It has been another notable year for Indiana University, with significant achievements in research and creative activity across multiple disciplines and foci. Our faculty’s achievements were recognized by nominations and elections to distinguished academic societies. For the second straight year, in FY2013, the American Association for the Advancement of Science recognized 12 IU faculty members as AAAS Fellows, including 10 faculty members from the IU Bloomington College of Arts and Sciences and two from the IU School of Medicine in Indianapolis. Similarly, IU Bloomington’s Department of Mathematics led all other math departments at U.S. higher learning institutions, with four faculty members selected as fellows of the American Mathematical Society. Five IU faculty members received the prestigious fellowship granted by the John Simon Guggenheim Memorial Foundation. Two IU Bloomington faculty members were nominated for Grammys, and the university celebrated the exceptional career of Distinguished Professor Menahem Pressler, who turned 90 in 2013 and was the first recipient of an award for extraordinary service from the Chamber Music Society of Lincoln Center.

FY 2013 also saw the addition of crucial infrastructure to support our faculty’s important work. In Indianapolis, the IU Health Neuroscience Center, a partnership between IU Health and the IU School of Medicine, added the Neurosciences Clinical Research Center, administered by the Indiana Clinical and Translational Sciences Institute (CTSI), and will soon mark the opening of the Neurosciences Research Building. The university confirmed its leadership in high-performance, data-intensive computing by unveiling Big Red II, a powerful new one petaFLOPS supercomputer. The first one petaFLOPS supercomputer owned entirely by a university, Big Red II is enabling vital new research in fields from physics to fine arts.

To support its many researchers in fields such as medicine, psychology, sociology, and anthropology who work with human subjects, IU implemented Kuali Coeus Institutional Review Board (KC-IRB), a comprehensive online system for the submission, review, and approval of human subjects research. IU is the first university to fully implement KC-IRB, which will help reduce the administrative burden on researchers submitting protocols for IRB review and ensure not only compliance with laws and regulations but also adherence to the highest ethical standards for research involving human subjects.

We have evidence that FY2014 will be marked by extraordinary achievement as well, as indicated by the exciting announcement last fall that the Indiana CTSI, a partnership among IU, Purdue University, and the University of Notre Dame, received a grant of nearly $30 million from the National Institutes of Health. This award will allow the Indiana CTSI to continue its mission of accelerating the movement of research discoveries from the laboratory to practical applications into at least 2018. Given the outstanding universities against which we were competing for a reduced number of grants, the Indiana CTSI award marks an exceptional achievement. The Indiana CTSI is capably led by Anantha Shekhar, associate dean for translational research and Raymond E. Houk Professor of Psychiatry at the IU School of Medicine. Shekhar, who has served as president of the Association for Clinical and Translational Science since 2012, was recently also named associate vice president for university clinical affairs at IU.

Needless to say, this is only a brief sampling of the achievements in research, scholarship, and creative activity at Indiana University. This report will share some of those accomplishments in more detail. I hope you will enjoy learning more about the exciting work Indiana University faculty are bringing to our world.

Sincerely,

Jorge V. José
Indiana University Vice President for Research

www.indiana.edu/~vpr/
2012 American Association for the Advancement of Science Fellows

- James Bever, Professor, Department of Biology, College of Arts and Sciences, IU Bloomington
- Hal Edward Broxmeyer, Distinguished Professor and Mary Margaret Walther Professor Emeritus, IU School of Medicine
- Yves Brun, Clyde Culbertson Professor, Department of Biology, College of Arts and Sciences, IU Bloomington
- Gregory Demas, Professor, Department of Biology, College of Arts and Sciences, IU Bloomington
- William “Clay” Fuqua, Professor, Department of Biology, College of Arts and Sciences, IU Bloomington
- David Giedroc, Professor and Chair, Department of Chemistry, College of Arts and Sciences, IU Bloomington
- James Goodson, Professor, Department of Biology, College of Arts and Sciences, IU Bloomington
- Julia Heiman, Professor, Department of Psychological and Brain Sciences, College of Arts and Sciences, and outgoing director, The Kinsey Institute for Sex, Gender, and Reproduction, IU Bloomington
- Karen Kafadar, Rudy Professor, Department of Statistics, College of Arts and Sciences, IU Bloomington
- Dennis Peters, Herman T. Briscoe Professor, Department of Chemistry, College of Arts and Sciences, IU Bloomington
- G. David Roodman, Kenneth Wiseman Professor, IU School of Medicine
- Eliot Smith, War Years Chancellor’s Professor, Department of Psychological and Brain Sciences, College of Arts and Sciences, IU Bloomington

Introduction

- Aiming high for translating research into practice in Indiana
- Leading the field in cybersecurity research
- Studying where and why we click
- Blink again
- Hate thy neighbor?
- Prayer vision
- The new frontier of studying human behavior
- Researchers take supercomputing to the extreme
- Study of neutron stars helps NASA plan future research missions
- Crunching data saves lives in heat waves
- Assessing the health of U.S. health care
- ReMaking education
- Enabling children with HIV to thrive
- Mobilizing stem cells against blood and bone marrow cancers
- The art of indigo
- Regenerating dental health
- Shaping new science, one nanoparticle at a time
- From one note to the Queen’s medal
- The power of story in medieval China
- Bacteria relationships may hold key to future fuel solutions
- Five Guggenheims Fellowships for IU faculty

Research highlights

Awards and expenditures
Indiana’s innovative approaches to translating research into new therapies were rewarded in 2013 when the National Institutes of Health renewed the Indiana Clinical and Translational Sciences Institute’s funding with a five-year, $30 million award. The Indiana CTSI involves collaboration with Purdue University, the University of Notre Dame, and other health sciences institutions across Indiana.

The creation of project development teams is a special Indiana CTSI innovation. These multidisciplinary teams work with investigators to develop translational research projects. The teams have been successful—investments of about $4 million by the Indiana CTSI resulted in external funding of more than $65 million.

Indiana CTSI-funded researchers also have produced six technology licenses, 18 discovery disclosures, 22 patents, and eight start-up companies. In addition, Indiana CTSI estimates it supports more than 80 full-time equivalent professional jobs across Indiana.

The NIH award was “a powerful vote of confidence in the Indiana CTSI’s success over the past five years, as well as a promise on our part to achieve even greater heights going into the next phase of this project,” says Anantha Shekhar, director of the Indiana CTSI.

He added that the grant is made more significant because it arrives at a time when the federal landscape includes overall reductions in scientific research dollars and steep competition from more than 30 highly regarded research institutions across the United States, all of which vied for the same NIH award.

The Indiana CTSI’s results have been achieved through three major efforts to strengthen the translational research pipeline across Indiana. First, with the project development teams, the Indiana CTSI helps researchers consider how a proposed study could impact a disease’s treatment from the earliest stages.

Second, Indiana CTSI created programs to smooth every phase of the research process, such as easy access to advanced laboratory technologies, biostatistical analysis, and anonymous medical records; patient recruitment services for clinical research studies; and legal and business services to encourage entrepreneurship.

Third, it developed education programs to foster the next generation of translational scientists. For example, Melissa Kacena, associate professor of orthopaedic surgery at the IU School of Medicine and an Indiana CTSI August M. Watanabe Translational Scholar, regularly mentors students in her lab who come from the Indiana CTSI-supported IUSM Student Research Program in Academic Medicine and from Indianapolis Project SEED, a summer research program for local high school students. As a Watanabe Scholar, Kacena herself will receive mentoring from Tadataka “Tachi” Yamada, past president of the Global Health Program at the Bill and Melinda Gates Foundation.

The Indiana CTSI also has expanded clinical research space at IU, including an 18,500-square-foot Children’s Clinical Research Center at Riley Hospital for Children at IU Health and the Neurosciences Clinical Research Center at the IU Health Neuroscience Center adjacent to IU Health Methodist Hospital. It also reached an agreement with Covance Inc., a global drug development services company, to increase clinical trials conducted on behalf of biotechnology and pharmaceutical companies at IU.

Further supporting clinical research, the Indiana CTSI created the INresearch.org website, where people can register their interest in participating in clinical research trials. Those whose health information matches a specific study may be invited to participate in a research study. A related site also provides a searchable online database of all active clinical trials across the School of Medicine.

The Indiana CTSI Community Health Engagement Program (CHEP) works to create links between academic researchers and community leaders to support local health and research initiatives and disseminate research findings.

As the Indiana CTSI moves into its next five years, it is partnering with the School of Medicine on several new initiatives, including faculty mentoring and review committees modeled after the project development teams, an industry collaboration portal to encourage faculty-industry research partnerships, and the creation of the Center for Health Innovation and Implementation Sciences, to speed the adoption of best practices by local health care providers.
Melissa Kacena, associate professor of orthopaedic surgery at the IU School of Medicine, works with Nicholas Lesh, Tomas Meijome, and Andrew Engle on research that could lead to a more effective treatment for broken bones. Lesh and Engle are IUPUI undergraduates. Meijome is an IUPUI graduate studying at the University of Pennsylvania. Photo by Juan Guzman
During the 2013 winter holiday shopping season, tens of millions of shoppers swiped their credit cards at checkout, gathered up their purchases, and headed off to their next errand without a second thought. Just another hectic day during the busiest shopping period of the year.

And so more than 100 million Target shoppers were later shocked to learn that their most sensitive data—names, credit and debit card numbers and expiration dates, even the three-digit security code—had been stolen by hackers who had used software to infiltrate the credit card swipe machines.

According to the FBI, during the past decade cyber crime has skyrocketed. The U.S. Congressional Cybersecurity Caucus has identified tens of thousands of cyber attacks against the U.S. Department of Defense every year, costing the Pentagon hundreds of millions of dollars. Hundreds of millions of dollars are stolen from U.S. banks every year, with an annual total of around 550 million victims of identity theft, hacked bank accounts, and other crimes.

The pressing need for better cybersecurity has spurred IT professionals and researchers around the world to develop ever-more sophisticated techniques for staying one step ahead of cyber criminals. Indiana University is home to several of the best and most forward-thinking cybersecurity researchers in the country whose work is crucial for helping to protect us all.

“Cybersecurity is constantly changing as technologies and threats evolve,” says Fred Cate, Distinguished Professor and C. Ben Dutton Professor of Law at the Maurer School of Law at Indiana University Bloomington and director of the Center for Applied Cybersecurity Research. “Sometimes I think it would be nice if the pace slowed down a little, but it’s never dull or boring.”

ENABLING TRUST
These days, it’s nearly routine to receive emails from bank or credit card companies including a link to a page asking you to input your social security number, bank account number, or credit card information. Many of us know by now to avoid these false emails, but many Internet users—especially older users not as familiar with online scams—remain vulnerable to such ploys.

Jean Camp, a professor at the IU School of Informatics and Computing, is working on empowering people to sniff out what’s known as “phishing”—dangling online bait in the hopes that vulnerable users will bite and willingly give up sensitive information.

“My focus is on consumers, students, and even elders who need safer interaction,” says Camp, who has received substantial funding for her research, including $150,000 from the National Science Foundation, $2.4 million from the U.S. Department of Homeland Security, and $900,282 from the Defense Advanced Research Projects Agency (DARPA). “If we built steering wheels that we had to work with our feet, we could still drive. But you would not say that the steering operation truly ‘worked.’ It’s the same with security and privacy technologies. Unfortunately, it is much harder to steer safely around the network than it is to turn your car to avoid visible hazards.”

Camp’s main goal, she says, is to provide people the security they need when they need it. “When you’re driving, you know to slow down in the rain because that risk is visible,” she says. “I want to make warnings timely, risks visible, and mitigation easy.”

To that end, Camp directs the Masters of Science in Security Information—a dual track program for students in computer science and other fields who want to become leaders in the burgeoning area of online security. “This program truly creates entirely new careers for some of the students,” Camps says. “Since our first class, graduation day has been one of my favorite days of the year.”

MOBILE SECURITY
“When I became a student in computer science, I was surprised to see that many of the network systems and cyber-enabled systems are incredibly vulnerable,” says Feng Li, an assistant professor in the Department of Computer and Information Technology in the School of Engineering and Technology at IUPUI. “I hope to contribute in making cyber systems more resilient and making cyber attackers’ tasks more difficult.”

Given the increasing importance and popularity of mobile devices, including smartphones and tablets, Li has focused his research on making these devices...
more secure, especially when used for work. “Companies are allowing and encouraging employees to use their own devices to access corporate data, but securing these devices is costly and intrusive,” Li says. To address the problem, Li uses an array of approaches based on social-cognitive theory, persuasive design, graph theory, cryptography, and malicious software epidemiology to better understand how to leverage the social nature of mobile devices toward better cybersecurity systems.

Li has received $270,000 from the National Science Foundation and further funds from Northrop Grumman Corp to support his research, including building an environment to enable students to learn how to create and implement security devices and networks in an environment increasingly dominated by cloud computing. Li is collaborating with colleagues at the Rochester Institute of Technology and Tennessee State University on the project.

“Cyberspace is a manmade complex system that, like any manmade system, has errors and weak points that can be exploited,” Li says. “The risks of being hyper-connected have become painfully obvious to us all.”

HELPING PEOPLE HELP THEMSELVES
As one of the leading and best-known cybersecurity advocates and researchers in the country, Fred Cate focuses his efforts on the human element of the cybersecurity equation.

“We know how to make effective cybersecurity tools, we just don’t know how to persuade people and organizations to use them,” he says.

We can build the world’s most secure network, but if users share passwords or other login information, even the best security is all for naught. The biggest challenges today, according to Cate, involve getting individuals and institutions to act responsibly.

Cate’s research focuses on several main areas, including bringing a risk management approach to online security and privacy.

“For too long we have told people to worry about everything, and the result is that many people and institutions feel powerless to do anything,” he says. “Identifying where the greatest risks are in terms of being exploited and the impact can help focus cybersecurity efforts more effectively.”

Cate is also interested in exploring the impact of government surveillance and data collection on security and privacy. When the National Security Agency creates back doors into systems or exploits vulnerabilities in software to harvest information, Cate says, it may aid national security but it also weakens information security and the ability of the United States to encourage other countries to adopt better data protection practices. To meet these challenges, Cate has been working with federal government officials around the world to help them develop more responsible information protection and privacy practices.

Finally, Cate devotes his energy to helping to secure the vast data infrastructure that pervades nearly all aspects of our society and our lives. “Power, communications, finance, transportation, entertainment—really every sector of our economy—increasingly rely on networked information, yet as a nation we have had a difficult time coming up with appropriate incentives to secure those networks and devices,” he says. A critical focus of Cate’s work is trying to create those incentives through law, markets, and education.

While cybersecurity threats loom large and are almost certain to increase in scale and number, Cate is confident that his work, and the work of his colleagues at IU and elsewhere, can make a difference. “One of the distinctive things about IU is its breadth,” he says. “When addressing cybersecurity issues, I have the good fortune to work not only with colleagues in law and business, but also in informatics and arts and sciences, and to work not only with other academics but with practitioners in our state-of-the-art network operations center and in industry and government.”
Remember the Yellow Pages, that “search engine” we used before the Internet? Today, our fingers no longer do the walking; instead, they do the typing, and our searching has become very big business. The search engine behemoth Google has surpassed the billion-visitor-a-month mark, and its site receives 67 percent of search queries conducted.

This makes understanding how we search, for products particularly, and why we click of keen interest to companies such as Google. With $100,000 funding from Google, Michael Baye, the Bert Elwert Professor of Business at Indiana University’s Kelley School of Business in Bloomington, has studied our searching.

For example, in a 2013 paper for the Journal of Law, Economics, and Policy, Baye (writing with his regular IU Kelley School of Business co-authors Babur De los Santos and Matthijs R. Wildenbeest) observed that use of price comparison sites (e.g. PriceGrabber) is fading away. Searches using sites such as eBay and Amazon, which have mushroomed into multi-seller marketplaces, now dominate, “dwarf[ing] those at comparison sites,” Baye and his co-authors write. “Retailer and marketplace/other sites are becoming the ‘go to’ place for conducting product searches.”

And when we get our results, why do we click on one link and not another? Location matters, of course. The prominence of a link’s position on search results pages clearly influences what we click (the first five pages are crucial). As a result, online retailers spend a lot of time strategizing about search engine optimization, or SEO—the techniques by which companies get that high-ranking placement on a search results page.

But in their study “Search Engine Optimization: What Drives Organic Traffic to Retail Sites?,” Baye and his co-authors argue that location is not the only thing that determines our clicks (organic clicks are “natural” ones, that is, not clicks on sponsored or paid advertising links). A company’s “name” matters too—the higher the quality of an online retailer’s website, the more we consumers will click its link in our list of results. Baye and his colleagues also found that search engines tend to place higher quality sites in better positions, resulting in more clicks.

Overall, the Kelley School co-authors conclude, “investments in the quality and brand awareness of a site should be included as part of an SEO strategy.”

In the world of online searching, it turns out the old adages apply: location (on the search results list) matters, but so does what’s in a name.
Your lesser brain may be greater than you think.

The part of the brain that coordinates the movement it takes to ride a bicycle or swing a baseball bat also may coordinate fluidity of thought and other cognitive processes.

This is not the traditional view of the lesser brain, that region at the base of the brain otherwise known as the cerebellum. But with the blink of an eye—or a technique known as eye-blink conditioning—a new paradigm for understanding this region of the brain has gained traction among a group of scientists in the Department of Psychological and Brain Sciences in the College of Arts and Sciences at IU Bloomington. That paradigm is turning conventional wisdom on its head, or at least relocating it to a different brain region.

The new view, says William Hetrick, professor and chair of psychological and brain sciences at IU Bloomington, “is part of a trend our lab is establishing in the field: that the cerebellum plays a role extending far beyond its traditional role as a motor organ in automatic, highly learned motor activities.”

The cerebellum, he continues, “is a unique structure. It accounts for one-eighth of the brain’s volume, but it accounts for up to 80 percent of the brain’s neurons. The connectivity it has to the rest of the brain is underappreciated in the scientific community.”

Hetrick suspects that the new model of the cerebellum could yield critical new insights into the symptoms of mental illness. The cerebellum, for instance, may play a much greater role in symptoms of schizophrenia than previously thought and could become an important new target for treatment.

This is the working hypothesis at the center of a major long-term collaborative study, led by Hetrick and now in its second five-year cycle of funding with a $1.9 million award from the National Institute of Mental Health. The study’s potential success, Hetrick says, lies in two prominent features: the collaboration of an unparalleled team of scientists and the translational properties of the study, drawing on knowledge and techniques honed in studies of animal models and applying them to studying humans.

The team encompasses a broad spectrum of clinical, theoretical, and technical knowledge. In addition to Hetrick, team members are schizophrenia researchers Amanda Bolbecker and Brian O’Donnell; functional magnetic resonance imaging (fMRI) experts Dai-Jin Kim, Aina Puce, and Sharlene Newman; and computational neuroscientist Olaf Sporns, all from the IU Bloomington Department of Psychological and Brain Sciences; and Alan Breier from the IU School of Medicine’s Department of Psychiatry.

Hetrick notes that “no single investigator on this project has expertise that spans the classification and diagnosis of schizophrenia, to the bio-behavioral mechanisms of eye-blink conditioning, to the highly sophisticated use of magnetic resonance imaging, to computational neuroscience and the mapping of brain connectivity.” The team’s combined expertise and synergy is what makes it possible, he says, “to understand something that may not be possible for any other group in the country to study in this way.”

In the study’s first five-year cycle, members of the team identified a possible risk factor for schizophrenia in people with the disorder and their first-degree relatives. An impairment in the circuits of the basic associative learning involved in eye-blink conditioning, says Hetrick, “may be a possible risk factor for schizophrenia which, when combined with other complications—psychosocial or developmental or life stressors or other neurological or genetic abnormalities—could lead to the disorder.”

In the current phase of research, the team is applying cutting-edge technology and new methods of network analysis to more directly determine the cerebellum’s possible impairment in schizophrenia by mapping out networks within the cerebellum and those by which it connects to other parts of the brain.

Among the findings currently emerging is nothing less than an entirely new map of the “lesser brain.”
From bottom left clockwise: Amanda Bolbecker, Aina Puce, Sharlene Newman, Dai-Jin Kim, Olaf Sporns, William Hetrick, and Brian O'Donnell; not pictured, Alan Breier.
Photo by Jenn Robison
Hate thy neighbor?

It’s been 45 years since the U.S. Congress passed the Fair Housing Act, which protects buyers and renters from discrimination. And yet, says Jeannine Bell, neighborhood segregation remains a very real, and often violent, problem in America.


“I’ve integrated neighborhoods all my life, and I’ve integrated them peacefully,” says Bell. “When I learned this kind of violence was happening in the 1990s and into the 21st century, I was shocked, and I had to write about it.”

Contemporary housing segregation is quite pronounced, according to Bell: the “average” white person today lives in a community that is 75 percent white, she says, while the average black person lives in neighborhoods that are 35 percent white. When minorities do move into white neighborhoods, they may experience anti-integration violence that ranges from graffiti slurs and assaults to cross burnings and arson.

“There is significant evidence that minorities who move into white neighborhoods experience violence on a nearly daily basis,” Bell writes, citing more than 400 incidents of anti-integrationist violence between 1990 and 2010, including 44 cases of arson and 96 burning crosses.

In her book, Bell considers the ways in which neighborhood integration violence harms not only the victims, but entire communities. Minorities who move into white neighborhoods, she says, are typically trying to increase opportunities for themselves and their children through access to higher-standard housing, good schools, closer proximity to employment, and services. When they experience violence, however, even middle-class minorities tend to leave.

The aim of Bell’s research is to shed light on how to break the cycle in which African Americans, particularly, are repeatedly segregated into neighborhoods with high crime rates and low-quality schools. In addition to curbing violence through legal remedies such as hate crime legislation, Bell advocates an approach of “complete integration,” that is, long-range multigenerational efforts aimed at creating “meaningful interaction across racial lines” in a variety of community spaces, from classrooms to playing fields to churches.

Reviewing Bell’s book, *Publisher’s Weekly* called Bell an “impassioned advocate” who “puts a human face on statistics, drawing our attention to the financial and psychological damage sustained by individual victims of move-in violence. . . . The cumulative effect is powerful and disturbing—a nuanced view of race relations in the age of Obama and a reminder to civil rights advocates of unfinished business.”
Kevin Ladd has spent much of his life in prayer. As a clergyman-in-training at the Princeton Theological Seminary and later a pastor, he not only led an active prayer life but thought deeply about the nature of prayer. Today, as an associate professor of psychology at Indiana University South Bend, Ladd continues to pursue these fundamental questions: What is prayer? What do people do when they pray?

In FY2013, Ladd received a grant of $987,058 from the John Templeton Foundation—an independent philanthropy funding research in science, religion, and other disciplines—for “Prayer Vision: How Spiritual Practices Determine the World You See,” a project exploring how people’s spiritual condition relates to how they see and interact with their environments.

The three-year research project is being carried out in the Social Psychology of Religion Laboratory at IU South Bend, which Ladd leads. Research in the lab focuses on the psychological components of spiritual journeys and beliefs, exploring topics such as the role of the body in expressing faith (including neuroscientific approaches) and the ways that belief influences response to trauma.

Ladd’s current Templeton Foundation grant is his second from the foundation. An earlier grant awarded him $735,000 to design a series of experiments exploring the psychology of prayer, including equipping test subjects with digital cameras to take pictures of things they considered spiritually important and then asking them to provide captions.

Ladd says his current research builds on his first Templeton-funded project. Noting that the language of spirituality is filled with visual imagery (e.g., “seeing the light”), he explains that the current project features an eye-tracking system that calculates the position of each eyeball and the gaze point on a screen when a participant is looking at a given image.

“We know that most Americans engage in prayer,” he says. “As psychologists, we want to understand what they’re doing.”

Still, Ladd would be among the first to admit that prayer is a stubbornly mysterious area for research. Writing for the New York Times’ Opinion Pages “Room for Debate” section in June 2013, Ladd said, “The bottom line is that prayer is a paradoxical spiritual practice that does not guarantee predictably discernible efficacy at every turn. It’s not a cosmic vending machine. So why do people pray? Because they have faith that it is the right thing for them to do.”

“The eye-tracking system helps us see what is happening when people with different approaches to spirituality look at a wide variety of images,” Ladd says. “Using eye-tracking equipment, we can examine, simply by the way a person gazes at certain digital images, whether one person can ‘see’ another person’s spiritual outlook.”

Ladd believes deeper understanding of how a person’s spiritual thinking shapes what he or she sees could contribute to improved interfaith dialogue and conflict resolution.

Many of Ladd’s findings on the topic of prayer are outlined in his recent book, The Psychology of Prayer: A Scientific Approach (The Guilford Press, 2013), co-authored with his longtime research colleague, Bernard Spilka of University of Denver. Over the years, Ladd and his colleagues have gone a long way toward establishing a systematic and scientific approach to studying prayer in its myriad forms.
Using his mood-tracking system, Bollen achieved an accuracy rate of 87.6% in predicting the daily ups and downs in the closing values of the Dow Jones.
The new frontier of studying human behavior

Heard of the Twitter Predictor?

Invented by Johan Bollen, associate professor of informatics and computing at IU Bloomington, the predictor is a social media mood-tracking system designed to predict how economic markets, such as the Dow Jones Industrial Average, will perform.

The predictor emerged from Bollen’s hypothesis that the stock market’s performance reflects public mood, and that public mood can be measured. Bollen’s system accomplishes this mood measurement by analyzing general sentiments (calm, happy, angry, confused, etc.) detected in hundreds of millions of tweets. It then correlates those sentiments to shifts in the performance of the Dow Jones or other indicators.

And it works. Using his mood-tracking system, Bollen achieved an accuracy rate of 87.6% in predicting the daily ups and downs in the closing values of the Dow Jones. In February 2013, Bollen and the IU Research & Technology Corp. received U.S. Patent No. 8,380,607. It licenses Bollen’s innovation, formally titled “Predicting Economic Trends via Network Communication Mood Tracking,” to Guidewave Consulting, the start-up company that Bollen formed after his predictor attracted international media, and investor, attention.

“A lot of companies can ask people how they feel about a specific brand, product, or topic, but we’re probing the underlying mood state of entire communities,” Bollen says. “We’re focused on offering our analytics to a wide variety of domains, from hedge funds and banks to government agencies and even personal investors.”

Bollen also studies how social media affect the academic community, particularly the impact on scholarly publications. Historically, citation statistics have been a key measure of an article’s impact, and “the view from the ‘ivory tower’ is that scholars make rational, expert decisions on what to publish, what to read, and what to cite,” writes Bollen (with co-authors Xin Shuai, School of Informatics and Computing, and Alberto Pepe of Harvard University) in the article “How the Scientific Community Reacts to Newly Submitted Preprints,” published in *PLOS ONE*.

But as scholarly publishing increasingly happens online, social media use is beginning to influence what scholars cite. Analyzing online responses to preprint publication of more than 4,000 scientific articles, Bollen and his colleagues found “a statistically significant correlation” between the number of tweets that mention a preprint article and how many times the article is downloaded from the web and cited. The more early Twitter mentions of a paper, the greater the downloads and the higher the citation level.

Similarly, in a spring 2013 paper, Bollen, along with IU Bloomington colleagues Joseph DiGrazia, Karissa McKelvey, and Fabio Rojas, found a statistically significant relationship between tweets and electoral outcomes. Analyzing 537,231,508 tweets plus data from U.S. congressional elections, they found that “modest increases in the tweet share measures produce substantively meaningful and highly significant predicted changes in the vote share.” In short, more tweets, more votes.

With more than 230 million active users who send 500 million tweets per day (an average 5,700 tweets a second), Twitter offers scientists a dataset like no other—constantly updated, broadly diverse, highly personal, and largely unfiltered. Twitter, say Bollen and his co-authors, represents “a new frontier for the study of human behavior.”
Researchers take supercomputing to the extreme

Wrap your brain around this: Today’s fastest supercomputers perform about 10 quadrillion (one million billion) operations per second. By 2020, computer scientists are hoping to build systems so fast they require a new word to describe them. These “exascale” computers will perform one quintillion (one billion billion) calculations per second.

Just like today’s supercomputers, these yet-to-be-realized extreme-scale supercomputers will enable vital new research and breakthroughs in fields ranging from medicine and physics to fine arts and global climate change. One Indiana University center is pioneering the research needed to arrive at this rapid-fire future.

The Center for Research in Extreme Scale Technologies (CREST), affiliated with the IU Pervasive Technology Institute, develops new methods and technologies to advance extreme-scale data analysis and computation. Other CREST partners include the IU School of Informatics and Computing and the IU Office of the Vice President for Information Technology.

Two of supercomputing’s foremost thinkers, Andrew Lumsdaine and Thomas Sterling, both professors in the School of Informatics and Computing at IU Bloomington, lead CREST as director and executive associate director, respectively. Sterling also serves as CREST chief scientist. Both have had long careers in the fields of high-performance computing and supercomputing. Sterling is best known as the “father of Beowulf” for his pioneering research that dramatically reduced the cost of supercomputers and made them far more available to many researchers. Lumsdaine’s work on large-scale graph computation has helped guide extreme-scale computing as its scope evolves to include data-driven problems and traditional scientific applications. Both men deliver keynotes and present workshops at conferences around the world, and in 2013, Sterling was named “A Person to Watch” by HPCwire magazine.

Under the leadership of Sterling and Lumsdaine, CREST has received millions of dollars in research funding, including a three-year, $1.1 million grant from the Department of Energy to develop software that improves the speed and programmability of supercomputers. This funding is part of a $7.05 million grant for the XPRESS (eXascale PRogramming Environment and System Software) project.

The grant will allow CREST researchers to create a class of software that enables supercomputers to run intelligently, across millions of processors. “It’s exciting to be able to advance next-generation supercomputing while supporting research into solutions for civilization’s biggest issues,” Lumsdaine says.

“We’re writing software that moves execution from static to dynamic, allowing supercomputers to use new information as it is being revealed,” says Sterling. “By doing so, supercomputers will ‘think’ about how they use their resources, as well as where and when they schedule various concurrent tasks.”

Sterling likens the advances that exascale computers will bring to the difference between a cannon and a guided missile—unlike the static cannon, the missile makes minute adjustments during flight in order to more accurately hit the target.

“Essentially, we’re building a guided computer,” says Sterling. “Our goal is to completely redesign the system to produce a revolutionary class of supercomputers. It is exciting that IU is at the forefront of such research, setting future directions for exascale computing and programming.”

With Lumsdaine and Sterling at CREST’s helm, a world in which machines can process one billion billion calculations per second may be closer than we ever thought possible.

By 2020, computer scientists are hoping to build systems so fast they require a new word to describe them. These “exascale” computers will perform one quintillion (one billion billion) calculations per second.
Andrew Lumsdaine, left, and Thomas Sterling with IU’s newest supercomputer, Big Red II

Photo by Ralph Zuzolo
Patrick Motl’s research is dense, and that’s an understatement. A specialist in the study of neutron stars, Motl explains that “one teaspoon of [a neutron star’s] matter weighs more than all of humanity combined. People don’t really know much about the state of matter at such extreme conditions.”

In early 2013, Motl, an assistant professor of physics at Indiana University Kokomo, was awarded a three-year, $353,000 grant for a project titled “Fully Relativistic Simulations of Black Holes and Neutron Stars with Global Magnetic Fields.” The grant comes from the NASA Astrophysics Theory Program. Motl’s goal is to learn more about how neutron stars behave, particularly when two neutron stars merge together and when one star merges with a black hole.

A neutron star, explains Motl, is comparable to taking “an entire sun’s worth of mass and squishing it down smaller than the size of Kokomo.” Such neutron stars are “stellar remnants” leftover after “a star much more massive than our own sun runs out of fuel and dies.”

Motl’s research on the behavior of neutron stars focuses especially on the very high-energy gamma ray bursts that occur when they merge with black holes. Overall, the research will advance understanding of how stars evolve and help NASA scientists in planning future space missions.

Neutron stars are not only incredibly dense but also extremely far away, so Motl’s research team is studying mergers between black holes and neutron stars using complex computer simulations. Undergraduate student researchers at IU Kokomo are helping with modeling, visualization, and analysis of the simulations. Motl is also a collaborator on a current project funded by the National Science Foundation to create better and faster ways for multiple computers to work together to solve astrophysics problems.

When he’s not in the laboratory, Motl often can be found pursuing public outreach related to astronomy and science, especially hosting monthly viewing sessions at the IU Kokomo Observatory, using the observatory’s sophisticated Takahashi refracting telescope.

“For a campus our size, it’s very unusual to have this nice a telescope,” says Motl. “The Takahashi provides exceptionally beautiful images of planets; Jupiter and Saturn just look spectacular up there.”
It’s an overwhelming scientific consensus that human activity is largely responsible for climate change, but it’s an undisputed fact that the planet is warming and summers are becoming hotter than ever. The most scorching summers on record in the United States have occurred during just the past few decades, potentially resulting in more than 150,000 deaths by the end of the century, according to the Natural Resources Defense Council.

To help prepare for an increase in deadly heat waves, Dan Johnson, an associate professor in the Department of Geography and director of the Institute for Research on Social Issues at IUPUI, creates models using socioeconomic and environmental data to identify areas in U.S. cities most vulnerable to extreme heat.

“This is a very important topic,” says Johnson, who continued work on a multi-year, $828,000 research grant in 2013 from the NASA’s ROSES program (Research Opportunities in Space and Earth Sciences). “Heat is a leading cause of weather-related death, but this is preventable. President Obama recently announced a $1 billion initiative to address climate resilience, so this is a very timely and important effort that needs further study and transference of the technology to decision makers.”

From an early age, Johnson was fascinated by geography. In his professional life, he has devoted himself to exploring the intersection of geography and urban health. Early in his academic career, he woke up late one evening with the idea of blending satellite sensing data of different temperatures in a city with socioeconomic data and heat-related deaths. “The idea for my current work,” he says, “blossomed from there.”

Beyond academia, Johnson’s research has the potential to literally save lives. His work, he says, has already demonstrated the ability to diminish suffering during a heat wave “by allowing emergency management agencies to identify the most vulnerable areas of cities” and to allow decision makers, including city planners and mayors, to more efficiently allocate resources to help people affected by extreme heat.

Alongside the important practical applications of his work, Johnson also enjoys the interdisciplinary nature of the research that brings together different perspectives to solve problems in new and sometimes counterintuitive ways.

“I also love the student involvement,” Johnson adds. “It allows me to take the perspective of some of the cutting-edge research I do and expose it to both undergraduate and graduate students. When they learn that I work with both NASA and the CDC on a regular basis, they think it’s pretty cool that their professor is involved with those organizations.”
Heat is a leading cause of weather-related death, but this is preventable.
Assessing the health of U.S. health care

Health economist Kosali Simon may be one of the few people who did not tire of hearing about the Affordable Care Act during 2013. A professor in the School of Public and Environmental Affairs (SPEA) at Indiana University Bloomington, Simon specializes in studying health care policy, health insurance, and health care access. Her research on the initial impact of the Affordable Care Act has established her as a leading expert on the state of U.S. health care policy.

For example, Simon has studied the impact of ACA’s young adult mandate, which requires private insurance companies that offer coverage for dependents to provide coverage for children until they turn 26. Writing for the London School of Economics and Political Science American Politics and Policy blog, Simon asked, “does the mandate work as intended?” Her research (carried out with Yaa Akosa Antwi, assistant professor of economics in the School of Liberal Arts at IUPUI, and SPEA postdoctoral fellow Asako Moriya) showed that the number of young adults age 19 to 25 covered by parents’ employer-provided health insurance has increased dramatically. Just over 2 million young adults were added to employer-sponsored insurance policies in the months following the act’s implementation. Of that 2 million, 938,000 previously had been uninsured.

Amid the controversy of the ACA, “this much is clear” writes Simon: “In the months following implementation of the dependent coverage requirements, the ACA erased uninsurance among targeted individuals with parental employer-sponsored insurance policies by one-third.”

In 2013, Simon was also a co-recipient of the Addington Prize in Measurement, awarded by the Fraser Institute, an independent think-tank focused on economic and public policy issues. The award, which includes a $10,000 prize, was for the paper “A ‘Second Opinion’ on the Economic Health of the Middle Class,” which Simon co-wrote with Richard Burkhauser of Cornell University and Jeff Larrimore of the Joint Committee on Taxation, U.S. Congress. The article was published in the National Tax Journal and won the Musgrave Prize for the best paper published in the journal that year.

The paper argued that economic growth of the middle class has been greater than many economists suggest. In other words, evidence of middle class decline depends on how you measure it. The reputed “failure of the middle class” can be explained, say the researchers, by “the use of an income measure which does not fully capture what is actually happening to the resources available to middle class individuals.”

Simon’s expertise in applying economic analyses has earned her a three-year term on the National Advisory Committee of the Robert Wood Johnson Foundation Scholars in Health Policy Research Program, a committee composed of 13 nationally recognized experts. The foundation is the nation’s largest philanthropy devoted solely to the public’s health, launched by the founder of the Johnson & Johnson health products corporation.

“How well we solve pressing health policy problems today can affect not just the health status of the population, but also the financial stability of societies for decades to come,” says Simon.
Meet Kylie Peppler, a Maker. Part grassroots movement, part DIY crafting, part educational innovation, the “umbrella of Make,” explains Peppler, encompasses growing communities of young people and adults who are designing and building things, especially by incorporating technology into their creations.

An artist by training, Peppler is now an assistant professor in the Learning Sciences Program at the Indiana University School of Education in Bloomington. Her research at the intersection of media arts, new technologies, and informal learning, especially her work on creativity among youth, has led to three books in print and four (co-authored) books in press as well as grants from the John D. and Catherine T. MacArthur Foundation and the National Science Foundation, among others.

What does Making have to do with education? Peppler believes Making affords people opportunities for authentic engagement in a variety of disciplines, which can lead to learning outcomes in the arts as well as in the disciplines of science, technology, engineering and mathematics (STEM). In a 2013 report commissioned from Peppler by the arts-focused Wallace Foundation, Peppler argues that today’s media-immersed children and teens use apps, mobile phones, computers, and more to create art that is “interest-driven”; that is, art that “emerges from children’s and teens’ own creative passions.”

“Youth are increasingly assuming public roles as artists, performers, designers, editors, and directors of creative products and are sharing their work through social media platforms,” she says. “Young people are producing this art solely because they want to, and they’re motivated by their own pride in their work and curiosity, not because of what others think or want.”

The breadth of such interest-driven arts was on display at the “Make-to-Learn Symposium” that Peppler and students from her Creativity Labs at IU Bloomington hosted in Chicago during 2013 (the symposium was supported by the MacArthur Foundation). Peppler says harnessing the impact of the Maker movement is crucial to enhancing and advancing arts and STEM education among young people.

“Whether a teen is building a robot, designing a video game, knitting a sweater, or crafting, there are a lot of complex STEM concepts undergirding each of these activities,” she says. “It gets us to not only think about how kids can learn STEM in the informal out-of-school hours, but also how we can re-envision STEM education.”

Improving science learning among young children is the focus of Peppler’s current National Science Foundation (NSF) funding. In September 2013, the NSF awarded more than $999,000 to Peppler, Joshua Danish (also an assistant professor of learning sciences in the IU School of Education), and Armin Moczek (associate professor of biology in the College of Arts and Sciences at IU Bloomington) for a project called BioSim.

Basically, Peppler and her collaborators are designing “e-puppets” to teach elementary-age students about complex biological systems. Electronically enhanced puppets that contain a wearable computer and wireless transmitter allow young students to simulate biological phenomena such as honeybees collecting nectar or army ants scavenging for food.

Using the e-puppets, the children learn how ecosystems work by playing. “Young children are already apt to explore the world through play-acting and games, especially those that involve playground-like dynamics among a large group of peers,” Peppler says. “We find a lot of commonalities between this type of play and the embodied exploration found in more advanced forms of scientific study.”

Peppler, Danish, and Moczek are creating a system that can accommodate large groups of 30 to 40 children and expanding it to include predators and other roles in an ecosystem. Their goal is to explore how the study of one ecosystem prepares youth to understand ecosystems more globally.

When the three-year project is complete, the researchers intend to make “how to” instructions publicly available so teachers and designers can create e-puppets through readily available materials. They envision partnering with science museums to make BioSim kits available. One partnership is already underway with the WonderLab Museum of Science, Health and Technology in Bloomington.
invigorate
The Indiana University-led AMPATH (Academic Model Providing Access to Healthcare) program in Kenya has developed an excellent system of care for about 120,000 HIV-infected people, many of them children.

That system and effective antiretroviral drugs are a life-saving combination for those with HIV, but growing children raise new issues for those treating them—including the difficult questions of how, and when, to tell them about their HIV status.

To help develop effective means of informing children of their HIV status, IU School of Medicine physician-researcher Rachel Vreeman was awarded a grant of nearly $500,000 from the National Institutes of Health to study how best to disclose HIV status to young people, particularly in resource-limited settings such as Kenya.

“As we are more successful in keeping children alive and growing on medicines in the clinics, we now must help children transition to taking more responsibility for their medicines. Children and adolescents eventually need to know why they are taking these medicines—to know that they have HIV,” says Vreeman.

The process of informing children about their status is complicated by pervasive stigmatization fears in Kenya. Parents, caregivers, and health-care providers worry that disclosure will result in discrimination against the child and the rest of his or her family.

Vreeman said the study will assess the effectiveness of a patient-centered disclosure intervention for HIV-infected Kenyan children and their families. At some AMPATH clinics, professional counselors will use an intensive method for counseling about and disclosing HIV status to guide families through the process. The curriculum includes culturally adapted short films, shown on handheld tablets, that depict the stories of children and caregivers wrestling with HIV disclosure.

Over a two-year period, the researchers will assess whether the intervention results in more disclosures and what impact it may have on the children’s clinical, psychological, and social outcomes.

“What we hypothesize is that this approach will help us disclose HIV status to more children, and to do so in ways that improve children’s health and their adherence to their medicines, with no increase in problems of stigma or social isolation,” Vreeman says.

To help determine whether children are taking their medications, her study team uses special medicine bottles with computer chips in the caps that can detect when the bottles have been opened. If the data indicates patients haven’t received the medications, clinic staff can work with parents or caregivers to determine what obstacles are deterring regular treatment.

Adherence is also complicated by social and cultural issues. With the continuing stigma surrounding HIV infection, simply taking medicines regularly can seem suspicious in a community where few people are treated for chronic illnesses. Moreover, children who are being treated successfully for HIV will appear healthy, making their need to take medications regularly seem odd to those who don’t know their status.

In 2014, Vreeman’s research team is launching a new study, with additional funding from the National Institutes for Health, to evaluate the impact of stigma on Kenyan households with HIV-infected children.

Issues of stigma, adherence, and disclosure have occupied Vreeman and colleagues for some time. They have validated a strategy for measuring children’s adherence to HIV medicines, studied the impact of missing clinic appointments, assessed the value of printed computer-generated reminders for overdue care recommendations given to clinicians for patient visits, and assessed disclosure practices for young HIV patients in limited-resource areas of Africa, Asia, and South America.

“Ninety percent of the world’s 2.3 million HIV-infected children live in sub-Saharan Africa. As these many HIV-infected children grow and thrive, clinicians in these settings face new challenges to understand how to provide the best treatment possible over the long term—even with limited resources. All of my research work is aimed towards figuring out how to do that,” Vreeman says.

To read more about Rachel Vreeman’s work in Kenya, see http://doctoroversea.com/
For some patients with blood or bone marrow cancers, a successful bone marrow transplant is key to returning to health. And a successful transplant relies on obtaining necessary stem cells in advance from the patient’s bone marrow to restore the body’s blood and immune system after chemotherapy.

The necessary stem cells can be harvested from the patient’s circulating blood, but getting enough of them can be a problem. In 2013, IU School of Medicine researcher Louis M. Pelus and his colleagues reported in the journal *Nature* that non-steroidal anti-inflammatory drugs could provide an important assist to physicians preparing patients for such transplants.

Pelus’s team reported that NSAIDs—which include common drugs such as aspirin and ibuprofen—increased the number of stem and progenitor cells harvested from the blood in animal testing and in a small human study. Stem cells and their immediate descendants, progenitor cells, are responsible for nearly all of the billions of blood and immune system cells produced in the body each day. These key ancestor cells spend most of their lives safely harbored in the bone marrow, but they are destroyed when physicians use high-dose chemotherapy. So before a bone marrow transplant begins, physicians collect stem and progenitor cells from the blood and then transplant them back to the patient following intensive chemotherapy, restoring the patient’s ability to produce blood and immune system cells.

To increase the numbers of stem and progenitor cells collected, physicians treat patients with proteins called growth factors, which mobilize some stem and progenitor cells to leave the bone marrow and enter the circulating blood. Up to 40 percent of patients fail to mobilize enough cells to get an optimum dose, however, potentially reducing transplant effectiveness. Patients with multiple myeloma and non-Hodgkin’s lymphoma are particularly at risk for low levels of stem cell mobilization. The drug Plerixafor is approved to help increase cell mobilization; however, its use can cost about $25,000 per patient.

“Researchers have been looking for new, more effective mobilizing agents, and NSAIDS could be those agents, and at a very low cost,” says Pelus, professor of microbiology and immunology at the IU School of Medicine and principal investigator for the study.

In animal studies, using an NSAID alone increased stem and progenitor cell counts in the circulating blood by four to six times, though the numbers of cells remained small. In combination with growth factors, however, the mobilization of cells was significantly greater than when the growth factors were used alone.

The transplanted cells mobilized with NSAID assistance in the animal studies also were more effective in repopulating the recipients’ bone marrow than those mobilized with growth factors alone.

In tests on nine healthy human volunteers, NSAIDs alone increased cell mobilization, but no tests using both growth factors and NSAIDS were conducted with the human volunteers.

Pelus and colleagues have been making preparations for the next step: larger clinical trials in humans. Plans call for Pelus and his clinical collaborator, Sherif Farag, the Lawrence H. Einhorn Professor of oncology, to begin clinical testing of the technique in 2014, using meloxicam, an NSAID selected because it is less likely to cause gastrointestinal problems and already is given on a chronic basis to treat arthritis.

About 120 patients—60 with multiple myeloma and 60 with non-Hodgkin lymphoma—will be enrolled in the Phase II clinical trial over the next four and a half years, with an interim analysis after the first 25 patients with each disease.

Pelus and Farag also have received a $2.67 million grant from the National Institutes of Health that will both provide financial support for the clinical trial and fund genomic research into the cells that are mobilized by the NSAID supplements.

“We know the cells mobilized with NSAID assistance are different—they engraft faster, but we don’t know why. The phenotype and genotype studies that will be supported by this grant will help us understand why and will also help us determine whether NSAIDs may be mobilizing a different population of stem cells that perhaps may be more selectively targeted in the future,” Pelus says.
Rowland Ricketts is an assistant professor by day, indigo farmer by night . . . and day, day and night. Indigo farming can be very labor-intensive.

A textile artist and member of the Hope School of Fine Arts in the College of Arts and Sciences at Indiana University Bloomington since 2006, Ricketts is also an indigo farmer and dyer. Trained in indigo farming and dyeing in Japan, Ricketts grows and processes his own indigo using Japanese methods that are centuries old. That connection is especially important to Ricketts.

"My experiences working with indigo make me aware of a connection that reaches back to my teacher’s teachers and the people they learned from, into a past where the processes I use were developed through the accumulated experiences of all who have ever worked with this unique dye," he says.

Ricketts grows his indigo near his rural Bloomington home and IU Bloomington’s Hilltop Gardens. His decision to grow and produce his own indigo is integral to his art.

"My choice to plant, transplant, weed, harvest, winnow, dry, and compost the indigo by hand is not one of necessity," Ricketts says. "It’s a conscious act of recognition that all the energy extended in the farming and processing of the indigo plants is just as much a part of the final dyestuff as the indigo molecules themselves."

Ricketts’ labor has resulted in stunning textile-based creations and installations featured in numerous group and solo exhibitions including I am Ai, We are Ai in Tokushima, Japan, an exhibition for the 2012 Japanese National Cultural Festival Project. In late 2012, Ricketts was named a United States Artists fellow, the first artist from Indiana to receive a fellowship from the national organization. He received a grant of $50,000. "It’s very exciting on many levels," Ricketts says of the fellowship award. "It’s become more and more difficult for individual artists to find funding, and this organization fills a gap."

Ricketts credits support he’s received from IU, including grants from the New Frontiers in Arts and Humanities program administered by the Office of the Vice President for Research, for helping him earn the U.S. Artists fellowship.

"The support I’ve received here at Indiana University for my work and for my creative activity is really what has made this sort of recognition possible," Ricketts says. "If it weren’t for all those factors, I don’t know that I’d have been able to do the work that has received this recognition."

Ricketts’ current and ongoing project is IndiGrowing Blue, a “participatory art project” involving the community of Bloomington and surrounding areas in the work of processing indigo. IndiGrowing Blue is “based on the belief that material and process are central to the artistic practice,” Ricketts says. "Raising your raw materials from a handful of seeds lends unique insight into how we live, create, and consume as contemporary Americans."
Regenerating dental health

Have you flossed lately? If not, you may well experience periodontitis, one of the most common oral health problems in adults. But just because it’s common doesn’t mean it’s not serious—periodontitis is an aggressive chronic inflammatory oral disease that causes gums to pull away from the teeth. If left untreated, the bones, gums, and connective tissue that support the teeth can be destroyed.

To address this common but dangerous condition, IU School of Dentistry clinician and scientist Marco Bottino has begun a five-year project to develop biomaterials that will regenerate tissue destroyed by periodontitis and to translate these materials to clinical practice.

Bottino’s research project, “A Novel Multilayered Membrane for Periodontal Regeneration,” is funded by a $715,525 grant from the National Institute of Dental and Craniofacial Research of the National Institutes of Health.

An assistant professor in the Department of Restorative Dentistry’s Division of Dental Biomaterials, Bottino is a materials scientist and a dentist. That makes him well equipped to bridge the gap between developing biomaterials and applying them in patient care.

“We are developing biomaterials to be placed into the periodontal defect that will regenerate bone and soft periodontal tissues at the same time,” Bottino explains. “Currently, dentistry doesn’t have a single implantable biomaterial that can consistently guide the coordinated growth and development of multiple tissue types, especially in very large periodontal defects.”

Bottino’s research will focus on coupling bioactive molecules with laboratory-made nanofibers, producing a multilayer, paper-like membrane that can be shaped and placed into a defect. After being placed, the membrane will degrade over time, releasing different kinds of molecules that will promote and encourage the formation of hard (i.e., bony) and soft tissues destroyed by periodontitis.

If the research and clinical trials are successful, it could lead to a treatment that would help patients retain teeth they otherwise might lose to periodontitis, avoiding the need for dental implants or other restorative dental treatments.

“We are mimicking what happens in nature,” Bottino says, “providing the body with the ingredients to make new tissues that hold teeth in place.”
Biomaterial made in the laboratory of Marco Bottino is spun onto a glove. Photo by Terry Wilson
“Exquisite examples of intricate forms exist in nature—snowflakes, stalagmites, and more,” says IU chemist and assistant professor Sara Skrabalak. “I find it beautiful and exciting that we can use chemical principles to achieve intricate forms in the laboratory, where atoms are assembled into nanostructures with defined shapes and architectures.”

Skrabalak, who was one of only 126 researchers to be named a Sloan Research Fellow by the Alfred P. Sloan Foundation in 2013, first became interested in studying nanoscale materials—materials on the scale of one billionth of a meter—while she was an undergraduate chemistry major at Washington University in St. Louis. Fascinated by the prospects of controlling the structure of such unimaginably small bits of matter, Skrabalak has since focused her research on demonstrating the best ways to shape nanomaterials for specific purposes.

For example, nanomaterials may prove to have widespread application in medicine and other areas of science directly impacting human well-being. On a nanoscale, Skrabalak says, “materials often display new properties that can be harnessed to treat disease and address our energy needs.”

Scientists around the world are experimenting with how nanomaterials may be useful in many ways: in delivering drugs, such as chemotherapy drugs, directly to infected cells; in creating nano-pits or ordered arrays of nanoparticles to manipulate light for more efficient solar cells or stealth coatings, and many other applications.

“My research program provides new strategies to make nanoscale materials with a high level of precision,” says Skrabalak, who received both a National Science Foundation Faculty Early Career Development Award and a Department of Energy Early Career Award in 2013. “We can then use the nanostructures made in our laboratory to answer questions related to how particle size and structure influence the properties of materials.”

Skrabalak’s research also may prove significant for energy science, chemical sensing, and more. As the development of technologies in renewable energy and other cutting-edge areas becomes more crucial, understanding how to shape and manipulate materials at the nano level may be key to solving many longstanding questions and problems, such as enabling engineers to invent more efficient and cost-effective fuel cells to power vehicles and any number of appliances typically powered by fossil fuels.

“Our research may allow people to make tailored materials for those needs,” Skrabalak says, “and a longer-term goal of our research is to use our synthetic skills and knowledge of how nanoscale structures influence the properties of materials to design efficient catalysts for fuel cells—a potentially more sustainable energy platform than what can be achieved with fossil fuels.”
IU Jacobs School of Music Professor of Music James Campbell, a clarinet virtuoso and a native of Canada, is an accomplished man with more than 40 recordings, upwards of 30 works commissioned, five TV specials, and performances in 30 countries and counting to his credit. But in FY2012-13, he added a special accolade to his list: a Queen Elizabeth II Diamond Jubilee medal. Created to mark the 60th anniversary of Her Majesty Queen Elizabeth II, the commemorative Diamond Jubilee Medal honors significant contributions and achievements by Canadians.

A member of the Jacobs School of Music since 1988, Campbell has been a soloist with more than 60 orchestras, from the London Philharmonic to the Russian Philharmonic, and has performed Copland’s Clarinet Concerto four times with Aaron Copland himself conducting. Campbell has even replaced an ailing Benny Goodman during a tour of California. Also a Member of the Order of Canada, Campbell is entering his 30th season as artistic director of the annual summer Festival of the Sound in Parry Sound, Ontario.

At a 2012 ceremony where he received an honorary doctorate from Wilfrid Laurier University in Waterloo, Ontario, Campbell delivered a commencement address in which he reflected on his deep passion for his musical career, which started as part of a junior high school band in a small town in Alberta.

“The first day of band we all played one long note, an F,” Campbell remembered. “Imagine what that sounded like! Yet, to my young ears it was the most thrilling sound imaginable. That note, that school, that teacher, that sound, awful as it must have been, somehow cut to the core of my musical being and opened the world to me. . . .

“My hope for you and your bright future,” he continued, “is that as your life proceeds and as you advance in your career, you will experience a vision of the truth and simplicity of what it is to go straight to the center, to the heart of your subject and indeed your life.”
The power of story in medieval China

From a young age growing up in southern China, Manling Luo loved to hear and read stories. Eventually, that passion for literature turned into a career as a scholar of traditional Chinese literature. Luo is now an assistant professor in the Department of East Asian Languages and Cultures (EALC), a part of the School of Global and International Studies within the College of Arts and Sciences at IU Bloomington, where her research remains focused on the power of storytelling.

In FY2013, Luo received a yearlong American Council of Learned Societies Fellowship and an American Fellowship from the American Association of University Women to support completion of her book, *Literati Storytelling in Late Medieval China* (forthcoming, University of Washington Press).

The literati at the center of Luo’s study are the educated scholar-officials from mid-8th to mid-10th century China. In Luo’s view, storytelling was very important for these men, playing a central role in enabling them to construct new identities during the Tang-Song transition, a time of political and cultural upheaval in Chinese history.

Arguing that literati storytelling of the period was neither strictly fiction nor folklore, Luo says the men of letters told stories as a way of defining their collective values. The Chinese literati of the time told stories about emperors, careers, morality, pedigree, poetry, supernatural encounters, sexual adventures, and more. Such narratives, Luo says, helped to “position the men of letters in relation to principal groups in the human world and in the greater scheme of the cosmos” and allowed them to negotiate and redefine major power relations.

“As a kind of proto-mass culture medium, literati storytelling holds the key to understanding how late medieval men of letters constructed their community as they adjusted to fundamental transformations in literati life,” Luo says.

Storytelling, Luo, says, is a “universal yet complex human phenomenon.”

Luo also received earlier support for her project from an EALC Research Fund, a travel grant from the College Arts and Humanities Institute, and a New Frontiers in Arts and Humanities grant from the Office of the Vice President for Research. New Frontiers, a university-wide internal funding program marking its 10th year in 2014, has granted nearly 700 awards to IU faculty across IU’s campuses.
Bacteria relationships may hold key to future fuel solutions

One of the hottest areas in biological research involves identifying and working with bacteria and other microscopic organisms capable of producing chemicals that can be used as fuel for cars, trucks, planes, and other vehicles. But while most scientists focus on an individual bacterium, IU Bloomington biologist James “Jake” McKinlay is charting new territory by investigating how microbes can work together in pairs and larger groupings to more efficiently produce biofuel and other valuable materials.

“I’m really excited that we can get two different bacterial species to cooperate in a test tube and then exploit their relationship to do something beneficial for society,” says McKinlay, who in 2013 received a $750,000 U.S. Department of Energy Early Career Research Program award—the agency’s most prestigious award for early-career, tenure-track scholars. “I’m also excited that we can establish these cooperative relationships between bacteria that were not known to cooperate previously, giving us the chance to examine how cooperative relationships are established and how they develop.”

McKinlay has been fascinated by the prospects for using bacteria as microscopic factories to produce useful chemicals or clean up toxic pollutants ever since his undergraduate days at the University of British Columbia. While many microbiologists know that bacteria behave in complementary ways, such as one bacterium producing waste that becomes another’s food source, the trick has been to create a steady connection between codependent bacteria in a laboratory setting.

“I fortuitously discovered a mutant bacterium that released nutrients into its environment and wondered if I could use this to form a stable relationship with another bacterium,” McKinlay recalls. “Sure enough, when paired with a bacterium that gives an essential nutrient in return, the two bacteria establish a stable cooperative relationship.”

McKinlay’s work is important for several reasons. From an academic perspective, getting bacteria to work together in the lab helps McKinlay and his colleagues learn more about how bacteria function, both apart and together. Since bacteria influence everything from greenhouse gas levels to how much nitrogen in the soil is available for crops, better understanding bacterial behavior is crucial. Because the paired bacteria that McKinlay studies produce a potential biofuel in the form of hydrogen gas, his research could have significant implications for how we produce and consume fuel.

“Nearly all the hydrogen gas our society uses comes from fossil fuels, which is really a shame because there are a variety of sustainable practices by which hydrogen can be made, including using bacteria to convert renewable resources into hydrogen,” McKinlay says. “Our co-culture shows promise for hydrogen gas production because the two bacteria make more hydrogen gas together than either could alone.”
The Guggenheim Fellowship is intended for recipients who are “exceptional,” a word which clearly applies to five IU Bloomington faculty members who received the fellowship award in 2013.

Biologist James Bever, linguist Robert Fulk, poet Ross Gay, religious studies professor David Haberman, and Polish translator Bill Johnston, all professors in the College of Arts and Sciences at IU Bloomington, received Guggenheim Fellowships. The Foundation receives nearly 4,000 applications each year and grants approximately 200 fellowships.

Bever is professor in the Department of Biology. A former Fulbright Fellow and Bullard Fellow, Bever also was named an American Association for the Advancement of Science Fellow in FY2012-13. His research focuses on the areas of ecology, evolution, microbial interactions, and pathogenesis. He will use his fellowship to write a book about plant-microbe interactions and the general dynamics of plant communities.

Fulk is Class of 1964 Chancellor’s Professor of English and adjunct professor in the Department of Germanic Studies. With a particular interest in the ways in which linguistics and language study intersect with the analysis of medieval literature, his research areas include early Germanic, Celtic, Old English, and Old Icelandic languages. His current project, supported by the Guggenheim fellowship, is “A Comparative Grammar of the Early Germanic Languages.” The last complete grammar in English devoted to the topic was published in 1939.

Gay is assistant professor in the Department of English and associate director of the Creative Writing Program. He is author of the poetry collection *Against Which*, and his poems have appeared in *American Poetry Review* and *Harvard Review*, among other publications. Gay is using his fellowship to explore new forms of writing and poetry, as well as to interview African American farmers from across the nation for a book project.

Haberman is professor in the Department of Religious Studies. His research interests include South Asian religious traditions and, more recently, the intersection of religion and ecology. He is using his fellowship to work on a book about the worship of Mount Govardhan, one of the most distinguishing features of the sacred landscape of Braj, the region in northern India associated primarily with Krishna.

Johnston is chair of the Department of Comparative Literature. Known as one of the leading translators of Polish literature in the English-speaking world, he has held fellowships from the National Endowment for the Arts and the National Endowment for the Humanities. Johnston will use his Guggenheim fellowship to work on a new translation of “Pan Tadeusz,” an epic poem in rhyming verse by Polish Romantic poet Adam Mickiewicz that was first published in 1834.
Medievalist receives National Humanities Center Fellowship

Patricia Clare Ingham, associate professor of English and medieval studies in the IU Bloomington College of Arts and Sciences Department of English, was selected as a National Humanities Center Fellow for 2012–13. During her fellowship at the center, Ingham completed a draft of her book *Medieval/NEW: Novelty, Innovation, and Ethics*, among other writing and editing projects. Ingham was part of a class of 33 scholars who came to the National Humanities Center from around the country and abroad to pursue scholarship in history, literature, philosophy, the arts, and more. The only major independent American institute for advanced study in all fields of the humanities, the National Humanities Center is supported by private foundations, the National Endowment for the Humanities, and individual donors, among other sources.

NSF CAREER Award winners at IUPUI

Two computer scientists at Indiana University–Purdue University Indianapolis earned CAREER Awards from the National Science Foundation in early 2013. Murat Dundar and Gavriil Tsechpenakis, both assistant professors in the Department of Computer and Information Science in the School of Science at IUPUI, became the fourth and fifth faculty members in the school with current CAREER Awards, which support outstanding early-career faculty. Dundar is using his $500,000 award to test theories related to machine learning. His research explores ways to refine how a computer actively and continually updates and adapts to the information it’s collecting. Dundar will also use his funding for outreach efforts, including supporting a summer computer science camp for K-12 students and mentoring student teams to compete in regional science fairs. Tsechpenakis earned his CAREER Award for research to identify the patterns by which neurons develop and connect to form a brain. A specialist in biomedical vision and computer imaging, Tsechpenakis is using his $600,000 award to continue his studies of how neural circuits develop in fruit fly larvae, in order to create an image-based computational model of how synaptic connectivity is established during brain development. His research also will explore how the brain compensates when synapses are lost or destroyed. Tsechpenakis hopes to create internships for high school students as well as support student travel to academic conferences and graduate student and postdoctoral research in his department.
**Health-care access for all**

Beth Meyerson, an assistant professor of health policy and management in the School of Public Health-Bloomington, studies what she calls “health system elasticity,” meaning the flexibility of health systems to create greater access for populations facing health inequalities. Working with colleagues in the Kinsey Institute for the Study of Sex, Gender, and Reproduction; the Rural Center for AIDS/STD Prevention; and the College of Arts and Sciences’ Department of Gender Studies; as well as external partners, Meyerson led the recent development of a pilot for offering HIV testing in rural pharmacies in Indiana. The study revealed that licensed community pharmacists in Indiana were open to an active consultation role when customers purchased over-the-counter HIV tests. Meyerson believes HIV testing in pharmacies could improve the health of populations across the country, especially in rural communities which often lack an HIV testing and treatment infrastructure. In another study, Meyerson and her research colleagues found that an opportunity for significant progress in addressing cervical cancer across the country is being squandered—not because of a lack of money, but because of a void of leadership and organization at the state level. Meyerson is examining cervical cancer screening policy adoption among states, with support in part from an IU Outstanding Junior Faculty Award she received in FY2012-13. “In the United States, we are in the enviable position to achieve cervical cancer elimination in our lifetimes,” Meyerson says. “Our success against cervical cancer depends in part on our understanding whether and how policy innovation is being adopted by states, and the factors that facilitate or prevent adoption.” One of Meyerson’s findings so far is that STD clinics could provide important access to cervical cancer screenings for women who traditionally have trouble receiving these screenings because of lack of insurance and other obstacles. Meyerson presented results of her recent studies at the 2013 STI & AIDS World Congress in Vienna, Austria.

**Advancing vision research**

Retinal vascular diseases such as diabetes and hypertension are major causes of blindness in the developed world. Observing the progress of the disease in the human eye is difficult, usually requiring injection of contrast dyes. With ongoing funding from the National Institutes of Health National Eye Institute (NIH-NEI), Stephen Burns is studying new techniques to improve visualization of the microvascular network in the living human retina. Using an adaptive optics scanning laser ophthalmoscope, Burns, who is professor and associate dean for graduate programs at the IU School of Optometry in Bloomington, has developed a noninvasive imaging approach that allows direct assessment of the cellular structure of the retina’s vascular wall. In FY2012-13, Burns’s research findings were published in *Investigative Ophthalmology & Visual Science* and *Biomedical Optics Express*. Burns also is leading a $444,415 NIH-NEI grant to support current and future vision research endeavors at IU Bloomington through the coordination of infrastructure resources such as research equipment and supercomputing technologies.
Hall of Fame researcher

In 2013, with a nearly 30-year research career to her credit, in 2013, Victoria Champion, Distinguished Professor and Edward and Sara Stam Culliper Endowed Chair at the IU School of Nursing, was inducted into the International Nurse Researcher Hall of Fame by the Honor Society of Nursing, Sigma Theta Tau International. The induction took place during the 24th International Nursing Research Congress in Prague, Czech Republic. With consistent funding by the National Institutes of Health and other agencies over decades, Champion’s research is focused on three primary areas: intervention programs to increase screening for breast and colorectal cancers; the use of technology to develop and deliver interventions that increase accessibility of cancer screenings for underserved populations; and cancer survivorship, including the study of quality of life issues for breast cancer survivors. Champion also serves as associate director of population science and co-leader of the Cancer Prevention and Control research program at the IU Simon Cancer Center; scientific director of the Behavioral Cooperative Oncology Group Symptom Management Center for the Mary Margaret Walther Program at the IU School of Nursing; and is a member of the executive committee for the Indiana Clinical Translation Science Institute (CTSI).

Improving public safety in northwest Indiana

The police of northwest Indiana are after Joseph Ferrandino. Through Ferrandino’s expertise and IU Northwest’s Center for Urban and Regional Excellence, police and emergency agencies in the region now have access to computer analyses typically available only in large metropolitan cities. An associate professor of criminal justice in the School of Public and Environmental Affairs at IU Northwest, Ferrandino and his students regularly provide crime mapping and data analysis to more than nine regional police departments. The data help to more fully inform area police chiefs, allowing them to better allocate law enforcement and emergency services. Ferrandino’s contributions to improving life in northwest Indiana earned him a spot on The Times of NWI’s “20 under 40 for 2013” list. Ferrandino refers to his work with the northwest Indiana community as his postdoctoral degree. “I’ve learned about police departments, politics, public administration, geography, and the cities I work with,” he told the Times of NWI on the occasion of his honor. “There’s something new every day, whether it’s a technical skill or some piece of information that just makes me curious. Every day is different.”
Two parties, two presidents?

Conventional wisdom blames Congress for today’s partisan conflict and paralysis in Washington, D.C., but David Orentlicher disagrees. In his book *Two Presidents Are Better Than One: The Case for a Bipartisan Executive Branch*, published by NYU Press in 2013, Orentlicher says today’s gridlock has its roots in the White House and the “imperial presidency” residing in the Oval Office. The seeds for political dysfunction were planted when America’s Founders chose a single president to head the executive branch, giving the immense power of the presidency to one person from one party, according to Orentlicher, the Samuel R. Rosen Professor of Law at the McKinney School of Law at IUPUI. The solution, he says, is power shared across party lines in the form of a two-party, two-president executive branch. Analyzing the histories of other countries with a plural executive branch and past examples of bipartisan cooperation within Congress, Orentlicher’s book shows why and how to implement a two-person, two-party presidency. Ultimately, he says, “two heads really are better than one.” Orentlicher’s book was featured on NPR.org and reviewed in the *Boston Globe, Chicago Tribune,* and *Washington Post.*

Archaeology for all

If archaeology and Indiana conjure up a swashbuckling, car-chasing Indiana Jones, meet Joshua Wells, a computer-wielding archaeologist who is assistant professor of anthropology and social informatics at IU South Bend. With funding from the National Science Foundation, Wells and colleagues from the University of Tennessee and the OpenContext.org archaeological data publication service are compiling The Digital Index of North American Archaeology (DINAA). A specialist in computer science, Wells’s goal is to link disconnected and incompatible data to make it useful for important archaeological research. Initially, DINAA will integrate public data drawn from repositories in up to 20 states that describe more than 500,000 archaeological sites in eastern North America. The linked datasets will become accessible to a wide range of scholars and researchers, promoting greater collaboration and opening up new research topics, such as how human populations in North America responded to climate change, population growth, and environmental issues over the past 13,000 years. Removing the barriers of disparate data will, Wells says, offer “an unprecedented new view on human use of the North American landscape across vast regions and time scales.”

Surveying physical fitness

In FY2012-13, NiCole Keith, associate professor in the School of Physical Education and Tourism Management at IUPUI, completed work on a grant from the National Heart Lung and Blood Institute, which she used to examine ways to improve physical fitness and health within an aging population. In an article on her study’s results published in *Medicine and Science in Sports and Exercise,* Keith describes the development of a self-reported fitness survey (SRFit) intended to estimate fitness in adults over 40. It’s well known that physical fitness is a key indicator of health, but “fitness is less easily assessed in a health care setting,” says Keith, for various reasons including time constraints and incomplete measurements. In the study, Keith’s pilot fitness survey was given to more than 100 participants in a fitness center, asking questions such as “How hard is it for you to move from a standing position to a seated position [in a chair] without using your arms?” The participants were also given basic physical tests such as blood pressure measurement and completing arm curls with a weight. Keith and her collaborators found that the SRFit survey was a valid and reliable tool for assessing physical fitness—in other words, the participants’ self-reported responses to the survey items correlated with the results of other fitness tests administered...
Research highlights

by the researchers. The survey also was efficient; most participants completed it in less than 10 minutes. Keith and her co-authors concluded that the SRFit survey’s “efficiency of delivery and completion and its correlation with existing physical fitness tests indicate the survey’s usefulness in future research and clinical practice.”

Six decades of Spanish and Portuguese

Edgar Illas, assistant professor in the Department of Spanish and Portuguese and director of the program in Catalan, received the 2013 North American Catalan Society Prize for Outstanding Work in Catalan Studies for his book Thinking Barcelona: Ideologies of a Global City. Illas’s home department, the College of Arts and Sciences’ Department of Spanish and Portuguese, celebrated its 60th anniversary in 2013 as well as the department’s receipt of a $533,000 grant from the U.S. Department of Education. The funding is being used to expand the department’s graduate program through at least a dozen fellowships to support the training of graduate students as scholar-teachers. “We’re thinking ahead of the increasing need for Spanish professors and teachers nationally at all levels, and not just Spanish language but scholars of literature and linguistics who can promote cultural literacy,” said associate professor and department chair Steven Wagschal, when the award was announced. IU Bloomington’s Department of Spanish and Portuguese is home to 21 faculty who specialize in Hispanic, Lusophone, and Catalan literatures and cultures, as well as Hispanic linguistics.

Bad business

As a former naval officer, Curtis L. Wesley II was immersed in an atmosphere of accountability. He has carried that background into his research as an assistant professor of management at the Kelley School of Business at IUPUI, where he studies corporate governance. In two controversial papers published in 2013, Wesley and his co-authors raised questions about unethical behaviors in business. “The Great Escape: The Unaddressed Ethical Issue of Investor Responsibility for Corporate Malfeasance,” co-authored with Hermann A. Ndofor of Texas A&M Mays School of Business and published in Business Ethics Quarterly, concluded that many investors benefit from management erroneously reporting firm earnings. The markets cannot discern between fraudulent reporting and unintended erroneous reporting, Wesley and Ndofor observed, so executive malfeasance may produce net gains for investors. Wesley and Ndofor propose the possibility of extending financial penalties beyond management and directors to include investors themselves. In “Providing CEOs With Opportunities to Cheat,” published in Journal of Management, Wesley, Ndofor, and Richard Priem (Texas A&M) explored how “information asymmetries”—complex information and lack of transparency—between CEOs and shareholders give CEOs the opportunity to commit financial reporting fraud. “Our findings indicate that having the opportunity afforded by information asymmetry may be all that is necessary for some CEOs to engage in fraudulent financial reporting,” write the co-authors. “The results support our contention that when shareholders have less information about the firm, managers have greater opportunity to engage in fraudulent activities.” They point to higher levels of board monitoring as one solution. Wesley points to personal accountability as well. “I’m a firm believer that being successful is an ethical imperative,” he says. “People are depending on CEOs to do the right thing. They’ve been given this responsibility to be the steward of the firm with hundreds and even thousands of people depending on them to make the right decisions.”
IU School of Medicine team coaxes stem cells into inner-ear hair cells

With a discovery by IU researcher Eri Hashino, scientists gained a better understanding of the inner-ear development process as well as possible paths to models for drug development or cellular therapies to treat inner ear disorders. A research team led by Hashino, Ruth C. Holton Professor of otolaryngology at the Indiana University School of Medicine, discovered a technique to transform mouse embryonic stem cells into key structures of the inner ear. By using a three-dimensional cell culture method, the researchers were able to coax stem cells to develop into inner-ear sensory epithelia—containing hair cells, supporting cells, and neurons—that detect sound, head movements, and gravity. The research was published in the journal Nature. Previous attempts to “grow” inner-ear hair cells in standard cell culture systems had worked poorly in part because necessary cues to develop hair bundles—a hallmark of sensory hair cells and a structure critically important for detecting auditory or vestibular signals—are lacking in the flat cell-culture dish. Hashino’s team determined that the cells needed to be suspended as aggregates in a specialized culture medium, which provided an environment more like that found in the body during early development. The team mimicked the early development process with a precisely timed use of several small molecules that prompted the stem cells to differentiate, from one stage to the next, into precursors of the inner ear. But the three-dimensional suspension also provided important mechanical cues, such as the tension from the pull of cells on each other, according to Karl R. Koehler, the paper’s first author and a graduate student in the medical neuroscience graduate program at the IU School of Medicine. Electrophysiology testing demonstrated that those hair cells generated from stem cells were functional and were the type that sense gravity and motion. Moreover, neurons like those that normally link the inner-ear cells to the brain also had developed in the cell culture and were connected to the hair cells.
Awards and expenditures

Awards by Direct Source
FY 2013

1. Federal, 52% $233,544,403
2. Nonprofit, 14% $64,278,035
3. Commercial/For profit, 14% $64,281,392
4. State of Indiana, 7% $31,254,168
5. Foundations, 6% $28,531,973
6. Higher Education, 6% $27,154,873
7. Other governmental, 1% $2,578,772

TOTAL $451,623,616

Technology Commercialization
FY 2009–13

<table>
<thead>
<tr>
<th></th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invention disclosures received</td>
<td>131</td>
<td>154</td>
<td>175</td>
<td>202</td>
<td>238</td>
</tr>
<tr>
<td>Licenses executed</td>
<td>34</td>
<td>27</td>
<td>39</td>
<td>38</td>
<td>35</td>
</tr>
<tr>
<td>Patent applications filed</td>
<td>210</td>
<td>244</td>
<td>302</td>
<td>331</td>
<td>399</td>
</tr>
<tr>
<td>Patents issued</td>
<td>8</td>
<td>15</td>
<td>28</td>
<td>26</td>
<td>35</td>
</tr>
<tr>
<td>Royalties, fees, milestones in millions of dollars</td>
<td>$5.9</td>
<td>$14.1</td>
<td>$11.1</td>
<td>$7.1</td>
<td>$5.9</td>
</tr>
</tbody>
</table>

To find out more, visit: iurtc.iu.edu

Research Expenditures
Department of Health and Human Services* and National Science Foundation

<table>
<thead>
<tr>
<th>Year</th>
<th>National Science Foundation</th>
<th>Department of Health and Human Services</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>$24</td>
<td>$153</td>
<td>$177</td>
</tr>
<tr>
<td>2010</td>
<td>$29</td>
<td>$167</td>
<td>$196</td>
</tr>
<tr>
<td>2011</td>
<td>$29</td>
<td>$177</td>
<td>$206</td>
</tr>
<tr>
<td>2012</td>
<td>$28</td>
<td>$163</td>
<td>$191</td>
</tr>
<tr>
<td>2013</td>
<td>$39</td>
<td>$171</td>
<td>$210</td>
</tr>
</tbody>
</table>

*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 2009–13

<table>
<thead>
<tr>
<th>Year</th>
<th>Federal</th>
<th>Non-federal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>$466</td>
<td>$202</td>
<td>$668</td>
</tr>
<tr>
<td>2010</td>
<td>$475</td>
<td>$220</td>
<td>$695</td>
</tr>
<tr>
<td>2011</td>
<td>$509</td>
<td>$231</td>
<td>$740</td>
</tr>
<tr>
<td>2012</td>
<td>$511</td>
<td>$213</td>
<td>$724</td>
</tr>
<tr>
<td>2013</td>
<td>$533</td>
<td>$239</td>
<td>$772</td>
</tr>
</tbody>
</table>

Research Expenditures by Unit*
FY 2013

1. **Medicine** $280,118,074
2. **Arts & Sciences** $105,983,253
3. **VP Research** $25,598,046
4. **VP IT** $14,292,661
5. **Informatics** $13,590,927
6. **Science** $13,544,008
7. **Education** $9,305,796
8. **Public & Environmental Affairs** $8,226,342
9. **Liberal Arts** $7,363,505
10. **Engineering & Technology** $7,156,400

*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.

Research Expenditures by Source
FY 2013

1. **Federal, 45%** $239,140,870
2. **University Internal**, 41% $218,896,238
3. **Foundations**, 6% $30,494,808
4. **Commercial**, 4% $19,711,963
5. **Nonprofit**, 4% $19,014,956
6. **State of Indiana**, 0.6% $3,019,929
7. **Higher Education**, 0.4% $2,279,214
8. **Other governmental**, 0.1% $560,399
9. **TOTAL** $533,118,376

*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 2013

1. **U.S. Department of Health and Human Services** $171,448,102
2. **National Science Foundation** $38,573,238
3. **U.S. Department of Defense** $10,021,749
4. **U.S. Department of Energy** $8,588,343
5. **NASA** $2,655,592
6. **U.S. Department of Education** $2,392,944
7. **Environmental Protection Agency** $1,022,672
8. **U.S. Department of Commerce/NIST** $697,398
9. **Director of National Intelligence** $668,078
10. **All other federal agencies** $3,072,754
9. **TOTAL** $239,140,870