underlying design principles governing native gene networks and to use these concepts to design novel synthetic circuits.

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Janet Braam. Professor. Chair and Professor. B.Sc. (1980) Southern Illinois University, Ph.D. (1985) Cornell Graduate School of Medical Sciences, Sloan-Kettering Division. braam@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=557

Major Research Interests

The Braam lab uses genetics, biochemistry, and cell biology to investigate diverse aspects of plant biology and responses to abiotic and biotic stress. We have uncovered roles for mechanical stress,

the circadian clock, and epigenetic regulation in plant defense against insect herbivores and fungal infection. Novel mechanisms of autophagy regulation, fungal perception, phytohormone accumulation, and chloroplast biogenesis and maintenance are under investigation. Translational work includes optimization of crop nutrition and longevity, nanoparticle-plant interaction, and the use of fundamental knowledge of plant biology to identify new anti-malaria drugs.

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Daniel Carson. Dean, Natural Sciences and Professor. B.S. (1975) University of Pennsylvania, Ph.D. (1979) Temple University, Daniel.D.Carson@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=184636

Major Research Interests

Dr. Carson's laboratory is examining the expression and function of cell surface components that participate in and regulate cellular interactions in developing embryos and various tumor cell models. One major research area focuses on the multifunctional cell surface mucin glycoproteins, MUC1, MUC4 and MUC16. Research involves the study of factors controlling mucin expression and function as well as the role these glycoproteins play in signal transduction processes in normal and pathological contexts. We also are testing the potential to use mucin glycoproteins as novel targets for drug and nanoparticle-based therapeutic approaches in cancer cells. A second research area involves the study of the heparan sulfate proteoglycan, perlecan, and enzymes that modify its structure in both the implantation process and in tumor cell contexts. Proteolytic enzymes and enzymes that modify the heparan sulfate polysaccharide chains of perlecan generate perlecan fragments with novel activities or modulate growth factor binding activities, respectively. Mapping the changes that occur in the expression of these activities provides biological insight into the function of this proteoglycan which is expressed in species from *C. elegans* to humans. Moreover, generation of soluble perlecan fragments and/or modified heparan sulfate structures is proposed to be a useful marker of disease states in the utero-placental unit as well as certain cancers.

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Mary C. (Cindy) Farach-Carson. Associate Vice Provost for Research and Professor. B.S. (1978) University of South Carolina, Ph.D. (1982) Virginia Commonwealth University, farachca@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=184627

Major Research Interests

Research in Dr. Farach-Carson's laboratory relates to the role of extracellular matrix in the progression of cancer following metastasis from primary sites, such as prostate or breast, to bone. In many cases, primary tumors are fairly slow growing and do not become life-threatening until they form tumors in bone. The growth factors sequestered in bone matrix provide a very rich environment to promote the growth of cancer cells that invade there. Many of these growth factors are bound to a class of proteoglycans that contain heparan sulfate that regulate their bioactivity. Studies in the laboratory are aimed at identifying and isolating the growth factors responsible for cancer growth and progression with the long-term aim of developing "molecular drugs" to combat cancer metastasis. A second, multidisciplinary project involves the use of proteoglycans, particularly those bearing heparan sulfate chains such as perlecan, in engineering of connective tissues such as bone, cartilage or salivary gland.

Michael C. Gustin. Professor. B.A. (1974) Johns Hopkins University, Ph.D. (1981) Yale University, gustin@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=973

Major Research Interests

Research in my lab is focused on two fundamental problems related to how organisms sense and respond to stress. (1) Using a combination of genetics, microscopy, and biochemistry, we are investigating how cells sense changes in water availability (i.e., osmolarity) in their environment. Our research group has identified an osmosensory domain of the plasma membrane protein Sln1 and is now testing two different hypotheses for signal transduction by this protein. (2) Together with John Olson's group, we are investigating how fungal pathogens defend themselves against noxious oxidants such as nitric oxide that are released by immune cells. Genes and proteins needed for an inducible nitric oxide protection system have been identified in *Candida albicans* and *Aspergillus fumigatus* and are being studied further using analysis of gene expression and enzyme kinetics, respectively. In addition, we are collaborating with Mary Estes, Margaret Conner and Sarah Blutt at Baylor College of Medicine to develop a yeast-based vaccine against rotavirus, a major killer of infants in underdeveloped countries.

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Dan Harrington. Faculty Fellow. B.S. (1996) (2004) Northwestern University, Ph.D. (2004) Northwestern University, dah5@rice.edu. http://biochem.rice.edu/FacultyDetail.aspx?p=0D1CA9F70E83FA2B

Major Research Interests

Design of biocompatible materials with engineered features that can influence cell phenotype. Tissue engineering of salivary glands, and 3D tumor engineering of cancer models.

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Dmitri Lapotko. Faculty Fellow. Ph.D. (1988) Belarussian State University, D.Sc. (2003) A.V. Lykov Heat and Mass Transfer Institute, dl5@rice.edu. http://lapotko.rice.edu

Major Research Interests

What does "nano" mean for biology and medicine? Since their invention, nanoparticles demonstrated both unique properties and an even more unique ability to manipulate energy at nanoscale. Although research into the biological, and especially the medical, applications of nanoparticles will result in entirely new knowledge and medicine, it is yet at the very beginning. In an effort to develop nanoparticle medicine into true nanomedicine, Lapotko's lab engaged at nanoscale the two major life-supporting phenomena, light and heat. Using a mechanism of plasmon resonance in gold nanoparticles, we developed novel, tunable and stealth type nanoprobes, plasmonic nanobubbles (PNBs), tiny vapor bubbles that are generated around gold nanoparticles with short laser pulses. PNBs will provide molecular and cellular imaging, diagnosis, therapy and theranostics (diagnosis and treatment united in one fast procedure) with the speed, selectivity and precision far beyond the limits of modern medicine. Our interdisciplinary research includes three major avenues: fundamental studies of physics, optics and biology of PNBs, studies of PNB-induced bioeffects in cells and organisms, and the development of PNB technologies for cell level imaging, theranostics, surgery, gene therapy and drug delivery.

Herbert Levine. Professor. Ph.D. (1979) Princeton, herbert.levine@rice.edu. http://brc.rice.edu/researchers.shtml

Major Research Interests

The Levine Lab interest is in the physics of nonequilibrium processes, especially in the emergence of spatial patterns in extended systems. Within this framework, I work on issues arising in condensed matter physics, chemical physics and most recently biophysics. Recent research topics in lab involve the systems: 1. Small Regulatory RNAs May Sharpen Spatial Expression Patterns; 2. Understanding Bacterial Cell Growth - "Bacteria As Art"; 3. Dictyostelium Chemotaxis; 4. Evolution; 5. Neural Systems.

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Peter Lwigale. Assistant Professor. B.Sc. (1994), M.Sc. (1997) University of Northern Iowa, Ph.D. (2001) Kansas State University, lwigale@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=173810

Major Research Interests

Dr. Lwigale's research involves events that regulate the differentiation of the multipotent neural crest cells during corneal development and neural crest-derived stromal keratocytes during cornea regeneration. The chick has been used as a model organism to show that: 1) only a subpopulation of neural crest cells can properly contribute to the cornea, 2) corneal keratocytes retain the stem cell-like properties of their neural crest progenitors when challenged in an embryonic environment and 3) the lens-derived axon guidance molecule, Semaphorin3A, regulates sensory innervation of the cornea. In addition to the chick model, studies designed to elucidate the role of guidance molecules during cornea development will involve the mouse as a model organism, to further our understanding of the genes involved in these processes. We are also studying the stem cell potential of keratocytes and their characteristics in the embryonic environment. The goal of our research is to provide an insight into how guidance molecules are disrupted in congenital eye disorders and cornea wound healing, which may lead to discoveries of remedies to these ocular problems.

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Seiichi P.T. Matsuda. Professor. B.A. (1984) Bethel College, Ph.D. (1994) Harvard University. matsuda@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=208

Major Research Interests

Terpenoids are compounds derived from isopentenyl pyrophosphate. Terpenoids that play crucial roles in vertebrates include the retinoids; the geranylgeranyl and farnesyl protein anchors; the coenzymes Q; vitamins A, D, and E; cholesterol; and the steroid hormones. Terpenoid are equally important in invertebrates. Plants control growth and development using regulatory terpenes, and many plants synthesize defense terpenoids that interfere with biological processes in potential herbivores. Some of these compounds are medicinally useful, such as taxol (anticancer), ginkgolide (Alzheimer's disease) and artemisinin (antimalarial). We are cloning and characterizing genes encoding terpene cyclases and terpene oxidases, which catalyze terpene biosynthesis. We engineer microbial metabolic pathways by heterologously expressing these genes. The resultant strains produce natural products, many of which are difficult to obtain by existing methodology. We are modifying terpene biosynthetic genes to produce catalysts that make novel natural products. In collaboration with the Bartel lab, we are studying terpenoids in the plant *Arabidopsis thaliana*.

Kathleen S. Matthews. Stewart Memorial Professor of Biochemistry and Cell Biology. B.S. (1966) University of Texas, Austin, Ph.D. (1970) University of California, Berkeley. ksm@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=293

Major Research Interests

Examination of protein-DNA interactions involved in regulating gene expression is the major focus of research efforts in this laboratory. Genetic regulation is an essential function in all organisms and provides the ability to respond to signals that reflect environmental conditions, determine developmental processes, and communicate other information within an organism. The lactose repressor (LacI) controls expression of the enzymes that metabolize lactose in E. coli. Our long-term goal is detailed insight into mechanisms by which both LacI recognition and regulation occur, and experiments with collaborators extend the applications of this protein. The Ultrabithorax gene encodes a member of the homeodomain family of proteins (Hox proteins) that participate in specifying segmental identity in the Drosophila embryo during development. Experiments are underway with collaborators to explore regulation of DNA recognition and transcriptional regulation and interesting materials properties of this protein.

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James A. McNew. Associate Professor. B.S. (1989) Texas A&M University, Ph.D. (1994) University of Texas Southwestern Medical Center, Dallas. mcnew@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=83

Major Research Interests

My lab is interested in the molecular mechanisms of membrane fusion. Membrane fusion events are at the heart of all cellular processes including fertilization, vesicular transport along the secretory pathway and organelle biogenesis. We use biochemistry, cell biology and molecular genetic techniques to study membrane fusion during vesicular transport in the budding yeast *S. cerevisiae*. A primary goal of the lab is the functional reconstitution of exocytosis in the yeast. SNARE proteins have been shown to catalyze membrane fusion during intracellular transport. The role of SNARE proteins and their regulatory factors will be examined. Additional studies involve membrane fusion events in other aspects of yeast cell biology including sporulation and cell–cell fusion during mating.

Another focus of the lab is the regulation of neurosecretion. We use our in vitro reconstituted fusion system containing SNARE proteins from several organisms to examine neuronal specific regulatory factors.

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Luay Nakhleh. Assistant Professor. B.Sc. (1996) Technion, M.C.S. (1998) Texas A&M University, Ph.D. (1999) University of Texas at Austin. nakhleh@rice.edu. http://www.cs.rice.edu/~nakhleh/

Major Research Interests

We work on a variety of biological questions including, but not limited to, phylogenetic networks and the phylogenomics of bacteria and plants, gene tree incongruence and species tree inference, ancestral recombination graphs and evolutionary analysis of populations, the coalescent and evolution of interaction networks, intra- and inter-cellular signaling in cancer, gene networks and detection of complex genotype-phenotype associations. We take an evolution-centric approach to almost all questions we work on. Work in our group involves mathematical modeling, algorithm design, software development, performance studies and data analysis. We are always looking for motivated individuals (un-

dergraduate, graduate and post-doctoral), who are intrigued by both the biology and computing aspects of our interdisciplinary projects, to join our group.

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Edward P. Nikonowicz. Associate Professor. B.S. (1985) St. Louis University, Ph.D. (1990) Purdue University. edn@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=300

Major Research Interests

We use structural (NMR spectroscopy and X-ray crystallography), biochemical and genetic methods to investigate the structural, biophysical and physiological properties of the component molecules and complexes in nucleic acid systems. We study the co-folding of protein and RNA molecules involved in the maturation of the 30S (prokaryotic) and 40S (eukaryotic) ribosomal subunit. *In vitro* selection of RNA aptamers for S8 and other r-proteins, followed by structural analysis and *in vivo* functional studies, is being carried out to identify potential surfaces for ribosomal inactivation. Another system centers on post-transcriptional modification of tRNA. We are studying the structural and dynamic effects of modification in the anti-codon loop and the specificity of tRNA recognition by modification enzymes. These studies will extend our understanding of protein-RNA recognition and will yield insight into the molecular role of base modification.

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John S. Olson. Ralph and Dorothy Looney Professor. B.S. (1968) University of Illinois, Ph.D. (1972) Cornell University. olson@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=310

Major Research Interests

Dr. Olson's laboratory has been using biochemical, biophysical, chemical and chemical engineering approaches to examine the fundamental processes involved in oxygen transport and storage in mammalian circulatory systems. He directs two major research programs, one involving basic molecular biophysics and the other involving the design of O_2 delivery pharmaceuticals. (1) Dynamics of O_2 binding to heme proteins: Mammalian myoglobin (Mb) and the subunits of human hemoglobin (Hb), and several invertebrate and bacterial Hbs. are being used as simple prototypes. The roles of specific amino acids in regulating O_2 binding, NO deoxygenation, and the resistance of the protein to unfolding are being identified by UV-visible, vibrational, CD, fluorescence and NMR spectroscopies; rapid mixing and ultrafast laser photolysis techniques; X-ray crystallography; and various computational methods. (2) The design of Hb-based blood substitutes: Rational, comparative and random mutagenesis techniques are being used to optimize six key properties of extracellular hemoglobin: (a) moderately low O_2 affinity and high cooperativity, (b) discrimination against CO binding, (c) high rates of O_2 exchange, (d) low rates of reaction with NO and autooxidation, (e) high affinity for heme and (f) resistance to denaturation.

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José Onuchic. Professor. Ph.D. Chemistry (1987) California Institute of Technology. M.S. Applied Physics (1982) Universidade de Sao Paulo. jonuchic@rice.edu. http://chemistry.rice.edu/FacultyDetail.aspx?p=51BE2F2C673C5991

Major Research Interests

José Onuchic has led the biological physics community as it attempts to devise an integrated picture of a variety of model biochemical and biological systems. His research has expanded across the scales of molecular-level interactions to cellular systems to organized multi-cellular structures. At Rice he will move this view towards medical applications focusing on cancer. In protein folding, he has introduced the concept of protein folding funnels as a mechanism for the folding of proteins. Convergent kinetic pathways, or folding funnels, guide folding to a unique, stable, native conformation. Energy landscape theory and the funnel concept provide the theoretical framework needed to pose and to address the questions of protein folding and function mechanisms. He also works on the theory of chemical reactions in condensed matter with emphasis on biological electron transfer reactions. He is now broadening his interests to stochastic effects in genetic networks.

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George N. Phillips, Jr. Ralph and Dorothy Looney Professor. B.A. (1974) Rice University and Ph.D. (1976) Rice University. georgep@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=330

Major Research Interests

The The overall goal of the research in my laboratory is to relate the three-dimensional structures and dynamics of proteins to their biological functions. We use techniques of X-ray crystallography and other biophysical and methods to elucidate the molecular structures, dynamics, and functions of the proteins. Extensive use is also made of computational methods to analyze the structures and their dynamics. Ongoing research projects include: Discovery of enzymes involved in natural product biosynthesis; Characterization of enzymes involved in the deconstruction of lignocellulosic materials for biofuels; New methods of improving the thermostability of proteins for potential commercial improvements; Structural genomics, the solving of structures whose function may not yet be known; and Computational biology, including the development of new algorithms from computer science and applied mathematics to solve interesting biological problems.

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Nicholas H. Putnam. Assistant Professor. Ph.D. (2004) University of California, Berkeley, B.S. (1996) Brown University. nputnam@rice.edu. http://nputnam.web.rice.edu/Putnam_Lab_at_Rice/Welcome.html

Major Research Interests

After five hundred million years of independent evolution since their divergence in the Pre-Cambrian, metazoan genomes still retain recognizable similarities that allow the partial reconstruction not only of their common ancestors' protein coding genes, but of its genomic organization (intron-exon structures, organization into chromosomes, and cis-regulatory elements). There is also new evidence for very ancient conservation of elements of the gene networks controlling body plan and neural patterning. These recent developments, and the dramatic increase in metazoan diversity spanned by genomic data sets, make comparative genomics a promising approach to some of evolution and development's most important questions: How do novelty and complexity arise in evolution? What impact does evolutionary history have on the architecture, function, and future evolution of biological systems? Our research approaches these questions by coupling the development of novel computational analyses with genomic experiments designed to leverage them. Our goal is to reconstruct ancestral genomes, pathways, and regulatory networks, and use these reconstructions to test the predictions of models of evolution, and functional hypotheses.

Laura Segatori. T.N. Law Assistant Professor in Chemical and Biomolecular Engineering, Bioengineering, and Biochemistry and Cell Biology. B.S. (2000) University of Bologna, Italy; Ph.D. (2005) University of Texas at Austin.

Major Research Interests

Professor Segatori's research interest focuses on cellular protein folding particularly in association with the development of human diseases. Proteins must fold into the correct three-dimensional conformation in order to attain their biological function. The balance between formation and maintenance of proteins' active conformations and their turnover, named folding quality control, is remarkably delicate. Thus, alterations in the amino acid chain by inherited sequence mutations or acquired age or stress related modifications might compromise the folding and the stability of proteins, and often result in cellular dysfunction and disease. Because proteins have a remarkably wide variety of functions, protein misfolding can lead to the development of a large number of human diseases, ranging from late onset neurodegenerative diseases, such as Alzheimer's and Parkinson's, to early childhood metabolic diseases, such as lysosomal storage disorders, to cancer. Professor Segatori's laboratory studies the ensemble of competing and integrated biological pathways within the cell that control the biogenesis, folding, trafficking and turnover of proteins and maintain protein homeostasis, or proteostasis. Particular interest is devoted to the design of protein engineering strategies to manipulate the proteostasis network and reprogram the innate folding capacity of the cell with the ultimate goal to rescue native folding of unstable, misfolding-prone proteins. The Segatori's lab specifically investigates i) loss-of-function phenotypes caused by excessive protein misfolding and degradation, using cells derived from patients with Gaucher's disease, ii) gain-of-toxic-function phenotypes characterized by aberrant accumulation of misfolded proteins and aggregation, using a cell model of Parkinson's disease, and ii) the macromolecular machinery that catalyzes degradation of misfolded proteins in mammalian cells.

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Yousif Shamoo. Associate Professor. B.S. (1983), Carnegie-Mellon University, Ph.D. (1988) Yale University. shamoo@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=662

Major Research Interests

My Since coming to Rice University I have built a group whose fundamental goal is to link the disciplines of molecular biophysics and evolutionary biology. A combination of functional genomics and biophysical approaches (X-ray crystallography, kinetics and so forth) can provide a quantitative and systems level understanding of adaptation. Experimental evolution is used to identify the molecular pathways that allow populations of cells to adapt to new conditions such as temperature, antibiotics or growth conditions. From the order and changes in specific molecular pathways, we are able to re-construct the adaptive networks and obtain essential information about which gene products are most relevant for drug design, biophysical analysis as well as how drug regimens may be altered to inhibit the rise of resistant strains. We are particularly interested in multi-drug resistant strains of Enterococci and how they adapt to first-line antibiotics. We also have a long-standing interest in RNA recognition using crystallographic analysis.

Jonathan J. Silberg. Assistant Professor. B.S. (1994), Ph.D. (2000) University of California at Irvine. joff@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=22153

Major Research Interests

The objective of my research group is to draw on concepts, principles, and methods from natural sciences and engineering to elucidate and manipulate the functions of proteins. One system under study in my group is mitochondrial proteins that are thought to be important for maintaining cellular energy homeostasis, with a secondary focus on protein design and in vitro evolution. Our expertise in both biochemistry and biomolecular engineering puts us in a unique position to study molecular and cellular processes, as we take advantage of classical methods for biochemical inquiry and develop and apply novel biotechnologies to support these lines of inquiry. The overarching goal in our study of human proteins is to develop sufficient understanding of protein structure and function to explain the biochemical origin of diseases that arise from defects in mitochondrial chaperones and iron-sulfur enzymes. Our protein engineering efforts are focused on developing tools that can aid in the discovery of treatments for human disease and in the development of new tools for studies of complex cellular systems.

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Michael Stern. Professor. B.S. (1978) Stanford University, Ph.D. (1985) University of California at San Francisco. stern@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=371

Major Research Interests

Drosophila peripheral nerves, similar structurally to the peripheral nerves of mammals, comprise a central core of motor and sensory axons, surrounded by two layers of glia: an inner glial layer, termed the peripheral glia, and an outer, perineurial glial layer. Although it is known that intercellular signaling occurs among these cell types, neither the signaling pathways involved nor their functional effects are completely understood. Using genetic methodologies, we have found that, first, intercellular signaling controls growth of the perineurial glial layer. At least seven genes participate in this regulation. These genes include Ras and the Ras-GTPase activating protein encoded by the *Drosophila* orthologue of the gene responsible for the human genetic disease of Neurofibromatosis. Further studies of this pathway are under way. Second, neuron-glia signaling also affects neuronal excitability via regulation of axonal sodium channels. Loss of function mutations in the inebriated (ine)-encoded neurotransmitter transporter increase sodium currents, whereas overexpression of ine reduces sodium currents.

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Charles R. Stewart. Professor. B.S. (1962) University of Wisconsin, Ph.D. (1967) Stanford University. crs@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=378

Major Research Interests

Infection of Bacillus subtilis by bacteriophage SPO1 causes profound changes in the genetic processes of the host cell. Synthesis of host DNA, RNA, and protein is shut off, presumably to prevent those syntheses from competing with the corresponding phage biosyntheses for materials, energy and access to biosynthetic machinery. Such global redirection of the cell's resources requires regulatory mechanisms of great sophistication and specificity to eliminate the host-specific biosyntheses, while exactly the same processes, specific to the phage genome, proceed with enormous efficiency in the same cell. Dr. Stewart's group is analyzing the

mechanisms by which SPO1 accomplishes this takeover of the host cell. They have identified a cluster of 24 genes in the terminal redundancy of SPO1, which specifies most or all of the necessary machinery. By observing the effect of expression of each gene in uninfected cells, and the effect of mutational inactivation of each gene on the progress of infection, they are defining the specific roles of the 24 gene products. Activities that have been identified for specific gene products include: (1) shutoff of host DNA and RNA synthesis; (2) regulation of the timing of those shutoffs; (3) inhibition of host cell division; and (4) regulation of expression of the 24 genes. The broad-spectrum bactericidal activity of some of these gene products makes them a potential basis for development of new antibiotics.

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Jeffrey J. Tabor. Assistant Professor. Ph.D. (2006) University of Texas. B.A. (2001) University of Texas. jeff.tabor@rice.edu. http://bioengineering.rice.edu/Content.aspx?id=196

Major Research Interests

Jeff Tabor builds synthetic genetic control systems to engineer complex biological behaviors such as pattern formation and social interactions. Molecular sensors, circuits and actuators are combined to program unnatural behaviors in tractable model organisms. Because the systems are constructed using well-characterized molecular parts, they are amenable to facile measurement and manipulation. This allows the development of well-parameterized mathematical models that can close the biological design cycle and increase the reliability with which novel behaviors can be engineered. This research is of interest to basic science and has broad biomedical and industrial applications. Projects in Tabor's Laboratory at Rice include engineering cellular sensors that respond to unnatural inputs such as light, building genetic circuits and signal transduction cascades to process sensory information, combining sensors and circuits to rewire metabolic pathways, engineering new modes of cell-cell communication, and combining all of these technologies to program synthetic social interactions and pattern formation. These methods are also being used to engineer 'smart biotherapeutics', or living cells that both diagnose and treat states of infection and disease.

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Major Research Interests

All RNA viruses encode an RNA-dependent RNA polymerase that catalyzes both the replication and transcription of the viral genome. The full activity of the polymerase, however, often requires additional viral and host factors. For example, while the influenza virus polymerase (PA, PB1 and PB2) alone is capable of synthesizing capped and polyadenylated viral mRNAs, the replication of the viral genome, which is neither capped nor polyadenylated, requires the presence of free viral nucleoproteins (NP). As a multifunctional protein, NP also helps to encapsidate the viral genomic RNAs into double-helical, rod-shaped structures called the ribonucleoprotein (RNP) complexes. One of the major goals of our research is to elucidate the replication mechanism of the influenza virus and how NP regulates the function of the viral polymerase. We tackle these problems with biochemical methods, electron microscopy and X-ray crystallography. Results from our studies are likely to uncover potential new targets for antiviral drug design.

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Major Research Interests

Dr. Wagner's research is focused on identifying essential elements required for the execution of morphogenetic movements in vertebrate embryos. All vertebrate embryos start as a relatively homogeneous population of cells and require specific programs of cell movements and cell shape changes to form a recognizable embryo. The Wagner lab is analyzing zebrafish mutants that display defective morphogenesis to determine the identity and functions of key genes regulating these processes. The zebrafish is a particularly attractive model organism in which to study vertebrate morphogenesis. The embryos develop externally, are optically transparent and develop rapidly, which allows direct observation of all of the morphogenetic movements in the embryo. The laboratory is currently focusing on two classes of mutants. One class is defective in morphogenesis of the anterior of the embryo and displays robust aberrant migration of a specific mesendodermal cell population. The second class is defective in a movement known as epiboly that is particularly dramatic in teleost fishes. The lab is applying genetic, molecular and embryological methods to determine the identity and function of the genes responsible for these mutant phenotypes.

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Major Research Interests

The research in my group is broadly concerned with many-body phenomena in biology, chemistry and physics. A major theme is understanding systems where a large diversity of long-lived states is involved, necessitating the use of a statistical characterization of an energy or attractor landscape. The most notable examples are glasses, liquids, biomolecules and biomolecular regulatory networks. In the area of protein folding we are interested both in describing folding kinetics in the laboratory and the development of bioinformatically based schemes for predicting structure from sequence using computer simulation. A key concept is that the energy landscape of a foldable protein looks like a rugged funnel. This idea guides the development of both simple folding kinetics models and structure prediction algorithms. Similar issues of attractor landscapes also arise in higher order biological processes, such as gene recognition and genetic network regulation, which we also study. The energy landscapes of supercooled liquids and glasses also present interesting problems. We have shown how a new approach based on "random first order transitions" explains many quantitative relations found empirically both in liquids and under cryogenic conditions where quantum effects play a role. The same ideas show promise in the study of systems as different as high temperature superconductors, polymer assemblies, and microemulsions. They are also useful for describing the three dimensional structure and dynamics of the interior of living cells.

Weiwei Zhong. Assistant Professor. B.S. (1997) University of Science and Technology of China, M.S. (2003), Ph.D. (2002) University of Georgia. wz8@rice.edu. http://biochem.rice.edu/facultydetail.aspx?riceid=195448

Major Research Interests

How does a genome specify the properties of an organism? One approach to answer this question is to inactivate a single gene and study the defects. However, the one-gene approach is inadequate for studying complex traits and diseases that are controlled by multiple genes and pathways. Our goal is to achieve a system-level understanding of genetic interaction networks, using both computational and experimental approaches to reach this goal. 1.) Computational prediction of genetic interactions: Taking a bioinformatic approach, we are developing data mining systems that apply machine-learning algorithms to statistically integrate genomic data. 2.) Experimental identification of genetic interactions: Using the nematode *C. elegans* as a model system, we are conducting large-scale, quantitative screens to reveal the genetic interaction networks that regulate development, behavior and physiology. We also are developing automated systems that employ computer vision and robotics to facilitate such high-throughput screens. With the systems biology approach, we expect to bring new insights into the classical quest for underlying mechanisms of genome function.

RESEARCH FACILITIES AND EQUIPMENT

Most department labs are housed in three adjacent buildings on the main campus loop, the M. D. Anderson Biology Building, George R. Brown Biosciences Building, and Keck Hall. We share space in these buildings with the Departments of Ecology and Evolutionary Biology, Chemical and Biomolecular Engineering, and Chemistry. We also have labs on three floors of the new Bioscience Research Collaborative, an innovative space where scientists and educators from Rice University and other Texas Medical Center institutions work together to perform leading medical research. The close proximity of research groups from various departments and institutions promotes an interdisciplinary, collaborative environment.

Some of the research equipment available in the department includes real-time PCR; 20-liter scale fermentation; mammalian cell culture; plant growth facilities; UV-visible, infrared, fluorescence, circular dichroism and EPR spectroscopy; high-voltage electron microscopy; low- and high-level radioactive studies; high performance liquid chromatography and gas liquid chromatography-mass spectrometry; confocal microscopy; phosphoimaging; stopflow kinetics with laser excitation; analytical ultracentrifugation; and confocal microscopy. Facilities for area detector-based X-ray crystallography and 800 MHz NMR spectroscopy are housed in Keck Hall.

The department also maintains a regular seminar program of national and international speakers. In addition to on-campus seminars, Rice students and faculty take advantage of the large number of seminars offered by other institutions in the Texas Medical Center.

HOW TO APPLY

The following information is required before an application can be considered:

1. Completed online application. (http://biochem.rice.edu/)

2. Transcripts of all previous college or university work. Admission to graduate study requires a bachelor's degree in biochemistry, chemistry or biology or the equivalent course experience.

3. At least three letters of recommendation from individuals familiar with the applicant's scholastic and personal qualities.

4. Scores from the aptitude portions of the Graduate Record Examination (GRE). International students must submit TOEFL scores.

Graduate Admissions Coordinator
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ADDITIONAL SPECIALIZED CENTERS

The Institute of Biosciences and Bioengineering

The IBB includes more than 90 Rice faculty members from diverse backgrounds, all pursuing research in the biological and biomedical sciences. The institute director is BCB faculty member Yousif Shamoo. The mission of the Institute is to promote cross-disciplinary research and education encompassing the biological, chemical, and engineering disciplines. The institute represents a unique educational environment in which to prepare students to meet the complex scientific, technological, and ethical challenges we face in the twenty-first century. A complete listing of faculty and research opportunities can be found at ibb.rice.edu.

SPECIALIZED TRAINING PROGRAMS

We have many specialized training opportunities available to students in our graduate program, including the Houston Area Molecular Biophysics Program (HAMBP), the Keck Center for Interdisciplinary Bioscience Training, the NSF Interdisciplinary Research in Science and Engineering (IRISE) program, the BCB Higher Education Teaching and Mentoring Certificate Program, and various Institute of Bioscience & Bioengineering training programs. Even students not directly supported by these programs have access to their facilities and training. To learn more about the specialized training programs, visit biochem.rice.edu/content.aspx?id=189.89.

ABOUT RICE AND HOUSTON

Rice is a leading American research university—small, private and highly selective—distinguished by a collaborative, interdisciplinary culture and a global perspective. Only a few miles from downtown Houston, it occupies an architecturally distinctive, 285-acre campus shaded by nearly 4,000 trees. State-of-the-art facilities and laboratories, internationally renowned centers and institutes and one of the country's largest endowments support an ideal learning and living environment.

The university attracts a diverse group of highly talented students and faculty with outstanding graduate and professional programs in the humanities, social sciences, natural sciences, engineering, architecture, music and business. With just 2,374 graduate students and 3,708 undergraduates, it offers an unusual opportunity to forge close relationships with eminent faculty scholars and researchers and the option to tailor graduate programs to specific interests.

Houston offers all the expected educational, cultural and commercial advantages of a large urban center, and more. It's home of the Texas Medical Center, the largest concentration of medical schools, hospitals and research facilities in the world, as well as several other universities. Rice has cooperative programs with the University of Houston, Baylor College of Medicine, the University of Texas Health Science Center and Texas Southern University. Houston is one of the few U.S. cities with resident companies in all four major performing arts—drama, ballet, opera and symphony. It also boasts a museum district featuring exhibits of national and international prominence.

As urban as it is, Houston also is a surprisingly green city. Houstonians enjoy the outdoors in more than 300 municipal parks and 120 open spaces, and many frequent the beach at Galveston Island, only a 45-minute drive away. Other short trips include Austin, the state's capital, and historic San Antonio, both of which are a little more than three hours away.

FOR MORE INFORMATION:

Rice University homepage:
www.rice.edu

Department of Biochemistry homepage:
http://biochem.rice.edu

Rice University Office of Graduate and Postdoctoral Studies homepage:
graduate.rice.edu

Graduate Student Association homepage:
www.ruf.rice.edu/~gsa

City of Houston homepage:
www.houstontx.gov

Houston information from the *Houston Chronicle*:
www.chron.com

Houston information from Houston InfoSource:
www.houston.tx.us

Houston information from Microsoft Citysearch:
houston.citysearch.com

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