Welcome to Research at Boston University 2007. This year we are delighted to present an expansion of the scope of the magazine to include research, scholarship, and creative activity in the humanities, social sciences, and fine arts. As in years past, you will also be introduced in these pages to researchers working in the natural sciences, medicine, engineering, and technology.

Given the extent of the scholarly activities in our seventeen schools and colleges, as well as dozens of centers and institutes, we realize it is impossible to provide a complete overview of research efforts at Boston University in one annual publication. But we hope the newly broadened scope will offer a more comprehensive and balanced perspective than in previous years.

Uniting researchers in all disciplines at Boston University is the conviction that research and teaching are complementary and that new discoveries augment and sustain our work as educators. Disc ut doceas—learn in order to teach. We hope this conviction is also reflected in the magazine.

Apart from the remarkable breadth and depth of traditional disciplinary research at Boston University, the articles demonstrate the many connections—some quite unexpected—across disciplines. As you will see, “Sights and Sounds: Explorations in the Arts” highlights collaborations between artists and scientists, while “Talking about Religion and Culture” looks at the ways in which faculty members from five very different academic disciplines—classics, economics, law, religion, and sociology—explore issues of faith. All of the articles illustrate the talent and ingenuity of our faculty and students and their engagement in the world around us.

While encouraging interdisciplinary, collective efforts, Boston University is also committed to fostering an environment that nurtures individual researchers. Our newly appointed Associate Provost and Vice President for Research, Andrei Ruckenstein, will seek to promote and advance this dynamic balance between strategic research initiatives and individual creativity. He will play a central role in enabling and enhancing research, scholarship, and inquiry throughout the University. In his own research—which extends across physics, molecular biophysics, and structural and computational biology—Dr. Ruckenstein has proven to be an influential and visionary leader. We are delighted to welcome him now and to entrust future issues of this magazine to him.

Like any publication of this nature, Research at Boston University is necessarily a snapshot in time. For the most up-to-date research news, please visit our website at www.bu.edu/research.
HEARING AND SPEAKING

THE CONVERSATION:

Although most of us take our ears for granted, the information that comes in through them goes a long way toward making us human. Even in the womb, we’re eavesdropping on the world around us, and, from the first day of life, we prefer the sounds of the language we’ve heard our parents speak to an unfamiliar tongue. Our alertness as babies to the sounds of familiar words turns us into the facile communicators we’ll be as toddlers. As adults, we need to hear ourselves to speak properly, and we often struggle in a world full of mechanical noise simply to listen to the words of the person sitting across from us.

It is the auditory system that makes possible the great conversation that is human life—and that system is almost fantastically intricate, involving not just our ears but a number of highly specialized brain structures whose functions scientists are only beginning to understand. Throughout Boston University, researchers are doing pioneering work to illuminate the ways in which we turn the universe of sound into an intelligible map of information and ideas.

Language Acquisition Before “Mama” and “Dada”

Leher Singh, assistant professor of speech, language, and hearing sciences at Boston University’s Sargent College of Health and Rehabilitation Sciences, studies language acquisition at its very earliest stages and quickly points out the irony of the way her target population is labeled: “Infant,” she explains, “comes from infans, which is a Latin term for ‘without language.’” Singh has done much to prove the contrary. Her work has demonstrated that babies as young as seven months are able to recognize and remember words they cannot yet say—and that this is an important prerequisite for speech. A recently completed longitudinal study found that children who were better at tracking words as babies had substantially bigger vocabularies at age three.

Clearly, it is not easy to evaluate word recognition in a population that cannot yet do more than burble. However, Singh and her research assistants are able to do it by training a baby to look at a flashing light while listening to a particular word over and over. Then, when the word is used in a sentence, the baby’s gaze will be directed toward the light measurably longer if he or she recalls the word.
Sinh explains what’s most interesting about her results. “We found that differences in vocabulary weren’t due to IQ. Demographic factors—parenting styles, whether the children were in day care, household income—had no reliable effects. What was predictable was that if babies did better on our memory tests at seven, nine, or ten months, they had bigger vocabularies at age three. Clearly, we are picking up on something developmental.”

A number of the infants identified in Singh’s study as being at risk for language delays were indeed independently flagged by their pediatricians at between 18 and 20 months. Singh points out, “Language delays are not just about vocabulary, but vocabulary is clearly a big part. It’s important to identify the risk markers as early as possible, because language acquisition becomes more difficult the older a child is.”

Helping Singh uncover the ways babies master language is undergraduate Chandni Parikh, a human physiology major. “As a sophomore, I wanted research experience,” Chandni explains, “and Leher Singh was very welcoming. Fortunately, I love kids.”

Over the course of the last three years, she assisted Singh with the longitudinal study of infants’ word recognition. Thanks to a grant from the Undergraduate Research Opportunities Program (UROP), Chandni was able to spend all of last summer in Singh’s lab, helping to finish the study. “It was an amazing experience for an undergraduate. My sister is a senior in high school and has friends applying to BU. I tell them all, you have to do UROP!”

She recently helped Singh conduct a study on affect. Chandni explains, “We played certain recorded words to babies, with either a high or a low affect—in other words, with a happy or neutral tone. Then we gave them the same words, in the context of a sentence, a day later. The children who had heard the words in a happy tone recognized those words far better the next day, even when they were now said in a neutral tone. The children who’d heard those words in a neutral tone couldn’t recognize them a day later, even if they were now said in a happy tone.”

“It seems that it’s better for kids to learn language in ‘motherese,’” says Chandni, referring to the slow, musical, hyper-inflected, and emotional style of speech adults tend to use with babies. Singh is currently interested in seeing whether the lack of such a preference for “motherese”—or other early indicators that language acquisition is not progressing normally—can be used to predict particular disorders. For example, collaborating with the Autism Center at the University of California-Davis Medical Center, she has found that the six-month-old siblings of autistic children—who are at a high risk for autism themselves—tend to prefer more neutral speech to “motherese.” Eventually Singh’s work may allow autism to be identified months or years earlier than it generally is today and allow therapies to be initiated in infancy.

Singh seems to be inspired by the mystery at the heart of human speech. “Language is an incredibly complex system,” she says. “Most of us can’t characterize its grammar until we learn a second language in school. Yet we have an implicit knowledge of the system’s rules and use them before we can tie our shoelaces.”

She admits that working with a pre-verbal population prone to crankiness when sleepy or hungry can be challenging. “Babies are not sympathetic to the fact that you need the data for some deadline,” she laughs. “But the value of the questions you can ask with them outweighs everything else.”

For more information, see http://people.bu.edu/leher

Three Dimensions from Two Ears

If language is an extremely complex system, hearing is another. H. Steven Colburn, professor of biomedical engineering and director of BU’s Hearing Research Center, emphasizes, “Even putting aside the biology and just trying to solve it from a pure engineering standpoint, the interpretation of sound is a messy problem.”

“The auditory system,” he explains, “has no spatial dimension, other than the fact that we have two ears. Sound arrives in the form of two pressure waves that vary in time. We have to create a sense of space from these two temporal wave forms.”

Colburn’s work focuses on the ways in which we exploit the two reception points of our auditory system—our binaural hearing—to interpret a three-dimensional universe. Our pair of ears help locate a sound in space in two ways. First, if a sound is on one side of us or the other, our head “shadowed” the sound, making it less intense from the more distant ear. Second, there is also a slight timing difference between the moment that the sound arrives at the closer ear and the moment it arrives at the farther one, which allows us to determine where the sound lies in the horizontal plane.

“We can perceive a five or ten micro-second difference. That blew my mind when I learned it,” says Colburn, who, as a graduate student, arrived at the study of hearing from an interest in signal processing in the field of electrical engineering.

Colburn points out how challenging such fine analysis is in a noisy environment, where we not only have to “slice up” the pressure wave to identify the sources of various noises, but we also have to regroup the relevant parts of the sound in order to pay attention to, for example, one particular conversation. “This ability to sort out the sources of sound and control which one you listen to has long been described as ‘the cocktail party effect.’ It’s the challenge I’m interested in, but I don’t mean to imply that it’s the only major challenge in hearing. However, it is the one hearing-impaired people complain about most.”

Colburn explains that modern life is organized in such a way that a sophisticated task is made even more difficult. “We’ve structured our environment today—with traffic noise, manufacturing noise, mechanical noise—so that our expectations are at the limits of what we can do,” he says.

In his lab, Colburn tests the limits of the auditory system in people with normal hearing, as well as in those with impaired hearing. His work has important implications for people whose hearing loss requires a cochlear implant. “Most people with a single cochlear implant do pretty well in simple environments, but they still have great difficulty in noisy environments.”

Colburn’s work may eventually offer a strong argument for two implants and may also illuminate ways in which implants need to be improved in order to function together with something approaching the finesse of two ears. “Just as we have better depth perception with two eyes,” he says, “we have better spatial localization with two ears.”

For more information, see www.bu.edu/dbin/bme/faculty/?prof=colburn.
Eavesdropping on the Conversations Between Neurons

Herbert Voigt, professor of biomedical engineering, also studies the ways in which our brain localizes sound. However, his interest lies in a part of the brain that interprets sound when our binaural hearing offers no clues, because the sound is equidistant from both ears in the medial plane either overhead or beneath us.

Here, “spectral notches” are the localizing information—the fact that thanks to the shape of our outer ear, energy is pulled out of a sound at certain frequencies, depending on its elevation. This spectral notch analysis is done in the dorsal cochlear nucleus, part of a brain-stem structure that is the first stop in the brain for information the auditory nerve has brought from the ear.

“When I was a graduate student,” Voigt points out, “the literature suggested that the dorsal cochlear nucleus was vestigial in humans, a meaningless leftover. Now we know it does spectral notch detection, and possibly much, much more. It may even be involved in the preliminary analysis of speech. Thanks to resonances of the vocal tract, there are spectral peaks and notches that characterize vowel sounds, too.”

Voigt’s research uses gerbils to unravel the neural architecture of the dorsal cochlear nucleus, because gerbils, like humans, hear very well at low frequencies. Working with graduate student Han Zheng, Voigt has developed a computational model of the gerbil’s dorsal cochlear nucleus that predicts the ways that key neurons will react when they are stimulated by particular sounds—as well as the ways different kinds of neurons converse with each other, either to excite or inhibit each other, depending on the qualities of the sound stimulus.

Currently, Voigt is recording the ultrasonic vocalizations of gerbil pups calling for their mothers. These are then played back for adult gerbils, so Voigt and his team can record the neural activity caused by this behaviorally significant sound.

Working with graduate student Rapeechai “Pom” Navawongse, Voigt has developed a head stage implant that allows an electrode to be inserted into a single neuron in the dorsal cochlear nucleus without anesthesia or a decerebration that destroys the feedback from the upper brain. Voigt emphasizes that the neural responses of an awake and intact animal are likely to give a far more illuminating picture of the ways that the brain processes sound.

“Most studies of the central auditory system,” says Voigt, “have been in the anesthetized brain, so we really have no clue what’s going on yet.”

For more information, see www.bu.edu/dbin/bme/faculty/hfv.

A head stage implant developed by Herbert Voigt is poised to shed new light on the central auditory system by allowing an electrode to be inserted into a single neuron without anesthesia or a decerebration that would destroy feedback from the upper brain.

“At one time, the literature suggested that the dorsal cochlear nucleus was vestigial in humans. Now we know it does spectral notch detection, and possibly much, much more.”

Melanie Matthies, associate professor in Sargent College’s Department of Speech, Language, and Hearing Sciences and associate dean for undergraduate programs at Sargent, focuses on the relationship between hearing and speech.

“We’re constantly monitoring our speech,” explains Matthies. “Even people with normal speech who experience significant hearing loss as adults may wind up with imprecise articulation. They can have trouble modulating pitch and loudness.”

Matthies says that people with hearing loss may speak loudly simply because they are not aware of their volume. “Another theory is that we’re desperate to hear our own voices. So we raise the volume or stress to get more auditory feedback—or even just to get the feeling we get when we’re speaking.”

Matthies’ work has done much to illuminate this connection between auditory feedback and speech production, though she is quick to point out that she’s worked with a long-time team of collaborators, who include speech scientist Joseph Perkell of MIT, cognitive and neural systems expert Frank Guenther of Boston University, and psychologist and linguist Harlan Lane of Northeastern University, allowing her to come at the problem from many different angles.

To Speak, We Have to Hear

Matthies is the audiologist in this group, and the subjects of their studies are people with normal hearing as well as those with hearing loss, including some people whose hearing loss is severe enough that they are given cochlear implants.

“A replacement cochlea is a very sophisticated electronic substitution,” she explains.

The cochlea is the part of the ear that transduces sound waves to electrical signals that are sent to the brain. It has a tonotopic organization: particular frequencies go to particular spots. “With an implant,” she continues, “since there are a limited number of channels, it’s a tricky thing to divide up the signals in an intelligent way.”

In the lab, she’s been able to use software that simulates different kinds of cochlear implant signals to help pinpoint what information is most important for optimal speech production. Working with the Massachusetts Eye and Ear Infirmary, she’s also followed the developing articulation of people first given implants. Using contrasting vowel sounds, as well as consonant pairs such as “r” and “l,” Matthies has documented significant improvement with a cochlear implant in people whose speech had previously deteriorated due to hearing loss.

“And with cochlear implants,” Matthies emphasizes, “there are huge improvements in people’s lives far beyond the detailed articulation that we study. They’re less tired by communication. They don’t withdraw from society. They continue talking.”

“People want to be intelligible,” she says. “They want to be understood.”

For more information, see www.bu.edu/sargent/about/faculty/m侣hies.

—Michele Owens
When Aaron Spevack began his doctoral work in Islamic studies at Boston University in the early fall of 2001, he considered his field to be somewhat esoteric—culturally and historically rich, but off the radar of the majority of Americans. Then came September 11, and suddenly the questions Spevack was examining—what is Islam, and what do Muslims believe?—became profoundly relevant. As the field was transformed by events on the world stage, scholars of Islamic studies began to expand the purview of their research. “Are we looking at Islam through a broad enough lens to be able to teach undergraduate classes, to write the popular texts on the shelves of Barnes & Noble?” Spevack asks. “Are we getting beyond the question ‘Why do they hate us?’ to understand Islam, and Muslim culture, more fully?”

In considering these questions, Spevack joins a community of more than 50 Boston University scholars from departments across the University and from nations around the globe who are engaging with topics of Muslim history, society, and culture. With the founding last year of the Institute for the Study of Muslim Societies and Civilizations (SMSC), the University has established a gathering place for these researchers, who share a common goal: not to define Islam but to explore, and then to teach about, the diversity of voices that together make up the Muslim world.

Understanding Islam

Islamic studies at Boston University has a long and distinguished history, but for many years researchers scattered across departments worked more or less independently. Since the formation of the new Institute for the Study of Muslim Societies and Civilizations, these faculty and graduate students have been brought together as members of an extraordinary community of scholars at BU.

The 29 faculty members and 25 graduate students affiliated with the SMSC study Muslim societies from a variety of angles: political science, anthropology, international relations, sociology, archaeology, women’s studies, literature, law, and art, among many others. They research and write about cultures and peoples who speak Arabic, Urdu, Persian, Turkish, and Bengali—as well as Chinese, French, and American English. “We truly are global in our interests and our expertise,” says SMSC director Herbert Mason, a University Professor and the William Goodwin Aurelio Professor of History and Religious Thought. “We have professors who are experts on Indonesia—which has the largest Muslim population in the world—as well as India, South Asia, and Central Asia. We have experts on Islam in America. And we didn’t
The notion of understanding, with its dual meanings of learning and of appreciation and acceptance, is at the heart of the institute’s goals.

His research sparked by years of wondering “why the Muslim world is in the eye of virtually every storm,” Husain Haqqani, a former journalist and diplomat in Pakistan, is trying to change attitudes and rhetoric in both the Middle East and the West.

have to recruit to make this possible; the professors were already here. We simply brought them together.”

And together they are working to build a world-class center for scholarship and teaching. In its first year, the SMSIC has become the point of origin for a variety of initiatives at Boston University, from developing new graduate programs that foster the study of Islam and Muslim cultures across the University curriculum to creating new graduate and postgraduate fellowships. Under the direction of Shahrizav Mutafa, the Arabic division of the recently restructured Department of Modern Languages and Comparative Literature is thriving. More than 130 students are currently studying Arabic at BU, and enrollments in Persian, Turkish, and Urdu language courses have also been increasing.

Underscoring the broader University commitment to support research in Islamic studies and related topics, the Howard Gotlieb Archival Research Center has recently acquired four major libraries of Middle Eastern and Central Asian primary and secondary texts. As the foundation of a major Islamic studies collection at BU, these libraries will enhance the institute’s scholarly resources as well as its ability to attract top-level faculty, graduate students, and other researchers.

In support of its growing scholarly community, the institute has become a vital home for collaboration, both between faculty and graduate students and across disciplinary lines. As Mason explains, “There’s no more crucial subject on the world stage today than Islam. And there is no greater need than understanding Islam.”

That notion of understanding, with its dual meanings of learning and of appreciation and acceptance, is at the heart of the institute’s goals. “Our mission here is very simple,” Mason says. “We seek to study, to teach, and, most importantly—to learn from these cultures.”

For more information, see www.bu.edu/smsicinst

The State of the Muslim World

In speaking about the origins of his current research, Husain Haqqani recalls a Newsweek cover from October 2001. Across a photo of a Pakistani child brandishing an automatic weapon were inscribed four troubling words: “Why They Hate Us.”

The director of BU’s Center for International Relations, Haqqani came to the United States after a career as a Pakistani journalist and statesman. He is a former ambassador and advisor to Pakistani prime ministers Benazir Bhutto, Gohulam Mustafa Jatoi, and Nawaz Sharif. He is also a practicing Muslim who studied in a madrassa, or traditional Islamic school, in Pakistan.

But throughout his distinguished career, one question has haunted him. “I have always wondered why the Muslim world is in the eye of virtually every storm, in my lifetime at least,” he says. “The Middle East is a cauldron. The India/Pakistan conflict has a Muslim dimension. In Russia, there’s Chechnya, another Muslim dimension.”

Why is the Muslim world plagued by instability, undemocratic governments, and sectarian violence? As Bernard Lewis asked in the title of his most recent book, “What Went Wrong?”

Whether we speak of understanding or use a vocabulary of terrorism and war, the words we choose can be as important as the message we seek to convey. Our leaders may be talking about building relationships—“between the Muslim world and the West,” but their very phraseology betrays a tacit difference between two disparate entities.

As a scholar of literature and Arabic language in the Department of Modern Languages and Comparative Literature, Shahrizav Mustafa is attuned to the significance of language’s nuances. In recent years, he has heard in the conversations of contemporary Muslim intellectuals the language of the Qur’an—not only in religious and political discourse, but in the arts as well.

For his current project, Qur’anic Negotiations: Contemporary Muslim Writers and the Holy Book, Mustafa is studying the varied ways in which Muslim authors use the Qur’an in their literary writings to critique political and social issues, to examine issues relevant to Muslims’ lives, and to spark dialogue about religion that might otherwise be censored.

These dialogues are happening worldwide: Mustafa’s study includes writers from Europe, West Africa, the Middle East, and Asia, from the United States and Canada to India and Turkey. For more information, see www.bu.edu/ir/faculty/haqqani.html.

Engaging with the Qur’an

Though Haqqani hopes his message will reach Muslim listeners, he believes that his research has something to teach Western policy makers as well. “Basically, I am saying that this is an entire section of the world that is reeling from the trauma of its decline,” he says. “How can the United States and other Western powers build relationships with the Muslim world without understanding what happens in the Muslim mind?”

For more information, see www.bu.edu/ir/faculty/haqqani.html.

What unites the authors who tell these stories is an interest in using an ancient holy text as a lens through which to examine the challenges of modern life.

The books in Shahrizav Mustafa’s office showcase his wide range of scholarly interests, including Irish drama, English poetry, Jewish-American fiction, and Iraqi fiction and poetry.
People do believe in the centrality of their faith, but they are not afraid to think about and examine it.

authors’ use of the Qur’an to critique the status of women both in Muslim societies and in the Qur’an itself. In the story “My World of the Unknown,” for example, the religiously observant author Alifa Rifaat depicts two women who consummate a lesbian relationship by reading the Fatiha chapter of the Qur’an; according to tradition, the Fatiha shows her characters engaging with the Qur’an as they make their way through their daily lives amidst changing attitudes toward Islam in the post-9/11 West. Mustafa sees literary works as a model for the way Muslims in Diaspora, Kibria, an associate professor in the United States in 1990 to study Irish literature at Indiana University, and his scholarly publications include writings on Irish drama, English poetry, Jewish-American fiction, and, in recent years, Iraqi fiction and poetry. But it was only after September 11, 2001, he says, that he became aware of how essential the Qur’an was becoming in Muslims’ lives.

He soon found the text’s significance reflected in the literature he studied. And in delving more deeply he discovered that Muslim writers have used the Qur’an for a wide range of purposes in their works. Some of these are deep subversive, as in the case of female

Muslims in Diaspora

Nazli Kibria has described her work as “part of a larger scholarly project of unravelling the ‘Islam versus the West’ framework, of digging beneath the polarizing rhetoric to uncover the complex realities of people’s lives.” Like Shakir Mustafa, Kibria, an associate professor in the Department of Sociology, is interested in understanding how individuals construct a sense of self in the context of the ideas and conditions that shape the lives of today’s Muslims. “What I have to teach is one very simple idea,” she says. “People who are Muslim, and who claim a Muslim identity, are not all the same. They have very different views—that’s true even among those who have orthodox views.”

Kibria’s forthcoming book, Muslims in Diaspora: Bangladeshis at Home and Abroad, is the product of several years of fieldwork, incorporating more than a hundred interviews with Bangladeshis who have left their home country either to work temporarily in the Middle East or to settle permanently in the United States or Britain. In her research she sought to explore how these immigrants’ identities are shaped by Islam and Muslim identity both internally, in terms of their relationships to their culture and their faith, and externally, in terms of how they are treated by others in the wider communities in which they live and work. She also gained insight into the recent rise of “Islamization,” a society-wide shift toward a more stringently fundamentalist practice of Islam. She calls this new, orthodox form of religion “revivalist Islam,” because it frequently represents a change from the Islam with which its adherents were raised. “I want to show how people understand themselves and what it means to be a Muslim,” says Kibria, who is herself a Muslim of Bangladeshi origin. “A lot of the discussions I see in the popular media here, when they talk about radical Muslims, there’s this sense that ‘They were just born like that,’ as though it’s an innate, almost a biological, quality.”

But in reality, Kibria’s research shows, the adoption of revivalist Islam is a social process shaped by changes in the course of people’s lives and the lives of the community. In some contexts, her respondents identify their conversion to orthodox Islam as a reaction to what they perceive as Western culture’s immorality or materialism; others describe finding a sense of community—and a haven from the stigmatization of Muslims in the West—as members of the global Ummah. But she found that in fact people’s reasons for turning to revivalist Islam differed from place to place and from individual to individual. For example, she spoke to young people who looked to an Islam different from that of their parents as a means of establishing an identity which distinguishes them both from their immigrant families and from the dominant society.

In Muslims in Diaspora, Kibria explains that the worldwide rise of Islam—and particularly of orthodox Islam—is far from the monolithic global movement it’s often portrayed to be. And she finds in her work a lesson of hope: “In my research you see people grappling with very complex questions, and responding differently to different circumstances,” she says. “Rather than this sense that Muslims are somehow ‘different’ from the rest of the world, you get a sense of the human condition that everyone shares.”

For more information, see www.bu.edu/sociology/fac-kibria.html.

“People who are Muslim, and who claim a Muslim identity, are not all the same. They have very different views—that’s true even among those who have orthodox views.”

Top: The front of a public elementary school in East London, named after Kobi Nazrul Islam, one of the national poets of Bangladesh. East London is home to one of the largest Bangladesh settlements in Great Britain."
From respiration to muscle movement, biological processes beneath the surface of all living things literally pulsate with electricity. By studying bioelectric activity—or by using electrical devices to probe biological systems—researchers at Boston University are discovering a lot about how everything from microbes to men function and malfunction. As a result, they’re sparking advances in fields as diverse as early disease detection and sustainable energy technology.

**Tapping the Power of Microbes**

Alternative energy proponents tout the hydrogen fuel cell as a new technology that could help reduce global warming and dependence on foreign oil. While hydrogen shows great promise as a cleaner, greener fuel source, refining it into a usable state can be expensive, and accessing supplies may be difficult in some geographic areas. There is, however, a much cheaper and more ubiquitous source of energy for a fuel cell: bacteria.

A microbial fuel cell resembles any other electrochemical fuel cell, except the conversion of the fuel source into electricity is transacted by one of several common species of bacteria. Feed a microbial fuel cell anything the bacteria can grow on, and the bacteria will split it into electrons and protons. As the protons flow through the cell on one side and recombine with oxygen on the other, an electric current will flow across the device and power whatever is attached to it. Such bacteria are called electrogens.

One promising microbial electron, a novel species of bacteria called *Shewanella oneidensis*, can convert glucose and other sugars into electrons during respiration and transfer those electrons to metals or electrodes. Unfortunately, the current produced is insufficient for practical applications beyond a single lightbulb. The maximum current output by electrogenic bacteria in the fuel cell is approximately 100 watts per cubic meter. That’s about one-tenth the input electrical energy contained in the sugars upon which the bacteria feed. But biomedical engineer Timothy S. Gardner believes this energy can yet be captured and exploited.

“We’re trying to tweak the genetics of these organisms to direct as close as possible to 100 percent of the fuel (sugar sources) to respiration and therefore to current production, rather than to generate more cells or go to waste,” says Gardner, whose research is supported by the U.S. Department of Energy. “If you can produce power outputs at 1,000 watts per cubic meter, you can light up a house or power a cell phone. Our goal is to generate as much power as we can from the smallest possible device.”

To achieve that goal, Gardner and eight graduate research assistants mapped the metabolic gene regulatory circuits of *Shewanella* representing about 800 to 1,000 genes, and identified some of the most important controlling “valves” of those circuits. “The cell is essentially a series of pipes,” he explains. “You push fuel in one side, it flows through these pipes and reacts and either becomes waste products or electricity. If you delete or mutate certain genes...
Detection of Lung Cancer Early

The electronic circuit board analogy not only describes biological processes, but also some experimental equipment used to investigate those processes. Using a DNA microarray whose wafer-like platform resembles that of a computer chip and an electric laser scanning microscope to “read” genetic patterns on the platform, Jerome Brody and Avrum Spira, have devised a promising method to detect lung cancer in its early stages.

And not a moment too soon. Lung cancer remains the most lethal form of cancer in both men and women. The disease has a mortality rate of about 85 percent, in large part because it is often diagnosed at a late stage. No effective diagnostic test yet exists to indicate its presence at an early stage.

To zero in on a biomarker for cancer in airway cells, Brody and Spira next plan to conduct a 600- to 800-patient clinical trial to validate that their biomarker in airway epithelial cells can robustly distinguish the presence or absence of lung cancer and to evaluate the ability of nose and mouth cells to serve as screening tools for disease.

For more information, see our pulmonomics.com.

Gauging Muscle Dysfunction

Researchers in the NeuroMuscular Research Center (NMRC) have developed an electronic device that measures electrical signals from contracting muscle and may also help to diagnose diseases early. Known as an electromyographic (EMG) signal detector, it enables researchers and clinicians to assess the extent of neuromuscular injury or disability and monitor the progress of rehabilitative therapies by tracking changes in muscle fiber control. The EMG detector acts as an early warning system that may ultimately allow physicians to slow or halt diseases of the central nervous system, such as ALS and Parkinson’s, before overt symptoms arise.

That’s the vision of biomedical engineer Carlo De Luca, who directs the NMRC and heads a 14-year-old spin-off company called Delays. To realize this vision, De Luca and his NMRC colleagues—physical therapist Serge H. Roy and electrical engineer Samir Nawab, along with four graduate students—are working to improve the accuracy of EMG signal processing algorithms for both clinical and research applications.

The EMG signal consists of a superposition of electrical pulses which propagate along the muscle fiber every time it contracts. As more muscle fibers are stimulated by the brain, more force is generated and the amplitude of the EMG signal increases. “EMG signals have small amplitude but radiate and reach the surface of the muscle,” says De Luca. “If you apply special sensors on or below the surface of the skin, it’s possible to detect the sum of all these pulses and to determine whether the muscle is firing in a normal or abnormal fashion, but it’s a noisy, complex signal.”

The firing behavior of healthy muscle fibers follows well-established rules, some of which were discovered by researchers at the NMRC. In several investigations, De Luca has shown that firing behavior remains unchanged even during fatiguing tasks or extended

(Valves), you can shut down pipes leading to waste products or maximize the number of pipes that lead to electricity production, and thus boost electrical output. Gardner is now trying to identify more genes involved in regulating Shewanella metabolism and to develop a genetic engineering strategy for key valves in the entire cellular “circuit board.” If he succeeds in boosting the bacteria’s electrical energy production tenfold, the microbial fuel cells that result could be used, for instance, to feed off of—and detoxify—sewage at a sewage treatment plant or waste at an agricultural dump while powering nearby houses or household appliances.

For more information, see http://gardnerlab.bu.edu.
bed rest, but is altered in elderly subjects, acute cerebellar stroke patients, and returning Space Shuttle astronauts. For the past three decades, he and his colleagues have developed and refined two types of sensors and algorithms to decompose the EMG signal into individual pulses, which reflect how individual muscle fibers are controlled within the muscle to perform particular functions. Intended for clinical purposes, the first sensor is attached to a needle that gets inserted into muscle, and has achieved 85 percent accuracy. The second sensor, developed by Deluca, is used for motor control studies. It works on the surface of the skin and has achieved 65 percent accuracy.

Over the next five years, De Luca aims to boost those figures to 95 percent and 85 percent, respectively. “We have shown this level of accuracy is sufficient to provide a good estimate of parameters needed to extract information that describes how the muscle is controlled,” says De Luca.

Developing and commercializing De Luca’s NMRC research, Delsys provides electromyography equipment, physiological sensors, and data analysis programs for educational, research, and medical markets across the globe. The company serves clients in 55 countries and attributes its rapid growth to funding from the Small Business Innovation Research program, sponsored by the Small Business Administration (SBA). Delsys received the SBA Tibbets Award in 2006.

For more information, see http://www.delsys.com.

Preventing Premature Labor

Like De Luca, biomedical scientist Kathleen Morgan is deciphering electrical activity in the muscle, but in an entirely different sphere: the uterus. Morgan’s research aims to better understand how uterine electrical signals trigger premature contractions, and ultimately to facilitate the development of a drug that could delay them. While medical science has improved its track record for keeping premature infants alive over the past three decades, there remains no truly effective way to halt preterm labor and the potentially serious lifelong disabilities that can go with it.

The growing fetus builds up stress on the uterus, which increases electrical activity in uterine smooth muscle cells—activity that tends to cause contractions. In humans, these electrical signals are uncoupled from mechanical activity to remain uncoupled for the normal duration of pregnancy. But in some women, these electrical signals tend to remain coupled, thus leading to contractions and early labor. The researchers next gave the rats a combination of RU486 and another drug, U026, that inhibits ERK activity. The animals did not go into labor. To learn whether inhibitors of ERK might be used in the treatment of preterm labor in humans, Li has obtained tissue samples from consenting BIDMC patients undergoing cesarean section.

One critical problem remains: ERK is not considered to be easily “druggable” because it resides deep inside the uterine muscle cell. “In signal transduction you have signals being transmitted to effectors through a cascade of molecules,” says Morgan. “We’re going upstream to look at signals that are physically closer to the surface of the cell, which would be more accessible to therapeutics.” Eventually the researchers aim to collaborate with a drug company to tweak the chemistry of U026 to better target the uterine ERK molecule.

For more information, see http://people.bu.edu/kmorgan/MorganLabHomepage.html.

Upgrading Kidney Stone Treatment

Mechanical engineer Robin Cleveland uses an electrical device to interfere in another unwanted biological process: the passing of enlarged kidney stones. Since 1984 American physicians have routinely broken up kidney stones deemed too large to pass easily by firing thousands of pulses at them with an electric-powered, acoustic shock wave device called a lithotripter. While the treatment is noninvasive and typically results in minimal side effects, scientists have determined that it occasionally causes significant soft tissue damage in the kidney, with side effects including kidney failure and hypertension.

“When I started this research, we still didn’t have the technology to do this,” says Cleveland. “So, we developed the technology. We now have a successful device to break up kidney stones.”

To identify the mechanisms by which shock waves damage tissue, he is currently investigating a number of promising hypotheses. One suggests that the deformation of the tissue builds up over hundreds of shock waves until the small capillaries in the kidney rupture, which then leads to more serious kidney trauma. To better understand how shock waves pass through kidney tissue and break kidney stones, Cleveland trains electric-powered lithotripters on artificial and human stones and animal kidneys in a large tank. One such device, an electrohydraulic lithotripter, sends 30,000 to 50,000 volts across the two tips of an electrode, producing a big electrical spark that generates an acoustic shock wave underwater. The electrode is placed within an ellipsoidal reflector that focuses the sound waves to where the kidney stone is positioned.

Cleveland’s research recently revealed the prominent role of shear waves in the fragmentation of artificial stones. When the incoming shock waves pass into the stone, they generate two kinds of waves in its interior: compression waves (similar to sound waves) and transverse waves (similar to the waves on a rope when you excite it with a snap of the wrist). The shear waves propagate through the stone and generate larger destructive forces within than the acoustic waves. “We identified this with our numerical model and confirmed it with experiments using artificial stones,” says Cleveland. “The next step is to apply the same model to human kidney stones.”

—Mark Dwortzan
Addressing Inequalities with Creative Strategies

When Edward Bernstein, professor of emergency medicine at the School of Medicine (BUSM) and professor of social and behavioral sciences at the School of Public Health (SPH), and his wife, Judith Bernstein, associate professor of maternal and child health at SPH and associate professor of emergency medicine at BUSM, put an older method of treating substance abuse into a new context the results were so successful that emergency departments around the country followed their lead.

For more than a decade, the Boston Medical Center has used the Screening, Brief Intervention to Referral and Treatment (SBIRT) strategy in its emergency department (ED). Long used as part of routine health care, this technique—which is designed to encourage substance abusers to seek appropriate treatment—had not previously been applied in an emergency medicine setting. Now, thanks to a grant from the Bureau of Substance Abuse Services at the Massachusetts Department of Public Health, seven hospitals around the state are implementing SBIRT in order to take advantage of the unique environment EDs provide.

It started with the Bernsteins’ realization that, somewhat counterintuitively, a visit to the emergency room can be a good time to start a conversation about controlling drug and alcohol use. Individuals are more likely to self-report substance abuse when they enter treatment than when they exit, so a patient who has been recently admitted to the ED is likely to be receptive to SBIRT. Moreover, individuals admitted to an emergency department are one and a half to three times more likely to report substance abuse than those seeing primary care physicians.

Edward Bernstein credits the success of the SBIRT approach to the unique conditions present in an emergency department as well as to the commitment of ED staff. “Massachusetts offers some of the best conditions for improving quality of care for ED patients,” he says. “It’s not only that we have a real commitment to medical innovation and advanced technology. This is also a state that is using creative strategies to address inequalities in access and to promote quality in health care services.”

The laboratories where discoveries are made, new drugs are developed, and diseases are brought one step closer to eradication can sometimes seem very far from the men, women, and children whose lives these discoveries are meant to improve. Even when breakthroughs receive media attention, researchers can seem distant, hard at work in their ivory towers. Not so at the Boston University School of Medicine, the Henry M. Goldman School of Dental Medicine, and the School of Public Health, where faculty have partnered with a number of local, state, and federal organizations to translate their research into direct and immediate community engagement. By bringing their expertise and the fruits of their scholarship directly to hospitals and classrooms in Boston and surrounding areas, these researchers are improving the health and well-being of community members who are disproportionately at risk from preventable addiction, disease, and illness.
Addressing Inequalities in Nontraditional Settings

Michelle Henshaw, associate professor and assistant dean for community partnerships and extramural affairs in the Goldman School of Dental Medicine, has also set a national example. Her outreach brings dental care and education to the Boston-area schoolchildren who need it most. Henshaw is the deputy director of the Center for Research to Evaluate and Eliminate Dental Disparities (CREEDD). The center was created in 2002 with joint funding from the National Institute of Dental and Craniofacial Research and the National Center on Minority Health and Health Disparities and is one of five NIH-funded programs to reduce oral health disparity. What makes CREEDD innovative, according to Henshaw, is not only its creation of new models of research, but also the implementation of these models in nontraditional settings.

One of the most recent components of CREEDD’s research is a partnership with New England Research Institutes (NERI) to complete an oral health survey of 10,000 children in kindergarten, third, and sixth grades in Massachusetts, a one-year project that Henshaw hopes will be funded every three to five years so that the data can be updated. “The survey is a means to an end,” she says, with the ultimate goal being the reduction of dental health disparity and the building of a new partnership with the community. Henshaw and her colleagues also expect that “the oral health survey will allow us to make more informed public policy decisions.”

In addition to her work surveying and assessing the state of dental care, Henshaw helps the Massachusetts community through Smart Smiles, a Boston-wide sealant program, and through the continued partnership between Boston University and the Chelsea Dental Program to offer education, dental screening, and referrals to children in the Chelsea area. First formed in 1991, the program has grown over the past 16 years and includes dental sealant programs, fluoride varnish applications, and oral health education to help treat and prevent dental decay.

Both partnerships are founded on the understanding that dental health is an important prerequisite to learning: a child in pain from a cavity is a child who will have a difficult time listening and taking in the day’s lessons. CREEDD’s research has revealed that 21 percent of children in the Greater Boston area have dental decay, with an even higher percentage of untreated decay in the city itself. Again, dental health has larger implications for students’ lives than it might first appear. Part of what CREEDD is doing, Henshaw says, is looking at the clinical burden of tooth decay in order to “measure the impact on the overall health of the family.”

For more information on CREEDD, see http://creedd.gov/ and http://smart.smiles.org.

Addressing Inequalities by Making Boston University Mobile

Like Boston University’s dental outreach program, CityLab—an educational outreach program created by Carl Franzblau—brings the University’s resources and knowledge directly to the community. Chairman and professor of biochemistry, as well as associate dean for graduate biomedical science studies and director of the Division of Medical and Dental Sciences at the School of Medicine, Franzblau started CityLab in 1991 with a grant from the National Institutes of Health’s National Center for Research Resources. The first students entered the program in 1992. Today, CityLab is still funded by NIH and is the longest ongoing grant for projects geared toward K–12 education and outreach.

Inside MobileLab, top, a biotechnology lab in a converted bus, children discover that science can be fun. MobileLab, shown in front of the Massachusetts State House, above, and its partner program CityLab reach approximately 1,000 students each year.

Franzblau was struck by the dearth of American students choosing the biomedical sciences as a profession and looked to science training in K–12 as the first step toward addressing this academic imbalance at the college and university level. From a series of Saturday morning meetings where he and his colleagues debated the best ways to deliver material to students, CityLab was born. They decided to open a laboratory where teachers could bring middle and high school students to learn about the biotechnology industry, and it wasn’t long before the lab’s success led to the creation of many other programs. A second laboratory was added, and these two labs are now filled with resources available to all teachers and students in the Boston area.

When the waiting lists grew long, Franzblau created MobileLab to bring resources to ever-greater numbers of students. A Blue Bird bus was converted into a biotechnology lab that could go directly to the schools. Donald DeRosa, clinical assistant professor in the School of Education and director of the School of Medicine’s CityLab and MobileLab, calls it “by far the most innovative combination of the scientist-educator partnership for educational outreach that CityLab has created.” DeRosa notes that MobileLab works closely with the

MassBiEd to provide high schools with professional equipment and resources to promote biotechnology education. Another benefit of MobileLab, he says, is that it “provides an equal opportunity for students in all schools to experience effective hands-on investigations in molecular biology regardless of socioeconomic factors.”

In addition to the needed resources that CityLab and MobileLab supply for schools in Massachusetts, CityLab provides a dose of educational fun to students and educators. Both CityLab and MobileLab, Franzblau says, are designed to show students that science can be interesting and exciting—a message that strikes a chord with children of all ages. “The more resources, “he adds, “we could reach down into kindergarten.”

In the meantime, Franzblau and DeRosa are capturing the imaginations of older elementary school children by turning science lessons into mysteries. One recent lesson saw students trying to track down missing stuffed animals—and the identity of the person who nabbed them. Second and fourth graders completed blood cell typing and solubility testing and found that it was a teacher who had swiped the toys.

Franzblau’s ambitions do not end with CityLab and MobileLab. He has also created a summer camp, already filled to capacity, and is looking into extending the summer sessions. Additionally, CityLab Academy was created in 1996 as a free nine-month training program in biotechnology and biomedical science for high school graduates. The program is overseen by Connie Phillips, director of both CityLab Academy and the Biomedical and Clinical Science Program at BUSM, and Carla Romney, associate professor and chair of the Science and Engineering Program in BU’s Metropolitan College, which offers extended education. Students take academic and lab courses and receive credits from Metropolitan College.

CityLab sees 7,000 students every year, and has reached approximately 300,000 children at BU and satellite campuses over the last 15 years. Teachers who visited CityLab or used MobileLab were extremely satisfied with the labs’ effective teaching of fundamental concepts and the promotion of a positive attitude about science, according to surveys completed in the spring of 2006. Similar programs have been created throughout the country and in Europe, modeled on CityLab’s innovative and effective science outreach.

Even now, Franzblau is always looking for ways to expand K–12 outreach in science and medicine. He envisions a Science Corps in the United States, similar to the Peace Corps, which will eventually recruit young teachers and educators to bring labs to “the hills of South Dakota and the inner city of Chicago.”

Like Edward and Judith Bernstein and Michelle Henshaw, Franzblau and DeRosa conceive of their outreach projects as a fundamental part of their academic goals, as the foundation for educating and analyzing the community so that Boston University’s economic and intellectual resources are intertwined with the welfare of Boston and the Greater Boston area and eventually with the national and global community.

For more information about CityLab, MobileLab, and CityLab Academy, see www.bumc.bu.edu/citylab.

—Meredith Barron
The profound effect of climate change on human life plays out in images from Surge and Acqua Alta by Deborah Cornell. In virtual reality and large-scale digital prints, cultural expressions combine with images of natural forces. Clockwise from top left: Still images from Surge, including a global view of the Surge environment and a Venetian mask with dice; details from Memory, City of Dust, and Faces Vanish—large-scale digital prints with transparent overlays from the installation Acqua Alta; viewers navigate through the 3-D immersive environment of Surge using the Deep Vision Display Wall in BU’s Computer Graphics Laboratory.

The word research generally evokes images of lab coats and petri dishes, or archives filled with musty volumes. Rarely would one associate research with the final creative product—a polished musical performance, finished script, or exhibited work of art. But research plays a vital role in the fine and performing arts, as demonstrated by the recent activities of five professors in the College of Fine Arts. The fruits of their labor only appear effortless. Careful scholarship, planning, and practice are needed to ensure that a finished work of site-specific art suits its environment, for instance, or that the performance of a long-unheard baroque composition sounds exactly as the composer had intended.

SIGHTS and SOUNDS: EXPLORATIONS IN THE ARTS

Art Meets Computer Science

As scientists hasten to assess the impact of climate change on our physical environment, scholars in the humanities and the arts have begun to ponder how global warming will affect human culture. Such is the inquiry posed by Surge, a collaborative multimedia artwork by Deborah Cornell, associate professor of art in the School of Visual Arts, and her husband Richard Cornell, associate professor of composition in the School of Music. Surge—which the Cornells describe as “an exploration of the reciprocal influence of environmental change on human culture”—was created with software developed by Boston University programmers and intended for exhibition in the Scientific Computing and Visualization group’s Computer Graphics Laboratory. In April, the Cornells premiered the work for the 2007 Boston CyberArts Festival, a biennial festival of international artists working in cutting-edge computer-based media. Surge was projected onto the lab’s 15’ x 8’ Deep Vision Display Wall, equipped with an eight-speaker sound system.

Concerned by the various effects climate change has on the world, Richard and Deborah Cornell began working on Surge through research that was largely experiential, informed by visits to Venice, Argentina, and other places where rising sea levels pose a distinct threat. The couple first collaborated in 1999 and have since presented three joint projects in venues such as the High-Speed Access Grid, concert halls in the United States and Taiwan, and galleries and museums both stateside and abroad. A sabbatical leave during the 2006–2007 academic year enabled both professors to spend a month in Buenos Aires, where they presented their joint project Acqua Alta at Proyecto’ace, a contemporary art center. Consisting of nine 3’ x 5’ digital prints and an original soundtrack, this installation also explored changes in sea level.

Engaging with similar themes and imagery, the virtual environment in Surge consists of a luminous spherical shape floating in black space. Equipped with a navigation device similar to a Playstation controller and a pair of 3-D vision glasses, the viewer—or, more accurately, the participant—enters the virtual realm. Inside, he or she meets a variety of objects and creatures, each symbolic of humankind’s impact on the natural environment. Three “lifeboats”...
containing images of human chromosomes float in the center of the sphere, while a colorful jester’s head and Venetian Carnivale masks reminded the audience of the threat Venice faces from rising water levels. Hovering nearby, a quotation from The Tempest takes on a new connotation in the context of global warming: “Nothing of him that doth fade / But doth suffer a sea-change.”

Surge’s soundtrack, carefully synchronized to one’s movement through the virtual space, enhances the journey. Running water, a rumbling thunderstorm, and other nature noises combine with sounds evocative of human culture, such as a Monteverdi choral passage and the ringing of the Lute bell, recovered from a sunken British vessel of the same name.

Boston University students in Laura Giannitrapani’s 3-D Animation and Design class also participated in the CyberArts Festival. As the manager of graphics consulting for BU’s Scientific Computing and Visualization lab, Giannitrapani has collaborated with the Cornells on several of their virtual artworks. Her students’ piece, Interactions, uses technology similar to that of Surge and also addresses humankind’s effect on the environment. Zoom in on a polar bear, for example, and watch it lumber across an iceberg while a chunk of the mass breaks off and falls into the water below. Both entertaining and educational, Interactions presents an innovative method for instructing young children about climate change.

“Cyberart can be anything from an examination of complex ideas about the nature of reality to sheer unadulterated fun,” wrote BBC reporter Rachel Rawlins of the 2007 CyberArts Festival. “And if you’re lucky,” she added, “both at the same time.” Surge and Interactions fulfill these criteria in encouraging playful exploration of the virtual realm, as well as serious reflection upon our relationship with the natural environment.

For more information, see http://people.bu.edu/rcrnl and http://scv.bu.edu/SCV/cgl.html

Bringing Baroque Music to Life

When Martin Pearlman joined the faculty of the College of Fine Arts as professor of music and director of the Historical Performance program in 2002, he offered the College more than his expertise as a renowned conductor. Boston Baroque, an acclaimed orchestra and choir founded by Pearlman in 1973, also joined the School of Music as a resident professional ensemble. This innovative collaboration allows graduate students in the Historical Performance program to work alongside professional musicians.

Boston Baroque has received wide recognition for both its live performances and its many recordings. The most recent season featured two Beethoven symphonies, Handel’s Messiah, Mozart’s Don Giovanni, and Vivaldi’s only surviving oratorio, Juditha Triumphans, composed in 1716. While works by Mozart and Beethoven are certain crowd-pleasers — Don Giovanni, for example, was radio broadcast by WGBH — Pearlman particularly enjoys performing pieces that contemporary audiences rarely hear, such as the Vivaldi oratorio and Cherubini’s Requiem in C minor, one of the previous season’s highlights. Most audiences are acquainted with Vivaldi’s concertos, but not with his vocal music. Juditha Triumphans, Pearlman says, “is not only one of the biggest, but also one of the best Vivaldi pieces that people haven’t heard.”

The preparation and performance of little-known music presents a distinct challenge to the conductor, especially if he or she wishes to re-create the music exactly as the composer himself had imagined it. Because instruments and methods of musical notation have evolved over time, Pearlman’s historical interpretation of a Baroque piece may differ considerably from a standard modern interpretation. In order to perform a work like Vivaldi’s oratorio, Pearlman must first find a suitable score, and then check it against the original manuscript. If it still exists, and against reproductions made over a period of nearly three centuries. Compiling variants and choosing the best among them involves a great deal of painstaking detective work and considered judgment. Because Vivaldi did not include cadenzas or ornamentation in his scores, Pearlman must also decide whether, and how, to ornament the music.

Determining the piece’s instrumentation can also be an arduous task. Contemporary instruments differ — often quite drastically — from their Baroque predecessors, and some manuscripts refer to instruments that no longer exist. Ensembles that wish to perform music in its historical form must determine what sorts of instruments the composer originally wrote for — is a salmo, for example, related to the Baroque chalumeau, an ancestor to the modern clarinet?

Pearlman’s investigations might continue with a review of recent literature by music historians to determine whether a similar instrument exists, or whether it has to be specially constructed. Last but not least, he must find performers who are proficient with these nearly obsolete instruments.

Graduate students in the Historical Performance program not only learn to play such instruments, they also observe and engage in the research process leading up to a performance. By understanding how a conductor decides to assign a certain instrument to a specific part, or why he might add a cadenza at the end of an aria, students prepare for careers in ensembles like Boston Baroque.

In re-creating music of the 17th and 18th centuries, Pearlman must first find a suitable score, and then check it against the composer originally wrote for — is a salmo, for example, related to the Baroque chalumeau, an ancestor to the modern clarinet? Pearlman’s investigations might continue with a review of recent literature by music historians to determine whether a similar instrument exists, or whether it has to be specially constructed. Last but not least, he must find performers who are proficient with these nearly obsolete instruments.

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Above: The orchestra and chorus of Boston Baroque perform Monteverdi’s Vespers in Jordan Hall, Boston. Conductor Martin Pearlman is a professor at BU’s School of Music, and soprano Kristen Watson (in purple dress) is an alumna. Right: During a recording session, Pearlman conducts Boston Baroque in Bach’s Orchestral Suites.

For more information, see www.bostonbaroque.org
as well as from music. These works highlight a clever parallel in the work of geneticists and that of jazz musicians—they both strive to assuage our “blues,” whether physically or emotionally induced, through innovation.

Students in O’Donnell’s Site-Specific Art course demonstrate a similar awareness of the spaces that their works might inhabit, as well as the people who use those spaces. After conducting research on public art, students develop their projects with the input of their community—primarily the faculty and staff in the building where the work is to be installed—and, in the final stages, University administrators. Some, though not all, projects are realized and installed on the campus.

As undergraduates, Brienne Rosner and Holland Dieringer created a work entitled *Visual Entanglements* for the Metcalf Science Center. Faculty and graduate researchers in the sciences helped the two students collect images related to their work on entangled photons, which the artists then used to create a series of 12 collage panels, hanging from the ceiling in two rows. Another pair of students, Rachelle Reichert and Kristie Eden O’Donnell, took their projects beyond the BU campus when they received commissions from Red Bull for the company’s office in Quincy, Massachusetts.

The course allows students to experience the reality of creative production, which O’Donnell claims is becoming increasingly collaborative and interdisciplinary. And when his students need guidance, they know where to go for advice. Says O’Donnell, “The same thing I teach, I do.”

For more information, see www.hughodonnell.com. To view a slideshow of site-specific art, visit www.bu.edu/alumni/buforward/archives/apr_2007/articles/campusart.html.
According to Jim Petosa, professor and director of the School of Theatre, students of all disciplines might view the University as a large laboratory—a place where new knowledge is gained through experience and experiment. “Works of art have to gestate,” he states, “but not in a library.” When creating a new play, a writer should ideally have an opportunity to see the work-in-progress staged. Just as researchers in the sciences refine their hypotheses through repeated experimentation, playwrights can best revise their works after seeing them performed. Petosa hopes to make the development of new plays a major part of the School of Theatre’s mission by working closely with emerging playwrights.

One of the most important aspects of training in the School of Theatre is students’ interaction with professionals in the field, enabled through collaborative programs with several professional theatre companies. Petosa is most enthusiastic about the opportunities that these professional affiliations provide for creating and workshopping new plays. Universities offer the ideal environment for this sort of experimentation, he explains, due in part to their relative freedom from the economic constraints that professional theatre groups often face.

The School of Theatre’s collaborative programs date to 1982, when the Huntington Theatre was founded in-residence at BU. Although the Huntington now functions independently, it is still affiliated with the University and remains a cornerstone of training at the School of Theatre by involving students in the preparation and staging of its productions. In 2002, the Professional Theatre Initiative expanded this collaborative approach, affiliating the School of Theatre with several other professional groups, including the Actors’ Shakespeare Project, the Boston Playwrights’ Theatre, and the Olney Theatre Center near Washington, DC.

Alumna Kira Lallas provides a striking example of the benefits that this professional workshopping model provides to young playwrights. She originally wrote *Translations of Xhosa*—an exploration of her experiences studying abroad in South Africa—for her senior thesis project in 2002. The play was subsequently staged at the Boston Playwrights’ Theatre, and Lallas was then invited to participate in the prestigious National College Theater Festival at the Kennedy Center in 2003. This fall, BU students and Huntington Theatre staff will present another original work by a graduate of the program—Ronan Noone’s *Brendan*.

These collaborations with professional theatre companies complement the University’s commitment to providing students in all areas of study with a broad liberal arts education. In breaking with the old model of conservatory training, which sequesters young performing artists and steeps them in their chosen discipline, the School of Theatre provides the ideal environment for students to think beyond the classroom or the stage. According to Petosa, performing artists must not only be skilled in their art form, they also need to strive for broader intellectual development. Art never exists in a bubble, cut off from the world around it, he says: “Contextualization of the art form is everything.”

For more information, see www.bu.edu/but and www.huntingtontheatre.org.

—Amy Chmielowski
One way to talk about what particle physicists are up to when they smash together beams of subatomic particles is to say that they are probing the structure of matter at infinitesimal distances. Another way to describe it is to say that they’re going back in time, creating energies that existed a fraction of an instant after the big bang, when the universe’s fundamental forces and particles were forming. And in the summer of 2008, when the Large Hadron Collider (LHC), located in a 27-kilometer circular tunnel deep beneath the Franco-Swiss border near Geneva, starts colliding two beams of protons traveling at nearly the speed of light, physicists will be able to look back farther than ever before.

The massive LHC is the flagship project of CERN (Conseil Européen pour la Recherche Nucléaire), a joint venture now officially called the European Organization for Nuclear Research and recognized by the scientific community as the world’s largest particle physics center. The LHC could help resolve theoretical disputes about the structure and evolution of the universe that have gone unresolved for years, or even decades, because of a shortage of the kind of experimental evidence that could determine a winner. And when the proton smashing begins, several Boston University scientists will be in the middle of the fray. Some are the developers or refiners of the competing theories. And some will be there as experimentalists who helped build and operate the massive particle detectors within the LHC to sift through mountains of data looking for signs of new particles—either those predicted by theories or, more likely, something totally unexpected.

Whether involved in theory or experimentation, LHC anticipation for most particle physicists has been career-long.

The long-standing mysteries revolve around shortcomings in the Standard Model of particle physics, which lists the simplest particles known to exist (such as electrons, muons, and quarks) and describes how three fundamental forces—electromagnetism, the strong force that holds together the nuclei of atoms, and the weak force that underlies radioactive decay—act on them. But the Standard Model neglects gravity and it offers no explanation for “dark matter,” a phenomenon indicating that most of the universe’s mass is invisible because it doesn’t emit light.

In addition, experiments have validated a theory developed in the 1970s by BU physics professor and Nobel laureate Sheldon Glashow (then at Harvard) and other theorists, that at the high energy levels of the early universe, the electromagnetic and weak force would have behaved similarly, both mediated by massless elementary particles. The Standard Model does not satisfactorily explain why, as the universe cooled, this symmetry disappeared: the particles of the weak force (the W and Z bosons, discovered in the 1980s by BU physicist James Rohlf, then at Harvard, and others at CERN) acquired mass, while the particle of electromagnetism (the photon) did not.
The LHC is a big microscope,” says Andrew Cohen, professor of physics. “It is seven times more powerful than today’s highest energy particle collider, the Tevatron at the Fermilab in Illinois. And the higher the energy, the more types of particles that can be created, particles predicted by the competing theories that go beyond the Standard Model to explain how the W and Z acquired mass. “We know at what energy scale we should start seeing the physics associated with this,” says Cohen, “and that’s where the LHC is going to get us.”

The Standard Model’s explanation for how the W and Z bosons get their mass is called the Higgs mechanism, developed in the 1960s. A nonscientific explanation of the mechanism, offered by physics professor Steven Ahlen, begins with the notion that “mass is associated with the difficulty of getting things moving.” Thus, says Ahlen, one can think of subatomic particles affected by the Higgs field as marbles moving through mazes, making them harder to move, giving them the appearance of mass. But experiments have been unable to find the new elementary particle predicted by the Higgs theory, the Higgs boson. Indeed, the hunt for this boson will be one of the LHC’s first tasks. In addition, particle predicted by the Higgs theory, the Higgs boson. Indeed, the hunt for this boson will be one of the LHC’s first tasks. In addition, all of these techni-particles should be within reach of the LHC, says physics professor Martin Schmaltz, who has spent many years working to refine super-symmetry. “It’s not just energy that counts,” Schmaltz says of the LHC. The new machine will also have a denser proton beam, meaning more frequent collisions (about 800 million per second), and hence more data to mine for evidence of new particles. “The things that we’re looking for are rare. They probably only happen once in a billion collisions,” he explains.

Schmaltz, along with Cohen, has also worked on another set of theories that go beyond the Standard Model—the notion that the divergence of fundamental particle masses and forces, including gravity, is due to extra dimensions beyond the three we know, which are curled up into such short distances that we remain unaware of them. Cohen explains the idea using the analogy of an ant walking across a piece of paper that’s been rolled into a tight cylinder. “The ant doesn’t know it’s on a two dimensional sheet,” he says. “It just thinks it’s on a line.”

Cohen explains the idea using the analogy of an ant walking across a piece of paper that’s been rolled into a tight cylinder. “The ant doesn’t know it’s on a two dimensional sheet,” he says. “It just thinks it’s on a line.” According to this theory, the apparent weakness of gravity compared to the other known forces, a puzzle ignored by the Standard Model, stems from the fact that gravity must leak over from another dimensional plane. It’s possible, says Cohen, that the LHC will have enough energy to probe the extremely short distance scales where effects of these extra dimensions would be visible.

Nevertheless, Cohen points out that the tighter these dimensions are curled, the higher the energy of any physics associated with them. And here the same energy/mass constraints that complicate the Higgs theory come into play, making extra dimensions, in Cohen’s opinion, look “not so terrific” for explaining the break in electroweak symmetry.

Indeed, when it comes to what “new physics” theories the LHC experimental data might support, Cohen is fond of one he helped pio-
More frequent collisions mean more data to mine: “The things we’re looking for are rare. They probably only happen once in a billion collisions.”

Physicist Steven Ahlen, who worked on detectors for the proposed Superconducting Super Collider in the 1980s, is one of nearly 2,000 collaborators worldwide working on the ATLAS detector at CERN, where experiments are slated to begin early next summer.

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Above, left to right: A section of the CMS particle detector weighing several thousand tons is lowered 100 meters underground into the experimental cavern. In the CMS underground electronics room, physicist James Rohlf inspects some of the thousands of channels of digital electronics that were designed and fabricated at BU. These electronics are used to measure the energy deposits of particles that enter the CMS detector and can process data from the collisions 40 million times per second. Below, left to right: A simulated proton-proton collision in the CMS detector, as viewed along the beamline. Two magnets are electrically interconnected in the LHC tunnel.

For more information, see http://physics.bu.edu/research.

—Chris Berdik
INTELLECTUAL PROPERTY IN THE 21ST CENTURY

Patent law and copyrights were created to provide incentives for innovation, in order to encourage the creative and economic growth of the country. But what if these laws do the opposite in practice? What if some intellectual property claims can actually “chill further innovation,” as Robert Bone, professor of law and Richard L. Godfrey Faculty Research Scholar, suggests.

While debates over intellectual property are not new, they have evolved along with changes in America’s information-based economy. Federal legislation for intellectual property (IP) is divided into three primary categories: patent, copyright, and trademark. The first two categories promote what the Constitution calls “the progress of science and the useful arts;” the third, trademark law, fosters accuracy in marketplace communication. Additional regimes such as trade secret law and rights of publicity are based in the laws of the various states. These categories have never been mutually exclusive, with plenty of gaps and overlaps between them. But all of them can require people to obtain licenses before copying or making certain artifacts, affecting a broad range of commercial and creative activity, both pragmatic and purely artistic.

Fundamental Questions

One of Wendy Jane Gordon’s interests is the way technology has come to restrain people from glancing through texts or reading their favorite books over and over, whether for entertainment or as part of their making new works. “Some courts see browsing the Internet as involving ‘copying,’” explains Gordon, a law professor and Paul J. Liacos Scholar in Law. “Back in the 1990s, prescient commentators like Jessica Litman and Richard Stallman feared copyright owners would assert an exclusive right over their reading, and the law may indeed be heading in that unfortunate direction.”

She notes that many of the inadvertent legal changes wrought by technology add new twists to an old problem—the question of how broadly rights should be crafted, given that every grant of rights to one person will simultaneously limit the liberties of other people. “Fundamental issues will recur over and over again,” she says. “We must continually address the limits of and justification for the whole system.”

Gordon also thinks that the field has been and continues to be so exciting because of the commingling of utilitarian and economic perspectives with moral arguments, such as the natural-law thinking of John Locke. A person’s right to his or her creation, according to Locke’s theory of property, is conditional on that person not depriving others of “enough, and as good,” thus framing the law’s compulsion in moral terms. Copyright, then, is not just about protecting ownership of individual “authors’ rights,” but ultimately also about encouraging free thought and the interchange of ideas. Gordon locates the real-world stakes of intellectual property in economics, moral philosophy, and the free speech debate. Her work has placed her, in the words of one online commentator, “at ground zero in the IP wars.” Gordon examines the many ways in which copyright affects the connections between the individual and the community. “Often markets can serve the interests of both copyright owners and users,” she says. “In such instances, a market in the copyrighted work can simultaneously further the well-being of both the author and the audience, fostering both incentives and dissemination.” But sometimes a market doesn’t exist or is flawed, or an alternative institutional arrangement (informal reciprocity, for example) is better suited to inducing the creation and circulation of the works at issue. “After all,” says Gordon, “artists don’t usually thrive in bureaucracies.” It may also be the case that non-monetizable interests like free speech are at stake, making a commercial market an inappropriate way to decide what uses of copyrighted work should or should not be permitted. In such cases, Gordon says, “The claims of the copyright owner can conflict with the claims of the public and of downstream authors. Often the claims of the copyright owner need to be reframed to give greater scope to the public interest. And we cannot rely on industry practice to tell us what the public interest requires.”

In a 2007 article in The Yale Law Journal Pocket Part she argued, “Roy licensing done out of fear of liability—whether reasonable or excessively risk-averse—is a poor guide to what a community believes.” Gordon holds that the divide between behavior and belief locates the real-world stakes of intellectual property in economics, moral philosophy, and the free speech debate. Her work has placed her, in the words of one online commentator, “at ground zero in the IP wars.” Gordon examines the many ways in which copyright affects the connections between the individual and the community. “Often markets can serve the interests of both copyright owners and users,” she says. “In such instances, a market in the copyrighted work can simultaneously further the well-being of both the author and the audience, fostering both incentives and dissemination.” But sometimes a market doesn’t exist or is flawed, or an alternative institutional arrangement (informal reciprocity, for example) is better suited to inducing the creation and circulation of the works at issue. “After all,” says Gordon, “artists don’t usually thrive in bureaucracies.”

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Looking at the Numbers
Megan MacGarvie, assistant professor of finance and economics in the School of Management, is one of the scholars at Boston University looking at technology issues. Since the creation of the United States Patent and Trademark Office in 1790, patents have historically been the avenue for innovation. Inscribed above the entrance to the Patent Office’s original headquarters is Abraham Lincoln’s famous quote, “The patent system adds the fuel of interest to the fire of genius.” But as technology has evolved, so have patents, and some fear not for the best.

MacGarvie notes that although the Patent Office has been issuing patents since the 18th century, only in the last decade or so has software been part of this office. In 1996 new guidelines for software patenting went into effect, resulting in an increase of software patents at a rate much higher than that of any other field. Controversial “bad patents” such as the Amazon One-Click case have been the subject of much media debate, but MacGarvie is researching a more subtle controversy—the “anticommons” phenomenon resulting from the cumulative nature of software innovation.

She has looked at broad patterns in software patent data to evaluate the effect of patents on entry by software firms into new markets and the effect on the market value of companies. MacGarvie’s research reveals that patent effect is not black-and-white.

In joint work with BU School of Management professor Iain Cockburn, MacGarvie discovered that after accounting for a variety of factors affecting the rate of entry into a market, markets with more software patents have lower rates of entry.

However, firms holding software patents related to a market are more likely to enter, possibly because holding patents helps in inter-company negotiation. Therefore, predictions of the ultimate net effect of increased patents depend on assumptions about the distribution of patent ownership among small and large firms. Based on these assumptions, increased patents will either decrease the rate of entry or have no effect.

MacGarvie noticed, in work with Bronwyn Hall of the University of California-Berkeley, when looking at stock prices in an event study, that the market perceived that firms without patents or firms in downstream sectors would not benefit from software patents, while middleware firms were expected to benefit. Her research is informing the debate over intellectual property by picking out the subtleties and the paradoxes of the patent system’s relationship to software.

For more information, see http://people.bu.edu/mgarvie.

Historicizing the Present
Robert Bone’s research into trademark and trade secret law also tries to answer the central question, “How big should intellectual property law be?” He approaches this question from the perspective of history and theory in articles such as “Enforcement Costs and Trademark Puzzles” and “Hunting Goodwill: A History of the Concept of Goodwill in Trademark Law,” Bone takes a hard look at claims that trademark law is overbroad and traces the historical reasons behind recent expansions. He argues that some expansions others have criticized are actually sensible ways to reduce potentially high litigation costs. However, he also finds that some expansions are not justified and traces their origins to the role that the vague and highly elastic concept of goodwill played in trademark law’s development.

A major goal of Bone’s trademark research is to provide a better understanding of the theoretical foundations of trademark law and the history of trademark doctrine. Theoretical and historical analysis, in turn, can identify the causes of current problems and ultimately lead to sensible reform.

Bone’s research into trade secret law also takes a critical bent. He carefully examines the policy underpinnings and shows that the law’s current scope is too broad to function properly in our information-based, technologically driven economy. “Secrecy begins with a kind of taint,” he says, making the whole body of trade secret law initially suspect. Encouraging secrecy chills future innovation by keeping information from others and increases litigation costs by complicating enforcement proceedings with adverse effects on competition and creativity. In the end, Bone recommends that most of trade secret law should be limited to contract-based liability principles.

Bone believes that sound IP policy must be based on carefully developed theory, which is informed by a firm grasp of history and guided by reliable empirical work shedding light on how IP law actually works in practice. His research illustrates what can be accomplished with this approach.

For more information, see www.bu.edu/law/faculty/profiles/fullcvs/full-time/bone_r.html.

Seeking Substantive Reform
Michael Meurer, professor of law and Michaels Faculty Research Scholar, has boiled down his recent research to one question: Do Patents Work? That’s also the tentative title of his forthcoming book with coauthor James Bessen. The answer, Meurer believes, is no.

His research has led him to the conclusion that patents are flawed for several reasons. “They do not give a positive right to practice technology, just a negative right to stop it,” says Meurer. Nor do they work as property, he claims. The inability of patents to clearly provide notice to the world of property boundaries for new technology hinders the demarcation of strong property rights that would encourage investment. Meurer’s findings show that in 1984 patents provided a subsidy to industry, but by 1999 the patents’ net effect was to discourage innovation by the typical firm.

While economists and patent lawyers usually think that those who infringe on patents are pirates, Meurer has found that the typical defendant in a patent case actually has more R&D and patents than the typical plaintiff.

He is quick to point out that the negative effects of patents are not applicable to all companies. “Patents on old, obvious technology are not as big a problem as patents on new and non-obvious technology,” he says. The pharmaceutical industry, for instance, benefits from the current patent system. Meurer explains, “Pharmaceutical companies invent products that can be clearly defined and patented more effectively than the products of information technology firms, such as Cisco, IBM, Microsoft, and Intel.”

Meurer’s empirical research is the first to provide a comprehensive accounting of the impact of patents as well as what he calls the “fuzzy boundary problem.” While economists and patent lawyers usually think that those who infringe on patents are pirates, Meurer has found that the typical defendant in a patent case actually has more R&D and patents than the typical plaintiff. And often the defendant and plaintiff are not so close in terms of industry and technology, which suggests that firms are not always able to determine all the parties with whom they need to negotiate in order to obtain the necessary licenses. Meurer places the blame in part on the specialized appeals court created by Congress 25 years ago, which expanded patents to include software and business methods.

“Bottom line,” he says, “is that some of the assumptions about who is infringing on patents are flawed.”

For more information, see www.bu.edu/law/faculty/profiles/full-time/meurer_m.html.

—Meredith Bartron
What do we talk about when we talk about religion? International relations, public education, the next presidential campaign—it’s almost impossible to talk about current events without touching on religious issues. And yet, precisely because religion is so important to so many people in so many different ways, dialogue on the subject can be difficult. “Richard Rorty famously argued that religion is a ‘conversation stopper’—that because religion appeals to God or the transcendent, you just can’t argue with it,” says Department of Religion Chair Stephen Prothero. “I disagree with that view.”

He’s not alone. In disciplines as diverse as sociology, economics, theology, classics, and law, Boston University researchers are studying, teaching, and talking about religion. And in doing so, they’re exploring how our beliefs shape our ideas, our worldviews, our societies, and our daily lives.

Teaching Americans about Religion

Americans are among the most religious people in the world, but in terms of knowledge about religion we have lost our way, Prothero says. “Religion is a conversation stopper of sorts, because when politicians appeal to religion in making an argument against abortion or for environmentalism, way too many of us go mum because we don’t know enough about religion to engage the debate,” he says. “What we don’t know about religion—both other people’s and our own—can hurt us as a society; we don’t ask hard questions of our politicians and pundits because we don’t feel we know enough to do so.”

“Democracy works only when citizens are informed,” Prothero continues. “And since lots of public policy debates implicate religion nowadays, we need to know something about religion in order to be effective citizens.”

In his new book, Religious Literacy: What Every American Needs to Know—And Doesn’t, Prothero proposes a solution to the problem of religious ignorance: he argues that religion does indeed belong in our public schools—not as theological training or indoctrination but as a means of providing Americans with basic information about the world’s religions. His reasons are persuasive and multifold, ranging from the importance of better understanding the current political situations in the Middle East to the civic responsibility to comprehend court cases on intelligent design in schools—or even to know what President George W. Bush was getting at when, in his first inaugural address, he promised that “When we see that wounded traveler on the road to Jericho, we will not pass by the other side.”

In Religious Literacy, Prothero traces the history of religion’s place in American education from its roots in the 17th century, when Protestant theology was a central part of children’s education, through a series of turning points in American religious literacy, such as the Second Great Awakening of the early 1800s and the Supreme Court decisions that in the 1960s banned prayer and Bible reading from public schools.

“Lots of public policy debates implicate religion nowadays. We need to know something about religion in order to be effective citizens.”

Due to a misunderstanding about the meaning of those decisions, many Americans now believe that religious studies can’t be taught in schools. Prothero argues that this notion is both mistaken and damaging to a population that’s increasingly ignorant about religion. And he goes on to propose that we remedy that ignorance by integrating the study of religion into public school and university curricula.

His ideas may be unorthodox, so to speak, but people are paying attention. He’s been profiled in Newsweek and has spoken about the book on The O’Reilly Show with Jon Stewart, The Oprah Winfrey Show, and numerous other television and radio broadcasts. Legislators and school administrators, including those at BU, are taking his recommendations into consideration as they reappraise their curricula. And, perhaps most importantly, the book has jump-started a national conversation on these issues, engaging Americans in thinking and learning about what we—and others—believe.

For more information, see www.stephenprothero.com.

Traveling the Middle Ground

Religion’s place in education, politics, and law is a contentious subject, but, luckily, First Amendment scholar Jay Wexler has little fear of engaging with controversial issues. An associate professor at the School of Law, Wexler writes about such volatile issues as the constitutionality of teaching intelligent design in schools and of displaying religious symbols on government property. But his conclusions may be surprising to those who see these issues in black-and-white. For Wexler argues that the Supreme Court has both wrongly stripped religions of the protections promised by the Constitution and wrongly chipped away at the necessary barrier between church and state. In staking out a position in the middle ground, Wexler has raised the hackles of the most vocal parties in the debate over church-state issues, the extremists—on both sides.

In the book he is working on now, Free Exercise, Expensive Gas: A Church-State Road Trip, Wexler discusses the nuances of American church-state law through the stories of the people and places the laws affect. He plans to travel to the sites that sparked landmark court decisions, like the notorious Ten Commandments monument at the Texas State Capitol, to collect interviews and anecdotes to help engage his readers in the complex legal, political, and cultural questions these are combustible topics, to be sure. But Wexler’s goal is not to stoke the fires of us-versus-them. Instead, he strives through his research to encourage people on both the secular left and the religious right “to listen more openly to what members of the other ‘side’ think and say about the issues that concern them.”

Though the book will chronicle a distinctly American journey, Wexler’s interest in promoting dialogue about law and religion doesn’t end at the U.S. border. He spoke last winter at the Conference on Law and Religion in Transitional Societies in Oslo, Norway—a conference sponsored, in part, by the Chinese government—and is currently preparing a paper and presentation for the Religion and Rule of Law in Southeast Asia conference, to be held this fall in Hanoi, Vietnam. “The U.S. church-state stuff is really interesting,” he says, “but it’s a little bit small and subtle compared to the big religious issues happening in the world, like in places where people actually don’t get to practice their religion.”
“A polytheistic religion looks to questions of harmony among the gods…. And of course that’s human beings’ concern, too: How do we share power?”

In their research Botticini and Eckstein challenge the standing theories that Jews primarily worked in skilled, urban occupations either because they were barred from agricultural work due to their religion or because they sought to sustain their shared cultural and religious identity by banding together in certain locations or professions. Farmers to Merchants looks instead to a cultural transformation that unfolded following a shift in Judaism’s focus from ritual and ceremony, which were concentrated in the Temple, to Torah study, which could be carried out in every Jewish home. By the end of the second century C.E., every Jewish father was expected to educate his sons.

Botticini and Eckstein trace the effects of this transformation on several important developments in Jewish history. For example, the lives of Jewish subsistence farmers left scant time and resources for book learning, and literacy, in turn, provided limited economic benefits to those who made their living in the fields. Correspondingly, conversion rates from Judaism were high among poor farmers, who could not afford to educate their sons as their religion demanded. Literacy proved to be of far greater economic value in urban areas, where educated Jews found work in crafts, finance, and trade. These changes contributed to both the urbanization of the Jewish populations and the expansion of the Diaspora, as Jews traveled widely in search of opportunities abroad.

The results of her questions is a project called “Spiritual Narratives in Everyday Life,” funded by a grant from the Templeton Foundation. For the project, Ammerman and her team of researchers have asked people from different spiritual traditions—Catholics, Mormons, Jews, and atheists, among others—to participate in interviews, record audio diaries, and take photographs of places they find spiritually meaningful. Ammerman and her researchers also attended services and other events at their subjects’ places of worship. By May, the research team had already made some eye-opening discoveries.

“We were a little bit surprised by the degree to which the people who are involved in standard, ‘name-brand’ religious organizations don’t necessarily talk about their lives in ways that are, shall we say, orthodox,” Ammerman says. She’s found that while her subjects do use stories and symbols from their religious traditions to talk about their lives, they also talk about finding meaning in spending time in nature or setting aside quiet, personal time to reflect. “They’re not necessarily talking about praying or doing standard religious practices,” she continues, “but they’re nevertheless doing things that are spiritual.”

The narratives of the project’s title—the stories people tell—are key. By asking open-ended questions, Ammerman allows her subjects to describe religion’s place in their lives in their own words, rather than trying to fit their experiences into any predetermined framework. This, she says, has made all the difference. “If people had been asked a battery of standard survey questions about what they believe about heaven and hell, they might look fairly orthodox,” she says. “But that might not tell you anything really about what’s going on in their lives.”

For more information, see www.bu.edu/sth/faculty/staff/nammerman.html.

—Tricia Brick
When students from 49 high schools in and around Boston filled the stands at BU’s Agganis Arena for the FIRST Robotics Regional Competition in March, the atmosphere had more in common with a rock concert than a science fair. In front of an enormous screen surrounded by flashing lights lay the competition area. Referees watched and students cheered as two rotating teams of three robots apiece scrambled to hang as many colored, donut-shaped balloons as possible—preferably in a row, for scoring purposes—onto a giant metal structure with three levels of hooks. Behind the scenes in “the pit,” where teams tweaked and repaired robots between matches, a rowdy camaraderie prevailed.

The FIRST Robotics Competition (FRC) gives each school only six weeks to design, prototype, test, and construct a robot. Students learn as much about teamwork in that brief period as they do about science and engineering. Twenty-seven Boston University Academy students and five BU undergrad mentors comprised Team 246 this year, with additional guidance from two BU Academy teachers, Gary Garber and Nicholas Dent, as well as manufacturing engineer Michael Gevelber and computer integrated manufacturing (CIMLAB) specialist Robert Sjostrom, both of the University’s Department of Manufacturing Engineering. Some BU Academy students worked on publicity, fundraising, and banner and T-shirt design. Others worked on the robot itself, named RoboRhett after BU’s mascot, Rhett the Boston Terrier.

Brandon Mensing, a Boston University junior studying computer science, estimates that he devoted 200 hours to this year’s competition. What makes RoboRhett unique, he says, is its lifting platform. Judges awarded bonus points at the end of each two-minute match to teams whose robot could support other robots 12 inches above the ground. “Most teams achieved this by building large ramps that fold out,” explains Brandon, but these can be difficult for other robots to maneuver. “RoboRhett actually lifts other robots. The lifter uses two gyroscopic sensors to detect if the platform is lifting unevenly and, if it is, to adjust the flow of pressure in the pneumatics to compensate.”

Three weeks into the competition, Michela Meister, a freshman at BU Academy, found that her hobby of making jewelry translated into a knack for electronics. By the end of the project, she’d learned to solder and use a drill press, applied concepts about electricity before she’d formally covered them in class, and even used her new skills to help the small, first-year team at William McKinley Preparatory School build and wire their robot when they needed an extra set of hands in the final week.

Preparatory School build and wire their robot when they needed an extra set of hands in the final week.

The BU Academy team, which participated in the FRC for the eighth time this year, has a strong tradition of mentoring rookie teams by offering workshops for teachers and hands-on help with projects. When McKinley Prep students won a spirit award on the first day of the competition, Team 246 gave them a standing ovation. Ultimately, scoring is secondary at the FRC—building lasting partnerships is what counts. “In the pit,” says Garber, “one school will make an announcement over the speaker system that they need a certain solenoid, and five teams will rush up with it.”

Most students who participate once are hooked, and many go on to serve as undergraduate mentors after graduating from high school. For more information, see www.burobotics.org.

—Cassandra Nelson

Clockwise, from below left BU Academy students Jacob Magid and Laurel DesRosier prepare RoboRhett for the first day of the regional competition; Brandon Mensing leans over the controllers used to direct RoboRhett’s movements while BU Academy student Benjamin Wilsker (foreground), BU Academy alumnus and MIT undergraduate Samuel Duffley, and BU Academy student Charles Waste look on; an aerial view of the color-coordinated displays and uniforms in the pit, where team spirit and teamwork go hand in hand.
It took a while for scientists to turn their attention to graphene, a strange and immensely promising carbon material that is only one atom thick and exists in the form of a honeycomb lattice. After all, says Antonio C. Castro Neto, a professor in the College of Arts and Sciences, graphene can be made by running a graphite crystal over a piece of paper, so it has been around at least since the pencil was invented in 1564. No doubt, explains the physicist, it was the material’s extreme slenderness that kept it literally out of sight—until a few years ago. Since then, however, it has been getting an awful lot of press. Last year alone, roughly 300 scientific papers were written about the bizarre properties and potential applications of graphene.

“It’s amazing,” says Castro Neto, who was part of the team that first imagined some of the strangest behavior of the material. “At this point, there are thousands of people around the world trying to figure out the full potential of something that almost no one was researching a couple of years ago.”

Castro Neto’s interest in graphene was piqued in 2005, when he read a paper written by Andre Geim of the University of Manchester in England, where physicists had found a way to isolate the unique carbon lattice. At the time, Castro Neto was collaborating on other projects with Guinea Neves and Niño M. R. Peres of Portugal, both of whom had come to BU as visiting researchers under the Quantum Condensed Matter Theory Visitors Program. Together, the three researchers took what Geim had shared about graphene and developed a theory that predicted something truly extraordinary: If graphene were subjected to a magnetic field, scientists would be able to observe effects that only occur with particles moving at a velocity close to the speed of light, although the electrons in graphene propagate at velocities 300 times slower than that. If the three BU researchers were correct, it would mean that graphene could be used as a kind of tabletop particle physics lab, a controlled environment in which scientists could test new physics ideas. Castro Neto contacted Geim and asked if their theory could be verified. He thought it could.

“At that point,” says Castro Neto, “if you look at the number of publications about graphene, you will see an explosion. Everyone was very excited.” Bennett Goldberg, chair of BU’s physics department, was not surprised by that excitement. “One of the great attractions of graphene,” says Goldberg, “is that Castro Neto and colleagues have discovered entirely new physics and new materials science from something so commonplace—the scratch of a pencil on a paper. This elegance has nowcoupled with tremendous technical and economic potential.”

An example of that potential, says Castro Neto, is in the manufacturing of computer chips made of silicon. Graphene can be fashioned into chips that are much smaller than those made of silicon. More importantly, chips made of graphene would have the enormous advantage of generating almost no heat. Castro Neto explains that computer circuitry heats up when electrons meet resistance while passing from one material, such as a transistor, to another material, such as the metal pathways that connect one transistor to another. With the graphene model, both the chips and connecting circuitry could be literally “carved out” on graphene. With such very low resistance, says Castro Neto, there would be very low heat.

There are other applications. Graphene’s extraordinary electrical properties, says Castro Neto, can signal the presence of a single molecule of a foreign substance. “Imagine you have a terrorist who is carrying an explosive,” he says. “There are always some residual molecules in the vicinity, and if just one of those molecules hits the surface of graphene, it will be detected.”

He finds it ironic that so much excitement has been unleashed on something that other researchers had been throwing away. Until physicists in Geim’s lab decided to take a closer look. For years, Castro Neto says, researchers have used Scotch tape in their attempts to cleave graphite crystals, and having done that, they would throw the tape in the trash.

“What Andre Geim did,” says Castro Neto, “was look at what was left over on the Scotch tape. Until then, no one had done that, because when people are familiar with something, they don’t look at it closely.”

This year, Castro Neto’s entire research group is hot on the graphene trail, working with funding from the National Science Foundation. “We are trying to understand the basic electronic properties of this material,” he says. “We are thinking about how we can tailor the properties so it can be used in other applications. For example, can we make this material into a magnet? If so, we can use it for lots of applications involving magnetism. Can we make graphene a superconductor? We are looking at ways to modify it both structurally and chemically to change its electronic properties.”

There is, says Castro Neto, one more thing about this unique lattice of carbon atoms—even though it is only one atom thick, it can actually see, appearing under a microscope as a strange violet-blue hue. That’s because when it is applied to a silicone oxide substrate that is exactly 300 nanometers thick, its wavelength is coincidentally a near-perfect match for the most sensitive cones in the human eye. “If it is,” says Castro Neto, “the thinnest thing human eyes will ever see.”

For more information, visit http://physics.bu.edu/~neto.

—Art Jahnke

Several well-known forms of carbon derive from graphene, top left which consists of a two-dimensional hexagonal lattice of carbon atoms. Graphite, top right famous for its use in pencils, is simply a stack of graphene layers; carbon nanotubes are roll-up cylinders of graphene, lower left, and a buckminsterfullerene molecule consists of graphene which has been baled into a sphere by introducing pentagons as well as hexagons into the lattice, lower right.
Brooke Blower (History), Susharita Chandran (Marketing), John Conner (Microbiology), and Marah Curtis (Social Welfare Policy) were awarded Peter Paul Career Development Professorships.

Zvi Bodie (Finance and Economics) was named the Norman and Adele Barron Professor in Management.

Donald Booth (Oral Surgery) was inducted into the Royal College of Surgeons.

Steven Borkan (Nephrology) received the Massachusetts Medical Society’s Grant V. Rodkey Award for outstanding contributions to medical education.

Lewis Braverman (Endocrinology, Diabetes, and Nutrition) received the Endocrine Society’s Robert Williams Distinguished Service Award.

Frederic Brunel (Marketing), Jonathan Hibbard (Marketing), and Peter Russo (Strategy and Policy) each received the Award for Excellence in Entrepreneurship Teaching and Pedagogical Innovation from the National Consortium of Entrepreneurship Centers.

James Burns (Danielson Institute) was honored with the Early Career Psychologist Award from the National Register of Health Service Psychologists and the American Psychological Association.

William Carroll (English) and James Winn (English) received Fellowships from the American Council of Learned Societies.

Christos Cassandra (Manufacturing Engineering) and David Castañón (Electrical and Computer Engineering) were named Distinguished Members of the Institute of Electrical and Electronic Engineers Control Systems Society.

Suzanne Chaplin (Curriculum and Teaching) received the 2006 Award for Exemplary Curriculum in Mathematics for Gifted and Talented Students from the National Association for Gifted Children.

Aram Y. Chobanian (Medicine) and Ha Jin (Creative Writing) were elected members of the American Academy of Arts and Sciences.

Cutler Cleveland (Geography and Environment) received the Adelman/Frankel Award from the United States Association for Energy Economics.

Alan S. Cohen (School of Medicine) was recognized with an outstanding achievement award at the International Symposium on Amyloidosis.

Herbert Cohen (Nephrology) was elected to the American Society for Clinical Investigation.

Hannah Cole (Visual Arts) received the Helene Wurlitzer Foundation Award and the Plate Clove Artist-in-Residence Fellowship.

Theodore Colton (Epidemiology) was selected by the American Public Health Association to deliver the 2006 Lowell Reed Lecture.

Wendy Caster (Occupational Therapy and Rehabilitation Counseling) received the Eleanor Clarke Slagle Lectureship Award from the American Occupational Therapy Association.

Ralph D’Agostino (Mathematics and Statistics) was named the Remington Lecturer by the American Heart Association.

Carlo De Luca (NeuroMuscular Research Center) and his company Delays, received a Tibbets Award from the Small Business Administration.

Isabel Dominguez (Hematology/Oncology), Haralambos Gavrais (Hypertension), Alhena Halpert, Brian Jacobson, Robert Lowe, Satish Singh, Diane Song, and Michael Wolfe (all of Gastroenterology), and Yuqing Zhang (Epidemiology) were named members of the National Guidelines Committee.

Thomas Einhorn (Orthopedics) received the Dr. Marian Ropes Award for Excellence from the Massachusetts Arthritis Association.

Sean Elliott (Chemistry), Emanuel Katz (Physics), Christopher Passaglia (Biomedical Engineering), Leonid Reyzin (Computer Science), Joshua Semeter (Electrical and Computer Engineering), and Jean Walker (Geography and Environment) each received a National Science Foundation Career Award. Emanuel Katz also received a Sloan Fellowship and Leonid Reyzin was named a Fellow of the Institute for Pure and Applied Mathematics.

Terry Everson (Music) led the BU Trumpet Ensemble to second place in the 2007 National Trumpet Competition.

Fred Foulkes (Organizational Behavior) received the American Compensation Committee’s Lifetime Achievement Award.

Alan Geller (Dermatology) received the Environmental Protection Agency’s Stratospheric Ozone Protection Award.

Barbara Gilchrest (Dermatology) was awarded the Stephen Rothman Medal by the Society for Dermatologic Investigation.

Michael Gredin (Health Law) delivered the Cabot Lecture at Harvard Medical School as well as the University Holocaust Lecture and Dean’s Lecture at Vanderbilt University.

Linda Heywood (African American Studies) received a fellowship from the W. E. B. DuBois Institute for African and African American Studies.

Ariel Hirsch (Radiology) received the Nathan Smith Award from the New England Surgical Society.

Alice Jacobs (Cardiology) received the American Heart Association’s Paul Dudley White Award.

Zhimon Jacobson (Dentistry) received an honorary doctorate from the University of Bucharest.

Peggy Johnson (Psychiatry) was named Clinical Psychiatrist of the Year by the Massachusetts Psychiatry Society.

Judith Jones (Dentistry) received the International Association of Dental Research’s Distinguished Scientist Award.

Shira Kamachi (Dentistry) received an Outstanding Faculty Award from Procter & Gamble.

Spencer Kemp (Dentistry) was named a Diplomate of the American Board of Oral and Maxillofacial Pathology.

Fred Klaeiner (Art History) received the Text and Academic Authors Association’s Text Prize for A History of Roman Art.

Nancy Koppel (Mathematics) received the Weldon Memorial Prize from the University of Oxford and was selected to be the John von Neumann lecturer by the Society for Industrial and Applied Mathematics.

Lev Levitin (Electrical and Computer Engineering) was named a Life Fellow of the Institute of Electrical and Electronic Engineers.

Don Lucas (Music) was elected President of the International Trombone Association.

Robert Marge (African American Studies) received the Ciio Award for exceptional service in cimetrics.

castle Jo Martin (Political Science) was named a Fellow of the Radcliffe Institute.

Norman Mazer (Endocrinology, Diabetes, and Nutrition) received the North American Menopause Society and Procter & Gamble’s Pharmaceutical Androgen Research Award.

Michael Meuer (Law) received the David Saul Smith Scholarship Award.

Hamid Nawab (Electrical and Computer Engineering) was elected a Fellow of the American Institute of Medical and Biological Engineering.

Patricia Nemec (Occupational Therapy and Rehabilitation Counseling) received the John Beard Award from the U.S. Psychiatric Rehabilitation Association.

Frank Perna (Mental Health and Behavioral Medicine) received the Walter Peach Award from the Association of Applied Sport Psychology.

Jean E. Ramsey (Ophthalmology) received the American Academy of Ophthalmology Achievement Award.

Amy Rosen (Health Services) received the Career Scientist Award from the Department of Veterans Affairs.

Ronald Roy (Aerospace and Mechanical Engineering) was named George Eastman Distinguished Visiting Professor at the University of Oxford.

Jeffrey Rubin (History) received an American Philosophical Society Fellowship.
Center of Excellence in Sickle Cell Disease
Communication Research Center
Danielson Institute
Editorial Institute
Eile Wiesel Center for Judaic Studies
Executive Development Roundtable
Fraunhofer Center for Manufacturing Innovation
Gerontology Center
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Faculty and Staff:
2,680 full-time faculty, 1,179 part-time faculty, 4,392 full-time staff, 382 part-time staff
The Campus
133 acres, 324 buildings, 474 classrooms, 2,006 laboratories, 10,686 total residence capacity
Computing Facilities
Supercomputers
IBM BlueGene/L supercomputer with 1,024 nodes
IBM pSeries 690 with 112 processors
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Specialized High Performance Computer Laboratories
Deep Vision Display Wall
Access Grid Conference Facility
Computer Graphics Laboratory
LIVE: Laboratory for Virtual Environments

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