Eli Lilly/Guidant Applied Life Science Research Center

2005 Report

ROSE-HULMAN
INSTITUTE OF TECHNOLOGY

Message from the Director

I send greetings from the Rose-Hulman campus. With the retirement of President Hulbert last June, 2004-05 had its challenging aspects at Rose. I am pleased to report that in the midst of those challenges, the Life Science Research Center is stronger than ever. With this report, we would like to inform you about the current activities and accomplishments of the center.

We are enjoying record enrollments in biology and biomedical engineering, and this successful enrollment translates directly to an increasing number of undergraduates being involved in applied life science research. We increased the number of faculty in the Applied Biology and Biomedical Engineering Department, as well as increasing our collaborative efforts with external partners like the Indiana University Medical School, Terre Haute Center.

Through the generous support of Eli Lilly & Company and Guidant Corporation, Rose faculty and undergraduates have access to funds required to support the work necessary to achieve important educational outcomes such as scientific publications, oral presentations, poster presentations, conference attendance and networking/exposure that increases and affirms student interest in applied biological research.

One sign of success in our undergraduate research program is the fact that, once again, RHIT student presentations won awards at the 2005, 41st Annual Rocky Mountain Bioengineering Symposium student paper competition. This result is representative of our goals at the center — top Rose-Hulman students doing quality scientific research and publishing their results in regional and national publications and conferences.

At Rose-Hulman, we believe that high quality education in the life sciences requires a significant research component. Students are introduced to the scientific method and become excited by the opportunity to create new knowledge. Faculty also benefit from increased opportunities for professional development.

Through this center, Eli Lilly and Guidant are having a significant impact on the education of scientists and engineers at Rose-Hulman.

Thanks very much,

Lee Waite
Director, Eli Lilly/Guidant Foundation
Applied Life Science Research Center

A Brief History of the Lilly/Guidant Foundation Applied Life Science Research Center

In 1994, Rose-Hulman Institute of Technology received a five-year $125,000 grant to establish the Lilly Applied Life Sciences Research Center. The intent of this grant was to establish a central location for multi-disciplinary projects demonstrating the application of engineering and scientific principles to problems originating within the life sciences. The program was intended to encourage the growing interest of Rose-Hulman Institute of Technology faculty and students in bio-related research and curriculum development.

From left, Rose-Hulman President Samuel F. Hulbert, Dr. Ronald Dollens, president and CEO of Guidant Corp., Dr. August M. Watanabe, retired executive vice president of science & technology Eli Lilly Corp., and James Baumgardt, president of Guidant Foundation

At the time of the initial award, Rose-Hulman Institute of Technology was maintaining a small graduate program in biomedical engineering and seeking to strengthen the biology and physiology curriculum offerings. The LASRC provided mission critical encouragement and support for those efforts. Numerous student and faculty presentations, publications, and undergraduate research projects encouraged yet larger numbers of faculty and students to investigate problems and pursue projects in the life sciences area.

In 2001, the initial five-year grant was renewed and expanded to $150,000. The Guidant Foundation entertained a proposal to join Eli Lilly & Company as a co-sponsor for the Lilly Applied Life Sciences Research Center program. The Guidant Foundation awarded Rose-Hulman Institute of Technology a matching grant for $150,000 over a five-year program, and the program was renamed the Lilly-Guidant Foundation Applied Life Sciences Research Center to reflect that partnership.

Rocky Mountain Bioengineering Symposium

With the support of the Lilly/Guidant Applied Life Science Research Center, Jameel Ahmed, Phil Cornwell, Lee Waite, and BE graduate students Saylan Lukas, Chaitanya Sathe, Seana Giardini, and Joshua Haarer attended the 42nd Annual Rocky Mountain Bioengineering Symposium in Copper Mountain, Colorado, April 8 through April 10. Dr. Gabi Nindl and Dr. Mary Johnson, both adjunct Rose-Hulman faculty members and assistant professors, IU Medical School (THCME), also attended the conference and presented research. The RMBS is the oldest continually running biomedical engineering symposium in North America. Four papers were presented by RHIT faculty and students.

Saylan Lukas, BE Graduate Student, presents research results at the RMBS paper competition.

All three student presentations were award winners. Seana Giardini won the Program Chair's Award in the oral presentation competition with her paper titled "Monitoring femoral component installation using vibration testing." Chaitanya Sathe won the President's Award in the oral presentation competition for his paper titled "Catheter-tip sensor to monitor production of hydrogen peroxide in small biosamples." Saylan Lukas won second place in the written paper competition with his paper titled "Selective protein adsorption on micro-textured P-type and N-type silicon wafers."

Lee Waite, President of RMBS, presents Chaitanya Sathe, BE Graduate Student, an award for his submission in the student paper competition.

Research results from the Lilly/Guidant Applied Life Science Research Center that were published in Volume 41 of the Biomedical Sciences Instrumentation (the proceedings of the RMBS) included:

- "Monitoring femoral component installation using vibration testing" Seana Giardini[1], Phillip Cornwell[1] & R. Michael Meneghini[2] [1]Rose-Hulman Institute of Technology, [2]St. Vincent Center for Joint Replacement
- "Selective protein adsorption on micro-textured P-type and N-type silicon wafers" S.J. Lukas & J. Ahmed, Rose-Hulman Institute of Technology
- "A photochemical microreactor used to analyze hydrogen peroxide ($H_{2}0_{2}$) production of T lymphocytes" Gabi Nindl[1], Werner Hess[2], Lee R. Waite[3] & Walter X. Balcavage[1] [1]Indiana University, [2]Stuttgart, Germany, [3]Rose-Hulman Institute of Technology
- "Catheter-tip sensor to monitor production of hydrogen peroxide in small biosamples" Chaitanya S. Sathe[1], Gabi Nindl[2] & Lee R. Waite[1] [1]Rose-Hulman Institute of Technology, [2]Indiana University

Seana Giardini, ME Graduate Student at Rose, wins award in the oral presentation competition at RMBS2005.

Jameel Ahmed

Richard Anthony

Mark Brandt

Neural Vascular Interactions in the Retina

Diabetic retinopathy, or blindness occurring as a result of diabetes, is the leading cause of blindness in adults aged 20-74 and causes 12,000-24,000 new cases of blindness every year. Recent studies have shown that the underlying cause of diabetic retinopathy is damage to the blood vessels that supply the retina. Dr. Jameel Ahmed and a team of undergraduate and graduate students at RHIT are working on a project to help increase our understanding of the underlying physiological mechanisms that control the blood supply to the retina. In particular, the program's major goal is to increase understanding of the control system that links retinal metabolic load with nutrient supply from the retinal circulation. Diabetic retinopathy is thought to disrupt this control system by damaging blood vessels.

In these experiments, blood flow will be measured using two techniques. The first technique is a microsphere technique in which labeled microspheres are injected into the left ventricle of an anesthetized rat and become embedded in the retina. After the animals are sacrificed, the retina is removed and wholemounted, and the spheres are counted using a fluorescent microscope. The second technique used in this study is the particle tracking technique. In this approach, very small microspheres (roughly 2 um in diameter) are injected intravenously. These particles are imaged using a microscope with a fluorescence attachment. Images are recorded on a VHS videotape, and blood velocities and flows are calculated.

Once these measurement techniques are optimized for use in the rat retina, the effects of neural activity on retinal blood flow will be investigated. First of all, the increase in retinal blood flow that accompanies flicker stimulation will be characterized in the rat retina. In later experiments, the Na+/K+ pump blocker TTX will be used to block action potential generation in inner retinal neurons to see if this activity triggers the increase in retinal blood flow that occurs in response to retinal stimulation.

This research program at RHIT was initiated with support of the Eli Lilly/Guidant Applied Life Science Research Center. This support provided funds for the purchase of basic equipment and supplies as well as support of a summer undergraduate research experience for RHIT undergraduate Alexis Nathaniel. As a result of this support, sufficient preliminary data was gathered that allowed submission of a grant proposal to the National Eye Institute of the National Institutes of Health. The NIH funded this proposal, which will provide summer research experiences for many RHIT undergraduates and graduate students.

Interdisciplinary Research Collaborative in Biology and Chemistry (IRCBC) Continues

Using funds awarded last year from the Merck-AAAS Undergraduate Science Research Program, Drs. Anthony, Brandt (Chemistry), Ingram, and Morris (Chemistry) have, over two summers, directed twelve students in undergraduate research projects. These projects range from probing the structure of the active site of the estrogen receptor to developing a rapid, bench-top method for determining plant available soil phosphorus. Participants in the 2004 session of the summer research program presented their research at the first annual IRCBC Undergraduate Research Symposium, as did colleagues on campus and from nearby Indiana State University. This year's research collaborators are looking forward to the second annual symposium, to be held in October. In addition to the summer research experience, the IRCBC co-hosted two speakers on the Rose-Hulman campus.

Study of Isolated Communities in Degraded Landscapes

Janice Bossart

The National Science Foundation awarded $300,000 to Dr. Janice Bossart to investigate the biodiversity of relict forest 'islands' from one of the most biologically unique, critically imperiled, and understudied regions in the world — the tropical forests of Ghana. Research supported by this project will address how fragmentation changes butterfly community composition, which habitats support the highest diversity of endemic species, what features characterize these habitats, and how these attributes correlate with historical and current species' distributions and persistence. The project emphasizes survey and conservation of forest reserves and irreplaceable sacred groves. Sacred groves are isolated forest areas that have been protected for hundreds of years by indigenous peoples and that were, within living memory, part of continuous forest. Butterflies are excellent models for evaluating the status of natural communities in degraded landscapes because they show a wide diversity of relative sensitivities to environmental change, are tightly linked to ecological systems as both primary consumers (herbivores) and food items, and are easily collected and identified. Primary field activities associated with the project will occur over three years and include regular and systematic survey of nine forest sites using baited traps and net collections, intensive spot surveys of at least six additional unique forest sites, measurement of forest characteristics at each site (e.g., size and canopy cover), and purposeful collection of caterpillars and their food plant dependencies to amass much needed, but largely nonexistent, information on species' biology and natural histories. The project will 1) greatly expand our understanding of forest biodiversity in tropical West Africa, 2) test broad ecological and biogeographic hypotheses that have relevance beyond this particular system, 3) establish a data and image-rich library of the Ghanaian butterfly fauna on the world wide web, 4) make species checklists and summary findings rapidly available to local communities and conservation agencies to facilitate science-based conservation plans, 5) help solidify permanent reference and museum collections in the host country, and 6) generate a reference framework for future research in molecular biology, ecology, evolution, and systematics.

The project emphasizes education, training, capacity building, and cultural exchange. It is an international collaboration that includes overseas research and professional opportunities for U.S. and Ghanaian students and scientists, and involves cooperating specialists from the U.S., Britain, Belgium, and Vietnam, and multiple institutions and staff in the U.S. (Rose-Hulman Institute of Technology and Carnegie Museum of Natural History) and Ghana (Forestry Research Institute of Ghana, Kwame-Nkrumah University of Science and Technology, Ghana Wildlife Division, and Nature Conservation Research Centre).

Blood Supply to the Retina

Dr. Jameel Ahmed's primary research interest is in the physiology of the blood supply to the retina and how nutrient supply to the retina is matched to the metabolic needs of retinal neurons. In order to do this, Dr. Ahmed and Rose-Hulman students are modifying the fluorescent microsphere and pharmacological dissection techniques for use in rats.

In addition to the retinal blood flow project, Dr. Ahmed and BME Graduate Student Saylan Lukas have recently completed a project investigating the biocompatibility of MEMS devices.

Jameel Ahmed

Assistant Professor of Applied Biology and Biomedical Engineering

Jameel Ahmed received a B.S. in Bioengineering from Syracuse University in 1990. This was followed by M.S. and Ph.D. degrees in Biomedical Engineering from Northwestern University. While in Rob Linsenmeier's lab at Northwestern, he developed a technique for measuring retinal blood flow in experimental animals using fluorescent microspheres. After graduating from Northwestern in 1997, Ahmed moved to Laura Frishman's lab at the University of Houston College of Optometry, where he spent two years using a pharmacological dissection technique to characterize the components that combine to make up the dark-adapted electroretinogram of the macaque monkey. Dr. Ahmed is currently Assistant Professor of Applied Biology and Biomedical Engineering at Rose-Hulman Institute of Technology, a position he took in September of 1999.

Graduate Student Advisor to:

Saylan Lukas - MS 2005
Nicki Lynn - MS 2006 (expected)

Grants:

NIH R15 EY014132 Neural-Vascular Interactions in the Retina

Recent Publications:

Lukas S., Ahmed J. (2005) Selective Protein Adsorption on micro-textured P-type + N-type Silicon wafers Biomedical Sciences Instrumentation 41: 181-186

Chen H.C., Ahmed J. (2004) Design and testing of a fluorescence glucose sensor which incorporates a bioinductive material. Biomedical Sciences Instrumentation, 39: 149-154

Robson, J.G., Saszik, S.M., Ahmed, J., and Frishman, L.J. (2003) Rod and Cone contributions to the a-wave of the electroretinogram of the macaque. Journal of Physiology, 547(pt 2): 509-530.

Dr. Ahmed is currently advising several graduate students on projects sponsored by the Eli Lilly/Guidant Applied Life Sciences Research Center.

Understanding Ribosomal Proteins

Dr. Richard Anthony's primary research is directed at understanding the role of ribosomal proteins in the antibiotic resistance or sensitivity of eukaryotes, as well as the role these proteins play in maintaining the accuracy of protein synthesis. A number of antibiotics work by binding to various components of the ribosome and perturbing the process of protein synthesis. The specificity of such antibiotics is often dependent on structural differences between bacterial and eukaryotic ribosomes. Anthony uses yeast as a model eukaryote to better understand the ribosomal components that account for the specificity of these interactions. In recent experiments, Anthony and his students isolated mutant yeast that actually requires an antibiotic to survive - normal yeast is not at all affected by this antibiotic. Current experiments are directed at determining the precise nature of these mutations and how they exert their effects.

Richard Anthony

Associate Professor of Applied Biology and Biomedical Engineering

Richard Anthony received a B.S. degree in Biology from Loyola University of Chicago in 1986 and his Ph.D. in Biological Sciences from the Laboratory for Molecular Biology at The University of Illinois at Chicago in 1995. After completing his graduate degree, Anthony worked as a Postdoctoral Research Associate in the Division of Biological Chemistry in the Department of Chemistry at The University of North Carolina at Chapel Hill. Prior to arriving at Rose-Hulman in the Fall of 1997, he worked as a Visiting Assistant Professor in the Biology Department at The University of Southern Florida in Tampa. Anthony is a member of a number of professional organizations including the Genetics Society of America, The American Society for Cell Biology, and the Association for Biology Laboratory Education. He also serves as the Chief Health Professions Advisor to Rose-Hulman's pre-health professions students. Anthony is married and has one son.

Other research interests include the study of complex systems and innovations in biology education.

Recent Publications:

Strack, R., West, S. T., and Anthony, R. A. (2002) Paromomycin-dependence in Saccharomyces cerevisiae. Abstr. 13th Annual Argonne Symposium for Undergraduates in Science, Engineering and Mathematics.

Anthony, R. A. and Gillie, L. L. (2002) Introducing the study of complex systems: Building a conceptual and functional understanding using case-based inquiry. Abstr. Association of College and University Biology Eductaors 46th Annual Meeting.

West, S. T. and Anthony, R. A. (2002) Antibiotic dependence in Saccharomyces cerevisiae. Abstr. Annual Wabash Valley Chapter of Sigma Xi Poster Competition (1st place undergraduate).

Recent Publications:

Bossart, J. L. Nestedness, passive sampling, and rare species. Oikos - In Review.

Bossart, J. L., E. Opuni-Frimpong, S. Kuudaar and E. Nkrumah. Butterfly species assemblages in relict sacred forests and forest reserves of Ghana. Journal of Insect Conservation - In Review.

Bossart, J. L. (2003) Covariance of preference and performance on normal and novel hosts in a locally monophagous and locally polyphagous butterfly population. Oecologia, 135:477-486.

Bossart, J. L. and C. E. Carlton (2002) Insect conservation in America: status and perspectives. American Entomologist, 48:82-92.

Stracey, C. M.* and Bossart J. L. (2002) Temporal survey of butterfly species in the Pine Barrens of New Jersey. In: Identification and protection of reference wetland natural communities in New Jersey: Pine Barren Savannas. Report for NJDEP, Division of Parks and Forestry, Office of Natural Lands Management, Natural Heritage Program. **undergraduate research project*

Diversification, Extinction, and Conservation of Biodiversity

Dr. Janice Bossart's research seeks to understand how evolutionary and ecological factors integrate to shape the distributions, abundances, and diversification of species. Bossart explores these issues using insects as her model system and integrates a combination of molecular techniques, population and quantitative genetics, and field studies of populations, communities, and habitat and resource use. Three primary lines of research are actively being pursued: conservation ecology and dynamics of forest butterfly communities in human-transformed landscapes; evolutionary ecology of life-history traits relating to resource use and the differentiation, extinction, and/or persistence of insect biodiversity; and molecular ecology and identification of the historical and contemporary factors that promote molecular genetic pattern across environmental landscapes. Multiple fundamental theoretical issues in evolutionary biology and ecology are being investigated within these three broad domains. But insights being discovered also have direct relevance to a number of important contemporary applied issues. For example, how do human activities impact non-human species and how can we mitigate these effects? Why are some insect species pests of crops, and how can we manage these with minimal environmental impact? How can we best preserve natural landscapes and the species they harbor?

Janice Bossart

Visiting Professor of Applied Biology and Biomedical Engineering

Janice Bossart embarked on her professional studies as a single parent and after a seven year hiatus from academics. She graduated magna cum laude with a B.S. degree in Basic Science from West Virginia University in 1985. This was followed by M.S. and Ph.D. degrees in Entomology/Ecology & Evolutionary Biology at Michigan State University. After graduation, Bossart worked as a postdoctoral researcher at the University of Maryland and as a postdoctoral fellow at Louisiana State University. Prior to arriving at Rose-Hulman in the Fall of 2003 as a Visiting Assistant Professor, she was a faculty member at The College of New Jersey (TCNJ). While at TCNJ, she guided the research projects of 11 undergraduate students, seven of whom have gone on to pursue graduate degrees. Dr. Bossart has been awarded nearly $400,000 in support of her research, including grants from the National Science Foundation and the National Geographic Society. She has 15 scientific publications and has given more than 40 scientific presentations.

Focus on Biomaterials

Dr. Christine Buckley's research interests can most broadly be described as biomaterials. This includes studies of the biocompatibility, corrosion resistance, and mechanical properties of traditional biomaterials used in orthopedic implants. She is currently collaborating with a group of orthopedic surgeons in Indianapolis on several research projects related to the biomechanics of orthopedic implants and the effect that implant placement has on the long-term clinical success of the implant. Dr. Buckley is also interested in new approaches to replacing damaged or diseased tissue, which falls under the umbrella term "tissue engineering." She is working with a student to evaluate a novel material for use as a scaffold for seeding bone cells in a device that could be used to engineer bone.

Christine Buckley

Associate Professor of Applied Biology and Biomedical Engineering

Christine Buckley received the B.S.E. degree in Biomedical Engineering from Duke University in 1988. She then attended Northwestern University where she received the M.S. (1990) and Ph.D. (1994) in Biomedical Engineering. Since 1994, she has taught Mechanical and Biomedical Engineering at Rose-Hulman Institute of Technology in Terre Haute, Indiana.

In 1998, Dr. Buckley spent one year working at LifeCell Corporation in Houston, Texas. LifeCell is a tissue engineering company whose products are based upon their patented AlloDerm® tissue processing technique. The company currently markets processed acellular human dermis for use in burn, plastic and reconstructive, periodontal, and urogynecological surgery.

Recent Publications:

M.H. Ware and C.A. Buckley, "The Study of a Light-Activated Albumin Protein Solder to Bond Layers of Porcine Small Intestinal Submucosa (SIS)," Biomedical Sciences Instrumentation, Vol. 39, p. 1, 2003.

Z.R. Nicoson and C.A. Buckley, "Bond Strength of Fibrin Glue Between Layers of Porcine Small Intestine Submucosa (SIS)," Biomedical Sciences Instrumentation, Vol. 38, p. 179, 2002.

Focusing on understanding the response of macrophages

Dr. Alicia Cecil's laboratory efforts are focused on understanding the response of macrophages to various stimuli. Macrophages are leukocytes that play a critical role in immune responses to infection. They are also implicated in the rejection and failure of implanted medical devices. Experiments in the lab are designed to study the genes that are activated in macrophages in response to foreign molecules from both bacteria and biomaterials. Additionally, the lab focuses on the activation to the signaling pathways in these cells as they respond to foreign materials. Comparing the reaction of the cells to both biomaterials and bacterial sources may help us to gain a full knowledge of the pathways involved in implant failure. Strides in these areas will also lead to improved methods for preventing or treating failure.

Another long-term project in the lab involves an investigation of the patterns of antibiotic resistance in E. coli from local lakes and streams.

Recent Publications:

Cecil, A.A., Klemsz, M.J. (2004) p38 activation through Toll-like receptors modulates IFN-gamma-induced expression of the Tap-1 gene only in macrophages. Journal of Leukocyte Biology, 75: 560-568.

Alicia Cecil
AssistantS Professor of Applied Biology and Biomedical Engineering

Alicia Cecil received a B.S. in Biology from the University of Southern Indiana in 1998. Cecil received her graduate training at Indiana University School of Medicine where she received a Ph.D. in Microbiology and Immunology in 2003. She joined the faculty at Rose-Hulman Institute of Technology in the fall of 2003 as Assistant Professor of Applied Biology.

Monitoring Femoral Component Installation using Vibration Testing

Dr. Phillip Cornwell's most recent research is directed at applying vibration testing to monitor femoral component installation. With emerging minimally invasive surgical techniques in total hip arthroplasty, there has been anecdotal evidence of an increase in periprosthetic fractures associated with the insertion of the prosthesis into the femur. This is likely the result of diminished visibility, auditory and tactile feedback for surgeon operating through much smaller incisions. Dr. Cornwell's research attempts to identify a means to supplement the surgeon's tactile and auditory senses by using damage identification techniques, typically used in civil and mechanical structures, to determine when a cementless femoral implant is fully seated.

Phillip Cornwell

Professor of Mechanical Engineering

Phillip Cornwell received his B.S. degree in Mechanical Engineering from Texas Tech University in 1985 and his M.A. and Ph.D. from Princeton University in 1987 and 1989 respectively. His present interests include structural dynamics, structural health monitoring, and undergraduate engineering education. Dr. Cornwell spends his summers working at Los Alamos National Laboratory where he is a mentor in the Los Alamos Dynamics Summer School and he does research in the area of structural health monitoring. Dr. Cornwell has received an SAE Ralph R. Teetor Educational Award in 1992, the Dean's Outstanding Teacher award at Rose-Hulman in 2000 and the Rose-Hulman Board of Trustees Outstanding Scholar Award in 2001. Cornwell is currently a Professor of Mechanical Engineering at Rose-Hulman Institute of Technology.

Recent Publications:

Giardini, S., P.J. Cornwell, R.M. Meneghini (2005), "Monitoring Femoral Component Installation using Vibration Testing," Biomedical Sciences Instrumentation, Volume 41, p. 13-18.

Farrar, C.R., P.J. Cornwell, N.F. Hunter, N.A.J. Lieven (2005), "Sensing and Data Acquisition Issues for Damage Prognosis", a chapter in Damage Prognosis : For Aerospace, Civil and Mechanical Systems, D. Inman, C.R. Farrar, V. Lopes, and V.Steffen editors, John Wiley and Sons 2005.

Van Zandt, T., J. McFarland, D. Wang and P. Cornwell (2005), "Optimizing Tuned Auxiliary Structures for Power Harvesting," Proceedings of the 23rd IMAC Conference on Structural Dynamics, Orlando, FL, Jan. 2005.

Cornwell, P., J. Goethals, J. Kowtko, M. Damianakis, "Enhancing Power Harvesting Using a Tuned Auxliliary Structure," to appear in the Journal of Intelligent Materials Systems and Structures.

Gray, G.L., D. Evans, P. Cornwell, F. Costanzo, B. Self (2005), "The Dynamics Concept Inventory Test as a Means of Assessing Curricular Innovations", McMat 2005 Conference, Baton Rouge, Louisiana.

Recent Publications:

A. Sorkin, K.C. Dee, M.L. Knothe Tate, "'Culture shock' from the bone cell perspective: mechanobiological considerations to emulate physiologic conditions in culture," American Journal of Physiology: Cell Physiology, 287(6):C1527-C1536, 2004.

E.A. Sander, A. Alb, W. Reed, E.A. Nauman, K.C. Dee, "Solvent effects on the microstructure and properties of 75/25 poly(D,L-lactide-co-glycolide) tissue scaffolds," Journal of Biomedical Materials Research, 70A: 506-513, 2004.

D.A. Shimko, C. Burks, K.C. Dee, E.A. Nauman, "A comparison of in vitro mineralization by murine embryonic and adult stem cells cultured in an osteogenic medium," Tissue Engineering, 10(9/10):1386-1398, 2004.

K.C. Dee, "Reducing the workload in your class won't buy you better teaching evaluation scores: Re-refutation of a persistent myth," Proceedings of the ASEE Annual Conference (2004).

Interfaces Between Cells and Their Environment

Dr. Kay C Dee's research focuses on elucidating and controlling events at the interfaces between cells and their surrounding environment. Dr. Dee and her students are often involved in collaborative projects that study cellular responses to mechanical and chemical stimuli, that control cell-biomaterial interactions, and that mechanically and biologically characterize tissue-engineered constructs.
For example, the focus of Rose-Hulman student Joshua Haarer's Biomedical Engineering M.S. thesis is the development and characterization of collagen fibers with varied cross-sectional areas and forms for use in the construction of novel collagen biomaterials. These biomaterials, made of short collagen fibers embedded in collagen gels, can be analyzed as classic fiber/gel composite materials and are intended for use in engineering many soft tissues (ligaments, cartilage, adipose/breast tissue, etc.). The collagen fiber/gel composites under development allow growth of viable tissues with desired shapes, sizes, and cellular functions; the fiber permutations currently being studied additionally allow the mechanical properties of the resultant tissues to be tailored to a specific application (i.e., ligament versus breast tissue). Another current project is a collaboration with Dr. Gabi Nindl at the Indiana University School of Medicine, and with Rose-Hulman Applied Biology undergraduate Derek Trobaugh, who is investigating hydrogen peroxide production in T-lymphocytes for his senior thesis.

Kay C Dee
Associate Professor of Applied Biology and Biomedical Engineering

Kay C Dee received a B.S. degree in chemical engineering from Carnegie Mellon University in 1992, and M.Eng. and Ph.D. degrees in biomedical engineering from Rensselaer Polytechnic Institute in 1994 and 1996. After completing her graduate work, Kay C worked first as an Assistant and then as an Associate Professor in the Department of Biomedical Engineering at Tulane University in New Orleans, Louisiana. She joined the faculty at Rose-Hulman in 2004.

Kay C has received a number of awards for her teaching and research, including the Louisiana "Professor of the Year" award from the Carnegie Foundation for the Advancement of Teaching, a Young Investigator award from the Biomedical Engineering Society, and a CAREER award from the National Science Foundation. She has advised more than 30 undergraduate students as they completed year-long research thesis projects, and is an author of more than 25 peer-reviewed publications, as well as the textbook An Introduction to Tissue-Biomaterial Interactions (John Wiley & Sons). Her educational research interests include student learning styles, teaching new faculty about teaching, and student evaluations of teaching. She has been the Principal Investigator or co-PI on grants worth over $1.5 million dollars for research and education projects, funded by organizations including the National Science Foundation, the National Institutes of Health, and the National Aeronautics and Space Administration.

Kay C's teaching portfolio includes undergraduate and graduate courses on: biology and biomaterials; cell-biomaterial interactions; cell and tissue mechanics; bioethics, science fiction, and tissue engineering; and teaching engineering.

Mutualistic Interactions in Temperate Deciduous Forests

Dr. Ingram's biological research is focused on understanding the dynamics of mutualistic interactions in temperate deciduous forests. The vast majority of plant species participate in mutualisms with soil-borne fungi; plants contribute carbon resources to fungi in exchange for phosphorus and other mineral nutrients acquired by fungi. In the absence of such fungal partnerships, many plant species, including many agriculturally important plants, suffer from reduced or failed reproduction. The model system for Dr. Ingram's work is the common herbaceous perennial mayapple, a plant ideally suited to studies of fungal mutualists because of large, easily accessible roots and mayapple's clonal reproduction, a characteristic that eliminates genetic differences among individual plants. Current projects include the development and implementation of a rapid, bench-top procedure for quantifying available phosphorus in local soils and a long-term analysis of the benefit of fungal mutualisms in in situ plants.

Ella Ingram

Assistant Professor of Applied Biology

Ella Ingram received a B.A. degree in Biology and Mathematics from Augustana College in Rock Island, Illinois, in 1997 and her Ph.D. in Ecology and Evolutionary Biology from Indiana University in Bloomington in 2004. While at IU, she taught as an adjunct faculty in the Department of Biology. Dr. Ingram continues research begun during her graduate studies, focusing on effective college science pedagogy, particularly on teaching evolution and the effectiveness of inquiry opportunities for increasing student learning.

Recent Publications:

Ingram, E.L. & C.E. Nelson. 2005. Relationships between students' acceptance of evolution or creation and achievement in an upper-level evolution course. Journal of Research in Science Teaching in press.

Ingram, E.L. & C.E. Nelson. 2005. Discussing multiple choice questions helps students reconstruct their understanding. American Biology Teacher in press.

Ingram, E.L., K. Myer Polacek, A.C. Love, & E. Lehman. 2004. Fostering inquiry in non-laboratory settings. Journal of College Science Teaching 34(1):39-43.

Ingram, E.L. & C.E. Nelson. 2004. A faculty development program in the scholarship of teaching and learning. Presented at the International Society for the Scholarship of Teaching and Learning, Bloomington, IN.

Ingram, E.L. 2004. Seasonal phenology of mycorrhizal colonization and root growth within rhizome systems of mayapple, Podophyllum peltatum. Presented at the Midwest Ecology and Evolution Conference, University of Notre Dame.

The Mechanics of Soft Biological Tissues and Synovial Joints

Dr. Glen A. Livesay's research focuses on the mechanics of soft biological tissues and their contribution to overall stability of synovial joints in the human body (e.g. the knee, etc.). He has a particular interest in the multi-scale nature of many problems in this area: The fiber arrangement within soft tissues controls their directional behavior, the insertions of these soft tissues into the bones governs their mechanical response, and this in turn affects overall joint stability. Addressing the mechanical interactions across these levels remains an important research emphasis, with consequences for both our understanding of the normal function of soft tissues and joints, as well as the successful replacement of damaged soft tissues with grafts or engineered constructs.

He is currently working with Rose-Hulman graduate student, Michael Morschauser, to assess soft tissue deformation near a bony insertion and to correlate these deformations to the underlying fiber geometry within the soft tissues using small angle laser scattering through thin sections. This research is investigating fiber-in-matrix composite models, but with modifications to account for the time-dependent and large deformation behavior of soft tissues when compared to traditional engineering materials (e.g. metals) or bone. An additional project being conducted with applied biology senior, Stefani Vande Lune, involves the measurement of the variation in longitudinal strain in ligaments of the knee joint. Regions near the bony insertions of soft tissue appear to experience much larger strains than the midsubstance regions under tensile loading. At the same time, ligaments increase in cross-sectional area as they near the bony insertion; so this may provide a mechanism for a smooth transition of loading from a soft tissue to a bony tissue with a modulus that is an order of magnitude greater. One important outcome of this work is the development of target design criteria for engineered tissue replacements, since a successful replacement must reproduce not only overall (end-to-end) behavior of the normal tissue, but also the regional behavior.

Glen A. Livesay

Associate Professor of Applied Biology and Biomedical Engineering

Glen A. Livesay received a B.S. degree in engineering from the University of California, Los Angeles (UCLA) in 1988, an M.S. degree in civil engineering in 1989 from UCLA, an M.S. degree in applied mechanics and engineering sciences (bioengineering) from the University of California, San Diego in 1990, and the Ph.D. degree in civil engineering from the University of Pittsburgh in 1996. Following his graduate work, Glen worked first as a post-doctoral associate at the University of Pittsburgh, and then as an Assistant Professor in the Department of Biomedical Engineering at Tulane University in New Orleans, Louisiana. He joined the faculty at Rose-Hulman in the Summer of 2004.

Glen has received awards for both teaching and research, including the John H. Stibbs award from the undergraduate student government at Tulane University for excellence in teaching and a CAREER award from the National Science Foundation. He has advised more then 30 undergraduate students during their year-long thesis research projects and has been an author on over 30 peer-reviewed publications in biomedical engineering. His interests in educational research are primarily focused on student learning styles and statistical evaluation of instruments for assessing learning styles, and he has published four peer-reviewed papers on educational topics.

Recent Publications:

Gentleman, E.D., Nauman, E.A., Dee, K.C., and Livesay, G.A.: Short Collagen Fibers Provide Control of Contraction and Permeability in Fibroblast-Seeded Collagen Gels, Tissue Engineering, 10:421-427, 2004.

Dee, K.C., and Livesay, G.A.: First-Year Students Who Leave Engineering: Learning Styles and Self-Reported Perceptions, Proceedings of the American Society for Engineering Education (ASEE) Annual Conference, 2004.

Gentleman, E.D., Livesay, G.A., Dee, K.C., and Nauman, E.A.: Tissue Engineering: Ligament, in the Encyclopedia of Biomaterials and Biomedical Engineering, Eds. G.E. Wnek and G.L. Bowlin, Marcel Dekker, Inc., New York City, NY, pgs. 1559 - 1569, 2004.

Livesay G.A. and Dee, K.C.: Test-Retest Reliability of Felder's Index of Learning Styles for First-Year Engineering Students, Proceedings of the American Society for Engineering Education (ASEE) Annual Conference, 2005.

Tackling T Cells

The goal of Dr. Gabi Nindl Waite's research is to develop an innovative way to inhibit overactive inflammatory T cells by changing oxidation reduction (or redox) dependent molecular processes. Inflammation is an indispensable process to survival, but in excess it is also the root for debilitating diseases such as rheumatoid arthritis, heart disease and some cancers. T lymphocytes are especially interesting candidates for redox regulation. T cells are vital in regulating inflammatory responses, and during inflammation they are exposed to exogenous reactive oxygen species such as hydrogen peroxide (H_2O_2), which is produced by other cells to kill bacteria. Multiple steps in T cell signal pathways are redox sensitive and H_2O_2 seems to promote either proliferation or death of inflammatory T cells, depending on the situation. But T cells cannot only sense H_2O_2, they also actively contribute to the redox signaling. We published evidence that T cells themselves are able to produce H_2O_2 in response to various activating stimuli.

It is currently a particularly exciting time for redox research. On the one hand, the significance of oxidative stress by molecules such as H_2O_2 has become increasingly recognized and it is discussed as a component of virtually every disease. On the other hand, H_2O_2's role as a signaling molecule is now postulated to have an importance similar to that of other ubiquitous signaling molecules such as cAMP, nitric oxide and calcium. Understanding the regulation of cellular H_2O_2 and redox metabolism will aid in developing novel therapeutic tools.

The research of redox signaling is a new area and thus requires development of novel research tools. Together with Harish Sharma, a Rose-Hulman biomedical engineering student mentored by Dr. Lee Waite, we developed in 2003 a H_2O_2 real-time sensor. A paper was published, and Harish gave an award-winning presentation at the Rocky Mountain Bioengineering Symposium.

In 2004, Chaitanya Sathe mentored by Dr. Lee Waite, continued the project and tested a microsensor that now allows us to measure real-time H_2O_2 production in volumes as small as fifty microliters. Chaitanya followed in Harish's footsteps, published the microreactor and received an award for his presentation at the Rocky Mountain Bioengineering Symposium in April 2005.

Also in 2005, Derek Trobaugh, a biomedical engineering senior mentored by Dr. Kay Dee, joined us. Derek has some clinical research training and currently is working on an extremely exciting project that aims to identify the biological source of T cell H_2O_2 production. For this project, Derek received additional financial support in the form of the Joseph B. and Reba A. Weaver Undergraduate Research Award. He plans to publish his results in the near future.

This project is a good example of the collaborative effort between RHIT and Indiana University School of Medicine. This collaboration is a win-win situation for all parties involved. Students learn to conduct clinical research, and I.U. medical scientists profit enormously from their and their mentors' engineering expertise. An improved understanding of the actions of H_2O_2 in T cells will have immense therapeutic implications since down-regulation of inflammatory T cells is the treatment of choice for many inflammatory diseases. The support of the Eli Lilly/Guidant ALS Research Center makes it happen.

Recent Publications:

Nindl Waite, G., Waite, L.R., Hughes, E.F. and Balcavage, Biophotonic hydrogen peroxide production by antibodies, T cells and T cell membranes. Biochem Biophys Res Commun, 338(2), 1110-1117, 2005.

Markov, M., Nindl, G., Hazlewood, C., and Cuppen, J. Interactions between electromagnetic fields and the immune system: possible mechanism for pain control. In: NATO Advanced Research Workshop Publication Series. Markov, M. and Ayrapetyan, S. (Eds.). Springer Verlag, 213-226, 2005.

Nindl, G. Hess, W., Waite, L.R. and Balcavage, W.X. A photochemical microreactor used to analyze hydrogen peroxide (H_2O_2) production of T-lymphocytes. Biomedical Science Instrumentation, 41, 2005.

Sathe, C., Nindl, G. and Waite, L.R. Catheter-tip sensor to monitor production of hydrogen peroxide in small biosamples. Biomedical Science Instrumentation 41, 193-198, 2005.

Nindl, G., Kennedy, B.G. and Echtenkamp, S. Physiology Questions. In: Appleton and Lange's Review for the USMLE Step 1, 5th Edition. King, M.W. (Ed.). The McGraw Hill Companies, U.S.A., Chapter 2, 5th Edition, pp. 55-105, 2005

Nindl, G. Hydrogen peroxide - from oxidative stressor to redox regulator. CellScience 1(2): 1-12, 2004.

Nindl, G., Peterson, N.R. Hughes, E.F., Waite, L.R.and Johnson, M.T. Effect of hydrogen peroxide on proliferation, apoptosis and interleukin-2 production of Jurkat T cells. Biomedical Science Instrumentation, 40, 123-128, 2004.

A Realistic Digital Human Model for Future Spacesuit Design

Dr. Renee Rogge's research efforts are directed toward biomechanics. She is currently collaborating with a group of engineers at Johnson Space Center to develop a realistic digital human model for future spacesuit design and for the evaluation of space hardware. Until recently, the models used for analysis were based on two-dimensional anthropometric measurements. Dr. Rogge and her students have incorporated three-dimensional body scan data to improve the accuracy and utility of the current models.

Other research activities include the evaluation of orthopaedic implants through finite element modeling and in vitro testing. She also works with students to evaluate human performance and sports biomechanics.

Renee Rogge

Assistant Professor of Applied Biology and Biomedical Engineering

Renee Rogge received a B.S. degree in Biomedical Engineering from Tulane University in 1996. She attended the University of Iowa where she studied the biomechanics of distal radius fractures and received her Ph.D. in Biomedical Engineering. Prior to joining the faculty at Rose-Hulman Institute of Technology in the fall of 2004, she was an Assistant Professor in the Environmental and Biomedical Engineering Department at Mercer University in Macon, GA. Rogge also spent two summers (2002 & 2003) as a NASA Faculty Fellow in Houston, TX working in the Anthropometry and Biomechanics Facility.

Recent Publications:

Rogge, R., Chappell, A., & S. Rajulu. "Development and Validation of a Digital Human Model for Space Hardware Design and Evaluation," SAE Digital Human Modeling Conference: 2005, Iowa City, IA.

Sumner, L.B. & R.D. Rogge. "Teaching with Technology: A Strategy for Pedagogy and Practicality using CAE Software," ASEE Conference: 2005, Portland, OR.

Rogge, R.D., Sumner, L.B., & J. Burtner. "Formative Assessment of a Computer-Aided Analysis Center: Plan Development and Preliminary Results," FIE: 2004, Savannah, GA.

Grosland, N.M., Rogge, R.D., and B.D. Adams. Influence of articular geometry on prosthetic wrist stability. Clinical Orthopedics 421:134-42, 2004.

Rogge, R.D., Adams, B.D., & V.K. Goel. An analysis of bone stresses and fixation stability using a finite element model of simulated distal radius fractures. J Hand Surgery 27A:86-92, 2002.

Heart Function Assessment

Assessment of heart function and quantification of heart valve pathologies are important in clinical practice, as well as in physiological research. Approximately 400,000 patients are diagnosed with congestive heart failure in the US each year. Elevated diastolic filling pressure in these patients leads to the development of congestive heart failure symptoms. Non-invasive assessment of diastolic function that does not require the use of intracardiac pressure has been an important goal; and in recent years, Doppler electrocardiography has become the "diagnostic modality of choice" to assess diastolic function. Since 1997, Professor Lee Waite has collaborated with surgeons at the Heart Surgery Laboratory at the University of Heidelberg to develop a mathematical model of blood flowing through the mitral valve. The goal is to use this model to assess diastolic function clinically based on Doppler velocity waveforms and other non-invasive heart measurements.

This work was most recently published in 2004 in the European Journal of Cardiothoracic Surgery. In an editorial in that same issue, editor J. Vaage wrote, "This is an excellent example of today's collaboration between cardiac surgeons on one side and computational and engineering expertise on the other side. The collaboration enables an accurate simulation of transmitral flow curves from pressure signals, or inversely, the estimation of pressure values from transmitral flow signals. Theoretically this can be very useful for noninvasive diagnostics."

Other research interests include instrumentation for the measurement of hydrogen peroxide and sports biomechanics. In 2004-05, Waite wrote a book on biofluid mechanics for McGraw-Hill. At the writing of this report, the book is in press and scheduled for publication, December 2005.

Lee Waite

Professor of Mechanical Engineering and Biomedical Engineering and Head of the Department of Applied Biology and Biomedical Engineering

Lee Waite received a BS degree in mechanical engineering from Iowa State University in 1980 and went to work as a design engineer for Fisher Controls International, Inc., Marshalltown, IA. In 1983, he returned to graduate school and received the M.S. and Ph.D. in biomedical engineering from Iowa State in 1985 and 1987, respectively. Waite is currently Professor of Mechanical and Biomedical Engineering at Rose-Hulman Institute of Technology, in Terre Haute, Indiana. He is also the Head, Department of Applied Biology and Biomedical Engineering. He worked as a visiting scientist at the University of Heidelberg, Heart Surgery Laboratory, in Heidelberg, Germany, during the summers of 1999 through 2003 and taught at Kanazawa Institute of Technology in Kanazawa, Japan, during the 1993-94 academic year. His research interests include modeling blood flow and biomechanics of running. His hobbies include foreign languages (German and Japanese), mountain climbing (Mt. Kilimanjaro in 1997), travel (25+ foreign countries), and reading. Waite is married with two children.

Graduate student advisor to:
Christoph Franck - M.S., 2002 Davis Soans - M.S., 2003 Harish Sharma - M.S., 2003 Chaitanya Sathe -M.S., 2005.

Recent Publications:

Waite, L., Biofluid Mechanics in Cardiovascular Systems. First edition. In press. McGraw-Hill, 2005.

Nindl, G., Hess, W., Waite, L., and Balcavage, W. 2005. A photochemical microreactor used to analyze hydrogen peroxide (H202) production of T lymphocytes" Biomedical Sciences Instrumentation, Volume 41, p. 187.

Sathe, C., Nindl, G., Waite, L. 2005. Catheter-tip sensor to monitor production of hydrogen peroxide in small biosamples. Biomedical Sciences Instrumentation, Volume 41, p. 193.

Szabo, G., Soans, D., Graf, A., Beller, C., Waite, L., Hagl, S., A new computer model of mitral valve hemodynamics during ventricular filling, 2004, European Journal of Cardiothoracic Surgery, Surgery 26 (2004) 239-247.

Waite, L. R. & Nindl, G. 2003, Human embryonic stem cell research: an ethical controversy in the US & Germany. Biomedical Sciences Instrumentation, Volume 39, p. 567-572.

Sharma, H.A., Balcavage, W. X., Waite, L. R., Johnson, M. T., Nindl, G. 2003, Characterization of a real time H2O2 monitor for use in studies on H2O2 production by antibodies and cells. Biomedical Sciences Instrumentation, Volume 39, p. 554-560.

Soans, D., Szabo, G., Bolind, C., Waite, L., 2002, A variable valve area, lumped parameter model of left ventricular filling.

Circadian Rhythms and Behavior Regulation

Dr. Bill Weiner's primary research goal is to understand the role that circadian rhythms play in regulating behavior. Advancements in this field have led to a number of important discoveries. For instance, it is now clear that the efficacy of certain drug therapies are dependent upon the time of day at which they are administered. Likewise, seasonal affective disorders and some other forms of depression have been linked to improper entrainment of the biological clocks of afflicted individuals. Even attempts to minimize jet lag or accidents in shift workers require a detailed understanding of how circadian rhythms affect behavior.

To investigate some of these issues, Weiner is using horseshoe crabs as a model system for studying basic circadian and visual processes. One of the projects that he is currently working on is to determine the seasonal effects of natural lighting on structural light adaptation in the lateral eye of the horseshoe crab. Preliminary data suggest that retinal structure is more affected by ambient light levels than time of year. Weiner also is in the process of designing a LabVIEW virtual instrument that will enable circadian data from horseshoe crabs to be collected and analyzed more efficiently. A third project that he is working on is to produce amoebocytes via organ-cultured gill lamellae of horseshoe crabs. These cells form the cornerstone of the Limulus Amoebocyte Lysate (LAL), a medical product that is used widely to screen injectable drugs and medical devices for bacterial contaminants. As horseshoe crab populations continue to decline, it becomes increasingly more important to develop an alternative sustainable source of these cells.

Some of Weiner's other research interests include:

(1) studying the regulation of membrane renewal in photoreceptor cells,
(2) determining how retinal sensitivity and daily quantum catch are affected by changes in the duration or intensity of the photoperiod,
(3) identifying the source of the electroretinogram in the lateral eye of horseshoe crabs, and
(4) applying a novel statistical algorithm (Ozturk Algorithm) to the analysis of biological data.

Bill Weiner

Assistant Professor of Applied Biology and Biomedical Engineering

Bill Weiner received a B.S. degree in Bioengineering from Syracuse University in 1991 and his Ph.D. in Neuroscience from Syracuse University in 2000. After completing his graduate degree, Weiner accepted a position as an Assistant Professor of Applied Biology and Biomedical Engineering at Rose-Hulman Institute of Technology where he currently is employed. Weiner is a member of a number of professional societies, including the Association for Research in Vision and Ophthalmology, the Society for Research on Biological Rhythms, the Biomedical Engineering Society, and Sigma Xi. He also serves as the coadvisor to the campus student chapter of the Biomedical Engineering Society. Weiner is married with one child.

Undergraduate researchers supported by Lilly/Guidant:

Chad Zarse, Elizabeth Deaton, Matt Sung, Amber Brannan, Roger Wiltfong

Recent Publications:

Zarse, C.A., Deaton, E.A., and Weiner, W.W. 2004. Light intensity appears to be more important than an endogenous seasonal clock for regulating structural rhythms in the lateral eye of the horseshoe crab. Biomedical Sciences Instrumentation, 40:407-412

Pieprzyk, A.R., Weiner, W.W. and Chamberlain, S.C. Mechanisms controlling the sensitivity of the Limulus lateral eye in natural lighting. 2003. The Journal of Comparative Physiology A 189 (8): 643-653

Lucas, J.C. Weiner, W.W. and Ahmed, J. 2003. Do weak adapting backgrounds uncover multiple components in the electroretinogram of the horseshoe crab? Biomedical Sciences Instrumentation, 39:105-110.

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