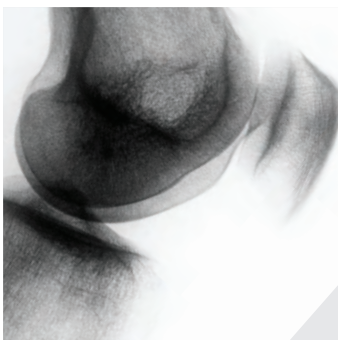
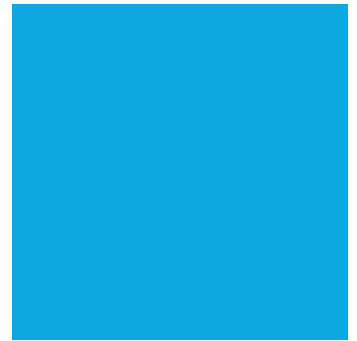
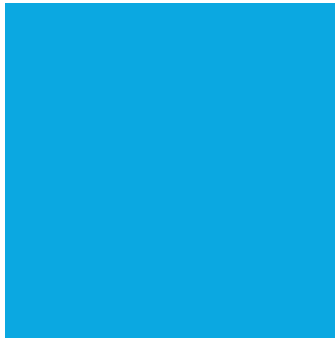


INDIANA UNIVERSITY

Annual Report 2011



IN FOCUS
Research & Creative
Activity at Indiana University

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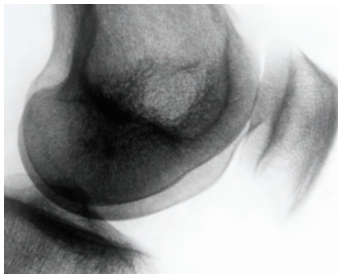
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■ Awards and expenditures, 2011

Welcome

It is my great pleasure to present our 2011 Indiana University Vice President for Research annual report, covering the research and creative activities of IUPUI, IU Bloomington, and IU's regional campuses in Fort Wayne, Gary, Kokomo, New Albany, Richmond, and South Bend.

Our faculty and researchers had a remarkably productive year in FY 2011; some highlights of their accomplishments are included here. For the first time, IU research expenditures — the actual dollars spent in research and creative activity — exceeded \$500 million in a single fiscal year. Federally funded research expenditures across IU totaled more than \$231 million, while the university's commitment to supporting research is evidenced in internally funded research expenditures, which totaled \$177 million in FY 2011.

IU's fiscal year 2011 research expenditures represent a 7 percent increase over the previous fiscal year, as calculated for the National Science Foundation's Higher Education Research and Development Survey (HERD).

Our record-breaking research expenditures point not only to high activity among IU faculty, but also to the significant ripple effect that research dollars generate as they are infused into the state's larger economy. Longstanding analyses of a university's economic impact on its region estimate that each dollar spent by the university generates \$2.30 in impact. IU's \$509 million in research expenditures represents a \$1.17 billion economic impact on the state of Indiana. In short, IU research is an economic engine for the university and has a significant impact on our state's economy.

But of course, research is about so much more than dollars and cents. In this issue of our annual report, we focus on IU research related to the area of pain. The authors of *Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education, and Research* (released in 2011 by the Institute of Medicine) observe that "our experiences with pain are deeply personal, filtered through the lens of our unique biology, the society and community in which we were born and live, the personalities and styles of coping we have developed, and the manner in which our life journey has been enjoined with health and disease." Noting that chronic pain affects at least 116 million U.S. adults, the report calls for a "cultural transformation in the way that pain is understood, assessed, and treated."

This *IN Focus 2011* report highlights some of the Indiana University researchers contributing widely to transforming our

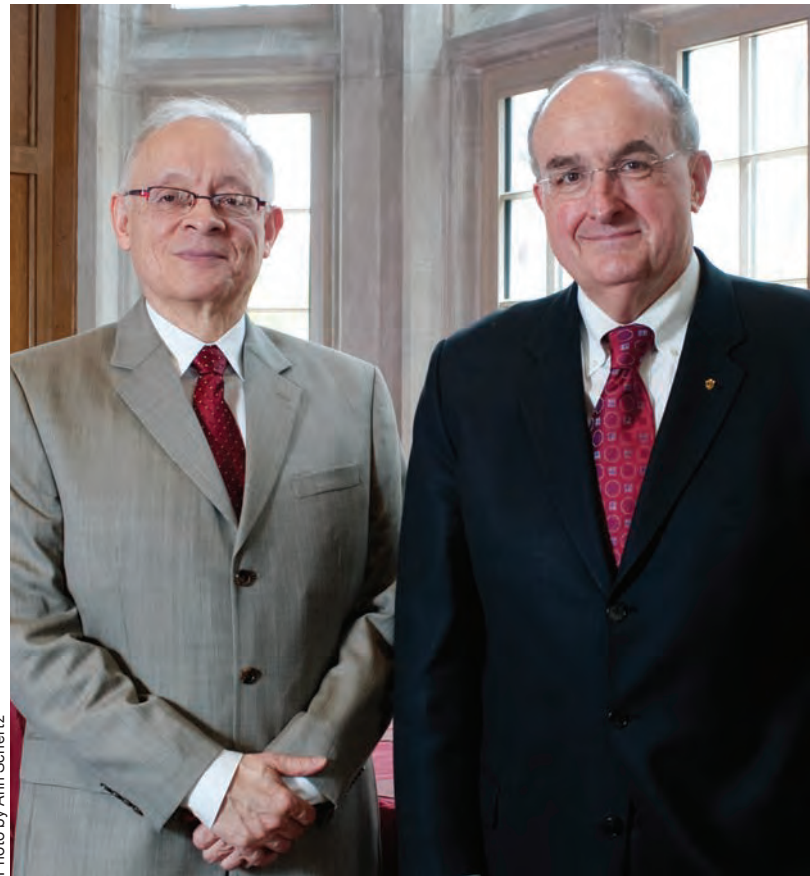


Photo by Ann Schertz

Vice President for Research Jorge José and President Michael McRobbie

understandings of pain and developing new approaches to the treatment of pain. There are, of course, many other faculty making equally significant contributions in other areas of research. We cannot cover all of the outstanding research our faculty members are undertaking, but we include here a sampling of some of the many significant achievements and contributions made by faculty across Indiana University.

We hope you will enjoy this report. To learn more, please visit our website at <http://www.iu.edu/~vpr/>.

Sincerely,

Jorge V. José
Indiana University Vice President for Research

Awards for collaboration

IU's Office of the Vice President for Research initiated the IU Collaborative Research Grants program in fall 2010. This program offers seed funding to collaborative projects that cross disciplinary, school, or campus boundaries.

2010–11 IUCRG Recipients

- **A Plant Biology Informatics Partnership to Compete in the Emerging Field of Epigenetics** Craig Pikaard (College of Arts and Sciences) and Haixu Tang (School of Informatics and Computing)
- **All-Atom Theory of Virus Behavior: Applications to Vaccine Discovery** Peter Ortoleva (College of Arts and Sciences) and Darren Brown (School of Medicine)
- **Citizen Participation in Environmental Science Studies: Addressing Air Quality Issues in Northwest Indiana** Julia Peller and Erin Argyilan (College of Arts and Sciences) and Ellen Szarleta (School of Public and Environmental Affairs), IU Northwest
- **Coupling Atmospheric Chemistry with Human Health: A Novel Approach to Investigating the Source of Chronic Childhood Lead Poisoning** Gabriel Filippelli (School of Science) and Sara Pryor (College of Arts and Sciences)
- **Drug-Drug Interaction Prediction from Large-scale Mining of Literature and Patient Records** Lang Li (School of Medicine), Luis Rocha (School of Informatics and Computing), and Jonathan Duke (School of Medicine)
- **Establishment of a Human in vitro Model System for Studies of Usher Syndrome** Jason Meyer (School of Science) and Eri Hashino (School of Medicine)
- **Functional Analysis of Protein Phosphatases in Tumorigenesis and Metastasis** Zhong-Yin Zhang and Weinian Shou (School of Medicine)
- **Injection of Endothelial Colony Forming Cells to Enhance Fracture Repair and Bone Regeneration** Jilian Li (School of Science) and Mervyn Yoder (School of Medicine)
- **Mathematical Modeling of Ocular Blood Flow and Its Relations to Glaucoma** Giovana Guidoboni (School of Science) and Alon Harris (School of Medicine)
- **Microbial Interactions Within Pathogen Vectors and Human Disease Risk** Keith Clay and Clay Fuqua (College of Arts and Sciences) and Frank Yang (School of Medicine)
- **Perioperative System Reengineering Program** Bradley Doebbeling and Matthew Burton (School of Medicine), Jason Saleem (School of Engineering & Technology), Hamid Ekbia (School of Library & Information Sciences), and Mikyoung Lee (School of Nursing)
- **Pilot Initiative to Improve Transfers of Care between Nursing Homes & Emergency Departments** Kevin Terrell (School of Medicine) and Susan Hickman (School of Nursing)

- **Provider Decision-Making for the Management of Comorbid Pain and Depression: A Novel Virtual Human Technology Investigation** Adam Hirsh (School of Science), Kurt Kroenke and Matthew Bair (School of Medicine), Marianne Matthias (School of Liberal Arts)
- **Real-Time Multichannel Neural Signal Processor System** Ken Yoshida and Richard Eberhart (School of Engineering & Technology), Jonathan Mills (School of Informatics & Computing)
- **Role of Kalirin in the Local and Central Control of Bone Mass** Angela Bruzzaniti (School of Dentistry), Teresita Bellido, Ruben Vidal, and Matthew Allen (School of Medicine)
- **Semiautonomous Decision-Making in Vehicle Emergency Safety Decisions** Kris Hauser (School of Informatics & Computing), Sarah Koskie (School of Engineering & Technology), and Michael Justiss (School of Health & Rehabilitation Sciences)
- **Towards Effectively Quantifying Programming Language Abstraction** Andrew Lumsdaine (School of Informatics & Computing) and Rob Goldstone (College of Arts and Sciences)
- **Understanding Spsc-DNA Interaction Via Chemical, Biochemical, and Structural Biology Studies** Millie Georgiadis (School of Medicine) and Lei Li (School of Science)

2011–12 IUCRG Recipients

- **A Search for New Spin-Dependent Forces of Nature** William Snow, Joshua Long, and Alan Kosteletzky (College of Arts and Sciences), Ricardo Decca and Ruihu Cheng (School of Science)
- **Amyloid Precursor Protein Brain Neuronal Markers in Children with Autism** Deborah Sokol, Debomoy Lahiri, Dean Hawley, and George Sandusky (School of Medicine)
- **Bacterial Vaginosis and Sexually Transmitted Infections among Women who have Sex with Women and Men and their Sexual Networks** Vanessa Schick and Barbara Van Der Pohl (School of Health, Physical Education and Recreation), James Fortenberry (School of Medicine), and David Nelson (College of Arts and Sciences)
- **Balance Control in Patients with Age-Related Macular Degeneration** Shirin Hassan (School of Optometry) and John Shea (School of Health, Physical Education and Recreation)
- **Effects of Chronic Cannabis Abuse on Associative Learning and Neuroplasticity in Early Adolescence and Young Adults** Amanda Bolbecker, Kenneth Mackie, and William Hetrick (College of Arts and Sciences), Charles Goodlett and Alan Breier (School of Medicine)

- **Family Environment and Its Role in Outcomes in School-Age Children with Hearing Loss** Rachael Holt and David Pisoni (College of Arts and Sciences), William Kronenberger and Jessica Beer (School of Medicine)
- **Integrating Clinical Data Systems with Social Context to Map Neighborhood Health** Lisa Staten and Marc Rosenman (School of Medicine), Christian Mushi (School of Health and Rehabilitation Sciences), and David Bodenhamer (School of Liberal Arts, Polis Center)
- **Ionizing Radiation Induced DNA Demethylation and Brain Development** Feng Zhou, Marc Mendonca, Yun Liang, and Amy Cristine Lossie (School of Medicine)
- **MIMP Modeling of Alzheimer's Disease Data Towards a Robust Diagnostic Test** Jake Chen and Xiaogang Wu (School of Informatics), Andrew Saykin and Li Shen (School of Medicine)
- **Modeling Epithelial Organization** Robert Bacallao (School of Medicine) and James Glazier (College of Arts and Sciences)
- **Neurobiological Mechanisms Underlying Affect Recognition Deficits After Brain Injury** Wang Yang, Dawn Neumann, Brenna McDonald (School of Medicine), Arlene Schmid (School of Health and Rehabilitation Sciences)
- **Novel Anti-cancer Agents Targeting G-Quadruplexes** Amar Flood (College of Arts and Sciences) and Brittany-Shea Herbert (School of Medicine)
- **Placenta Stem Cell-Based Tissue Engineering of the Trachea: Airway Management of the Future** Stacey Halum and Michael Murphy (School of Medicine), Marco Bottino (School of Dentistry)
- **Quantifying Reproductive Transfer of Cadmium Burden in Daphnia** Laura Wasylenki (College of Arts and Sciences) and Joseph Shaw (School of Public and Environmental Affairs)
- **Self-limiting Mechanisms Inhibiting Thrombus Growth** Elliot Rosen (School of Medicine), Horia Petrache (School of Science), and Bogdan Dragnea (College of Arts and Sciences)
- **The Role of Phototropins in Optimizing Photosynthesis in Soybean** John Watson (School of Science) and Roger Hangarter (College of Arts and Sciences)
- **Translational Potential of Combined Electrical Stimulation and Testosterone Treatment for Peripheral Nerve Injury Repair** Dale Sengelaub (College of Arts and Sciences) and Kathryn Jones (School of Medicine)

Pain

Pursuing the promise of **relief**

Scientists at Stark Neurosciences Research Institute
develop **21st-century approaches to chronic pain**



When Fletcher White talks to medical students about his pain research, he notes that, all things considered, our pharmaceutical armaments against pain, particularly chronic pain, haven't progressed that much since the late 1890s, when scientists at the Bayer company in Germany developed aspirin — and heroin.

It's an unfortunate situation, because chronic pain is both widespread and costly. According to the 2011 Institute of Medicine report *Relieving Pain in America*, chronic pain affects an estimated 116 million Americans and costs \$560 billion to \$635 billion annually. It is the number one complaint patients bring to their doctors.

But with research by White and his colleagues at the Stark Neurosciences Research Institute at the Indiana University School of Medicine in Indianapolis, there's promise of more effective relief for chronic pain on the way.

The Stark Neurosciences Research Institute was created in 2003 with a \$15 million gift from Paul and Carole Stark and is supported with funds from the Indiana Genomics Initiative. Building on those resources, the institute has developed research groups working in several areas including brain and spinal cord injuries, movement and neurodegenerative disorders, and addiction as well as pain, adding the skills of researchers recruited from other institutions to a strong core of scientists who were already at IU. Nearly 50 IU scientists are members of the institute.

"I think it's safe to say, and most people on the outside would agree with this, that what we've done here has caused a slight shift in the center of gravity nationally in pain research. We have a very well recognized pain research group," says Gerry Oxford, executive director of the institute and professor of pharmacology and toxicology at the IU School of Medicine.

New targets and new methods for getting molecules into cells has researchers looking for ways to affect cellular signaling and to alter the interactions among cellular receptors, Oxford explains.

"Rather than hammering the components that are right out there on the cell surface that you can see," he says, "hammering away at the signaling events that link them together and orchestrate their interactions may be a better avenue for drug development."

And, he adds, "we're only now beginning to appreciate that for any given target, sometimes you have to distinguish between two molecular states of the target—one that facilitates normal pain sensation that is good for you to avoid injury, and another that is pathological and yields chronic pain even in the absence of an injury stimulus."

A sampling of the investigators at Stark demonstrates the range of efforts underway to better understand and identify targets for treating specific types of pain. Theodore Cummins, a School of Medicine associate professor of pharmacology and toxicology, came to IU in 2003 from Yale and now serves as director of the pain group. He credits the sequencing of the human genome with enabling an explosion of pain research into the mutations, molecules, receptors, and cellular signaling systems involved with pain and offering potential targets for new compounds.

"I think we've made a lot of progress," says Cummins.

White, the Vergil K. Stoelting Professor of anesthesia who came to IU in 2008 from Loyola

University of Chicago, is exploring the role of chemokines—proteins whose roles include directing immune-cell movement, such as gathering at an infection site. But the receptors or cellular “docks” for those chemokines are found on neurons as well as immune-system cells. White and his team study analgesic-induced hyperalgesia, the counterintuitive condition in which morphine treatment results in the patient feeling more pain.

“When a patient needs more morphine for the same benefit—what some would term developing ‘tolerance’ for the drug—we take the attitude that the drug itself is producing off-target effects, including manifestations that serve to augment the pain,” White says.

He cites his laboratory’s experiments with rats that underwent a morphine treatment regimen. After the treat-

ments stopped, they showed increased sensitivity to pain—via tactile stimulus causing them to withdraw their paws—even though they had had no injuries at all.

Other experiments demonstrated that opioid administration to cells in the laboratory caused the expression of

more receptors for the CXCR4 chemokine, suggesting that excessive expression of CXCR4 receptors might play a role in the enhanced pain behavior. How to test that notion? The answer came from past AIDS research—as it happens, the HIV virus makes use of CXCR4 receptors to invade cells, which led scientists to develop an anti-HIV drug that targeted the CXCR4 receptor.

The FDA-approved anti-HIV drug was withdrawn due to serious cardiovascular side-effects. But when White used it in the rats affected by morphine-induced hyperalgesia, the pain problems went away. White and colleague Natalie Wilson published those results in the March 25, 2011 issue of *Brain, Behavior and Immunity*, suggesting that a compound that selectively targeted the CXCR4 receptor could combat the ill effects of morphine.

A short walk down the hall from White’s lab, Rajesh Khanna and his laboratory team are exploring another promising route to pain management: calcium channels.

Calcium and other ion channels are like tiny valves on cell membranes that let ions flow in and out, affecting cell activity and signaling.

Khanna, an assistant professor of pharmacology and toxicology who came to IU in 2007 from the Toronto Western Research Institute, describes himself as a neurobiologist who moved into pain research as it became clear that his particular calcium channel of interest was a promising target.

Drug development efforts often involve blocking a target, but completely blocking the calcium channel was not a promising tactic because the channel plays important roles in the physiology of the heart and other organs. So having identified a protein that binds to the channel and alters its pain-transmitting activity, Khanna and his team developed a peptide that in turn modulated the protein. The result, in animal studies, was a striking reduction of pain. Their findings were published in *Nature Medicine*.

More testing is underway to develop potentially more effective variants of the peptide and to answer questions such as whether it is targeting just those neurons that are hyperactive and therefore the likely cause of chronic pain. Khanna has also created a new company, Sophia Therapeutics, to explore the commercial potential for the compound and its successors.

Stark investigator Cynthia Hingtgen, associate professor of neurology, is combining her care for patients as director of the IU Neurofibromatosis Clinic with research into the pain and itching problems those patients can suffer. There are three forms of neurofibromatosis, a genetic disorder that causes tumors to grow on nerve cells. Although relatively unknown, neurofibromatosis is more prevalent than cystic fibrosis, Duchenne muscular dystrophy, and Huntington’s disease combined, according to the Children’s Tumor Foundation.

Neurofibromatosis patients complain of itching from tumors, frequent headaches, and excessive pain or itching from “normal” situations such as having a mosquito bite or a shirt rubbing against a benign tumor, Hingtgen says.

Working with Stark investigator Grant Nicol, she is looking for changes that seem to make peripheral neurons more excitable. Once again, changes in an ion channel—this time, sodium channels—seem to be suspect, as experiments have shown changes in the types of sodium channels expressed on cells with neurofibromin mutations.

Cummins, meanwhile, is also focused on sodium

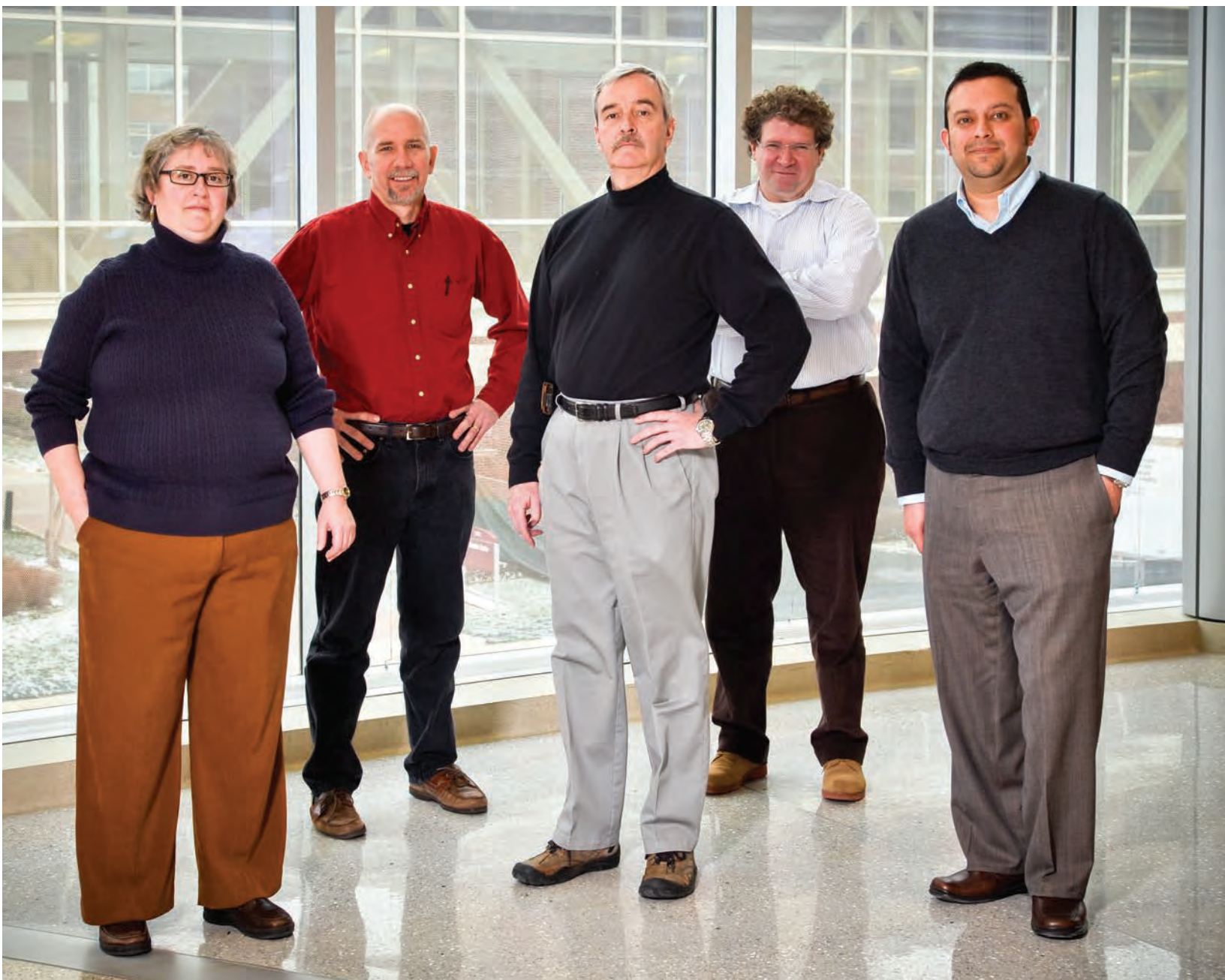
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—Gerry Oxford

executive director of the Stark Neurosciences Research Institute and professor of pharmacology and toxicology at the IU School of Medicine



From left, Cynthia Hingtgen, Theodore Cummins, Gerry Oxford, Fletcher White, and Rajesh Khanna of the Stark Neurosciences Research Institute, Indiana University-Purdue University Indianapolis

channels. Since his arrival at Stark in 2003 from Yale, he has been looking at sodium channel mutations that result in two different inherited chronic pain syndromes, both of which cause patients severe burning pain sensations.

“We wanted to know why the mutations cause such severe pain and were so hard to treat. We hoped that would give us insight into acquired types of pain,” Cummins says.

More recently another mutation in the same sodium channel has been identified that has the opposite effect—people with the mutation feel no pain at all. The syndrome was discovered among street

performers in Pakistan, who are able to perform dangerous and normally painful stunts without feeling their injuries.

The mutations in the street performers eliminated pain by blocking activity of the sodium channel. Cummins is now working with naturally occurring toxins produced by tarantulas and scorpions that also seem to block activity of this channel.

“If we can understand how nature has developed specific inhibitors of ion channels we may learn new ways to develop small molecules with the same effect that could be used to treat chronic pain problems,” Cummins says.

Working together, the researchers of the Stark Neurosciences Research Institute continue to broaden our scientific understanding of what causes pain.



To find out more, visit:
snri.iusm.iu.edu/

Studying the neuroscience of **reproduction**

Photo courtesy Kinsey Institute for Research in Sex, Gender, and Reproduction



Up to 25 percent of women suffer from chronic pelvic pain (CPP) — a potentially debilitating disease involving intermittent or constant pain in the abdomen, pelvis, and sometimes legs and lower back. There's no cure for CPP and few reliable treatments. Scientists hardly even understand what causes the disease.

But since her days as a graduate student at Florida State University, Heather Bradshaw has worked to trace the causes of CPP down to the cellular level, focusing on cells of the reproductive tracts, immune system, and nervous system.

"It's really about cell communication," says Bradshaw, who is now an assistant professor in the College of Arts and Sciences Department of Psychological and Brain Sciences at Indiana University Bloomington. "When cells communicate as they're supposed to, everything functions beautifully. I'm trying to understand what happens when cellular communication gets garbled and how that may play a role in causing pelvic pain."

Although there's not been much hard evidence to draw on, Bradshaw, who is also affiliated with The Kinsey Institute for Research in Sex, Gender, and Reproduction, did have one clue: that doctors used to prescribe cannabis extract to treat pelvic pain. Supposing that chemical compounds in cannabis may in some way mute pelvic pain, Bradshaw has spent the past several years pursuing this hypothesis, and she's made some interesting discoveries.

Many endocannabinoid molecules — signaling molecules produced naturally in the body that help regulate many brain and body processes — are made in the uterus and brain. Intrigued by this fact, Bradshaw reasoned that endocannabinoids may be involved in endometriosis — a female health disorder where cells from the uterus migrate and latch on to other parts of the body, causing irregular bleeding, infertility problems, and pain, possibly including pelvic pain. Through her research, Bradshaw has discovered that the body's cannabinoid system does indeed play an important role in endometriosis.

"We've found that endocannabinoid compounds can both instigate and stop the migration of cells out of the uterus," she says. "We have data on what protein is being produced on the membranes of uterine cells that's involved in the process, and it's exciting to think that there may be a way to manipulate endocannabinoids to block endometriosis."

At this relatively early stage, Bradshaw's research has revealed more questions than answers. But the prospect that her work might eventually provide relief for millions of women suffering from chronic pelvic pain makes the search worthwhile.

"It's incredibly exciting to think that some day part of our work in the lab could contribute to not just stopping the pain but treating the disease that causes it," Bradshaw says. "That's why you come into work every day. Even if it's 50 years away, what keeps us going is the idea that the work we do could be the foundation for understanding how the disease works and how to stop it."

“

It's incredibly exciting to think that some day part of our work in the lab could contribute to not just stopping the pain but treating the disease that causes it. That's why you come into work every day.

”

—Heather Bradshaw

assistant professor in the Department of Psychological and Brain Sciences, IU Bloomington



To find out more, visit:
www.bryteideas.org/home

Harnessing the body to **stop the hurt**

Andrea Hohmann feels your pain, and she wants to make it stop. A professor of psychological and brain sciences and Linda and Jack Gill Chair of Neuroscience in the College of Arts and Sciences at Indiana University Bloomington, Hohmann studies how the body's built-in endocannabinoid system — a brain-based system that releases marijuana-like compounds — might be harnessed to reduce and inhibit pain.

“If we can increase levels of endocannabinoids in the brain and prolong their effects, we might be able to help people suffering from chronic pain while avoiding the psychoactive effects of drugs like marijuana and morphine,” Hohmann says.

Scientists have long been aware of an effect called “stress-induced analgesia,” where pain is delayed for a short time after an injury. Hohmann’s research has focused on understanding the mechanics of this effect and devising ways to enhance it.

Under normal conditions, the body’s cannabis-like compounds bind to cannabinoid receptors on nerve cells to dull pain and are then broken down by enzymes. Working with an endocannabinoid compound called 2-AG, Hohmann and colleagues at IU, the University of Georgia, and University of California at Irvine have been zeroing in on ways to block the enzymes, thereby allowing 2-AG to go about its pain-soothing work for longer periods. When Hohmann tested an enzyme-blocking compound in rats, it significantly boosted stress-induced analgesia in the rodents.

Hohmann’s ultimate goal is to push the basic science of endocannabinoid enhancement to the point that applied researchers can use it to engineer a drug for patients with chronic pain who currently rely on opiates with undesirable side effects.

“Chronic pain is a significant problem affecting millions of people, taking a toll on the U.S. economy, and driving up health-care costs,” Hohmann says. “It’s exciting to know that it may be possible to use the body’s own pain suppression mechanism to help people.”

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—Andrea Hohmann

professor in the Department of Psychological and Brain Sciences and Linda and Jack Gill Chair of Neuroscience, IU Bloomington



To find out more, visit:
www.indiana.edu/~gillctr/hohmann.shtml

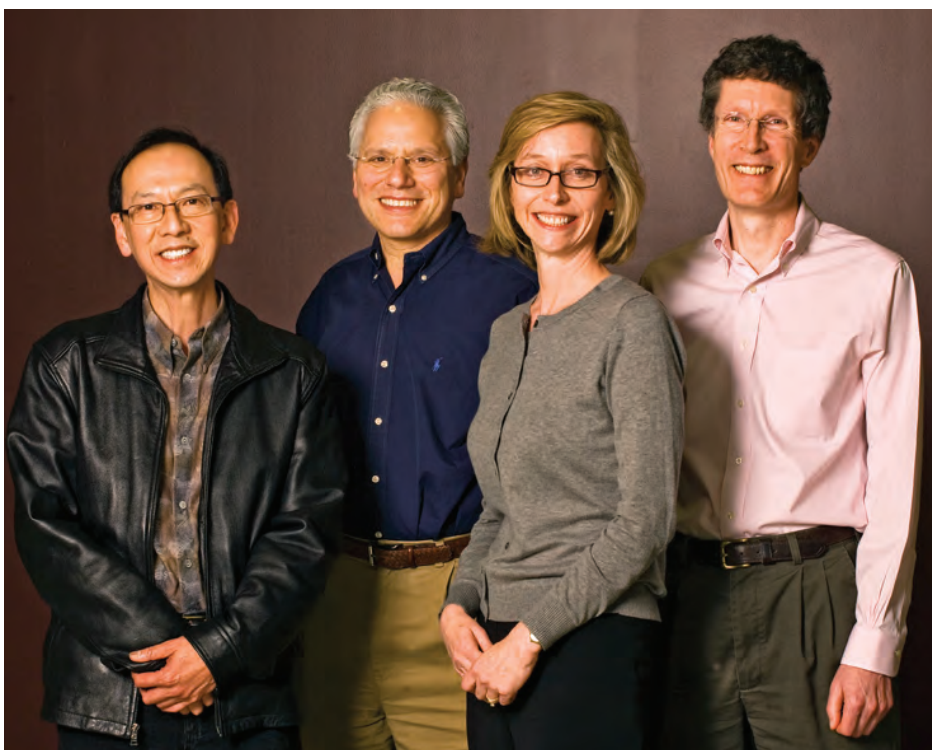


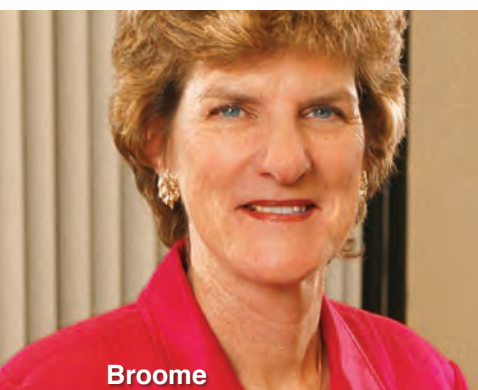
Photo by Kevin Mooney

Gill Chairs in the Linda and Jack Gill Center for Biomolecular Science at Indiana University Bloomington (left to right): Cary Lai, Richard D. DiMarchi, Andrea G. Hohmann, Ken Mackie

Caring for children in pain

Everyone knows that children experience pain and anxiety the same as adults. Don't they? In very recent history — as close as the 1980s — there was essentially no attention paid to pain in children. In fact, it wasn't until 1978 that pain in children was even a recognized problem in the health-care literature. When early research demonstrated that children do indeed experience pain, physicians and nurses were reluctant to administer pain-relieving medications for fear of addiction and respiratory depression.

Marion E. Broome, dean and distinguished professor at the Indiana University School of Nursing, has spent 20 years studying pediatric pain management. Her work, funded by the National Institutes of Health, American Cancer Society, and Pfizer Inc., has demonstrated that although treating most children's pain would require pain-reducing medication, pain relief and anxiety could



Broome

be enhanced by nonpharmacologic therapies, like relaxation and distraction.

According to Linda Franck, professor and chair of Children's Nursing Research at the Centre for Nursing and Allied Health Professions Research, Great Ormond Street Hospital for Children in London, "If we were to delete all of Dr. Broome's studies from the literature [concerning pediatric pain management], we would have very little evidence for evidence-based practice to care for children in pain, and we would not know how best to use what evidence we did have."

Broome is a pioneer in a revolution that occurred in children's pain management—a dramatic increase in compassionate practice to reduce the stress and anxiety of children and their families during painful experiences. Her early research also revealed that parents were the most reliable sources for information about their children's pain and that children themselves were much better self-reporters of pain than previously understood.

Broome's work has spanned the spectrum of pain problems from the relatively minor pain associated with immunization to the profound pain of oncologic and hematologic diseases. Her efforts, as well as those of colleagues in the medical, nursing, dentistry, and psychiatry fields, led to health-care professionals' ability to objectively describe the behavior of children and their parents during painful procedures. This research was pivotal in leading to a new understanding within the scientific and clinical communities of the

negative effects of untreated pain in children.

Fear and anxiety are important components of children's responses to pain. As part of her research program, Broome developed the Child Medical Fears Scale (CMFS)—a major contribution to the field. The 29-item questionnaire, developed from interviews with 140 school-age children, is used to assess the level of reported fears of medical experiences. Over time (with subsequent testing, the CMFS was reduced to 16 items), the scale has demonstrated strong reliability and validity and has been translated into five languages.

Broome also has carried out research in intervention studies. She conducted a multisite study — 384 children in 13 children's hospitals — and has led other important trials on the effectiveness of nonpharmacological interventions, particularly distraction and imagery. The findings from these trials have had enormous impact on the way children are cared for during painful procedures. Her work also shed light on the unique challenges in preventing, assessing, and managing pain in preterm neonates and in children with diverse conditions such as cancer, migraine, cardiac conditions, sickle-cell disease, and cystic fibrosis.

Nurses are in key positions to work with young patients and their parents to help identify the severity of pain and determine the best coping strategies. Broome developed and tested both a guided imagery intervention and a pain education booklet as a tool for nurses and parents. Her research findings demonstrated that these measures greatly reduce the fear, anxiety and pain that children and adolescents experience.

According to Broome, "children coping with pain draw upon two critical skills—understanding what is happening to them and being distracted so that the pain perception is reduced. The parent of a patient, especially a warm, caring, and involved parent, is in the best position to provide active support in helping them use these coping skills."

Thanks to Broome's body of work, health-care professionals can help children, even those who are nonverbal, measure and communicate their pain. Physicians and nurses can now observe and study pain phenomena in young patient populations. And, most important, health-care professionals can be more proactive in addressing pain and employing cognitive behavioral therapies to reduce patient and family distress.



To find out more, visit:
nursing.iupui.edu/directory/mbroome

A musical Rx for adolescents with cancer

Cancer treatment is challenging for all ages, but treating a child with cancer often seems too much for families to bear. IU researchers are exploring how music can empower adolescents and young adults — as well as their families — to manage the emotional pain and distress associated with treatment.

Sheri Robb, associate scientist and member of the Research in Palliative and End-of-Life Communication and Training (RESPECT) Center at the Indiana University School of Nursing, and Joan Haase, Emily Holmquist Professor in pediatric oncology nursing and co-director of the RESPECT Center, are leading a collaborative study exploring the effectiveness of a music-therapy intervention to improve positive health outcomes including resilience, family support, and communication in young people ages 11 to 24.

“When adolescents or young adults begin to share things, we want to know how to keep that dialogue going,” says Robb, who notes that communication between parents and teens is always a challenge, and cancer can cause it to degrade or cease altogether. “How do you stop that connection from shutting down?”

Robb designed a therapeutic music video intervention to give adolescents and young adults a creative way to express what is important to them. The treatment is specifically targeted to adolescents and young adults undergoing stem-cell treatment for cancer. With support from the National Institutes of Health, Children’s Oncology Group, and the Indiana Clinical and Translational Sciences Institute, Robb is using music to help create a sense of structure in the chaotic hospital environment.

“We started with children who received stem-cell transplants because their treatment has many difficult side effects, and they’re generally in the hospital for a prolonged period of time,” says Robb. “Depending on cancer type, these patients can also face some fairly high mortality rates. These patients and their families experience distress not only from physical symptoms, but also psychosocial distress.”

Stories and Music for Adolescent/Young Adult Resilience During Transplant, or the SMART Study, was conducted at Riley Hospital for Children, IU Health University Hospital, and seven other children’s hospitals nationally. A board-certified music therapist was brought into hospitals to meet with inpatient adolescents twice a week for three weeks, during which they would write new lyrics to an existing song using “song scripts.” These scripts served as a blank slate upon which patients could express what was important to them.

Once patients wrote the song lyrics, they recorded an audio track of their song. The patients then had the opportunity to sing their songs, or physicians, nurses, and others on the medical team helped them sing. In the final phase of the project, patients used a storyboarding process to pair visual images with their lyrics. The

patients’ recorded songs and visual images were then combined to create a slide-show style music video that they could share with family, friends, or health-care providers through a video “premiere.”

The next step in this research will be SMART II, says Robb. The project will include adolescents and young adults with high-risk cancers. It will also include a parental component designed by Haase that will give parents strategies to help manage their own distress, support their child’s autonomy during treatment, and sustain a meaningful dialogue about messages shared through their child’s music video.

“We’re going to see if we can do this intervention with not only stem-cell patients, but patients who are receiving outpatient treatment,” Robb says. “We want to learn how this intervention can work even when you’re not an inpatient for three weeks, to explore how more adolescents and young adults can benefit.”

Also supporting the project are Patrick Monahan, associate professor of biostatistics, IU School of Medicine; Paul Haut, director of the pediatric stem cell transplant program at Riley Hospital for Children at IU Health; and Debra Burns, associate professor of music therapy, Department of Music and Arts Technology at Indiana University-Purdue University Indianapolis.



Haase and Robb



To find out more, visit:
www.iupui.edu/~irespect/

Virtual humans help physicians **treat** **patients better**

A physician sits across from a patient whose facial expression reveals she is suffering from serious chronic pain. Research has shown that this can be a frustrating encounter for doctor and patient. The doctor may feel inadequately equipped to meet the patient's desire for pain relief. The patient may feel she isn't getting the help she needs. In this instance, however, the "patient" is a computer image, a virtual patient playing an important role in a study that could help improve how physicians work with patients in pain.

This is the work of Adam Hirsh, assistant professor of psychology in the Indiana University-Purdue University Indianapolis School of Science, whose research focuses on the biopsychosocial aspects of pain.

Hirsh and three colleagues received an IU Collaborative Research Grant (IUCRG) of \$51,675 to use the virtual-human technology, along with physician interviews, to better understand how physicians make decisions about chronic pain treatments and how differences in patient race and gender may affect those decisions.

"We know certain patients are treated less well. There's some evidence in the literature that women get treated differently than men. And there's pretty good evidence in the literature that black patients get treated differently for their pain than white patients," Hirsh says.

Researching these doctor-patient interactions isn't easy. Studying medical records provides specific information but not the controls a researcher wants — did a patient's gender affect treatment, or were other factors not in the record involved? Interviews and "tests" using written vignettes provide controlled data, but not a realistic environment.

So Hirsh has been working with computer engineering colleagues at the University of Florida, where he received his doctorate in clinical and health psychology, to develop the virtual-human technology that attempts to create a realistic and controlled research environment. The virtual-human system draws on technologies similar to those used to create computerized "avatars," or game characters. Using the technology, Hirsh has created a study website that enables physicians to

participate in settings convenient to them.

Initially, as a graduate student at Florida, Hirsh attempted to use actors in sessions with physicians to portray patients in pain. Training actors to verbally describe their problems worked, but factoring in issues of age, race, and gender was more difficult. Then, “we tried to train the actors to display certain pain expressions, and it just blew up, it wasn’t feasible at all,” he says.

The IUCRG-funded study uses still-frame images—extracted from full-motion animations—of a series of patient faces. The technology enables Hirsh to manipulate “the pain face”—features of the face that research has shown represent pain. The physician at the computer also is given a written description of the patient’s complaints and history. Armed with this visual and textual information, physicians are asked to rate the amount of pain the patient is experiencing and indicate what treatments they would use for the patient. For example, how likely are they to prescribe an opioid pain medication or to refer the patient to a pain specialist?

More than 100 providers have completed the online work, with about 20 also participating in in-person interviews “so we can supplement the quantitative data with really rich qualitative data,” Hirsh says.

While the current research data is being analyzed, Hirsh is looking to improve the virtual patients to incorporate full-motion animation of

virtual patients’ entire bodies, which would allow additional pain cues such as how the patient sits or shifts weight and how much he or she weighs.

In the meantime, Hirsh notes, “across all the interviews the main thing that [physicians] can’t say enough is how important chronic pain management is, and how challenging they find it to be,” whether due to lack of time with patients, inadequate treatment options, or patients’ lack of resources to access available treatments.

The notion that physicians feel unprepared to deal with patients’ chronic pain may seem unusual, but it’s familiar territory to Hirsh’s colleagues on the collaborative research grant.

Some physician-patient encounters dealing with chronic pain can be stressful, occasionally even downright traumatic, says Marianne Matthias, a Regenstrief Institute investigator, adjunct assistant professor of communication studies in the IUPUI School of Liberal Arts, and a research scientist at the Roudebush VA Medical Center. She reported in a recent issue of the journal *Pain Medicine* that a survey of 20 primary-care providers at Roudebush VA Medical Center found many were critical of themselves because they felt unable to treat chronic pain adequately.

“In most visits there are no issues but it’s the ones that are particularly problematic, when there may be trust issues or outright hostility, that stand out because they are just so difficult,”



Images courtesy of Adam Hirsh

The pain face

Using still-frame images of a series of patient faces, Indiana University researcher Adam Hirsh manipulates “the pain face”—features of the face that research has shown represent pain. Armed with visual and textual information, physicians are asked to rate the amount of pain the patient is experiencing and indicate what treatments they would use for the patient.



Adam Hirsh is looking to incorporate full-motion animation of virtual patients' entire bodies into his research, which would allow for additional pain cues such as how a patient sits or shifts weight.

Matthias says. "Providers are not trained to deal with it, but they're stuck with it."

Pain symptoms can also put patient and physician priorities at odds when a patient has other disease issues that are potentially more threatening, Matthias notes. "If you have high blood pressure right now, you don't feel it. But if you have pain that's really bad, you feel it, and you want to address that."

Working with patients in pain has driven physician Matthew Bair's research as well.

"As a physician myself, it's really been frustrating to find effective means to treat patients with chronic pain," says Bair, assistant professor of medicine and an investigator at the Regenstrief Institute. "My colleagues in primary care are frustrated as well. We desperately need new treatment tools."

"I think there's a growing sense that opioids are not a panacea, they're not a magic bullet," Bair continues. "While they may be the most potent pain medicine, only about a third of the time at best do they give people meaningful relief. And that's in addition to the array of side effects ranging from gastrointestinal discomfort to the potential for abuse and addiction."

Bair researches the relationship between chronic pain and psychological distress such as depression or anxiety. He also develops clinical trials to test methodologies for treating chronic pain in primary-care settings. A current study, the CAMEO (CAre Management for the Effective Use of Opioids) trial, will enroll about 450 veterans with chronic lower back pain being seen at the VA Hospital in Indianapolis and its community outpatient clinics in Bloomington and Terre Haute.

The trial has two types of treatments being tested – first, a structured, stepwise approach to using non-opioid pain relievers guided by a nurse-care management system to implement the treatments, and second, an approach that focuses on behavioral and psychological aspects to chronic pain treatment.

The strategy is to start with simple pain relievers such as acetaminophen or NSAIDs (non-steroidal anti-inflammatory drugs) such as aspirin or ibuprofen. Next would be the use of co-analgesics, which are drugs developed for other purposes that have pain-relieving properties, first trying antidepressants and then anticonvulsants. Next would be the use of topical creams.

"We're trying to optimize the use of these co-analgesics, these non-opioid treatments first, before we would add an opioid or switch to an opioid or increase the dose of an opioid," Bair said.

"Each step is guided by how the patient responds to the previous step. Did their pain improve or not? Did their function improve or not? Do they desire a change in treatment?"

The medications being used are not new, but the algorithmic approach is. Also new is implementing the approach using a nurse-care management system, Bair says. The VA has nurse-care managers who manage conditions such as diabetes and high blood pressure. It's an effective system, Bair says, and "we want to show that it can be used effectively for chronic pain."

Better delivery of pain management to patients and combining analgesics with behavioral and other nonpharmacological interventions also are areas of focus for Kurt Kroenke, Chancellor's Professor, professor of medicine, and an investigator at the Roudebush VA Medical Center and the Regenstrief Institute.

With the increased recognition of the need to respond differently to acute (such as postsurgical) and chronic pain, the role of opioids is problematic.

In the past, Kroenke says, "the focus has been on acute pain and the use and role of opioids there. We don't know what the role is if people are going to be taking them for 20 years."

Much as insulin and other diabetes medications are more effective in combination with exercise and lifestyle changes, chronic pain calls for similar combination therapies, managed in ways that are more effective for patients.

In a study of cancer patients, for example, Kroenke and



From left, IUPUI researchers Marianne Matthias, Kurt Kroenke, Adam Hirsh, and Matthew Bair have received an IU Collaborative Research Grant to study how physicians assess pain.

colleagues found that a combination of automated data collection and personal phone calls from nurse managers reduced the impact of pain and depression.

“I’m looking at the role of technology both to monitor how people are doing and to build in and reinforce self-management strategies, because together these will make whatever medications we use more effective,” he says.

The automated calls, or Internet sessions, can be used to collect data, while clinicians — nurses, doctors or others — can provide follow-up conversations that are personalized and reduce the need for office visits that cost patients time and money.

While some might worry that an automated system would be impersonal, Kroenke says that “it’s not an either-or situation: a person or a machine, the human or technology. Instead, it is the coupling of what the machine can do effectively so that the human, the clinician, can use his or her time with the patient at the highest level.”



To find out more, visit:
www.psych.iupui.edu/People/Faculty/Hirsh/



Kora

Located 900 miles west of Lhasa in Tibet, Mount Kailash is worshiped by four religions — Buddhism, Hinduism, Bön, and Jainism — as the center of the spiritual realm. The religious significance of Kailash stems from its uncanny resemblance to the image of a universal mountain described in ancient scriptures. Pilgrims believe that by circling the mountain on an arduous 34 mile-long path, they can cleanse the sins of a lifetime.

Jawshing Arthur Liou's project to film

this mystical landscape in Tibet has its roots in his sorrow over the loss of his daughter, who died of cancer at age four. Listening to an album by a Tibetan Buddhist singer, Liou had a vision of vast windswept plains, deep blue sky, and distant snowcaps. Later, he was shown an image of Mount Kailash by a Tibetan monk and recognized the eerie similarity.

In summer of 2011, Liou, associate professor of digital art in the Hope School of Fine Arts at IU Bloomington,



made a four-week expedition to western Tibet, which included a four-day kora around Kailash. (Kora is a type of pilgrimage and meditation in the Tibetan Buddhist tradition, performed by walking around a temple, stupa, or other sacred site.)

The images here are stills taken from Liou's ultra high-definition video project, *Kora*. In his artist's statement about the work, Liou writes: "The harsh elements and expansive landscape turned my thoughts inward. There was no immediate enlightenment but gradual realization that the pilgrimage was a mirror to

my solemn confrontation with past and future. The mountain is immense, and my efforts seemed trivial. With each strenuous step, I was reminded that my goal is not just to reach the end of the path. The humbling walk helped me reconcile my life within a greater continuum. I hope the work will provide an equivalent living experience."



To find out more, visit:
<http://vimeo.com/37866446>



Liou

Photo courtesy of Arthur Liou



Stills from *Kora*, 3K ultra high-definition video. Stereo soundtrack composed by Aaron Travers, assistant professor of composition, and Melody Eötvös, Ph.D. candidate, in the IU Jacobs School of Music Department of Composition. Violin, cello, and viola performance by Federico Agostini, associate professor of violin, and graduate students in the Jacobs School of Music. Images courtesy of Arthur Liou.



Testing prayer



“Pain is the principal complaint of those seeking prayer, accounting for 37 percent of all prayer requests by those surveyed, and pain relief is the principal claim of those who reported experiencing healing.”

”

—Candy Gunther Brown

associate professor in the Department of Religious Studies,
IU Bloomington



To find out more, visit:
www.indiana.edu/~relstud/faculty/GuntherBrown.shtml

When sickness strikes, people around the world pray for healing. Many of the faithful claim that prayer has cured them of blindness, deafness, and metastasized cancers. Some believe they have been resurrected from the dead.

Can science test such claims? Should it? A number of scientists say no, concerned that empirical studies of prayer will be misused to advance religious agendas. And some religious practitioners agree, worrying that scientific testing could undermine faith.

Science cannot prove prayer’s healing power, but according to Candy Gunther Brown, associate professor of religious studies in the College of Arts and Sciences at Indiana University Bloomington, what scientists can and should do is study prayer’s measurable effects on health. If prayer produces benefits, even indirectly (and findings suggest that it does), then more careful attention to prayer practices could improve global health, particularly in places without access to conventional medicine.

“Pain is the principal complaint of those seeking prayer, accounting for 37 percent of all prayer requests by those surveyed,” says Brown, “and pain relief is the principal claim of those who reported experiencing healing.”

Brown delves into the healing power of prayer in her recently published book *Testing Prayer: Science and Healing*. Drawing on data from Pentecostal and Charismatic Christians, clinical research, before-and-after medical records, survey responses, and eight years of ethnographic follow-up with those reporting healing experiences, Brown’s book counters a number of stereotypes about believers in faith-healing such as the idea that poorer, less educated people are more likely to

believe in the healing power of prayer and less likely to see doctors.

Brown has found that the widespread *perception* of prayer’s healing power has demonstrable social effects, and that in some cases those effects produce improvements in health that can be scientifically verified.

Brown also recently edited the related book *Global Pentecostal and Charismatic Healing*. The collected essays examine practices on six continents, depicting the extent of human suffering and powerlessness experienced by people and the attractiveness of a global religious movement that promises material relief. “The primary appeal of Pentecostalism worldwide is as a religion of healing,” she says.

“‘Miracle’ is not a word that makes sense within the paradigm of scientific naturalism. The term ‘healing’ likewise can mean different things and the same with ‘science,’” Brown says. “All these terms take on a life of their own. The question is how people interpret their experiences of illness and healing, and of pain and pain relief.”

“When people are sick or in pain,” she continues, “many look for healing wherever they can find it. They really don’t care about philosophical or theological consistency.”

Brown currently has two more books-in-progress: *The Healing Gods of Christian America: Complementary and Alternative Medicine in the Mainstream* examines the spiritual healing approaches of yoga, meditation, martial arts, acupuncture, energy medicine (for example, shiatsu massage, Therapeutic Touch, Reiki), homeopathy, chiropractic, and anti-cancer alternatives. *Miracle Cures? Divine Healing and Deliverance in America* traces a cultural history of divine healing practices in the United States from the 1860s to the present and examines modern-day interactions with healing practices in other countries.

The many sides of **empathy**

You've had a wretched day at work, and things aren't so hot at home, either. You unload to your best friend or the stranger next to you at the bar, and your confidante responds, "I know how you feel." Ah, you think, a little empathy at last.

Generally speaking, we think of empathy as a good thing — a little bit like sympathy, a little like compassion — overall, something to strive for. But that "folk concept" of empathy, as Richard Miller calls it, is far too one-dimensional. "Empathy," he says, "is a complex phenomenon. I would call it promiscuous. It's not a single emotion, it refers to one's responses to others' emotions."

Miller, professor of religious studies in the College of Arts and Sciences at Indiana University Bloomington, is principal investigator for an interdisciplinary project called "Virtuous Empathy: Scientific and Humanistic Perspectives." Sponsored by IU's Poynter Center for the Study of Ethics and American Institutions, which Miller directs, the project received funding from the Arete Initiative at the University of Chicago and the John Templeton Foundation, as part of a larger \$3 million research effort called the New Science of Virtues.

The IU Bloomington project winds up in spring 2012 after two years of seminars, speakers, brown-bag lunches, and an international symposium in November 2011, all focused, Miller says, on the "interrogation" of empathy.

Miller credits John Bodnar, Chancellor's Professor of history and director of the Institute for Advanced Study at IU Bloomington, with the initial idea to examine the topic of empathy. Other IU Bloomington participants joined from the fields of cognitive science, education, Germanic studies, philosophy, psychology, and religious studies.

The interdisciplinary study of the topic has been one of the virtuous empathy

project's greatest strengths, says Miller. "It was a very interesting learning experience. Our work together really helped sort out different concepts of empathy, which required some pretty careful, discriminating thought."

What sort of different concepts? For one thing, the researchers have looked in depth at empathy's dark side. "One can be empathic in order to gain a competitive advantage," Miller points out. The ability to know and understand how another person is feeling can be used toward manipulative ends — think sales pitches, advertising, or political rhetoric.

There is clearly such a thing as undesirable empathy, Miller says. Envy and spite can be born of empathy, and "a torturer or sadomasochist can be empathic in that they respond to other's feelings."

In other words, empathy is no panacea. According to Miller, throughout their study, project participants have "gotten a more finely grained account of what empathy is, and we've worked out a set of distinctions that enable us to grasp when empathy is problematic and when it is not."

So when is empathy a virtue? It depends. "Empathy as a virtue is dependent on other virtues." Miller says. "It can't stand alone; it's insufficient. It needs to be informed and disciplined by other virtues such as equity, judgment, and fairness."

As the Virtuous Empathy project draws to a close, the IU Bloomington investigators are looking for new support to extend their explorations. Deeper understandings of how empathy works, how it can be taught, what its good and bad forms are, have applications in a wide range of areas including politics, marketing and advertising, criminology, animal behavior, and philanthropy.

"Our group is very keen to continue, and we've got a lot of momentum now," says Miller. He notes that out of the 19 projects funded by the New Science of Virtues

initiative, the IU Bloomington effort was "the most ambitiously collaborative." The active participation of faculty from across the humanities and sciences is a true hallmark of the IU Bloomington campus, he says.

"I'm always reminded about how departments and disciplines at other institutions can be siloed off from each other," says Miller. "Our interdisciplinary conversation really put us ahead of the curve. IU Bloomington has great potential for this kind of collaboration. We benefit from our campus culture; there's no question about it."



To find out more, visit:

poynter.indiana.edu/empathy.shtml



Miller



Understanding how we move through age

Studies of muscles, brains, and bones help us 'go the distance' as we grow older

The human body is a marvel of engineering. Millions, even billions, of parts, from the smallest cells to the largest bones, work together seamlessly to allow us to walk, talk, think, run, jump, and do everything else a body does. At least, that is, when all the parts are in working order. Like most complex machinery, the body is fragile and vulnerable to injury. As we age, our bodily systems wear down. The brain's neural networks slow. Bones become brittle and break. Aching knees make running and jogging a painful chore.

But is slowing down and suffering painful setbacks an inevitable consequence of aging? Or are there ways, if not to stop aging, then at least to mitigate some of its painful side effects? Indiana University researchers are at the forefront of investigating these questions, doing basic research about how the body works and moves that may one day lead to better ways to treat and prevent painful injuries related to movement and aging.

Unsteady Aging

It doesn't take a Ph.D. to know that the older we get, the less reliable and steady our bodies become. For the elderly, balance is a key concern; one wrong step on unsteady feet can result in broken bones and lengthy, painful stays in the hospital.

"The elderly can become fearful of navigating life because they're afraid of making the wrong move," says S. Lee Hong, assistant professor in the departments of Psychological and Brain Sciences and Kinesiology at IU Bloomington. "And that fear can lead to more inconsistency and unsteadiness."

The central question, for Hong, is why we grow unsteady as we age. The answer, he suspects, lies in the brain, specifically in biochemical changes hampering the brain's ability to communicate effectively with the body. "The million-dollar question," he says, "is what can we do about it?"

Pharmaceutical solutions meant to slow the

decline of aging brains often come with debilitating side effects, so in his research, Hong looks for alternative, more holistic approaches. Working with mice, he has discovered that animals afforded multiple opportunities for social engagement and movement fare much better in older age than mice who live in isolation or are limited to playing with only one or two toys.

Much anecdotal evidence and hundreds of self-help books purport similar ideas about humans; namely, that regular and varied exercise keeps the mind and body supple as we age. Hong's goal is to do the science necessary to understand how and why such preventive measures seem to work. Without the basic science, he says, the challenges of aging will remain a mystery.

"The most important thing to understand about aging is that we know very little about it," Hong says. "This is really the first time in history that humans have lived this long, and our demographics are shifting. By 2020 it's expected that at least 20 percent of the population of the United States will be older than 65. Our emphasis is to try to make sure that as humans age we can still have a good quality of life."

Young Bones, Strong Bones

Where old age is usually equated with brittle bones, its opposite — the golden age of youth — embodies strength and fitness. In fact, it was once a common notion that exercising while young could help keep the decay of aging at bay, at least where bones are concerned. Stress-inducing exercise builds bone mass and so, the theory went, carrying more massive bones into old age meant those bones would take longer to reach a more fragile state.

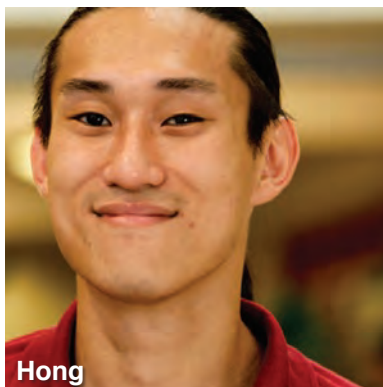
But recent data has shown the bone mass built during an active youth disappears more or less as soon as you stop exercising regularly. By the time most people hit old age, their bones are no more massive than they would

be had they never exercised at all.

According to Stuart Warden, however, being active when young still benefits older bones. Although bone mass may revert to baseline and decline in old age, bones built by exercise in younger days retain structural benefits into old age. In other words, says Warden, who is associate professor and director of research in the Department of Physical Therapy at Indiana University-Purdue University Indianapolis, "bones inevitably hollow out as they age, losing material from the inside. But bone built up on the outside through exercise doesn't disappear, giving even older bones more overall surface area, which makes them stronger."

Like Hong, Warden works with animals — rats, in his case — to study the effects of exercise on bone development. Warden's research involves anesthetizing rats and then strapping one limb to a machine that gives them a solid one-limb workout. After seven weeks of three-a-day sessions, the bones of the rats' developed limbs gain mass and volume. Warden has found that over time, while the stressed bones eventually return to their preworkout mass, they're still generally larger and stronger than the bones that were never trained.

"We find the same phenomenon in former Major League players years after they've retired," Warden says. Decades after former pitchers threw their last fastball, the bones of their pitching arms are still considerably sturdier than those in their nonthrowing arms.

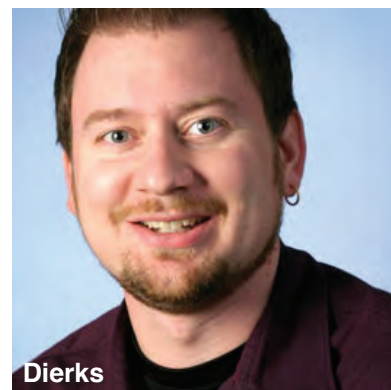


Hong

“
Bone built up on the outside through exercise doesn't disappear, giving older bones more overall surface area, which makes them stronger.
”

—Stuart Warden

associate professor and director of research
in the Department of Physical Therapy,
IUPUI



Dierks



Warden

The takeaway, Warden says, is that it pays to be active when you're young, especially in ways that put stress on bones. He recommends activities that require lots of starting and stopping, like basketball and volleyball. As for perhaps the most common form of exercise, running, Warden is less enthusiastic. "Running and jogging work the bones, but in a repetitive way," he says. "Stress bones the same way for too long, and the bones get bored."

Born to Run

Although it may be difficult to imagine bones being bored, it's not at all hard, especially for runners, to conjure memories of painful, aching bones. "So many people run to stay fit, but when it becomes painful, many eventually stop running as the pain persists," says Tracy Dierks, associate

“
When you run [and] the hip muscles are weak and not doing their job, the kneecap tends to slide forward, and you have stuff rubbing together in an awkward way.
”

—Tracy Dierks

associate professor of physical therapy, IUPUI

professor of physical therapy at IUPUI. "Then the pain creeps into everyday life so that even sitting with bent knees or going up and down the stairs becomes painful."

Dierks studies patellofemoral pain syndrome (also known as "runner's knee") — a common but complex condition involving intense pain in and around the kneecap. The syndrome's complexity stems from its multiple potential causes. One approach to understanding the problem is to study the knee. Another focuses on the feet. But Dierks has taken a novel approach by looking at the muscles of the hip.

"When you run, it's the job of the hip muscles to keep the knee from sliding inward and to keep the femur [thigh bone] from rotating inward,"

Dierks says. "When the hip muscles are weak and not doing their job, the kneecap tends to slide forward and you have stuff rubbing together in an awkward way."

To investigate the role of the hip muscles in patellofemoral pain syndrome, Dierks conducted a relatively simple study. He gathered several dozen women runners with the syndrome (women are especially at risk), put them through a program designed to strengthen their hip muscles, and measured the results. "After the program, they all ran pain-free, which is a pretty strong indication that the hip muscles have a lot to do with preventing knee pain."

Sometimes, running injuries are exacerbated by a runner's determination to keep doing long miles. It might seem obvious that running while fatigued could lead to problems, but as Dierks notes, runners are notorious for powering through injuries. "Most runners I see who are injured either kept running despite pain or tried to ramp up the mileage too quickly," he says.

When runners tire, Dierks says, fatigue causes their strides to become less efficient, and they use wider motions to cover the same distance. The resulting stress is linked to a range of problems, from muscle strains to plantar fasciitis — a painful and debilitating condition caused by inflammation of the thick tissue on the bottom of the foot.

The simple remedy for those who want to keep their legs going despite exhaustion, Dierks says, is to build up mileage slowly and to stop running when fatigue becomes a factor.

For long-distance runners, and for all of us who are trying to "go the distance" in life, IU researchers are expanding our knowledge and awareness of how to age with strength and balance.



To find out more, visit:

www.indiana.edu/~neurosci/faculty/hong.php
shrs.iupui.edu/about/profile.php?emp_id=37
shrs.iupui.edu/about/profile.php?emp_id=32

Abstracts

Photo courtesy of the National Humanities Center



Three IU fellows at National Humanities Center

Three faculty members in the College of Arts and Sciences at Indiana University Bloomington were selected as fellows at the National Humanities Center in 2011.

They are among 32 leading scholars from 21 colleges and universities chosen to spend a year working on research projects at the center in Research Triangle Park, N.C. The National Humanities Center, which began operation in 1978, is an independent institute for advanced study in all fields of the humanities. Since 1978, IU Bloomington has had 15 faculty members selected to receive National Humanities Center fellowships.

The 2011 IU Bloomington fellows and their projects are:

- Jennifer L. Fleissner, associate professor in the Department of English, “Maladies of the Will: Literature as a Symptomatology of Modernity”
- Paul E. Losensky, associate professor in the departments of Central

Eurasian Studies and Comparative Literature, “Sa’eb Tabrizi and the Poetics of Effulgence”

- Jutta Schickore, associate professor in the Department of History and Philosophy of Science, “Hazardous Operations: Experiments with Snake Venom, 1660–1960”

Fleissner teaches in the fields of 19th- and 20th-century American literature and culture. Her current project looks at 19th-century characterizations of various psychological disorders as “maladies of the will” and their relationship to modernity’s account of human beings and the meanings of personhood. She is the author of *Women, Compulsion, Modernity: The Moment of American Naturalism* and many articles.

Losensky’s scholarship focuses on the literature of the 16th and 17th centuries in Iran, India, and Central Asia. He is the author of *Welcoming Fighânî: Imitation and Poetic Individuality in the Safavid-Mughal Ghazal* and, most recently, *In the Bazaar of Love: Selected Poems of Amir Khusrau* (with Sunil Sharma).

Schickore’s research interests include historical and philosophical aspects of scientific experimentation. Her publications include *Going Amiss in Experimental Research* and *The Microscope and the Eye: A History of Reflections, 1740-1870*.



Fleissner



Losensky



Schickore

Studying the nation's report card

U.S. fourth- and eighth-graders are making small but significant gains in math and reading, according to Peter Kloosterman, the Martha Lea and Bill Armstrong Chair for Teacher Education and a professor of mathematics education at Indiana University Bloomington. Kloosterman is in the middle of a three-year study using data from the National Assessment of Educational Progress to analyze past and present student performance in mathematics. His study is funded by a \$1.3 million National Science Foundation grant.

The U.S. Department of Education's NAEP is called "The Nation's Report Card." In 2011, national results in math for grades four and eight were up one point since 2009, following substantial improvement in math over the last 20 years. Kloosterman says it's encouraging to see gains, given the state of funding for education.

"Scores in reading have not improved nearly as much as math over time, and while there was no gain this time at grade four, there was a one-point gain at grade eight," he notes.

Kloosterman's project, called "What Mathematics Do Students Know? Implications from NAEP for Curriculum and Policy," examines the mathematical

skills that U.S. students know now as compared to students from the last three decades. The study is also measuring how performance links to specific math courses students take in high school. Kloosterman says results of the study will point to aspects of curricula that affect performance and identify math areas where student knowledge is underdeveloped.

"We're looking at how achievement has changed in mathematics over the last 30 years and how that relates to what has been taught — where we are doing better and what topics in math we still need to improve on," Kloosterman says.

Kloosterman is conducting the current project with Nathaniel Brown, assistant professor of learning sciences in the IU School of Education; Crystal Walcott, assistant professor of mathematics education at Indiana University-Purdue University Columbus; and Doris Mohr, associate professor of mathematics at the University of Southern Indiana.



Kloosterman

Supporting new neighbors through education at IU Southeast

Magdalena Herdoíza-Estévez, originally from Quito, Ecuador, has devoted herself to responding to the needs of what she calls "our new neighbors."

For the last five years, Herdoíza-Estévez, professor of education and international studies at Indiana University Southeast, has been director of the New Neighbors project, supported by a \$1 million grant from the U.S. Department of Education's Office of English Language Acquisition. The project got its start with funding from IU Southeast.

The New Neighbors project is dedicated to improving the learning success of English Language Learners by strengthening teaching at the local school district level. Herdoíza-Estévez and project team members work with eight elementary, middle, and high schools in the southern Indiana area.

"We provide critical support for programming, curricula, and crucial resources such as workbooks and technology," says Herdoíza-Estévez.

The New Neighbors program emphasizes building support outside the classroom too, by encouraging parent participation and offering professional development opportunities to principals, counselors, bus drivers, food service employees, and administrative personnel as well as teachers. The goal is to help all school-related personnel improve cultural awareness and skills in working with English learners and their families.

Similar professional development opportunities are offered to IU Southeast education faculty. In November 2011, the New Neighbors project co-sponsored the first-ever English as a New Language conference at IU Southeast. Herdoíza-Estévez's OELA-funded project also has enabled IU Southeast, in partnership with IU Bloomington School of Education,

to provide an English as a Second Language licensing program to teachers. Thirty teachers have completed the program.

When she is not busy with her duties as professor and director of the New Neighbors grant, Herdoíza-Estévez leads the Summer in Ecuador study abroad program, which brings groups of IU Southeast students and faculty to teach in schools in Quito as well as the indigenous community of San Gerardo located in the Andes mountains. The exchanges have been going on for more than a decade. The Summer in Ecuador program has helped renovate San Gerardo's only school and recently, IUS donated a computer lab.

"The schools in Ecuador count on us, and the community counts on us," says Herdoíza-Estévez. "Never did I expect that we would have such an influence."



Herdoíza-Estévez

Holy Harlots, religion, and Brazil

Sovereign of the Cemetery, Queen of the Crossroads, Mistress of the Night. Those are just a few of the titles given to Pomba Gira, a popular yet controversial

Afro-Brazilian spirit entity venerated throughout Brazil. Kelly Hayes has come to know her well.

"Many Brazilians see Pomba Gira as a devil-like figure and associate her with black magic because in life she is said to have been a prostitute or immoral woman," Hayes

says. "Her followers, however, view her as someone who understands their problems because of her own difficult life while on earth."

Published in 2011, *Holy Harlots: Femininity, Sexuality, and Black Magic in Brazil* is Hayes's exploration of the intersections of magic, morality, and gender in contemporary Brazil through the figure of Pomba Gira. Hayes especially focuses on how Pomba Gira figures in the life of devotee Maria Nazaré de Souza Oliveira, a working-class housewife, mother, and spiritual healer who lives with her extended family on the outskirts of Rio de Janeiro.

Hayes is an associate professor of religious studies in the School of Liberal Arts at Indiana University-Purdue University Indianapolis. Her book was published by University of California Press with an accompanying DVD entitled *Slaves of the Saints*, a documentary film Hayes made about Afro-Brazilian religions.

Afro-Brazilian religions are a mix of Catholic traditions brought to Brazil by Portuguese colonizers and African religions brought by slaves, according to Hayes. In Afro-Brazilian religious belief, various spiritual beings are active in the

lives of humans, for good or ill.

"My book's real subject is the myriad ways that individuals endeavor to transform themselves and the world around them through stories and ritual practices invoking this spirit entity, and how they are transformed in the process," Hayes says. "While the book focuses on Afro-Brazilian religious practices, it examines a phenomenon that is common to all religions: how people draw on religious resources to solve problems in their lives.

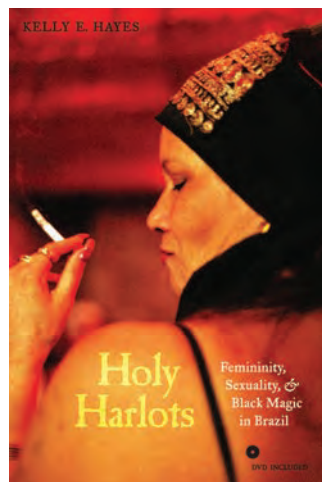
"People's lives and religious practices are intimately enmeshed," Hayes adds. "If you want to understand religion writ large you have to look at how people have appealed to the religious resources available to them to make sense out of their lives."

The 65-minute *Slaves of Saints* documentary received five screenings at Festival do Rio, the largest film festival in South America. It was also screened in film festivals and at universities in the United States. Because of Hayes's long-standing relationships with her Brazilian subjects, she and her documentary collaborator Catherine Couch were able to film sacred rituals and other activities that outsiders are usually not permitted to see.

Hayes received an IUPUI Research Frontiers Trailblazer Award in 2011, recognizing her pioneering work in the study of Afro-Brazilian religious practice among Brazil's poor and working class.



Hayes



From Bradbury to the Bible

What do science fiction and the Holy Book have in common?

Both are subjects of scholarly inquiry at two unusual research centers based in the School of Liberal Arts at Indiana University-Purdue University Indianapolis.

The Center for Ray Bradbury Studies is one of five projects that make up IUPUI's Institute for American Thought, a center that houses the Frederick Douglass Papers, dedicated to publishing a multi-volume scholarly edition of works by the 19th-century human rights activist; the Pierce Edition Project, reconstructing the manuscripts of Charles Sanders Pierce, known as the founder of pragmatism; the Santayana Edition, producing critical editions of works by philosopher and cultural critic George Santayana; the Josiah Royce Papers, also preparing critical editions of works by this philosopher and colleague of Santayana; and the Center for Ray Bradbury Studies, promoting research and understanding of the science fiction writer's wider contributions to American thought and culture.

Jonathan Eller, a professor of English at IUPUI, is involved with most of the projects at the Institute for American Thought, serving as senior textual editor for the IAT as well as textual editor for the Pierce and Santayana editions. But the Center for Ray Bradbury Studies may be closest to Eller's heart.

In 2011, Eller, who is director of the center, published *Becoming Ray Bradbury*, a new biography of the writer who has been hailed as America's "prose poet for the space age."

Called fascinating by reviewers, Eller's biography examines Bradbury's life up until age 33, when Bradbury was just becoming famous for books such as *The Martian Chronicles* (1950) and *The Illustrated Man* (1951). Perennial best-seller *Fahrenheit 451* was just about to be released.

"It's sort of a biography of Bradbury's mind," says Eller. "I always wanted to write about how he learned, how he read, and how he became a writer."



Learning how Americans read their Bibles is at the heart of *The Bible in American Life*, a three-year research project recently launched by the Center for the Study of Religion and American Culture at IUPUI. The Lilly Endowment Inc. awarded the

center \$507,000 to support the project, which is the first large-scale national study of the way scripture is read and interpreted in everyday life.

"We do not know enough about how, where, when, and why Americans use the Bible,

especially uses outside of worship services," says Philip Goff, professor of religious studies and executive director of the Center for the Study of Religion and American Culture. "Religious leaders preach and teach the Bible, politicians quote it, and many Americans say they believe it to be divinely inspired or even infallible, but claims about its use often contain conflicting information that can be difficult to interpret."

Goff is one of three principal investigators for the new study. His co-investigators are Arthur Farnsley, associate director of the center, and Peter Thuesen, professor and chair of the

Department of Religious Studies at IUPUI.

The researchers will examine questions such as: How do Americans use the Bible in their personal lives? How does the Internet shape individuals' comprehension of scripture? What is the Bible's role in Americans' daily decision making?

It's difficult to overstate the importance of the Bible in American culture, according to Thuesen. "Since Europeans colonized these shores," he says, "it has always been the biggest American bestseller."

IUPUI theater opens with lost Shakespeare play

In April 2012, Indiana University-Purdue University Indianapolis celebrated the opening of its new Campus Center Theatre with a "lost play" by William Shakespeare. It was a performance of *The History of Cardenio*, written by Shakespeare and younger contemporary John Fletcher, based on Miguel de Cervantes' *Don Quixote*.

Accompanied by an international academic colloquium of Shakespeare and Cervantes scholars, the show marked the first North American production and the world premiere of the play with complete staging and professional actors. It also showcased the product of a remarkable ongoing research project at IUPUI.

The History of Cardenio was directed by Terri Bourus, associate professor of English drama in the School of Liberal Arts at IUPUI. Bourus, an Equity actor herself, is also director of the New Oxford Shakespeare Project at IUPUI, part of an

international research project led by Professor Gary Taylor at Florida State University, who reconstructed the text for *The History of Cardenio*. Bourus and John Jowett, deputy director of the Shakespeare Institute at Stratford-upon-Avon, are the project's general editors.

Commissioned by Oxford University Press, the New Oxford Shakespeare Project will create a 21st-century Shakespeare edition in multiplatform, multimedia formats. OUP will publish the edition in 2016.

Because Bourus is as passionate about Shakespearean performance as she is about textual scholarship, she founded Hoosier Bard Productions as the theatrical arm of the New Oxford Shakespeare Project. Hoosier Bard links an IUPUI student theater group with actors and theater specialists around the Indianapolis community. It also allows the New Oxford Shakespeare editors to test ideas about

what Shakespeare created, how it should be edited and performed, and what it means today. The first performance by Hoosier Bard Productions in early 2011 staged a little-known 1603 quarto text of *Hamlet*. Directed by Bourus, the show sold out and had to add an extra performance.

Off-stage, Bourus's scholarly

accomplishments also get rave reviews. The recipient of numerous grants and awards from various sources, Bourus has received an IUPUI Research Frontiers Trailblazer award honoring her position in the national and international spotlight as a Shakespearean scholar and editor.



Photo by Emily Schwank

The science of human-environment interactions

“**R**each deep and think big.” That’s the advice Emilio Moran offered students when he accepted an honorary degree from Michigan State University in 2011. It’s advice Moran has long followed himself.

An internationally recognized ecological and environmental anthropologist, Moran has been a part of the Indiana University Bloomington faculty since 1975. He is director of the Anthropological Center for Training and Research on Global Environmental Change, housed at IU Bloomington, and also Distinguished Professor and James H. Rudy Professor Emeritus of anthropology. Moran was elected to the National Academy of Sciences in 2010 and inducted in spring 2011.

Moran’s particular area of expertise is the interactions between human populations and

environmental change, especially populations in the Amazon Basin experiencing dislocation and resettlement. His work has been “instrumental in positioning anthropology as a major contributor to the study of global environmental change,” according to Eduardo Brondizio, chair of the IU Bloomington Department of Anthropology and a longtime collaborator with Moran.

The goals of his current research, says Moran, are to develop a multisite, longitudinal, and comparative approach to the study of how people impact forests, how they organize to manage their resources, and what role population plays in their actions.

With continuous funding from the National Institutes of Health’s National Institute of Child and Health Development, among other sources, Moran and his research colleagues have been explor-

ing the relationship between the social and economic processes associated with land use and land cover change, particularly deforestation. Moran points out that deforestation has been recognized as an important contributor to carbon emissions and climate change. The Brazilian Amazon basin contains the largest continuous rainforest in the world, representing a potentially huge source of carbon/greenhouse gases emissions if it is deforested.

Now in Phase III of his long-running project, Moran and colleagues

have added a new area — Lucas do Rio Verde in the state of Mato Grosso — to two regions they have already examined. Together, the three areas encompass some 10,000 square kilometers, more than 1,000 properties, and more than 2,500 households, making it the largest social science survey carried out in the Amazon region.

Data from the three regions will allow Moran to assess differences in the roles and effects of small-farm and large-scale agricultural production on the landscape.

Among the key research questions he is exploring are: How do land use and land cover change vary over time and in total impact (particularly total area deforested and percent of area deforested) between areas of highly capitalized agriculture and small farming? Are farm income and farm productivity positively or negatively related to moves to the city? Do increases in productivity due to capitalization create enough employment for displaced small farmers?

To address such questions, Moran and his research team are building on the extensive database of survey and remote sensing (e.g. satellite) data collected in previous phases of the project. Brondizio describes Moran as a “pioneer on the integration of remote sensing and spatial methodologies in anthropology and frameworks for collaborative interdisciplinary research.”

Above all, says Brondizio, Emilio Moran is “a great fieldworker whose understanding of the reality of the Amazonian people he loves so much helps to ground his broad vision of a science of human-environment research and contribute to real solutions to global problems.”



Moran



Jacinthe

Digging in to study farming practices

Enter the laboratory of Pierre-André Jacinthe, associate professor of earth sciences in the School of Science at Indiana University-Purdue University Indianapolis, and you'll likely see things you expect: student researchers working at a central table, state-of-the-art equipment. You'll also see some things that make you wonder, including boxes of seemingly empty glass bottles and a large refrigerator filled with hundreds, maybe thousands, of bags of dirt.

Jacinthe, a biogeochemist, has been interested in soil and water since his childhood in rural Haiti, a country with some of the world's most degraded farmland. In the United States, his research has focused on the Midwest, which possesses some of the world's richest farmland.

Since 2009, with U.S. Department of Agriculture funding, Jacinthe has been investigating the exchange of carbon dioxide, methane, nitrous oxide, and other greenhouse gases between land surface and the atmosphere. He also studies water in the region's streams and rivers, looking for agricultural contaminants that may ultimately wind up in municipal reservoirs.

"Intensive plowing leaves the soil bare and unprotected, exposing it to erosion," Jacinthe says. "Farmers know this is bad. Our studies show that, in addition to decreasing erosion and maintaining soil health, less plowing—or not tilling the land at all—can also lessen the transfer of greenhouse gases from the land to the atmosphere, and even increase the capacity of surface soil to consume atmospheric methane."

Farmers don't want to waste tillable land so they plant up to the field edge, Jacinthe explains, meaning fertilizer and pesticides wind up in nearby streams.

"Our research indicates that creating land areas, called buffers, along streams or rivers and keeping them in a natural forest-like state makes a difference. A buffer of only a few yards can prevent a significant amount of noxious chemicals from entering streams. Contaminated water is expensive to treat, and some municipalities do not have the facilities to remove key contaminants, especially pesticides."

Buffers are not an ideal solution, however. In a 2011 study, Jacinthe and colleagues

determined that buffer areas are hot spots of nitrous oxide, especially after short periods of flooding as compared to long-term flooding. "We need to be aware of these trade-offs," he says.

Other research by Jacinthe in 2011 looked at the impact of organic farming, which eschews chemical fertilizers and pesticides, in arid climates. He and his research colleagues found, rather unexpectedly, that soil quality in New Mexico did not improve with nine years of organic farming.

"This shouldn't discourage farmers from becoming or remaining organic," Jacinthe says. "It may be that organic farmers are plowing down more frequently to control weeds rather than using artificial herbicides. Technically, this can be solved."

Out in the fertile fields of Indiana and Ohio, Jacinthe and his students collect soil, water, and air samples to take back to the lab and analyze. Back in the lab, their findings may positively impact the quality of our soil, water, and air for generations to come.

Developing new antibacterial applications

Despite the widespread availability of potent antibiotics, bacterial infections are still a major cause of illness and death, especially among hospital patients, the elderly, and those with compromised immune systems. Also, bacteria used in possible bioterrorism attack or biological warfare could pose a significant potential threat to public health. These risks make immediate broad-based protection to prevent or stop infection extremely beneficial.

Innate immunity, the body's ability to fight off infection without the help of immune cells, is an effective first line of defense to combat bacterial infections immediately after exposure. Enhancing innate immunity at the site of contact with bacteria could prevent infection or complement other therapies, saving lives in epidemics, biological warfare, or bioterrorism attacks.

One group of human proteins that act as the body's innate defense against invading bacteria use a molecular trick to induce bacteria to destroy themselves. That's the finding of a research team at the Indiana University School of Medicine-Northwest, led by Roman Dziarski, professor of microbiology and immunology.

The research may point the way toward powerful new antibacterial treatments. The findings were reported in the journal *Nature Medicine* in 2011. Dziarski's research is funded by grants from the National Institutes of Health.

The proteins, called peptidoglycan recognition proteins (PGRPs), are able to detect and target

bacteria because bacteria have peptidoglycan polymers in their cellular walls. The mechanism that PGRPs use to kill bacteria, however, had not been determined.

As part of ongoing research to determine how these human antibacterial proteins kill bacteria, Dziarski and his research team discovered that the PGRPs are able to induce a suicide response in targeted bacteria by binding to sites in bacterial cell walls in ways that exploit a bacterial defense mechanism known as protein-sensing two-component systems. These systems, which normally enable bacteria to detect and eject malformed proteins, interpret the PGRPs as malformed proteins. Unable to dislodge the PGRPs, the bacteria activate a suicide response.

This approach is different from those employed by other antibacterial mechanisms such as the immune system's white blood cells, according to Dziarski. "This could be a target to develop new antibacterial applications," he says.

Because the peptidoglycan recognition proteins are naturally produced in human blood or on body surfaces, they could be safely used without fear of allergic or toxic reactions. Dziarski's laboratory is focused on developing therapeutic applications that use these proteins to enhance people's defenses against bacterial infections.

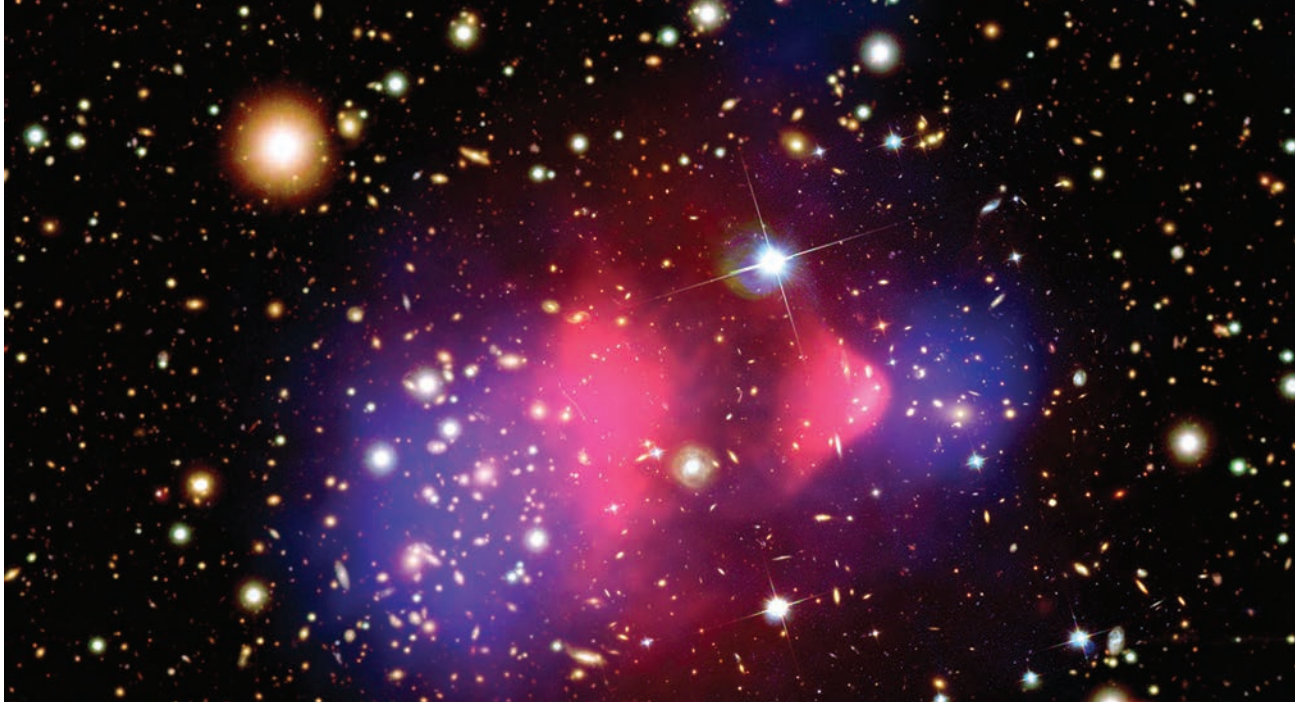
Roman Dziarski ended 2011 in style, with a rare invitation to Stockholm to sit with the Nobel Prize winners in Physiology or Medicine. The 2011 prize was split, one half given to Ralph M. Steinman "for his discovery of the dendritic cell and its role in adaptive immunity" and one half given jointly to Bruce A. Beutler and Jules A. Hoffmann "for their discoveries concerning the activation of innate immunity." Hoffman, the research director and member of the board of administrators of the National Center of Scientific Research in Strasbourg, France, shares the same field of study as Dziarski and is his close colleague. Hoffman has often cited Dziarski's published research, and he invited Dziarski to personally witness the Nobel ceremonies.

"I am part of the innate immunity field that has become prominent to the point that it was awarded the Nobel Prize," Dziarski says. "I feel like I am part [what] contributed to recognition of the whole field."

IU Northwest Professor Roman Dziarski, right, attended the 2011 Nobel Prize lectures at the invitation of his friend and colleague Jules Hoffmann, left. Hoffman won the 2011 Nobel Prize in Physiology or Medicine along with two other researchers.



Photo courtesy of Roman Dziarski



Photos: X-ray: NASA/CXC/M. Markevitch et al. Optical: NASA/STScI; Magellan/U. Arizona/D. Clowe et al. Lensing Map: NASA/STScI; ESO WFI; Magellan/U. Arizona/D. Clowe et al.

This image shows the galaxy cluster 1E 0657-56, also known as the “bullet cluster,” formed after the collision of two large galaxy clusters. A composite from three telescopes, the image shows galaxies in orange and white, clustered mass in the blue areas, and hot gas as two pink clumps. The hot gas was slowed by the collision. In contrast, the dark matter was not slowed by the impact because it does not interact directly with itself or the gas except through gravity. During the collision, dark matter clumps from the two clusters moved ahead of the hot gas, producing separation of the dark and normal matter. “The long and short of the story is that this is a smoking gun for the existence of dark matter,” says Ilan Levine.

The hunt for dark matter

The search for the universe’s “dark matter” is one of astrophysics’ most enduring mysteries. It’s also the search at the heart of Ilan Levine’s research. Levine, an associate professor of physics and astronomy at Indiana University South Bend, is currently using two National Science Foundation grants to pursue his search.

Dark matter is a term used to describe the universe’s invisible missing mass. We cannot see dark matter because it doesn’t emit or absorb light, but astronomers have evidence of its existence because of the gravitational pull it produces. Currently, scientific evidence suggests that dark matter accounts for 85 percent of the total mass of the universe, with stars, planets and galaxies representing the other 15 percent.

One leading explanation for the composition of dark matter is a particle called a neutralino, also known as Weakly Interacting Massive Particles (because they interact weakly with ordinary matter), or WIMPs.

Levine works closely with two research groups, COUPP (Chicagoland Observatory for Underground Particle Physics) and PICASSO (Project In CANada to Search for Supersymmetric Objects). Both groups are involved in the search to detect WIMPs.

In the U.S.-based COUPP experiment, Levine and collaborators at the University of Chicago, Fermilab, and Virginia Tech have designed special bubble chambers as a tool to search for dark matter particles. The

chambers hold superheated liquids. If a dark matter particle collides with a nucleus in a superheated droplet, the collision causes a heat spike, which triggers a small explosion into a bubble of gas. The mini-explosion is accompanied by an acoustic pulse.

Using sound sensors and equipment developed with the help of IU South Bend students, Levine and his research team record both photographic and acoustic evidence of particle collisions, which they examine for the rare occurrence when a dark matter particle may hit the nucleus of an atom in the liquid. These sensors are of such high quality that they enable Levine and his students to distinguish the sounds induced by alpha particles from radioactive decay from those caused by neutron collisions (which are used to mimic dark matter effects in the detectors). In results published in a 2011 issue of *Physical Review Letters*, the COUPP group reported observations of three dark-matter candidate events. (These events are not claimed as specific evidence for dark matter collisions, since known neutron sources are expected to cause that number of events.) A newer version of the detector nearing completion will dramatically improve the possibilities for observation and detection, Levine says.

The COUPP and PICASSO experiments are both located two kilometers deep in the Sudbury Neutrino Observatory Laboratory



Photo courtesy of Ilan Levine

(SNOLAB) in Sudbury, Ontario, Canada. Dark matter experiments take place underground to reduce interference from surface-level cosmic rays and other radiation.

PICASSO researchers — about 38 participants from four countries — also use superheated liquids to try to detect dark matter, suspending superheated droplets in gel. They have 32 larger detectors at work, enabling them to achieve great sensitivity in their search to detect dark matter interactions.

Despite the persistent experimental challenges at the heart of his research, Levine is enthusiastic about the future of the COUPP and PICASSO astroparticle experiments. “With most of the matter in the universe waiting to be discovered,” he says, “who wouldn’t be interested in this research?”

Breaking new ground in plant science research



Photo by Ann Schertz

When Craig Pikaard entered college, he wasn't considering a scientific career; he majored in horticulture and hoped to start a home and garden business with his father after graduation.

His plans changed as soon as he took a few college-level science courses. "I was enthralled by biochemistry and physiology classes," recalls Pikaard.

That revelation turned out to be a boon for the field of plant genetics. Over the past two decades, Pikaard has made numerous discoveries about how plant cells silence gene expression. In 2011, he was selected by the Howard Hughes Medical Institute and the Gordon and Betty Moore Foundation as one of the nation's most innovative plant scientists.

He is taking part in an initiative that boosts funding for fundamental plant science research. HHMI and the GBMF are investing \$75 million in the research program over five years.

HHMI and the GBMF formed the collaboration out of concern that basic plant science research has long been underfunded. Both organizations say the investment is critical: According to the United Nations, today's

global population of nearly 7 billion people is expected to jump by 3 billion by 2050 — and one billion people are already suffering from lack of nutrition. The demand for energy is rising, too, even as the long-term consequences of using fossil fuels become more apparent, thus increasing pressure on agriculture to grow fuel as well as food.

Pikaard, the Carlos O. Miller Professor of plant growth and development in the Indiana University College of Arts and Science's Department of Biology and Department of Molecular and Cellular Biochemistry, joins 14 other scientists as HHMI-GBMF investigators.

Pikaard's laboratory is focused specifically on the evolution of RNA polymerases, the enzymes responsible for decoding the information stored in chromosomes. He has previously discovered two enzymes that help transcribe DNA into RNA. He's also shown that the pathway in which these enzymes work is involved in nucleolar dominance: a pathway in which short RNAs direct the addition of methyl groups to DNA, which effectively tags genes that are to be silenced.

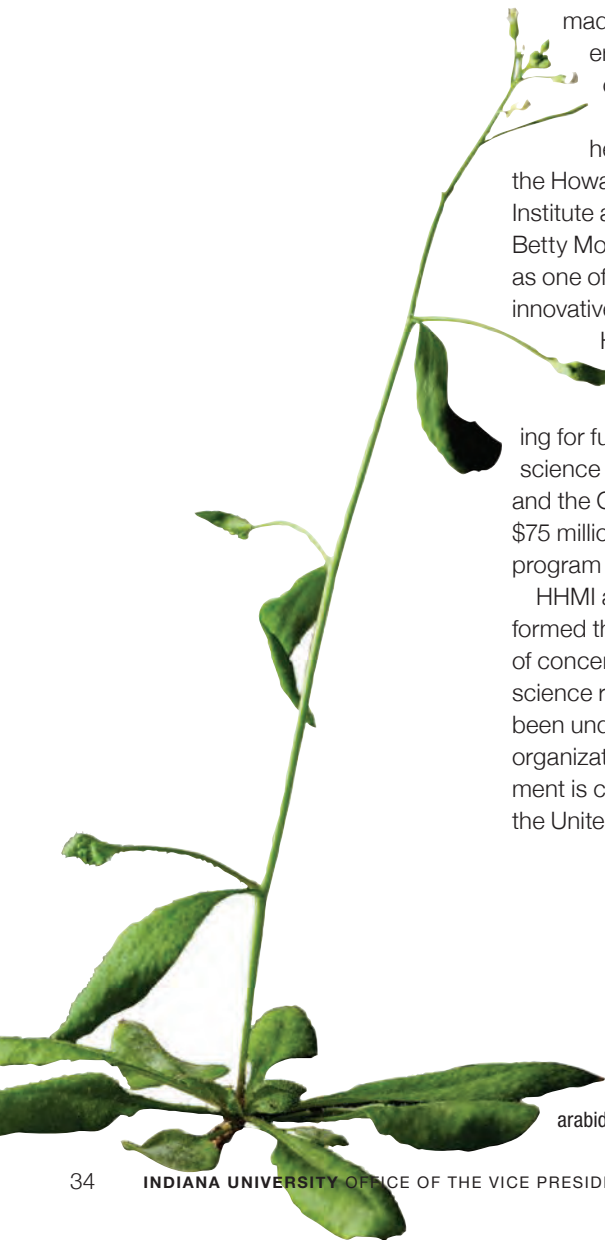
Still, some of the most fundamental questions about the gene silencing

behind nucleolar dominance have not been answered. Why doesn't the cell just damp down both sets of genes equally? How does it tell the two sets apart? How and why does it choose one of them? "These are things we're pursuing now," Pikaard says.

Pikaard is encouraged and excited about participating in the new HHMI-GBMF program focused on fundamental plant science. "It will buy a lot of creative freedom," he says, "both by allowing me to focus more time on research and by making it financially possible to move the lab in new directions that mix genetics, genomics, cell biology, and protein biochemistry and that take full advantage of the amazing facilities we have here at IU."

Although Pikaard moved to IU Bloomington in large part because its cutting-edge technological facilities will help him answer his research questions, his green thumb still comes in handy as he and his team grow indoors all the plants his experiments demand.

"It's keeping the bugs down that's the hard part," he says, laughing. "All the things we worry about in the garden happen in our growth room, too."



arabidopsis thaliana

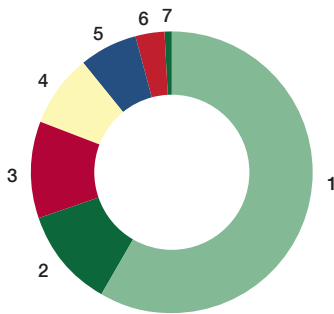
Awards and Expenditures

Awards and expenditures

Awards by Direct Source

FY 2011

| | |
|-------------------------------|----------------------|
| 1. Federal, 58% | \$285,499,211 |
| 2. Commercial/For profit, 11% | \$56,032,614 |
| 3. Foundations, 11% | \$53,205,586 |
| 4. Nonprofit, 8% | \$40,600,842 |
| 5. Higher Education, 7% | \$32,602,494 |
| 6. State of Indiana, 3% | \$16,568,054 |
| 7. Other governmental, 1% | \$3,710,510 |
| TOTAL | \$488,219,311 |



Technology Commercialization

FY 2007-11

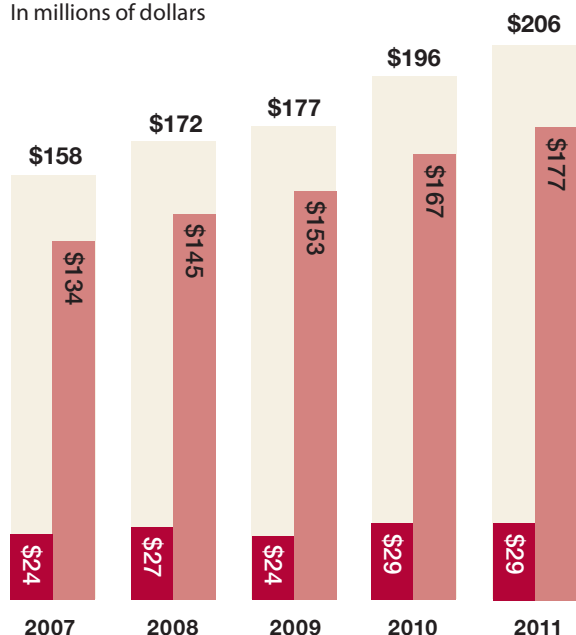
| | FY07 | FY08 | FY09 | FY10 | FY11 |
|--|-------|-------|-------|--------|--------|
| Invention disclosures received | 216 | 144 | 131 | 154 | 175 |
| Licenses executed | 70 | 35 | 34 | 27 | 39 |
| Patent applications filed | 118 | 170 | 210 | 244 | 302 |
| Patents issued | 24 | 16 | 8 | 15 | 28 |
| Royalties, fees, milestones in millions of dollars | \$4.2 | \$4.9 | \$5.9 | \$14.1 | \$11.1 |



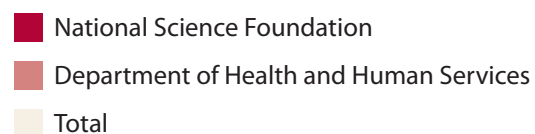
To find out more, visit:
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Research Expenditures Department of Health and Human Services* and National Science Foundation

In millions of dollars



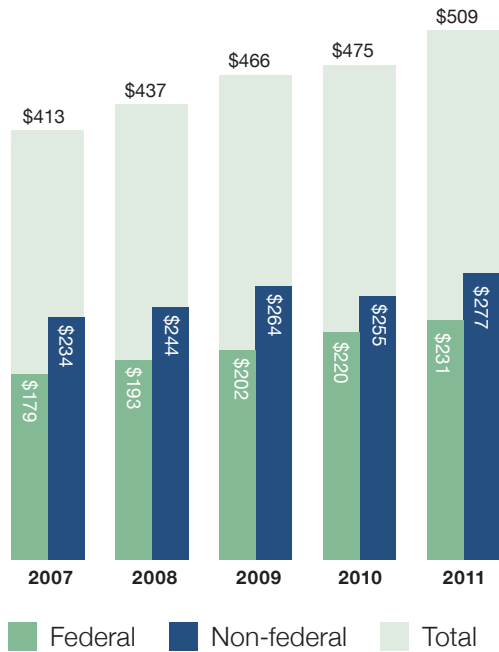
*The Department of Health and Human Services comprises 11 operating divisions, including the National Institutes of Health. The NIH is made up of 27 institutes and centers, each with a specific research agenda. Over the past five years, NIH funding made up 92% of all DHHS funding to Indiana University.



Research Expenditures

FY 2007–11

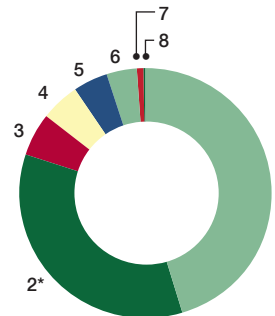
In millions of dollars



Research Expenditures by Source

FY 2011

| | |
|------------------------------|----------------------|
| 1. Federal, 45% | \$231,249,522 |
| 2. University Internal*, 35% | \$176,948,912 |
| 3. Foundations, 6% | \$28,216,377 |
| 4. Commercial, 5% | \$24,950,312 |
| 5. Higher Education, 5% | \$23,257,197 |
| 6. Nonprofit, 4% | \$19,454,827 |
| 7. State of Indiana, <1% | \$3,981,570 |
| 8. Other governmental, <1% | \$680,900 |
| TOTAL | \$508,739,617 |



* University Internal consists of direct costs on internally funded accounts as well as calculated indirect costs. It also includes cost share and unrecovered indirect costs on sponsored projects.

Research Expenditures by Federal Agency

FY 2011

| | |
|--|----------------------|
| 1. Department of Health and Human Services | \$177,315,459 |
| 2. National Science Foundation | \$28,951,949 |
| 3. Department of Defense | \$11,975,900 |
| 4. U.S. Department of Energy | \$4,767,694 |
| 5. U.S. Department of Education | \$1,786,226 |
| 6. NASA | \$1,687,061 |
| 7. Department of Veterans Affairs | \$1,663,533 |
| 8. Environmental Protection Agency | \$849,886 |
| 9. Department of Commerce/NIST | \$805,346 |
| 10. All other federal agencies | \$1,446,468 |
| TOTAL | \$231,249,522 |

Research Expenditures by Unit*

FY 2011

| | |
|-----------------------------|---------------|
| 1. Medicine | \$269,680,977 |
| 2. Arts & Sciences | \$95,765,952 |
| 3. VP Research | \$29,096,925 |
| 4. VP IT | \$16,638,323 |
| 5. Science | \$12,202,460 |
| 6. Engineering & Technology | \$10,570,084 |
| 7. Education | \$10,245,788 |
| 8. Informatics | \$8,598,705 |
| 9. Business | \$8,890,667 |
| 10. Nursing | \$6,643,261 |

* Includes University Internal funding. University Internal consists of direct costs on internally funded accounts as well as calculated indirect costs. It also includes cost share and unrecovered indirect costs on sponsored projects.



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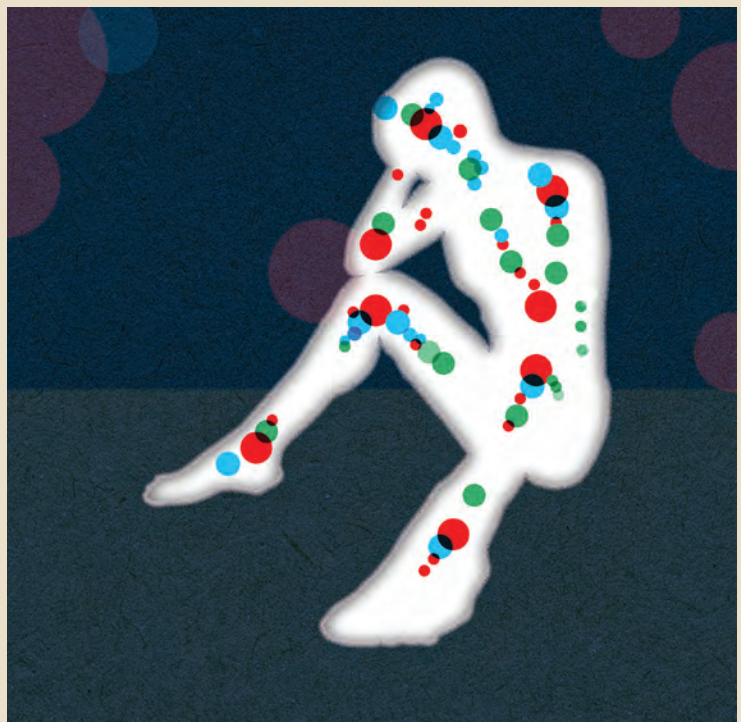
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Indiana University scientists, scholars, and artists are contributing widely to transforming our understandings of pain. See inside for more on IU researchers' efforts in the area of pain research as well as news about research and creative activities on all of IU's campuses.