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Candid Cameras

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Structural Changes

A College of Engineering facility ushers in a new era of biomedical engineering research at Notre Dame.

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For the last eight years the College of Engineering has used this phrase in many of its promotional materials. More than words, there is tangible evidence of the exciting path that the college has been traveling as it works to address the challenges of tomorrow and prepares its students to do the same.
Eight years ago I was attracted to the University of Notre Dame by Father Theodore Hesburgh’s vision of creating a great Catholic university. As president of Notre Dame for 35 years, and one whose contributions to the University were transformational, Father Ted envisioned an institution that provides undergraduate educational experiences of high quality, has world-class graduate education and research programs, and combines its Catholic mission with a strong commitment to diversity. As I now prepare to step down as dean of the College of Engineering, I am prompted to reflect on the extent to which these goals are being achieved and on work yet to be accomplished.

While there is never room for complacency, any objective assessment of our undergraduate programs would conclude that they are exceptional and distinctive. The first-year curriculum has been enriched; each of our degree programs has been strengthened; numerous opportunities are provided for undergraduate research; and our students leave with a good understanding of today’s societal, corporate, and global manifestations of engineering. We are blessed by a faculty culture that attaches a high priority to undergraduates and by undergraduates of high aptitude and character. Notre Dame’s uniqueness derives from a combination of the foregoing attributes with a faith-based environment characterized by strong commitments to community and service.

In graduate education and research, we remain a work in progress. Limited by our size, we have endeavored to think strategically and act collaboratively. We have experienced strong growth in areas such as environmental science and engineering, aeronautics and aeropulsion, nanotechnology, biomedical engineering, and wireless communications. Our graduate student enrollment and research expenditures have increased by approximately 40 percent and 100 percent, respectively, and we are on track to relieve our space constraints with two new buildings. However, the environment for funding research and for recruiting outstanding faculty and students is becoming ever more competitive, and we must maintain our resolve if we are to close the gap currently separating us from the nation’s top programs.

I will leave my position with a deep sense of gratitude to those who brought me to Notre Dame, to the faculty and staff with whom I’ve had the pleasure of working, and to the many alumni and friends of the college for their support. The next dean will find a strong and dedicated faculty with high aspirations, an excellent student body, and a University administration that is focused on taking Notre Dame to the next level. Opportunities will no doubt be accompanied by challenges, but I am optimistic that Notre Dame will continue on its trajectory of becoming a great Catholic university.

Frank P. Incropera
Matthew H. McCloskey Dean of Engineering
H. Clifford and Evelyn A. Brosey Professor of Mechanical Engineering
Launched in 1948 by Allen Funt, Candid Camera brought smiles to millions of people around the world. During the show hidden cameras caught ordinary people being themselves. There was no pretense; their reactions to the sometimes bizarre situations set up by the Candid Camera staff were genuine and funny. Today, using cameras to capture the actions and features of people in a variety of settings is no laughing matter.

In fact, the emphasis on human recognition and identification, specifically recognizing terrorists and other security related issues, has grown exponentially since 9-11. Authorities around the world are anxious to quickly and accurately confirm an individual’s identity or assess suspicious behaviors with or without that individual’s consent or, in some cases, their knowledge. Biometrics is the tool they are using.

A biometric measurement can be taken of any part of the body. Ideally, the measurement should be constant so that it doesn’t change over time or with a person’s mood. It should be distinctive so that no two people could exhibit the same features. As important, it should be something that can be easily and quickly measured, cataloged, and referenced.

A young and vibrant endeavor, the Notre Dame biometrics program is contributing substantially to biometrics research and recognition technologies:

From fables about a wolf in sheep’s clothing
to fears of federal Orwellian tactics.
The truth is that the field of biometrics —
separating people who mean to do harm
from their potential victims —
is part of the world we live in,
and it’s here to stay.
Fingerprints are perhaps the best known form of biometrics. Researchers in the College of Engineering are making breakthroughs in face, ear, gait, and iris recognition technologies. Kevin W. Bowyer, the Schubmehl-Prein Chair of the Department of Computer Science and Engineering, and Patrick J. Flynn, professor of computer science and engineering, direct the college’s biometrics efforts. “Although we started later than computer vision groups at other universities,” says Flynn, “we have made significant advances in this area in a relatively short time.” Both professors stress that the program’s success is due largely to the work of undergraduates, graduate students, and postdoctoral scholars. “Our projects have been national in scope with the potential to have very high impact,” he says. “We were able to identify niches and develop sufficient data to make credible statistical inferences in many areas.”

FACE RECOGNITION

In spite of warnings to not judge a book by its cover, people around the world have been judging faces since time began. Look at the portraits in any museum. The faces reflect beauty, youth, wisdom, age, innocence, and evil as seen through the artist’s eyes. Today, instead of trusting what can be seen, facial recognition systems are helping security forces distinguish the innocent from the evil beyond what is readily visible.
Wise as an owl, blind as a bat, clever as a fox, boarish, catlike, having horse sense ... people are often described in relation to animals. It’s not surprising that researchers might apply similar terms when attempting to categorize specific groups. In fact, in 1998 George R. Doddington, who was at that time the senior principal scientist with SRI International and visiting scientist at the National Institute of Standards and Technology, co-authored a paper on performance variability in speaker recognition systems in which he suggested that all people could be classified into one of four groups in regards to their speech patterns and how well they could be identified by such systems.

Doddington’s menagerie was based on sheep, goats, lambs, and wolves. Sheep represented the majority of the population. Readily distinguishable one from another, they were easy for recognition systems to identify and model. Goats were speakers who were more difficult for a system to recognize. A goat, for example, might not provide a match to itself from one day to the next. Lambs adversely affected the performance of a speech recognition system, because they were so similar one to another and were very easy to imitate. Wolves, according to the Doddington scale, also negatively affected recognition systems, because they were great imitators.

Notre Dame researchers are extending Doddington’s concept to facial recognition systems. “It is one of the most interesting new projects in our lab [the Computer Vision Laboratory],” says Patrick J. Flynn, professor of computer science and engineering. “Not only are we examining Doddington’s Zoo in the context of facial biometrics, but students are playing a key role in the process.”

Flynn and undergraduates Michael G. Wittman and Patrick M. Davis are hoping to determine if the zoo exists and to identify what percentage of the population can be found in each of the categories. Perhaps more interesting to the team is the possibility of applying the zoo concept to other biometric systems, such as iris recognition or three-dimensional face shape.

In addition to his work on this and other vision recognition projects, Wittman, a senior in the Department of Computer Science and Engineering, interned with the Intelligence and Information Systems division of Raytheon in Falls Church, Virginia, during summer 2005. He will begin working as a full-time Raytheon employee, a software engineer, in the Internal Biometrics research and development program later this summer.
added to a gallery of images. The Notre Dame collection is one of the largest databases of faces in the world, featuring images captured repeatedly from students, staff, and faculty throughout the University over a four-year period.

More than 75,000 images from the Notre Dame collection are being used as part of the 2006 Face Recognition Grand Challenge (FRGC), which is sponsored by the National Institute of Standards and Technology, Department of Homeland Security Science and Technology Directorate, the Federal Bureau of Investigations (FBI), the Intelligence Technology Innovation Center, and the Technical Support Working Group. Participating researchers are provided with the images and a six-experiment challenge which incorporates three-dimensional scans, high-resolution still images, multiple still images taken under a variety of conditions, multimodal face recognition, multiple algorithms, and preprocessing algorithms. The goal of the FRGC is to reduce the error rates in current systems so that they may be deployed for real-world applications.

**EAR RECOGNITION**

Ears are like fingerprints in that they are unique to each individual and, without surgical intervention, do not change shape throughout a person’s life. For this reason, ears have been used as biometric tools but much less frequently than faces or fingerprints. In fact, the United States Citizenship and Immigration Services, formerly
the Immigration and Naturalization Service, used to require that every applicant provide two identical photos showing the entire face, including the right ear and left eye, for use in visas or passports. This policy was changed in August 2004 to comply with the Border Security Act of 2003. All new photos must now exhibit a full-frontal face position in color.

The change in photographic requirements, however, does not negate the usefulness of the ear as a tool in biometric recognition. In a recent Notre Dame project, which was funded by the National Science Foundation and the Intelligence Technology Innovation Center, Bowyer and Ping Yan, a graduate student in the Department of Computer Science and Engineering, captured multiple images of ears from more than 400 individuals. One of the largest experimental investigations of ear biometrics ever conducted, Bowyer and Yan applied four different approaches to test the accuracy of their methods.

Among other variables, they studied three different landmark selection methods. A landmark on an ear, similar to one on the ground, provides a constant point of reference and measurement. The landmarks they used each featured two points: the first measured the distance between the triangular fossa and antitragus, the second between the triangular fossa and incisure intertragica, and the third measured the distance between two lines ... one along the border between the ear and the face and the other from the top of the ear to the bottom, reflecting the size of the ear.

They then applied Principal Component Analysis, also called “eigenear,” which is widely used in face recognition, to test for intensity, depth, and edge matching. Bowyer and Yan found that ears are geometrically complex and require a complex set of algorithms to assess the collected data.

Although the experiment was conducted under controlled circumstances, it appears that ear recognition based on a three-dimensional approach is more than 90 percent accurate. However, the results also suggest that while there is no significant difference between recognition performance using the ear versus the face, using both the ear and the face in a multi-modal system results in a statistically significant improvement in recognition.

**GAIT RECOGNITION**

What do the story of the prodigal son and Ashley Wilkes’ homecoming in Gone with the Wind have in common? Both the young man’s father and Melanie Wilkes identified a loved one from a distance. Their recognition was not solely for dramatic effect; the manner in which an individual walks can be an identifying feature. The most recent evidence of this was described in an article titled “Visual Analysis of Gait as a Cue to Identity,” which was published in the December 1999 issue of Applied Cognitive Psychology. The article indicated something known to anyone waiting and watching for a loved one’s return: humans can, with very brief exposure and under a variety of lighting conditions, identify other individuals by their gait.

Extensive research has been done to address how accurately a subject could be identified by the characteristics of his or her walk: How even are the strides? Is there a noticeable limp?
In the field of biometrics, fingerprinting is the oldest and, to date, the most successfully applied technique. The use of fingerprints as a means of identification, such as a legal and binding signature on official documents, is recorded as early as 1000 B.C. In 1686 Marcello Malpighi, a professor of anatomy at the University of Bologna, was the first to document and type fingerprints. But it wasn’t until 1880 that Dr. Henry Faulds suggested that fingerprints could be used as a means of personal identification. In an article published in “Nature,” he outlined a distinct classification system and described how best to capture and record prints.

Building upon Faulds’ work Sir Francis Galton became the first to prove that a person’s fingerprints remain the same throughout his life and that no two individuals have the same prints. In fact, he calculated that the odds of finding identical prints were approximately 1 in 64 billion. In 1892 Galton published *Fingerprints*, a book detailing the types (arch, loop, and whorl) and characteristics (minutia) of fingerprints, which are still used today.

Fingerprints, however, were not widely used to identify criminals until 1901, when Sir Edward Richard Henry began training Scotland Yard investigators in the Henry Fingerprint Classification System, a uniform system of identification that featured 1,024 classifications.

Another milestone in law enforcement technology occurred in 1902, when Alphonse Bertillon, director of the Bureau of Identification of the Paris Police, made the first identification of a criminal by matching an unknown print found at a crime scene with a print already on file. By 1903 fingerprinting technology was being used in the United States, and a few years later a central storage location for North American fingerprints was established in Ottawa, Canada. At its opening it held 2,000 sets of prints.

Congress established the Identification Division of the Federal Bureau of Investigation (FBI) in 1924, the basis of the bureau’s fingerprint repository, and by 1946 the division had processed 100 million fingerprint cards. By 1971 that number had doubled.

A computerized system of storing and cross-referencing criminal prints, the Automated Fingerprint Identification System, was established in the 1990s, enabling law enforcement officers to search millions of fingerprint files in a matter of minutes. By 1999 the FBI had phased out the use of fingerprint cards. Although the cards are still kept on file, the computerized fingerprint records for more than 33 million criminals can be accessed in a matter of seconds.

In addition to applications in law enforcement, fingerprinting technologies are being used in child identification kits for parents. They are also employed by companies in a variety of different applications and markets as biometric sensors. For example, companies are spending millions of dollars to erect firewalls and install intruder detection systems on their computer networks, but many are also replacing passwords with fingerprint sensors. These sensors can control laptops, computer mice, portable hard drives, and are even being used to personalize wireless devices. In some cell phone systems different fingers operate different speed dials or open separate buddy lists. Fingerprint biometrics can also control door locks and smart card readers.

Tried and true, fingerprinting is not the ultimate biometric. Nor can it be used to accurately identify everyone. The fingers of bricklayers, rock climbing enthusiasts, senior citizens, and toddlers often lack the ridges needed to produce a defined print. Other errors, technological or human, can also plague the identification process. For example, in May 2004 the FBI arrested Brandon Mayfield as a material witness in the March 2004 commuter train attacks in Madrid. FBI officials said Mayfield, an Oregon attorney who was also Muslim, had been identified as the source of a fingerprint on a bag of detonators connected to the attack. Mayfield was released two weeks later, after the FBI examined the prints of a suspect the Spanish National Police had correctly identified as the source of the print.

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IRIS RECOGNITION

Although some of the biometric techniques depicted by Hollywood are more science fiction than fact, iris recognition is one of the most accurate forms of identification known to man. The probability of the irises from two individuals being identical is estimated at 1 in $10^{72}$. Even identical twins have unique irises.

Iris recognition technology differs from retinal pattern technology. A colorful organ that surrounds the pupil, the iris acts like a shutter regulating the amount of light that the eye receives. It features fibers, furrows, freckles, and other patterns useful in a biometrics context. An iris is externally visible; a retina is not. Located in the back of the eye behind the cornea, lens, iris, and pupil, the retina is connected to the optic nerve. It helps process images. The retina also provides accurate
biometric information, because of the unique vessel patterns located in it. Like the iris, retinal patterns are also thought to remain constant throughout a person's life.

Benefits of iris recognition include the fact that it is a non-invasive form of technology. High-resolution cameras quickly capture, store, and analyze images without touching a person or damaging the eye. The challenge faced by iris recognition systems is rooted in the initial image capture. Currently, researchers acquire images from a stationary subject positioned within inches of a camera. In controlled facilities, such as a corporate laboratory or military base, the subject might sit or stand six to 12 inches away from a camera’s lens. Many controlled facilities also ask subjects to remove their glasses, although it is not clear how an image is affected if a subject is wearing glasses or contacts.

The cameras in automated teller machines, which can also capture iris images, operate best when a subject is 17 to 19 inches away from the lens. Most important in either application, the subject must hold completely still, remaining within camera range. There must also be proper lighting.

While these types of systems might work well in a corporate laboratory or on a military base, where individuals expect to be scanned for identification purposes, they are not yet practical for public places, where people are moving around and lighting may not be consistent from one side of a room to another. These are some of the factors being addressed by the Iris Challenge Evaluation (ICE), an independent evaluation of iris recognition technology being conducted by the National Institute of Standards and Technology.

Researchers at Notre Dame, in conjunction with ICE sponsors (the FBI, Intelligence Technology Innovation Center, National Institute of Justice, Technical Support Working Group, and the Transportation Security Administration of the U.S. Department of Homeland Security), have provided image data sets and software that ICE participants (academia, industry, and research institutes) will use as they assess and measure current iris recognition efforts. The goal of the challenge is to advance iris recognition technology so that useful images may be acquired at greater distances, from a variety of angles, under limited lighting conditions, and with or without the subject’s knowledge.

Students, staff, faculty, and others have been serving as volunteers, allowing College of Engineering researchers to capture face, ear, iris, and gait images as they continue their research in vision recognition systems. The University has participated in a number of national challenges, substantially growing the young program.
MULTI-MODAL BIOMETRICS

Although the adage “two heads are better than one” was written long before the advent of biometrics, Bowyer and Flynn contend it applies quite well. In fact, they suggest that the future of biometrics lies in the use of multi-modal systems. For example, iris recognition alone cannot be applied to everyone. One in 17,000 people in the U.S. have some type of albinism, which affects the pigment in their irises. Acquiring an accurate image of an albino’s iris is difficult. Involuntary eye movement can also confuse iris recognition systems. Speaker recognition systems will never work on a mute person. Gait technologies may trigger a false positive for someone who has back problems or has had hip replacement surgery or polio. Because of the involuntary motion associated with Parkinson’s disease, the faces of people afflicted with that disease are difficult to capture. Another segment of the population wears veils for religious reasons, which means that facial recognition systems will not work on them either.

In these cases, should authorities violate civil liberties with additional and more invasive searches? Or can using a series of biometric measurements, a multi-modal approach, help identify potential threats while maintaining personal freedoms? The benefit of multi-modal techniques, according to Bowyer and Flynn, is that they offer a robustness of data which provides more accurate assessments while maintaining most of those freedoms. But there is no simple answer. Still in its infancy, biometrics will continue to evolve to meet the challenges of identification, verification, and security that are prevalent in today’s world. It will continue to help nations assess what cannot always be seen with the naked eye.

ONLY HISTORY IS SECURE

Patrick Henry is famous for saying, “Give me liberty or give me death.” But he also said, “Guard with jealous attention the public liberty. Suspect everyone who approaches that jewel. Unfortunately, nothing will preserve it but downright force. Whenever you give up that force, you are inevitably ruined.” In the Historical Review of Pennsylvania, Benjamin Franklin wrote, “They that can give up essential liberty to obtain a little temporary safety deserve neither liberty nor safety.” Obviously, both founding fathers valued liberty, perhaps above all else.

Discussing his memorial tribute “Let’s Roll” in the April 2002 issue of USA Today, Neil Young called Franklin’s love of personal freedom into question. He said, “Benjamin Franklin said that anyone who gives up essential liberties to preserve freedom is a fool, but maybe he didn’t conceive of nuclear war and dirty bombs.”

It’s probable that neither Franklin nor Henry envisioned a day when a jet could fell a building and kill almost 3,000 people in a matter of minutes. Neither did they imagine a device small enough to hold in the palm of a hand but powerful enough to record a conversation inside a building or behind a wall. They certainly could not have conceived of nuclear war and dirty bombs.

Technology was as foreign to them as it is familiar to today’s society.

The question raised, however, is the same: Is security (safety) or personal liberty (privacy) more important? On September 12, 2001, most Americans would have gladly sacrificed a little convenience, even a little privacy, to change the horror of the previous day. Powerless to change the past, they (we) continue to search for answers, philosophical and technological, so that this particular piece of history can never repeat itself.

FOR MORE INFORMATION ABOUT COMPUTER RECOGNITION TECHNOLOGY AT NOTRE DAME, VISIT HTTP://WWW.CSE.ND.EDU/~CVRL.
Diane R. Wagner, assistant professor of aerospace and mechanical engineering, stands in the future Cell and Tissue Culture Laboratory. She specializes in tissue modeling, understanding the mechanical forces in the body and how they can affect biological tissues, prompting diseases such as osteoarthritis or disc degeneration. Wagner, who joined the University in 2005, is one of several College of Engineering faculty moving into the new bioengineering facility on the north end of campus later this summer.
Whether it’s bricks and mortar or flesh and bones, a solid foundation is key to a healthy future.

Fund-raisers leading a building campaign for a new hospital, school, or church often say “It’s not about a building.” They stress that the structure is simply a tool to increase the performance and impact of the health care, education and outreach, or religious activities performed within its walls. But sometimes it is about a building. Sometimes a building is the catalyst that sparks a rise to excellence, affecting a neighborhood, a community, or a world.

In July 2006 five faculty from the Department of Aerospace and Mechanical Engineering, one from the Department of Chemical and Biomolecular Engineering, and their graduate students and postdoctoral fellows will move from laboratories in Fitzpatrick Hall to a 25,000-sq.-ft. state-of-the-art facility dedicated to multidisciplinary research related to biomedical engineering applications.

Located on the north side of campus next to the Hessert Laboratory for Aerospace Research, the new building is visible evidence of the commitment the University has made to biomedical research. “This is not a me-too program or facility,” says Glen L. Niebur, associate professor of aerospace and mechanical engineering. “Although Notre Dame began biomedical research later than many universities, we have been very successful in teaming with other institutions, with medical schools, and with a variety of industry partners nationwide, including several major orthopedic manufacturers located in Warsaw, Indiana.”

Lack of a medical school on campus has not affected the development of the bioengineering program or the building, which houses laboratories for nano-mechanical characterization, biomaterials processing and characterization, cell and tissue culture, and tissue engineering. A tribology laboratory, tissue mechanics lab, manufacturing area, biomedical imaging lab, and histology and specimen preparation area are also part of the new facility.
“Moving into a new building is always exciting, particularly since we [the faculty moving into the facility] were able to work very closely with the architects to design cutting-edge research space,” says Timothy C. Ovaert, professor of aerospace and mechanical engineering. A key benefit of the new building, according to Ovaert, will be the synergistic environment created by placing faculty and students who share common interests together. “We will be able to focus more on research and interaction with other groups, instead of logistics.”

Ryan Roeder, assistant professor of aerospace and mechanical engineering, is looking forward to the new space for a number of reasons. “As flexible as the space in Fitzpatrick Hall has been, it was not designed for biomaterials processing or cell and tissue culture,” he says. “I am also looking forward to having all of my graduate students in the same space and being able to work closely with them and with other faculty.” For the past three years Roeder has been partially utilizing the lab space of JoEllen Welsh, professor of biological sciences. “Dr. Welsh has been very generous in allowing us to do all of our cell culture in her lab space, which puts an added burden on those facilities,” says Roeder.

Because most of the faculty who will be occupying the new building hold degrees in more traditional engineering disciplines, questions they often field include “What can engineers contribute to a biomedical revolution?” Engineers play a huge role in biomedical engineering. Combining the traditional strengths of engineers — a knowledge of materials and mechanical systems, experience in the design and control of systems, and expertise in materials processing — with the strengths of biologists and surgeons can impact society. It’s happening at Notre Dame.
For example, Steven R. Schmid, associate professor of aerospace and mechanical engineering, and James J. Mason, formerly a faculty member and now a researcher at Zimmer, Inc., worked with the Warsaw, Indiana, based company — a leader in the design, manufacture, and distribution of orthopedic implants and fracture management products — to produce devices that could be used in minimally invasive surgical procedures. Together, the team pioneered a hip fracture implant featuring curable, metallic and polymer components that allow for a 25mm surgical incision instead of the traditional 300mm incision. The new implant and replacement procedure causes less trauma and promotes a shorter hospital stay and faster rehabilitation process. Zimmer began clinical trials of the device in February 2005. With more than 350,000 hip fractures occurring in the U.S. annually, and approximately four percent of the patients who undergo hip fracture repair surgery dying during the initial hospital stay and another 40 percent needing long-term care, the potential impact is huge.

Similar projects on the horizon for Notre Dame researchers include a mechanically stable blood substitute, a bioartificial liver assist device, the development of synthetic bone substitutes, and studies of microdamage in bone (in relation to osteoporosis and osteoarthritis).

In addition, the Ernestine Raclin and O.C. Carmichael Jr. Hall, which houses the Indiana University School of Medicine-South Bend and the W.M. Keck Center for Transgene Research, was opened in 2005, expanding collaborative opportunities for engineering faculty.

Much has been accomplished to date, but much more will be accomplished as faculty continue to explore the intersection of engineering, biology, and medicine. “Our efforts, which mesh so well with the Catholic mission of the University,” says Schmid, “will impact the quality of life as we know it ... in very tangible and direct ways.”
Energy is vital to dynamic societies and healthy economies. Consider the effects of the August 14, 2003, blackout, the largest in the history of North America. Within 15 minutes of the initial outage, five power grids and more than 50 million people — from southeastern Michigan through Ontario and from northern Ohio to New York City — were in the dark. Many were without power for three days.

This was not an isolated incident; the power problem is a global one. In June 2003 Italian electricity firms ordered the first nationwide power cuts in more than 20 years. A year later China faced one of its most severe power shortages since the 1980s. In fact, several provinces imposed brownouts in an attempt to conserve energy. For the last several years Scottish and British officials have been warning that, without a significant investment to build power supplies and infrastructure, blackouts similar to the August 14 event could occur in their countries.

In the United States as politicians and power companies struggle with technical concerns, consumer confidence, and ethical issues — such as the roles of managers and regulators in the power industry — researchers in the Notre Dame Energy Center are studying cost-effective ways to produce clean, safe, and renewable energy, in order to lessen the country’s dependence on foreign oil and other fossil fuels and reduce greenhouse gas emissions.
The energy center was established in November 2005 to develop new energy technologies. According to Center Director Joan F. Brennecke, the Keating-Crawford Professor of Chemical and Biomolecular Engineering, the center also hopes to play a key role in energy education and literacy, the development of energy policy, and the exploration of the ethical implications associated with energy. Notre Dame researchers have a proven track record in energy related research, but with the creation of the center, they join many universities across the country actively pursuing clean energy technologies. “It is such a huge challenge,” says Brennecke, “that we cannot afford to have just one place working on it. We need the full force of our scientific and engineering expertise focused on this issue.”

At the same time, Brennecke stresses that the energy center cannot physically tackle all of the challenges associated with energy. Instead, the center will target five areas in which University researchers have expertise: energy efficiency; clean coal utilization; carbon dioxide (CO\textsubscript{2}) separation, storage, and usage; safe nuclear waste storage; and renewable energy sources.

The concept of being more efficient with energy sounds simple. After all, choosing an energy efficient light bulb for a floor lamp isn’t exactly rocket science. But for those interested in conserving energy, it’s as important as turning down the temperature of a water heater, upgrading leaky windows, insulating hot water pipes, or driving a hybrid vehicle. These and other “mundane” actions may seem insignificant when considering the global energy picture, but a commitment to using energy wisely while developing advances in energy efficiency, and other viable energy technologies, is vital in both the short- and long-term.

It is especially important if governments, industries, or consumers think they can rely indefinitely on fossil fuel reserves. According to Brennecke, if the usage of fossil fuels were to remain constant (zero population growth with no increases in usage), oil supplies would last for approximately 35 years, natural gas for 60, and coal for 400.

Engineers at Notre Dame and around the world have been looking for ways to extend fuel reserves by developing more efficient ways of generating power. For example, fuel cells, which function like batteries, are inherently more efficient than combustion power cycles and can generate electricity up to two times more efficiently than a traditional power plant. Unfortunately, because most fuel cells use platinum and other expensive catalysts, they are not cost competitive. Durability is another issue. Fuel cell systems need to be as robust and reliable as combustion engines to be effective.

In projects supported by the U.S. Army and the Indiana 21st Century Research and Technology Fund, College of Engineering researchers are targeting new and less expensive materials for methanol (direct methanol) and hydrogen (polymer electrolyte membrane/PEM) fuel cells. By changing the flow patterns within a PEM fuel cell (the units most often used in vehicles), they have already achieved a dramatic increase in the efficiency of a cell.
Sometimes seen as a reddish-brown layer of air above urban areas, NOx contributes to the formation of acid rain and nutrient overload that can deteriorate water quality. A significant contribution to acid rain is also made by emissions of SO$_2$.

Researchers are also exploring ways to capture and store the CO$_2$ produced when coal and other fossil fuels are burned, instead of releasing it into the atmosphere. One of the most promising processes involves the use of ionic liquids for flue gas and coal gasification separations.

Ionic liquids, organic salts that are liquid at room temperature, easily absorb a variety of gases. Researchers at Notre Dame have pioneered a technique using ionic liquids to separate CO$_2$ from the flue gas discharged by conventional power plants. The process is especially important to reducing greenhouse gas emissions that contribute to global warming.

According to the National Snow and Ice Data Center, summer ice covering the Arctic Ocean shrank to its smallest size in more than a century. The decades-long shift in ice cover is difficult to explain without accepting, at least in part, man’s impact upon the environment. An increase in CO$_2$ concentrations in the atmosphere has also occurred since the onset of industrialization. Today, CO$_2$ concentrations have reached approximately 380 parts per million, a number that’s expected to rise to 500 or more parts per million by 2050.

According to the Mineral Information Institute, the average American will use 588,906 lbs. of coal in a lifetime. Fortunately, it is prevalent in the United States, and estimates are that the global coal supplies would last 400 years. (Graphic supplied by the Mineral Information Institute.)
According to an Associated Press report dated April 29, 2006, “Taken together Exxon, Chevron, and ConocoPhillips made a profit of $8.19 for every $100 in sales. In contrast, Internet bellwethers Google Inc, Yahoo Inc., and eBay Inc. collectively turned a $19.20 profit on every $100 of their combined revenue.” So why aren’t politicians, consumers, and industry leaders clamoring to impose higher taxes on these Web giants too?

Perhaps the difference lies in the fact that society does not need the Internet to survive, in spite of what teenagers believe. It does need energy. But the blame for the energy dilemma cannot be laid solely at the feet of the oil giants. The Energy Information Administration (EIA) estimates that gasoline accounts for approximately 17 percent of the energy consumed in the United States. Likewise, even though the demand for electric power in the U.S. has risen by 30 percent in the last decade, while transmission capabilities have grown by 15 percent, power shortages cannot be attributed only to power companies.

Could it be that Americans are energy hogs? The EIA’s Annual Energy Outlook estimates that the average amount of energy used per person will continue to increase through 2030. Commercial energy use is also expected to rise, being affected largely by economic factors and population trends. Think about it: As Generation Xers age, they accumulate more disposable income, which is spent in hotels, restaurants, stores, theatres, and for transportation. In the ever-growing information age, there is also more need for electrically powered devices. The truth is that a discussion of energy policy is long overdue, yet changes would be unlikely to have an immediate effect since consumer and industry behavior is part of the problem. Consumers seem reluctant to scale back their usage, and industry is unlikely to make changes that negatively affect the bottom line without federal intervention.

Current technologies for separating CO₂ do so at a 30 percent energy penalty, meaning that 30 percent of the energy generated is lost in the separation process. The Notre Dame method offers the potential to significantly reduce this penalty and has garnered considerable national attention. Funding for ionic liquids research at Notre Dame over the last five years has exceeded $5 million.

Nuclear power does not rely on fossil fuels and creates no greenhouse gases that need to be sequestered. Yet nuclear power produces only 20 percent of the nation’s electricity. While countries like France and Japan have embraced nuclear power, the U.S. has been reluctant to build more nuclear power plants.

Part of President Bush’s Advanced Energy Initiative, the Global Nuclear Energy Partnership teams the U.S. with supplier and user nations. Its goals include development of a new generation of power plants; new technologies that would recycle spent fuel, reducing the volume of waste that would need to be stored in a geological repository; new small-scale reactors for developing countries; and enhanced safeguards that would make it more difficult to “divert nuclear materials or modify systems without immediate detection.”

The biggest problem with nuclear fission is what to do with the radioactive waste. Where should it be stored? How should it be stored? And, how long can it be safely stored before leaching into the environment?

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Accounting for 20 percent of the world’s electricity, hydropower depends on the volumetric flow of the water and the height from which it descends. One of the main advantages of hydrosystems is that they do not require fuel. Without a doubt the most identifiable source of hydroelectric power in North America is Niagara Falls. In 1893 water was first diverted from the Canadian side of the falls to generate electricity, and a 2,200 kilowatt plant was built just above the Horseshoe Falls. Today, approximately 2 million kilowatts of electricity are generated from a number of sites along the Canadian side of the falls. On the American side, additional power plants generate more than 2.4 million kilowatts.

The world’s largest producer of hydropower, Canada generates more than 70 percent of its electricity from hydroelectric sources. Austria produces 67 percent, Iceland produces 83 percent, and Norway produces virtually all of its electricity using hydrosystems.

Another source of renewable energy is geothermal power. The world’s first geothermal power plant was built in Larderello, Italy, in 1911. It remained the only industrial producer of geothermal power until 1958. Today, Larderello produces 10 percent of the world’s supply of geothermal electricity, powering a million households. Although global geothermal production has doubled in the last 20 years, geothermal power trails hydropower production. It is also not a viable option in many parts of the world, as not all geothermal areas have a high enough temperature to produce steam.

Can energy supplies from clean coal technologies or nuclear power meet the needs of a growing population? Or are other solutions needed? From 1900 to 2006, the world’s population more than quadrupled. During the same time period, energy consumption increased more than 16-fold. Today, there are 6.5 billion people who need energy to survive. By 2050, there may be 10 billion demanding their piece of the energy pie, except they will have fewer resources from which to draw.

The options open to them will likely be a combination of carbon-neutral energy (clean coal technologies if commercially viable), nuclear power (which, if used to address the entire projected need, would require the construction of a new nuclear power plant every day for the next 50 years), and renewable energy sources, such as hydropower, geothermal power, wind, biomass, and solar energy. Unlike renewable energy sources, such as hydropower, geothermal power, wind, biomass, and solar energy. Unlike fossil fuels, renewable energy sources never run out.

Researchers in the College of Engineering have pioneered a technique to separate carbon dioxide from flue gas that is potentially more efficient than current technologies.

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was added in North America, making it one of the world’s foremost implementers of wind power. In fact, the Statue of Liberty and Ellis Island are powered totally by wind energy.

Like other renewables, wind lessens dependence on fossil fuels, such as coal and natural gas, provides clean energy, and has the potential to support additional economic development. The wind turbines, which can stand alone or connect to a utility grid, operate up to 100 meters above the ground, where they intercept faster, less turbulent air. When operating at peak power, wind farms in the U.S. are expected to generate 25 billion kilowatt-hours of electricity in 2006.

Biomass fuels (energy stored in organic matter) provide three percent of all of the energy consumed in the U.S. and produce 9 percent of the world’s energy needs. Wood, agricultural waste, municipal solid waste, sugar or starch crops, grass straw, soy beans, and waste vegetable oil are all sources for biomass fuels, which can be converted to liquid fuels, such as methanol and ethanol, as well as to heat and electricity. Although a subject of great debate regarding the specific percentages involved, it may take almost as much energy (most likely in the form of fossil fuel) to produce one liter of biomass fuel as is obtained from burning one liter of the fuel. Currently, only the sugar/carbohydrate content of plants is used to produce biomass fuels; the higher the sugar/carbohydrate content, the larger the ratio between the energy produced and the energy consumed. So while this renewable energy source appears to be a promising alternative to gasoline, there are many aspects in need of further research — such as using the whole plant, including its cellulose, or developing crops specifically for use in biomass fuels — before these types of fuels are commercially viable.

Solar power can be used for heating and to produce electricity. In the simplest of terms, a solar cell converts light from the sun into electricity. A photovoltaic cell is composed of a semiconductor material that absorbs visible light and converts the incident light into electricity. Though a clean and sustainable source of energy, photovoltaic cells are not currently competitive when compared to other options. However, the decreasing cost of production and increasing demand for clean energy are likely to make photovoltaics a viable option in the future.

University researchers are working to reconfigure photovoltaic cells using nanomaterials. In particular, they are studying means by which cells and photocatalytic processes can be made more efficient and less costly through the use of nanoparticles and hybrid inorganic-organic materials.

As focused as the country seems to be on energy, or at least on gas prices, energy ... having the resources to power cell phones, computers, airplanes, grocery stores, and home heating systems ... has long been taken for granted. People joke about the quality of life today compared to 40 or 50 years ago: "When I was growing up, we didn’t have cable or iPods."

They share stories about hauling firewood or stoking coal stoves. They even suggest that if George Washington or Abraham Lincoln were alive today they wouldn’t recognize the country or know how to use most of the devices they would encounter.

The fact of the matter is that Washington and Lincoln would probably fare better in the 21st century than today’s consumers would in the 1700s or 1800s — with no Internet, no cell...
Undergraduates entering the College of Engineering have many opportunities. Among the most exciting are hands-on research experiences, particularly in the field of energy. This year four students were selected to participate in the Vincent P. Slatt Endowment for Undergraduate Research in Energy Systems and Processes. Junior Laura Adams, civil engineering and geological sciences; senior David Couling, chemical and biomolecular engineering; senior Mark Palladino, electrical engineering; and junior Peter VanLoon, computer science and engineering, were chosen as Slatt scholars.

The Slatt Endowment was created by Christopher (B.S., EE ’80) and Jeanine Slatt in honor of Vincent P. Slatt (B.S., EE ’43), the visionary incorporator of the National Rural Utilities Cooperative Finance Corporation (CFC). Founded in 1969, CFC provides financing for more than 1,050 electric cooperatives nationwide. These cooperatives serve more than 39 million people (12 percent of all U.S. consumers) and account for approximately five percent of electricity generating capacity. The endowment recognizes and supports the energy related research activities of undergraduates, from the use of fossil fuels and nuclear and renewable energy sources to the development of more efficient transportation and energy utilization systems.

This year’s projects highlighted a wide range of topics. Adams studied factors that could impact the release of radioactive materials from a nuclear repository, such as the facility in Yucca Mountain, Nevada. Her adviser was Peter C. Burns, the Henry J. Massman Jr. Chair of the Department of Civil Engineering and Geological Sciences.

Making the most efficient use of ionic liquids as industrial solvents, specifically for gas separations, was the focus of Couling’s research. Couling studied the equilibrium solubilities of different mixtures of gases in a variety of ionic liquids to determine the optimum mixture for gas solubility. His adviser was Joan F. Brennecke, the Keating-Crawford Professor of Chemical and Biomolecular Engineering and director of the Notre Dame Energy Center.

Palladino worked with X. Sharon Hu, associate professor of computer science and engineering, to address energy consumption in electronic systems. Preliminary results of the project, which included a novel cache design, were presented at the International Conference on Computer Aided Design, a premier conference in the field of computing.

VanLoon explored the feasibility of a new tunneling transistor that would require less power to change the transistor from “on” to “off.” A device built using such transistors would conserve energy. Working on the nanoscale with adviser Alan C. Seabaugh, professor of electrical engineering, VanLoon employed electron beam lithography and other processes available in the department’s nanofabrication facility.
On May 3, 2006, during an interview on NBC’s “Today” show, Rex W. Tillerson, the chairman and chief executive officer of Exxon Mobil Corp., was questioned about the company’s record profits and their relationship to skyrocketing gas prices. His response was pointed. He said, “We work for the shareholder ... Our job is to make the most money for them so their pension[s] are secure.” While charging what the market will bear and returning a good profit for investors are parts of any sound business plan, many would argue that the bottom line is not the sole factor that should be considered when dealing with energy in the 21st century.

From the responsible use of a shrinking supply of fossil fuels to the economic consequences and ethical implications of current energy policies, today’s college students will face serious energy challenges throughout their lives. In order to help students better understand the challenges while appreciating that engineers cannot operate in a vacuum, the College of Engineering introduced courses relating to energy, society, and the climate in 2005.

The first course, “Energy and Society,” is one of several Engineering, Science, Technology, and Society courses offered. It provides a comprehensive review of the role of energy in society and covers a variety of social, economic, and political issues associated with energy, as well as scientific and technical applications. Last semester under the direction of Dean Frank P. Incropera, the course instructor, engineering and non-engineering undergraduates studied different forms of energy, as well as the limitations of current technologies. They reviewed the economic and environmental impact of alternative energy sources, and they followed the actions of many of the global players, such as the Organization of Petroleum Exporting Countries (OPEC), Russia, China, and the United States. Most importantly, through consideration of ethical and social justice issues, they attempted to integrate their faith with decisions concerning future energy utilization and development. For more information on “Energy and Society” and other ESTS courses, visit http://www.nd.edu/~engineer/energy/ESTS.htm.

Another course, “Energy and Climate,” addresses the magnitude of world energy needs, quantifies the link between energy use and climate cycles, and identifies the challenges of producing environmentally friendly energy sources. “Part of what Notre Dame brings to the table,” says Joan F. Brennecke, director of the Notre Dame Energy Center and Keating-Crawford Professor of Chemical and Biomolecular Engineering, is the integration of research and teaching with regard to energy. It is vital for the next generation to understand how we utilize energy and incorporate it into our daily lives, so that they can make sound decisions about energy usage and energy policy.” Taught by Brennecke and Mark J. McCready, professor and chair of the Department of Chemical and Biomolecular Engineering, course topics include power cycle analysis, atmospheric chemistry and climate modeling, coal, biomass fuels, wind and hydroelectric power, weather cycles, and nuclear energy.
Collaborative Supercomputing Grid Established with Department of Energy Funds

A total of $6.5 million was appropriated by Congress from the U.S. Department of Energy to create a high-performance computer grid, the Northwest Indiana Computational Grid.

The grid will create a high-technology infrastructure connecting Notre Dame with Purdue’s West Lafayette and Calumet campuses. It will also connect the institutions with U.S. government research facilities, such as Argonne National Laboratory.

According to Sen. Richard Lugar, R-Ind., who worked with U.S. Rep. Pete Visclosky, D-Ind., to champion the project, the grid will offer a supercomputer network that operates at speeds much faster than that available elsewhere in the country. “This investment in technology,” he says, “is important for many reasons, including the innovative research it will foster in enhancing the national security of the United States.”

Two Faculty Named AAAS Fellows

Frank P. Incropera, the Matthew H. McCloskey Dean of Engineering and H.C. and E.A. Brosey Professor of Mechanical Engineering, and Wolfgang Porod, the Freimann Professor of Electrical Engineering, have been named fellows of the American Association for the Advancement of Science (AAAS). The AAAS is the world’s largest scientific society, serving more 120,000 members.

Incropera was cited by the organization for “distinguished contributions to the field of heat transfer and for significant contributions to engineering education as both a classroom teacher and an engineering dean.” A member of the National Academy of Engineering and one of the 100 most frequently cited engineers in the world, his research deals with fundamentals of heat and mass transfer and their application to energy and electronic systems.

Porod, the director of the Center for Nano Science and Technology, is the co-inventor of the Quantum-dot Cellular Automata (QCA) concept, a transistorless approach to computing. His research focuses on solid-state physics and its application to electronics, quantum devices and architectures for nanoelectronics, as well as the limits imposed by the laws of physics on computation.

Visclosky, who is the ranking democrat on the House Energy and Water Appropriations Subcommittee, believes the infrastructure created by the grid is key to Indiana’s economy in the 21st century. “We must have the high-technology infrastructure in place to attract the jobs of the future.”

The collective power of the grid provides researchers at both universities with the tools to perform sophisticated modeling and simulation for chemical, biological, and radiological dispersion during a terrorist attack. It will also help authorities predict the spread of a toxic substance, by determining the threat to the public and developing additional life-saving steps. Other applications include transportation and environmental studies for use in city planning, health-care management, biocomputing and the study of protein structures for synthesis of pharmaceuticals, and research in advanced carbon materials. In short, the grid will encourage and assist researchers as they address some of society’s most complex problems.

The grid will also be a tool for economic development as it supports the state’s plans to create more high-tech, high-wage, and high-skill jobs.
Paolucci Named ASME Fellow

Samuel Paolucci has been elected a fellow of the American Society of Mechanical Engineers (ASME). The rank of fellow is the highest level of membership in the ASME. It is conferred upon an ASME member with a minimum of 10 years of active engineering service who has also made significant contributions to the field. Less than three percent of the ASME members receive this honor.

Paolucci, whose research focuses on fluid mechanics, is the 10th member of the Department of Aerospace and Mechanical Engineering to receive such a designation. Other ASME fellows in the department are Viola D. Hank Professor Hafiz M. Al-Assil, Clark Equipment Professor Thomas C. Corke, Professor Patrick F. Dunn, McCloskey Dean of Engineering Frank P. Incropera, Professor Emeritus Thomas J. Mueller, Professor John E. Renaud, Professor Mihir Sen, Professor Emeritus Albin A. Szewczyk, and Professor Emeritus Kwang-Tzu Yang.

Faculty Honored for Publications

Several faculty in the Department of Chemical and Biomolecular Engineering have been recognized for their publications, many of which are topping the most accessed and highly-cited lists.

In February 2006, the Journal of Physical Chemistry A & B announced that 24 papers published since 2000 have garnered more than 100 citations. Four of these articles were authored by faculty in the Department of Chemical and Biomolecular Engineering: Joan F. Brennecke, the Keating-Crawford Professor of Chemical and Biomolecular Engineering; Prashant V. Kamat, professor of chemistry and biochemistry and concurrent professor of chemical and biomolecular engineering; and Edward J. Maginn, professor and director of graduate recruiting and admissions for the department.

Brennecke had two papers in the list: “High-pressure Phase Behavior of Ionic Liquid/CO₂ Systems” at No. 16 and “Solution Thermodynamics of Imidazolium-based Ionic Liquids and Water,” co-authored by Maginn, at No. 19.

Professor Kamat’s “Photophysical, Photochemical, and Photocatalytic Aspects of Metal Nano-particles” was the fifth most cited article on the list. Professor Maginn’s “Solubilities and Thermodynamic Properties of Gases in the Ionic Liquid 1-n-butyl-3-methylimidazolium hexafluorophosphate,” co-authored by Brennecke, was No. 24.

http://ame.nd.edu
Most of the stories coming from the Gulf Coast in the aftermath of the 2005 hurricane season have centered around human and economic tragedy, which is as it should be. People lost their lives, their homes, and their livelihoods. An entire city may have lost its identity. But there are also stories that lie beneath the surface, like the mold that’s proliferating in New Orleans.

An October 2005 report issued by the Mold Work Group of the Center for Disease Control and Prevention stated, “The duration and extent of flooding and the number of structures flooded as a result of Hurricanes Katrina and Rita make the likelihood of massive mold contamination in buildings a certainty.” This wasn’t news to Jennifer R. Woertz, assistant professor of civil engineering and geological sciences. She had already submitted a proposal and been awarded a grant from the Small Grants for Exploratory Research program of the National Science Foundation in September 2005.

At that time Woertz, in collaboration with Wilasa Vichit-Vadakan, the Clare Boothe Luce Assistant Professor of Civil Engineering and Geological Sciences, and Dustin Poppendieck, assistant professor of environmental resources engineering at Humboldt State University in Arcata, Calif., were finalizing plans to study eight homes in the Orleans Parish over a three-month period in order to determine the type and extent of mold growing in the homes, as well as establish a guide for safe reconstruction efforts in the area.

In addition to monitoring the moisture content of the materials in the homes, the team monitored the levels of mold in the ambient air. “Mold is hydrophobic,” says Woertz. “It’s very difficult for spores, which are two to five microns in diameter, to infest a material when the material is saturated. So we didn’t expect to record a lot of mold until the drying out process began.”

Shown left to right, Dustin Poppendieck, assistant professor of environmental resources engineering at Humboldt State University, and Notre Dame’s Assistant Professor Jennifer R. Woertz, Research Technician Kristine Mitchell, and Clare Boothe Luce Assistant Professor Wilasa Vichit-Vadakan prepare to enter some of the structures involved in their three-month study of mold growth in New Orleans.
In November 2005 as part of an American Mathematical Society report to the U.S. House Committee on Science, Joannes J. Westerink, associate professor of civil engineering and geological sciences, and Clint Dawson, professor of aerospace engineering and engineering mechanics at the University of Texas, presented “From Katrina Forward: How Mathematical Modeling Predicts Storm Surge.” During the presentation, they described the research that has been conducted over the last decade and how it has increased the accuracy of predictions regarding the extent and magnitude of flooding as a storm progresses.

Westerink’s research focuses on mathematical modeling and computer simulation as tools in forecasting storm surges due to hurricanes and tsunamis. He developed the Advanced Circulation Model (ADCIRC), an authoritative computer model for storm surge prediction, with Massachusetts Institute of Technology classmate Richard A. Lueftlich Jr., professor of environmental sciences and engineering and director of the Coastal Circulation and Transport Laboratory at the University of North Carolina at Chapel Hill. Westerink is also co-leader of the surge and waves team of an Army task force that is evaluating hurricane safety policies for New Orleans and southeastern Louisiana.

ADCIRC, used by Westerink and his team, is also used by the U.S. Army Corps of Engineers, the Federal Emergency Management Agency, researchers at Louisiana State University, and the state of Louisiana to help predict water levels during storms and design levees.

The report to Congress should prove useful as local, state, and federal officials continue to plan for what is predicted to be an active 2006 hurricane season. The

According to the National Oceanic & Atmospheric Administration (NOAA) of the U.S. Department of Commerce, an unnamed Category 4 hurricane was the deadliest to ever make landfall in the United States. It hit Galveston, Texas, in September 1900. More than 6,000 people were killed. The 2005 hurricane season was one of the most intense ever with a record number, 26 in all, of named storms.

The spores the team found, mostly penicillium and aspergillus, are two types of molds that can cause respiratory problems, triggering allergies or exacerbating asthma. They can also cause skin infections in people with weaker immune systems. “We’re expecting to see a variety of health problems arise in the months to come — affecting the evacuees returning to live as well as workers attempting reconstruction,” says Woertz. “Proper respirators will be vital for construction workers. But it is especially important that people whose immune systems are compromised, such as the elderly or small children, not return to contaminated homes.”

Woertz’s concern is that unlike asbestos and lead, which are controlled by strict Environmental Protection Agency guidelines, no clear cut ties exist between increased respiratory problems, such as asthma, and mold contamination. For this reason, there are no standards or threshold limits as to the amount of mold that is acceptable in a home. There are also no governmental certifications given to companies who claim they remove mold.

Another concern that the study addressed is the structural integrity of the buildings. Although it does not grow quickly, mold eats whatever it is growing on to survive. It is also very difficult to remove. Because it is everywhere, it is impossible to completely remove. Contractors in New Orleans will need to work under negative pressure, venting the air, and the airborne spores released by the demolition process, outside. The next step should involve a HEPA vacuum or filtration process, to make sure as many of the spores have been removed as possible. According to Vichit-Vadakan, should the mold attached to surfaces not be removed, it could cause dry rot and destroy the structural integrity of a building.

Atlantic Basin season, responsible for many of the storms hitting the U.S., runs from June 1 through November 30. Forecasters anticipate 17 named storms, nine of which will be hurricanes. Five of those will be major hurricanes. According to the Saffir-Simpson Hurricane Scale, which uses wind speed, estimated property damage, and potential flooding possibilities as markers, a major hurricane is one in which the wind reaches or exceeds speeds of 111 m.p.h. Between 1950 and 2000, there have been an average of two major hurricanes a year. Three major hurricanes were predicted for 2005, but seven occurred.
New Class of Materials Discovered

“No one has seen anything like these materials,” says Peter C. Burns, the Henry J. Massman Jr. Chair of the Department of Civil Engineering and Geological Sciences. He’s speaking of the actinyl peroxide compounds that he and Lynda Soderholm, a chemist at Argonne National Laboratory, discovered. These nano-sized compounds, which represent a new class of materials, are believed to be important in environmental systems because of the way they could impact the transport of heavy metals and radionuclides in geologic fluids.

Soderholm believe that these nanospheres most likely form in alkaline mixtures of nuclear waste, such as in nuclear waste tanks.

They encountered the materials during studies conducted in conjunction with the Environmental Molecular Science Institute at Notre Dame. As the research continued, the project was moved to Argonne because its facilities enabled safe interaction with neptunium. Argonne’s Advanced Photon Source was also used during the studies.

Formed from uranium and neptunium peroxide solutions, actinyl peroxide compounds self-assemble into nano-sized shells that may prove useful in a variety of applications. For example, if these nanostructures could be harnessed and manufactured, industry could use them as catalysts, computer chips, solar cells, flexible batteries, or data storage devices.

Project Confirms Skyscraper Design

The initial results of the Chicago Full-scale Monitoring Project as reported in the November 2005 issue of Engineering News Record show that U.S. design assumptions are generally valid in predicting building sway. The three skyscrapers featured in the study have been performing as previously predicted, although they have not yet faced a severe storm.

Ahsan Kareem, the Robert Moran Professor of Civil Engineering and Geological Sciences, worked in conjunction with Skidmore, Owings & Merrill (SOM), a leading architecture firm, and Canada’s Boundary Layer Wind Tunnel Laboratory. The team was funded by the National Science Foundation and is currently seeking more funding to expand the study.

The project involved fitting three Chicago buildings with accelerometers, which were able to detect each skyscraper’s motion along perpendicular axes, as well as any twisting movement. Data from the instruments were transmitted to a communication hub in Chicago’s SOM building and then relayed to Notre Dame. Results indicated that the buildings have been responding in accordance with their design, even though they were built when scale-model testing and computer modeling techniques were not as advanced as they are today.

The types of quakes identified from the more than 12,000 events recorded, include quakes generated by meteorite strikes; deep moonquakes, which occur approximately 700 kilometers below the surface; thermal moonquakes, which occur close to the surface as a result of temperature fluctuations at dawn when the sun hits the surface of the moon; and shallow moonquakes, which occur only 20 to 30 kilometers below the surface.

Although classified as “shallow,” these types of quakes are the most powerful and long-lasting. According to Neal, a few of the shallow quakes measured up to 5.5 on the Richter scale. “Most earthquakes last a minute or two,” says Neal. “Shallow moonquakes can last up to 10 minutes.” Because the seismometers were placed in a relatively small region of the moon, the data is inconclusive, but it does suggest that additional analysis is needed before constructing a permanent lunar base.
NSF Awards Funds for Wireless Emergency Response System

The National Science Foundation (NSF) Dynamic Data Driven Applications Systems program has awarded Associate Professor Gregory R. Madey, computer science and engineering, and Professor Albert-László Barabási, the Emil T. Hofman Professor of Physics, a $500,000 three-year grant for the development of an integrated wireless phone based emergency response system. The goal of the system, which would be capable of monitoring the activity of millions of wireless phone users in real time, is to collect and analyze data so that it can generate traffic forecasts, issue emergency advisories, and alert public safety and emergency response personnel. David Hachen, associate professor of sociology, is assisting Madey and Barabási.

Poellabauer Receives CAREER Award

Associate Professor Christian Poellabauer has been named a recipient of the National Science Foundation’s (NSF) Early Career Development (CAREER) Award for his proposal “Judicious Resource Management in Wireless Systems.” He is the 11th faculty member in the department to receive the award, which is the highest given by the government to faculty at the beginning of their careers.

Among other related issues, his research project seeks to develop efficient integrations of multiple wireless resources and to prevent the side effects of interdependency.

Also receiving the CAREER Award while they were members of the Department of Computer Science and Engineering were Jay B. Brockman, Surendar Chandra, Danny Z. Chen, Nikos Chrisochoides, Vincent Freeh, Sharon X. Hu, Jesus A. Izaguirre, Andrew Lumsdaine, Hsing-Mean Sha, and Aaron Striegel.

Chen Honored for High-impact Papers

Two papers authored by Danny Z. Chen, professor of computer science and engineering, have been recognized for their impact. “Skew Voronoi Diagrams,” published in the June 1999 issue of the International Journal of Computational Geometry and Applications (IJCGA), and “Topological Peeling and Applications,” published in the April 2003 issue of the same journal, were cited as the first and sixth most accessed articles in the IJCGA.

Bowyer Receives Award of Excellence

The Philadelphia chapter of the Society for Technical Communication has presented, Kevin W. Bowyer, the Schubmehl-Prein Chair of the Department of Computer Science and Engineering, with the 2005 Award of Excellence. The award, given annually, recognizes excellence in technical communication. Bowyer was honored for an article published in the spring 2004 issue of IEEE Technology and Society Magazine titled “Face Recognition Technology: Security versus Privacy,” which discusses the social controversy surrounding the field of biometrics in the wake of September 11. Bowyer’s research interests are in the areas of computer vision and pattern recognition, with a special emphasis on biometrics and data mining.
Laneman Receives Recognition from NSF and Thompson

Assistant Professor J. Nicholas Laneman, has received the National Science Foundation’s (NSF) Early Career Development (CAREER) Award for his project proposal “Toward a Renaissance in Finite Blocklength Information Theory.” Laneman is studying optimum blocklengths. Longer blocklengths lead to more reliable transmissions, but they also contribute to delays, which may be acceptable for some applications, such as e-mail or text messaging, but not for cell phone calls or video streaming. He and his students are testing for the optimum blocklengths of specific applications to balance the tension between reliable communication and tolerable delays.

In addition to directing the CAREER project, Laneman is also the principal investigator for the collaborative research project “Delay Constrained Multihop Transmission in Wireless Networks: Interaction of Coding, Channel Access, and Routing,” which is funded by the Theoretical Foundations program of the Computer and Information Science and Engineering division of the NSF. According to the NSF, the grant supporting this project was the largest among the 31 awards made by the program in 2005.

A paper Laneman co-authored with David Tse, professor of electrical engineering and computer sciences at the University of California at Berkeley, and Gregory W. Wornell, professor of electrical engineering and computer science at the Massachusetts Institute of Technology, “Cooperative Diversity in Wireless Networks: Efficient Protocols and Outage Behavior,” was also recently featured as one of the “New Hot Papers” by Thompson Essential Science Indicators. The paper was originally published in the December 2004 issue of IEEE Transactions on Information Theory.

Bernstein Named IEEE Fellow

Gary H. Bernstein, professor and associate chair of the Department of Electrical Engineering, has been named a fellow of the Institute for Electrical and Electronics Engineers (IEEE), “for contributions to techniques for fabricating nanoscale devices and circuits.” Bernstein’s interests are in ULSI fabrication and related areas, including the experimental study of quantum-effect devices based on semiconductor and metal systems; digital integrated circuits based on resonant tunneling devices, which have been demonstrated to operate at speeds greater than 10 Ghz; and the reliability of deep submicron metal interconnects for future ULSI applications. He joins 14 current engineering faculty who also hold the rank of IEEE fellow.

IEEE Recognizes Haenggi and Tabuada for Highly Accessed Papers

According to IEEE Xplore — an online directory of technical literature in electrical engineering, computer science and engineering, and electronics, the paper authored by Assistant Professor Martin Haenggi titled “Routing in Ad Hoc Networks: A Case for Long Hops” was ranked 52 among the top 100 documents accessed in November 2005. It was originally published in the October 2005 issue of IEEE Communications Magazine.

ScienceDirect’s TOP 25 Hottest Articles cited Assistant Professor Paulo Tabuada’s paper titled “Bismulation Relations for Dynamical, Control, and Hybrid Systems” as the sixth most read paper in Theoretical Computer Science. It was printed in the September 1, 2005, issue.

New Instrument Produces Nanostructures without Lithography

A team of researchers led by Alan C. Seabaugh, professor of electrical engineering and associate director of the Center for Nano Science and Technology, has developed a new instrument capable of positioning vacuum-deposited metals, semiconductors, and dielectrics with nanometer-scale resolution. The instrument enables the formation of three-dimensional nanostructures, shown here, without organic resists and customized masks (traditional lithography). The piezoflexure-enabled nanofabrication (PEN) technique can produce features at the nanometer scale and allow for the clean characterization of surfaces near room temperature.

Funding for the instrument was provided by the Nanotechnology Exploratory Research and Major Research Instrument programs of the National Science Foundation, as well as the University’s Office of Research.

IEEE Recognizes Haenggi and Tabuada for Highly Accessed Papers
Magnets are currently used in memory and data storage applications, however; they have not yet been used to perform logic functions. Researchers in the Center for Nano Science and Technology recently demonstrated magnetic quantum-dot cellular automata (QCA). Center Director Wolfgang Porod, the Freimann Professor of Electrical Engineering, and University researchers Alexandra Imre, Lili Ji, Alexei Orlov, and Professor Gary H. Bernstein, in conjunction with Gyorgy Csaba of the Institute for Nanoelectronics at the Technical University of Munich, applied magnetic systems to QCA implementations. In their demonstration nanomagnets hold information, and magnetic interactions execute logic functions.

One of the advantages of magnetic QCA is that it can operate at room temperatures, using little or no electricity. Magnetic QCA also leverages advances made by the magnetic-storage industry for patterned media and offers the potential of an all-magnetic information processing system.

Demonstrating the concept is the first step in the development of an all-magnetic system. It is important because current technology relies on traditional transistors, which are nearing their physical limits. “As we proceed, we would like to fabricate larger structures, beyond the single majority logic gate we demonstrated,” says Porod. “We would also like to realize electronic ways to set the input and to read the output.”

The concept for magnetic computing stemmed from QCA, a transistorless approach to computing which was pioneered at Notre Dame by Porod and Craig S. Lent, the Freimann Professor of Electrical Engineering. According to Porod, “The basic idea of magnetic QCA is the same as it was for electronic QCA, except that nanomagnets hold the information, and magnetic interactions are used to perform logic.”
In March 2006 the Minority Engineering Program in the College of Engineering hosted its first annual “Is Engineering for Me?” program for students in sixth through tenth grades. The goal of the day-long event is to introduce students to engineering as they explore what engineers do and how they contribute to society. In addition to hands-on engineering challenges, such as designing and constructing a Lego® building that can withstand the Notre Dame shaker table as it simulates a Magnitude 4 earthquake, students learn about high school and college requirements for engineers.

For more information, visit http://www.nd.edu/~mepnd.