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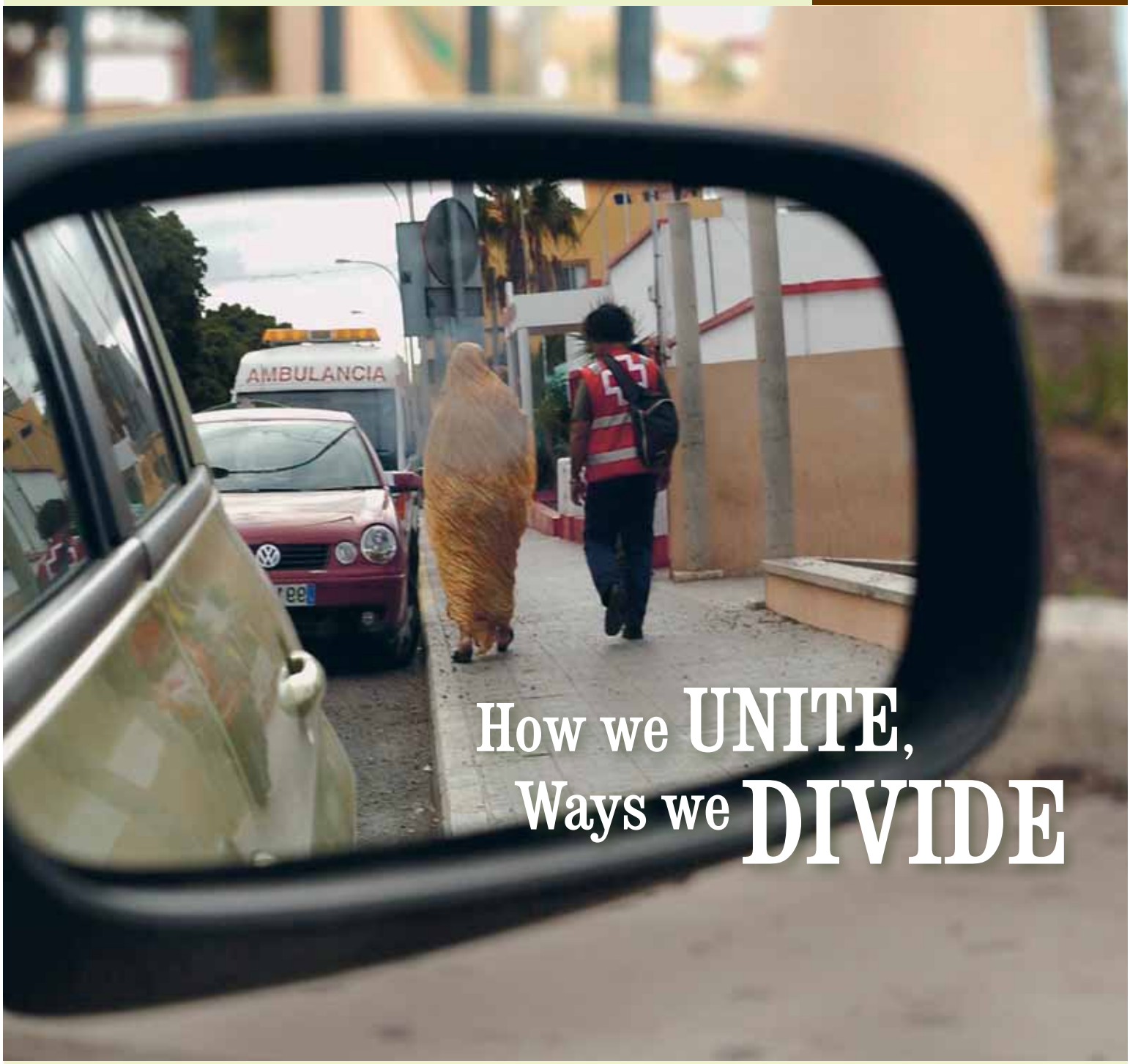

How we UNITE, Ways we DIVIDE

LEHIGH UNIVERSITY® | COLLEGE OF ARTS & SCIENCES

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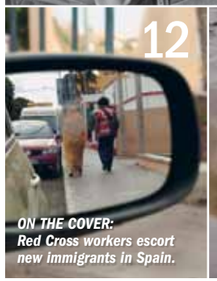

ON THE COVER: Red Cross workers escort new immigrants in Spain.

UP FRONT

FEATURES

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Message from the Dean

CREDIT TO COME

Finding Insight and Hope

This issue of the annual research magazine explores how faculty research, scholarship and creative work are making a difference.

There is nothing better than finding a comfortable spot and getting lost in a good book—whether you read a bound book printed on paper, or one viewed digitally on a Kindle or IPad. A good book draws you in, captures your imagination, and can influence the way you view yourself and the world around you. A compelling narrative has the power to give voice to hopes and fears as well as tensions and conflicts within society.

Conflict both unites and divides and these notions run throughout the stories as a common theme in this issue of *Acumen*. Each story presents faculty who come together and contribute to the research and creative work in their respective disciplines. Our cover story, *How We Unite, Ways We Divide,* examines how identity, solidarity, and political and social processes are communicated through literature, media, and political discourse. Our second feature, *The Spectrum of Language,* shows how language is not only an avenue for expressing our thoughts and perceptions, but also a powerful element in defining social identities.

The impact of human development on the environment has been at the fore as the Gulf Coast struggles with an oil spill and the resulting consequences. Water is a natural resource that many of us take for granted, yet clean water is a resource that is beginning to shrink rapidly worldwide. The feature, *Man or Nature?,* takes a look at the work of three Lehigh faculty and issues surrounding clean water.

Research, scholarship, and creative work are essential components of today's universities. Research generates the sparks of discovery that drive creativity and innovation and is integral to the educational process. We close with *Robotic Dimension,* which shows how the abstract work in the field of mathematics can create a link with the practicalities of robotics development.

While many point out that conflict keeps us apart, conflict also provides us with opportunities to find ways in which we come together. It forces us to look at alternative points of view, to confront our fears, and to find those connections that create a collective good. Universities play a fundamental role in finding the connections that bring us together rather than drive us apart.

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Enjoy this issue of *Acumen*. I look forward to sharing our contributions and accomplishments with you and welcome your thoughts and comments.

Anne S. Meltzer
Herbert and Ann Siegel Dean

Art

Fresh Perspectives

Ricardo Viera, professor of art in the department of art, architecture and design, traveled to Guatemala in July to assist and advise a young group of artists and art administrators who established a photography festival in Guatemala City.

In its inaugural season, Guatephoto Festival celebrated both contemporary art and a panoramic overview of local and national photography. As a member of the board of advisers, Viera helped shape the concept of this international event by conducting interactive talks and photographic portfolio reviews at La Fototeca and Museo Nacional de Arte Moderno Carlos Merida.

Guatephoto Festival is just one of many events Viera, curator and university museum professional, has been tapped for internationally. He often consults with small communities in the Caribbean or major museums in Spain and Central and South America. The process he developed in the classroom is the base of his integrated research for solving museum issues in diverse cultures.

LUIS CRUZ AZACETA, *THE CROSSING*, 1991

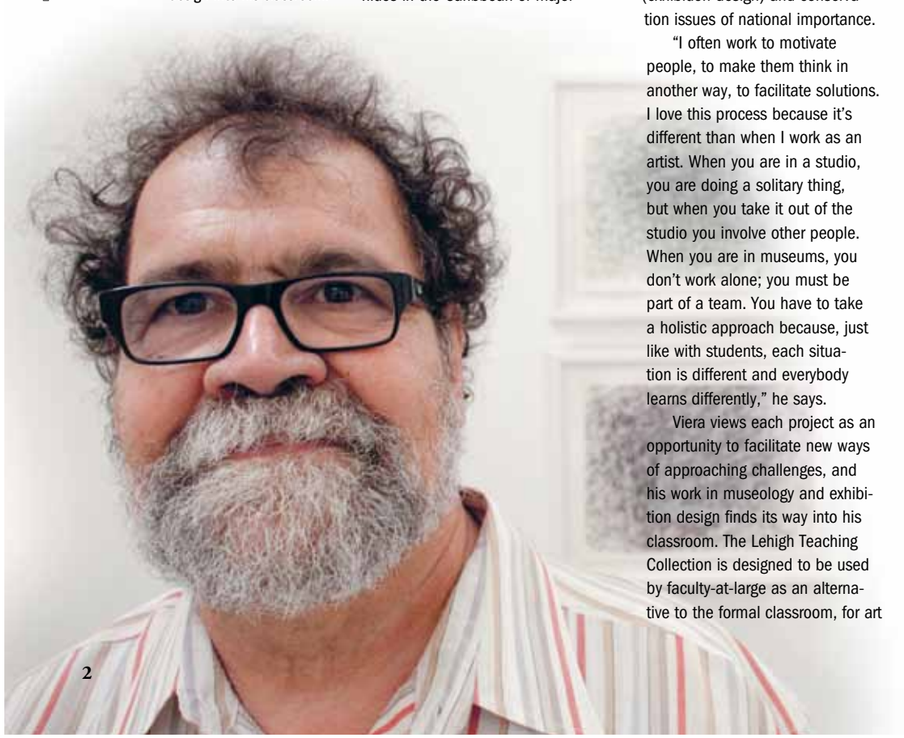
Viera, who is also director and curator of the Lehigh University Art Galleries/Museum Operation, has established a visual laboratory and teaching collection program as well as a nationally recognized collection of Latino and Latin American photography and video. He has organized, curated, co-curated and served as consultant to important exhibitions throughout the world. He has served on many occasions as a cultural envoy for the U.S. Department of State, recently in the Dominican Republic, conducting workshops and master classes, and presenting seminars and lectures. As an envoy, he often works with museum directors, professional staff and government officials, negotiating significant administrative, museographic (exhibition design) and conservation issues of national importance.

"I often work to motivate people, to make them think in another way, to facilitate solutions. I love this process because it's different than when I work as an artist. When you are in a studio, you are doing a solitary thing, but when you take it out of the studio you involve other people. When you are in museums, you don't work alone; you must be part of a team. You have to take a holistic approach because, just like with students, each situation is different and everybody learns differently," he says.

Viera views each project as an opportunity to facilitate new ways of approaching challenges, and his work in museology and exhibition design finds its way into his classroom. The Lehigh Teaching Collection is designed to be used by faculty-at-large as an alternative to the formal classroom, for art and ethnographic scholars as well as museum interns and students.

"I have to constantly change hats. I work with artists and I work with the business, social, community and communication aspects of museums. It is an embryonic process that involves everyone, because I don't teach museum professionals; I teach museum consumers," says Viera. "But unlike many other museums, the university museum students are involved throughout the process. And like anybody working in a museum, they encounter difficulties while developing an exhibition and find ways to solve them. They grow while they are with me *in situ*."

DOUGLAS BENEDICT



Professor Ricardo Viera integrates his work in museology and exhibition design into his classroom.

Music

A Constant Voice

Steven Sametz, professor and Ronald Ulrich Chair in the department of music, was commissioned by the Lehigh Choral Union to compose a new work for the internationally renowned choral ensemble Chanticleer, which was performed at a special concert last spring in Lehigh's Zoellner Arts Center. The commission recognized Sametz for his contributions to the choral arts at Lehigh.

The Lehigh Choral Union, the community outreach arm of Lehigh Choral Arts, was founded by Sametz 25 years ago and is composed of 150 students, faculty, staff and community members who come together to rehearse and perform major works from the choral-orchestral repertoire.

Sametz has a 20-year history composing for Chanticleer. This season, its tour program included his setting of the e.e. cummings text, "in time of daffodils/who know." Chanticleer performed "in time of" as well as the premiere of the newly commissioned work "Not an End of Loving" at an April concert at Lehigh.

"in time of" was originally composed in 1995 for Choral Arts as a version for multiple choirs and orchestras. Sametz later "distilled" it for the 12 voices of Chanticleer. In an interesting reversal of the creative process, Sametz took the title section of the new work premiered by Chanticleer and re-worked it for Choral Arts with orchestra, which was then performed at their final concerts on April 30 and May 1.

The three sections of "Not an End of Loving'' examine three phases of love. The first section, "Where I Become You,'' based on a text by the South African poet Antjie Krog, represents the white heat of love's first encounter. The second movement, "We Two Boys Together Clinging,'' based on a text by Walt Whitman, portrays the maturation and commitment of a relationship. Eternal love is the theme of the final section, ''Not an End of Loving,'' a translation of a Latin clerical letter by the eighth-century monk Alcuin of York, in a translation by Helen Waddell. Sametz has a fondness for medieval Latin texts and he has used Latin clerical letters in the past as components of his compositions.

Steven Sametz

THEO ANDERSON

"The entire experience of the commission and composition of this new work was exciting and humbling," says Sametz. "That the members of the Choral Union chose to honor our work together with the creation of a new piece speaks to our commitment over the years to not only study and present the finest in established choral-orchestral repertoire, but to add our own contribution to the future of choral arts. That they commissioned it for such a world-renowned group as Chanticleer also attests to our own very high standards. Chanticleer's performance was tremendous, and reworking the last movement for all our choral artists—both regular members and returning members who were on hand for our alumni reunion—gave the piece special resonance. Going from 12 singers to almost 300—and adding orchestra—was something that could only happen at Lehigh: the various aspects of the commission and performances demonstrated the very highest commitment to the creative process and how that process brings us together and shapes our lives."

Sametz's works have been performed throughout the world and are included on numerous recordings, including Chanticleer's Grammy-award winning CD *Colors of Love*. Sametz also serves as artistic director of The Princeton Singers, a professional a cappella ensemble.

Architecture

Virtual Space

Nik Nikolov finds that the traditional architectural practice of two-dimensional drawings is lacking. He is convinced that the future of architecture lies in virtual space.

Nikolov, an assistant professor of architecture in the department of art, architecture and design, is interested in the perception and conception of space and centers his research on virtual building design processes. Much like the worlds created in the latest video games, architects can use virtual technologies to address the challenges found in any building process. Virtual reality offers designers the opportunity to work with the same legitimacy as in the real world, whereas conventional plans present an impossible set of viewpoints.

"Virtual design gets architects much closer to experiencing how a space will act in its environment and change over time," he says. "Virtual and physical space are both temporal. We experience space through movement and change over time. Our perceptions are based on movement. A lack of movement leads to a lack of perception. The virtual gets us much closer to that temporal experience than line drawings, because in the virtual you can put yourself in a space. You can manage an environment. You can traverse, fly, edit. You can assume multiple vantage points, not just a single one."

To address these design situations, Nikolov is advancing current computer-aided design and developing a truly immersive environment. Borrowing graphics software systems from the gaming industry, he is working to create an interactive design environment that is not a representation of the space but a true habitation. Driven by motion sensors and 18 projectors that wrap the space around the architect, this new technology allows architects to edit in real time and the scale of the space is parallel to the scale of the human body.

New HR tk

Images from Nik Nikolov's "Implicit Geometrics" show parametrically generated surfaces and structures that use real-time modeling and editing in 3D.

CREDIT TO COME

"You're no longer looking at a computer screen or a set of prints. A door handle is the same size as a true handle. A table is the size of an actual table," he says. "You have a more innate, inherent relationship to what you are representing. It allows an architect to move a window or to make the window larger in real time instead of waiting weeks for plans to be redrawn. Architects will be able to experience the space with their clients and the builders. It centralizes the role of the architect, yet at the same time makes the design process more inclusive. That's very empowering."

Nikolov is working with his students to develop a test environment for a prototype. Ultimately, he says, architects will be able to define construction parameters, test them in a virtual environment, make changes and output full-scale building materials for testing in their working environment. The technology will streamline the design process and help eliminate major mistakes.

Nikolov sees the development of these new technologies as intimately related to his other line of research, which investigates the relationships of geometry, building units and methods of construction involved in the use of masonry veneer wall systems. He is in the design development stage of a "mortarless" ventilated masonry facade system that has particular implications for the architectural profession.

BETTMANN / CORBIS

North Africans arriving at Marseille have their papers checked by French Immigration inspectors.

Modern Languages and Literature

The Intruder

In the late 1950s and early 1960s, France experienced large-scale immigration from its former North African colonies such as Algeria, Tunisia and Morocco. The influx of these postcolonial immigrants created a social and racial clash that France is still addressing. Many of these immigrants are now French citizens, some for generations, and France must adapt to these citizens and respect their identities. Yet, to many French, these immigrants are too culturally, socially and racially different to be immersed into society.

Because these immigrants have been kept on the cultural and societal boundaries, a generation of immigrants lacks a sense of belonging. They are not viewed as French, yet they are no longer viewed as Moroccan or Algerian. Taïeb Berrada, assistant professor of French in the department of modern languages and literature, studies these issues by examining 20th- and 21st-century postcolonial narratives about or from the Algerian and Moroccan diasporas in French literature, film and graphic novels. These French or African writers have long discussed the impact of French colonial rule on the formation of subjectivity, selfhood, memory and narratives in postcolonial North Africa and in the North African diaspora in France today.

Berrada examines how North African writers recall their memories and experiences through text and film. While critics have historically believed that there is a clear, distinct division between French and North African histories, Berrada argues that French and North African writers show in their works that France and North Africa share a colonial past and therefore a common history.

GONZALO FUENTES / CORBIS

Muslim immigrants in Paris

To address these issues, Berrada has borrowed a figure from French philosopher Jean Luc Nancy—the Intruder. The Intruder, whether it is a character or a narrative voice in a novel, a foreign language in a country, an image in a film, a box in a graphic novel or simply a word, represents the person who does not fit in or does not belong to a particular space or a particular discourse. While the commonly seen "Other" is outside society, the Intruder is challenging norms from within. Following the figure of the Intruder, North Africa is inside France as much as France is inside North Africa when it comes to areas such as culture, language and history.

"French citizens of North African descent are intruders, because they are not considered French by mainstream France. They represent a threat because they are shifting the perception of French society which has become multicultural, multiethnic, multireligious, etc.," Berrada says.

Expanding on this work, he is now looking at different aspects of illegal immigration in France by analyzing novels and films and critiquing the current postmodern and postcolonial interpretations of displacement and exile. He argues that these narratives about or by illegal immigrants constitute a "clandestine" argument that interrupts mainstream discussion regarding transnationalism and notes that they demonstrate a need to reassess the idea of migration between France and North Africa. France has traditionally upheld the values of freedom, human dignity and understanding, and these writers bring to light ethnic and religious intolerance.

"They question the idea of universalism in France, that everybody is equal, free and fraternal. It doesn't work that way because it's a French sense of universalism," he says.

Philosophy

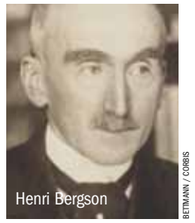
The Metaphysics of Sensuality

Henri Bergson was perhaps the most influential French philosopher at the beginning of the 20th century. Bergson wrote that intuition, as the discoverer of truth, reveals the real world, not intellectual analysis. Gordon Bearn argues there is a striking similarity between Bergson's notion of metaphysical intuition and the concept of sensuality.

Bearn, professor of philosophy, began his examination of sensuality in 2008. It is easy to misconstrue pleasure as a subjective sensation like pain, but this error is avoided if we consider enjoyment. What we enjoy is the peach, not the effect of the peach on us. He has been examining sensual enjoyment, a definite way of enjoying something, and enjoying it sensually.

"Take a spoonful of soup and suppose you are the cook. You can taste the soup to see if there is too much cumin, too much salt, or not enough. You're not really enjoying the soup. You're just freezing that experience as a cumin experience or a salt experience. But you can also hold the soup in your mouth, close your eyes, plunge into the flavors—'mmmm.' That's my target: floating sensual in liquid corporeality.

"What you enjoy when you plunge into the soup is the soup. Losing track of time, you feel the thickness of the soup in your mouth, the passage between textures and flavors. I think that blurring of all the sensual things together, the passage between what we habitually separate, is the key to sensual enjoyment," he says.



Henri Bergson

BETTMANN / CORBIS

Normally, said Bergson, we don't really see things at all, we just read labels attached to them. Sensual enjoyment will only be ours if we resist intellectualizing and categorizing our experience of the world and if we break our habits of practical engagement. Bearn enjoys putting this as: If it ain't broke, break it.

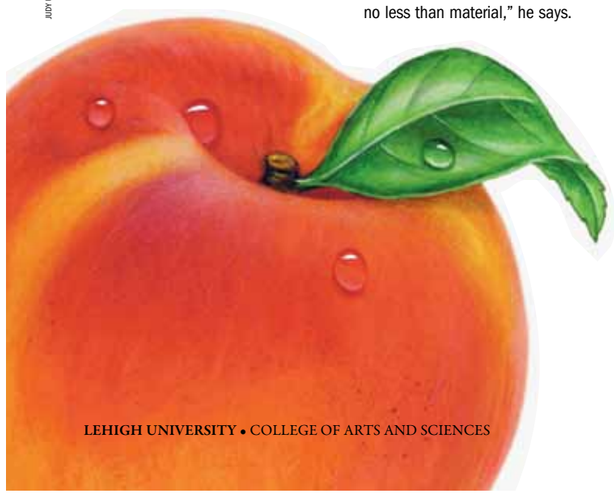
Although the supposed requirements of a conformist morality have mostly forced sensual enjoyment beyond the horizon of philosophy, philosophers do admit that sensual enjoyment exists. But the sensual enjoyment of linguistic life, if it is even conceded existence, is almost never interrogated. Bearn is interested in both dimensions of sensuality—the sensuality of things, but also the sensuality of language, a sensual semantics.

"Many people think of language as a tool. We habitually think of a word as a series of phonemes, a complex type of sound, arbitrarily associated with its significant use. It might be arbitrary but it is not therefore, as a phoneme, without significant expressive force."

The long sound "a" is made way down the throat. Learning about the way our bodies resonate to different phonemes is learning about the expressive sources of our language, for example: "mmmm." And enjoying words both as signifiers and as resonators can be sensual, he says. Moreover, there is no stopping the expressive force of sounds. The singular utterance will always precipitate feelings and thoughts that resonate in variously expressive ways with the surroundings of the utterance—semantical and material.

"To see the world, we need to exercise the painful violence of sensation to reach Bergsonian intuition. The logic of sensation is the logic of metaphysical intuition. It can provide heterogeneous sensual enjoyments, linguistical no less than material," he says.

JUDY UNGER / GETTY IMAGES



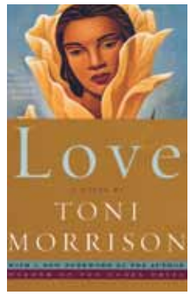
English

Learning from the Landfill

Discussion regarding the current state of our environment is not limited to scientists and policy makers. Some noted contemporary authors focus on the waste produced by society. Mary Foltz, assistant professor of English, studies 20th-century writers and examines their depictions of waste—representations of landfills, sewage systems and other methods of disposal—in fiction. Her research finds that these writers are deeply committed to depicting society's destructive practices of disposal through fiction.

Whether it is the parodic works of Thomas Pynchon or the depictions of marginalized communities by Toni Morrison, Foltz argues that many postmodern novelists not only provide a critique of waste-disposal practices, but they also speak to the value and pleasure society finds in waste. Environmental authors such as Reinaldo Arenas or William Gaddis depict representations of waste that connect to issues such as race, gender and class. They construct alternative subjects like scavengers and trash artists who refuse to bury or to forget the wretched. Rather than indulging in a routine call for recycling, Foltz says these writers show that discussing waste and claiming things that others discard leads to the development of truly sustainable communities. She finds that many postmodern authors are primarily concerned with why human civilizations are attacking the world with waste.

Many of the authors Foltz studies are more interested in why humans consume and dispose in such an aggressive manner. Their waste-focused ethics illustrate that the continuation of human life lies with addressing our waste and refusing to imagine a separation between the natural world and ourselves, says Foltz.



DOUGLAS BENEDICT

Mary Foltz, assistant professor of English, (bottom) explores waste produced by society through authors such as Thomas Pynchon and Toni Morrison.

"Many current literary texts encourage the reader to avoid participation in the ecological disaster by finding value in the waste of both the individual and society. These authors create fictional communities and individuals who find pleasure in materials that might appear worthless to society," she says.

Examining the works of postmodern writers gives Foltz opportunities to explore the importance of contemporary fiction in addressing today's environmental challenges.

"I can work with environmental scientists, work with legal theory or study the works of people like James Fullard, who is working in environmental racism—choosing impoverished communities in which to put landfills or incinerators.

Foltz's current effort brings into the mix Fluxus art, or art made from waste, and connecting it to novels like Don Delillo's *Underworld* or Pynchon's postmodern novel, *The Crying of Lot 49*. These artists are important in contemporary fiction because they are exemplary in their rethinking and reimagining of how to work and interact with the world.

"It's an important ethical question for all of us as readers. I can examine these issues while maintaining a primary focus on the fiction. I think fiction can reflect a contemporary subjectivity—a violent subjectivity of disposers—and yet it can push us to imagine alternative ways of being in the world."

Postmodern authors are concerned with why humans attack the world with waste.

JENNIFER ESPERANZA / GETTY IMAGES

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Religion Studies

Theosemiotic

Pragmatism is perhaps America's most significant contribution to the history of philosophy. Charles S. Peirce (1839–1914), who lived the last 30 years of his life to the north of Lehigh University in Milford, Penn., is often recognized as being the founder of pragmatism.

In 1989, Michael Raposa, professor of religion studies and E.W. Fairchild Chair in American Studies, coined the term "theosemiotic" to serve as a label for Peirce's basic metaphysical perspective on the world, as well as to identify his highly original philosophical methodology for addressing religious questions and understanding religious truth claims. Two decades later, Raposa, in his latest project, continues to explore the religious dimension of Peirce's pragmatism.

Theosemiotic is a distinctive tradition in American religious thought that can be traced back through Ralph Waldo Emerson to Jonathan Edwards. It came to its zenith with Peirce, and then influenced the work of William James, Josiah Royce and others. Raposa suggests that theosemiotic also has some medieval roots, most especially in the thought of the 13th-century Franciscan John Duns Scotus. Raposa argues that if one traces the legacy of Scotus to its modern development in Peirce's thought, then a different picture of Scotus' relationship to modernity emerges. Peirce himself read Scotus carefully and regarded him as one of the most important philosophers who ever lived. Raposa's project attempts to provide a clear sketch of theosemiotic, not only as Peirce conceived it, but as it might be understood and further articulated by contemporary philosophers of religion. He argues that there is a common theme that runs through the work of these American thinkers.

"It is a notion that the created universe is a system of signs, signs that religiously trained people can read and interpret, even as others would fail to recognize them," he says. "From a pragmatic perspective, the way that we test the validity of our interpretations is by evaluating the impact that they have on our ongoing behavior and practices. Peirce believed our human experience of the world is also always a matter of interpretation. Even the simplest perceptual judgments take the form of inferences, albeit often ones that are unconscious and not subject to immediate self control. The implications of such a view for the philosophy of religion are profound."

As with the other American pragmatists, Peirce insisted on the continuity between theory and practice, thought and feeling, interpretation and behavior. Experiences and practices labeled as "religious" are not simply raw data to be subjected to careful philosophical scrutiny, says Raposa. They themselves have a fundamentally interpretive dimension and function, so that the meaning of religious ideas is signified by and embodied in certain habits of feeling and patterns of conduct. For Peirce, our disciplined practices display a logic that more effectively exposes the meaning of religious beliefs and ideas than any carefully articulated verbal argument or explication ever could.

Mathematics

Gene Expression by the Numbers

In cancer research, scientists attempt to build better predictive models of diagnosis and therapy for patients and drug development based on gene expression profiles. Yet one of the challenges is a low sample size of available data as compared to a very huge number of genetic entities. The latest work by statistician Ping-Shi Wu, assistant professor of mathematics, is expanding our understanding and analysis of gene expression in medical research. He proposes a new technique to resolve the complications caused by high-dimension and low sample-size data and has demonstrated its excellence in the classification of gene expression data as an example.

Current technologies present investigators with the task of extracting meaningful statistical data from spaces where the dimension of the data vectors may be much larger than the sample size. A new tactic is needed for very high-dimensional data, and in particular the need for effective classification procedures for such data, says Wu.

Ping-Shi Wu

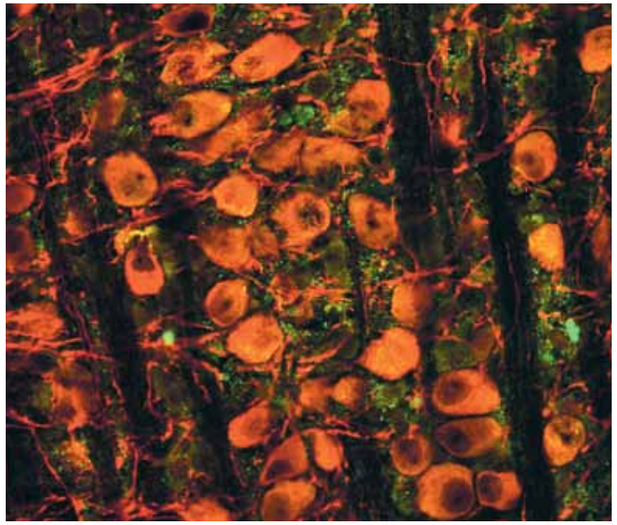
DOUGLAS BENEDICT

The properties of high dimensionality are often poorly understood or overlooked in data modeling and analysis. Wu proposes a new theory regarding classification of high-dimensional data for DNA microarray. Working with gene expression vectors in four types of cancer, Wu, in collaboration with Hans-Georg Müller at the University of California-Davis, developed a connection between the functional data analysis (FDA) and multivariate analysis (MVA) approaches for cases in which the dimension of the multivariate data is much larger than the sample size. Wu has introduced a functional embedding technique that uses the crossing points between multivariate and functional data, aiming at borrowing strength across the sample through FDA techniques in order to resolve the difficulties caused by the high-dimensional data.

FDA techniques are commonly used to assist researchers with developing models and analyzing curves. However, these curves vary over a continuum, typically time, space, or both, making estimates necessary to create smooth curvatures or slopes between X and Y coordinates.

"When analyzed, especially when the sample size is much less than the dimensionality, the multivariate technique doesn't work. The intuitive solution is to use functional data analysis. If you want to apply FDA to multivariate data, the question is how to convert it to functional data. For whatever multivariate data is a vector, originally the order of entries is not meaningful," says Wu.

Wu has developed a connection between the FDA and MVA approaches. He proposes an ordering of the variates by means of multidimensional classical scaling. Once the components of high-dimensional data have been ordered and embedded into a function space, FDA approaches can be applied in subsequent analysis. This bridge allows researchers to bring the whole array of FDA methodology to bear on high-dimensional data.



"Functional embedding is promising compared to other methods that have been proposed for the classification of high-dimensional data. The method has potential to be more widely useful for the analysis of very high-dimensional data."

Biological Sciences

Processing Sound

Michael Burger, assistant professor of neuroscience in the biological sciences department, is interested in how the auditory system processes sound information. His research, titled "Efferent Inhibitory Mechanisms in Binaural Processing," has been funded through a five-year grant from the National Institutes of Health's National Institute on Deafness and Other Communication Disorders. The Deafness Research Foundation also funded Burger's earlier work in this field in 2008.

To process sound, the ear and the brain work in tandem to determine its location, relying on a specialized neural circuit in the

DOUGLAS BENEDICT

Michael Burger, assistant professor of neuroscience, examines structures in the brain (above) called the medial nucleus of the trapezoid body (MNTB). The MNTB is a major source of inhibition to other auditory centers in the brain. In this image, the red labels microtubules, or proteins that are highly enriched in neurons, while the green labels receptors for inhibition. Thus, the inhibitory MNTB nucleus is itself inhibited.

brain devoted to the process. The brain is able to compute where sound comes from by determining when a sound wave strikes each ear. Auditory neurons can detect the tiny microsecond differences in arrival time of a sound between the two ears. This system also has to function over a wide range of sound intensities, making this computation particularly challenging.

DOUGLAS BENEDICT

Postdoctoral research fellow William Coleman and graduate student Sonia Weimann prepare tissue for immunohistochemical analysis in Michael Burger's lab.

The research centers on the question of how cellular, synaptic and systems-level properties are integrated to allow sensory neurons to extract and represent features of the acoustic environment. Burger is exploring how the inhibitory components of the circuit influence processing in each brain area involved in computing sound-source location.

Burger and the other members of his lab work with chickens, which have brain circuitry similar to human brain structures. Chickens also serve as good developmental models because researchers are able to study hearing at any stage. Over the long term, Burger hopes to use the findings gleaned from his work with chickens to build a mechanistic understanding of sound localization circuitry in vertebrate systems.

Burger first began studying hearing at a bat auditory neuroscience lab at The University of Texas at Austin and later started working with birds as a senior postdoctoral fellow at the Department of Otolaryngology—Head and Neck Surgery at the University of Washington. In 2005, he was awarded a prestigious Alexander von Humboldt Research Fellowship at the University of Munich.

While this research may be fundamental in nature, its contributions could play a significant role in clinical applications. Understanding how normal brain circuits function can help develop or improve prosthetic devices, such as cochlear implants. These electronic devices substitute for damaged structures in the ear that may not function properly, and can restore hearing to deaf patients.

Although much is known about the process of how information flows from the ear to the brain, less is understood about efferent feedback—the information that travels from the higher regions of the brain back to lower processing centers. Burger says that current prosthetic devices don't take into account any such feedback.

Some of the work he is researching today stemmed from questions he began investigating during his time in Munich. Burger and the scientists in his lab recently finished a major investigation into the role of synaptic modulators in the processing of sound location cues funded through a Howard Hughes Medical Institute (HHMI)—sponsored program at Lehigh.

Moving forward, Burger says that questions which have already come out of the HHMI research are helping to broaden his inquiries as he focuses on the NIH-funded research. "You have to let the science drive you to branch out and explore new things," says Burger. "That's one of the most exciting parts of being a scientist."

Physics

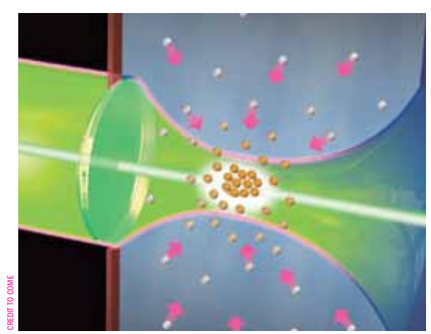
Focusing Light on HIV

The data are clear and sobering. Although a small-but-growing number of countries are beginning to contain the spread of the AIDS virus, the epidemic is expanding in all areas of the world, outpacing the response. Many of the affected countries lack the financial and staffing resources to effectively test for HIV, but the solution might lie in the laboratory of Daniel Ou-Yang.

Ou-Yang, professor of physics and bioengineering and director of Lehigh's Emulsion Polymers Institute, uses light to collect and study the behavior of nanoparticles. Using polystyrene spheres, he uses a laser to catch particles measuring less than 100 nanometers in a football-shaped focal point he calls an "optical bottle."

In an optical bottle, light triggers or alters the interactions of colloidal nanoparticles, allowing researchers to study and analyze these interactions or control their transport behavior.

"Particles much smaller than one micron cannot be tweezed, but you can entice the particles with light and you can ask questions about particle activity," he says. "You can't trap individual nanoparticles, but you can study their interactions inside the optical bottle. Using light, we can manipulate how particles behave in surrounding media."



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Light is used to trigger and alter the dynamics of particle interactions within an "optical bottle."

Using optical bottles, researchers can assess the interaction energies between the light and the nanoparticles in the bottle as well as the osmotic interaction between the particles by measuring the extent to which they fill or leave a bottle. Originally conceived for engineering applications, the technology can be applied to finding new diagnostic techniques. Focusing on detecting HIV viral particles in blood, Ou-Yang believes this new method may be an alternative for quantifying nano-scale colloidal parameters in general, as it is easier to operate than conventional methods, and the experiments can be performed with lower concentrations at a sensitivity unattainable before. One particular benefit of this technique is the reduced number of false positive cases during HIV diagnoses, he says.

Typically, the viral concentration in a blood sample is extremely low, so clinicians concentrate the virus to the extent that it can be detected. The current method requires that blood samples be taken and clinicians measure the quantity of ribonucleic acid (RNA) fragments that are believed to be specific to HIV present in each milliliter of a person's blood. Then the RNA is augmented exponentially by a string of replications. Then a complex mathematical estimation is used to try to ascertain how many RNA fragments were present in the original sample of blood. Each one of these steps introduces the potential for inaccurate results.

"Eventually you get enough of a concentration, but it's not very accurate," says Ou-Yang. "Imagine it's like a copy machine copying. If you start with some blemish in the original, then the original keeps getting amplified. Using this alternative technique gives us greater sensitivity in detecting the HIV particles directly instead of those RNA."

Ou-Yang's technique traps viral particles to more accurately enumerate their presence. He has determined that optical bottles induced improved concentration levels. Using optical bottles, he hopes to develop a simple, reliable and affordable diagnostic technique that uses light to isolate and detect HIV particles.

Earth and Environmental Sciences

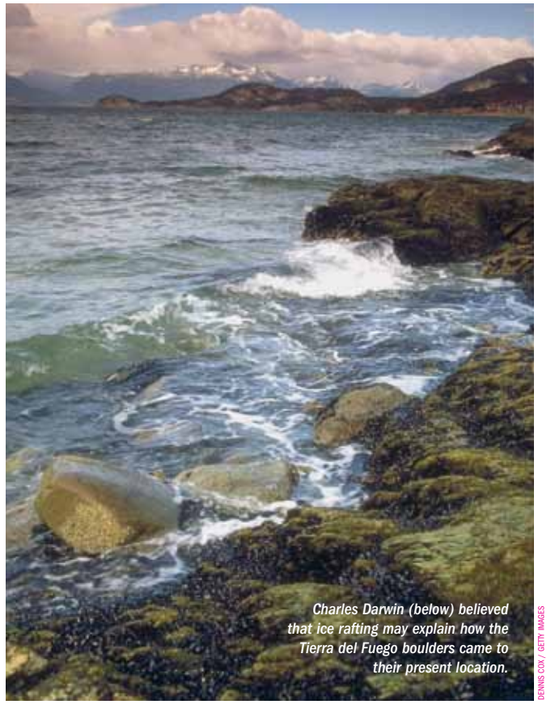
Darwin's Boulders

In 1833, Charles Darwin stopped in the Tierra del Fuego region of South America to study a strange collection of granite boulders located on the coast of Bahía San Sabastian. Darwin was puzzled by the distribution of the rocks, which numbered approximately 500 and spread out in a banana shape. The region was a flat plain, so Darwin wondered how they came to lie there.

Darwin proposed that ice rafting was the explanation. On a glacier that goes into the sea, boulders fall off the hillside onto a glacier. The glacier produces icebergs, or calves, when its tongue extends into the water. Some of these calves have boulders on them. The calves drift around until the iceberg runs aground and the ice melts and deposits the boulder on the seabed until uplift raises them out of the water.

In the fall of 2009, Ed Evenson, professor of earth and environmental sciences, visited the site of these boulders as part of a mapping project. Several years earlier, Patrick Burkhart, one of Evenson's graduate students, had mapped the region and discovered the banana-shaped distribution. Evenson realized he could use these boulders to date the age of the glaciation that put them there. He hypothesized that the boulders had been carried across Tierra del Fuego riding on a glacier during the Ice Age. Evenson proposed that the boulders were not the result of icebergs but of glaciers.

"In the Andes, due to glaciers eroding the sides of the valleys, you get oversteepened mountainsides. Then you get earthquakes, because Chile is an earthquake-prone area and down out of the mountains come rock from a mountain face.



DENNIS COX / GETTY IMAGES

Charles Darwin (below) believed that ice rafting may explain how the Tierra del Fuego boulders came to their present location.

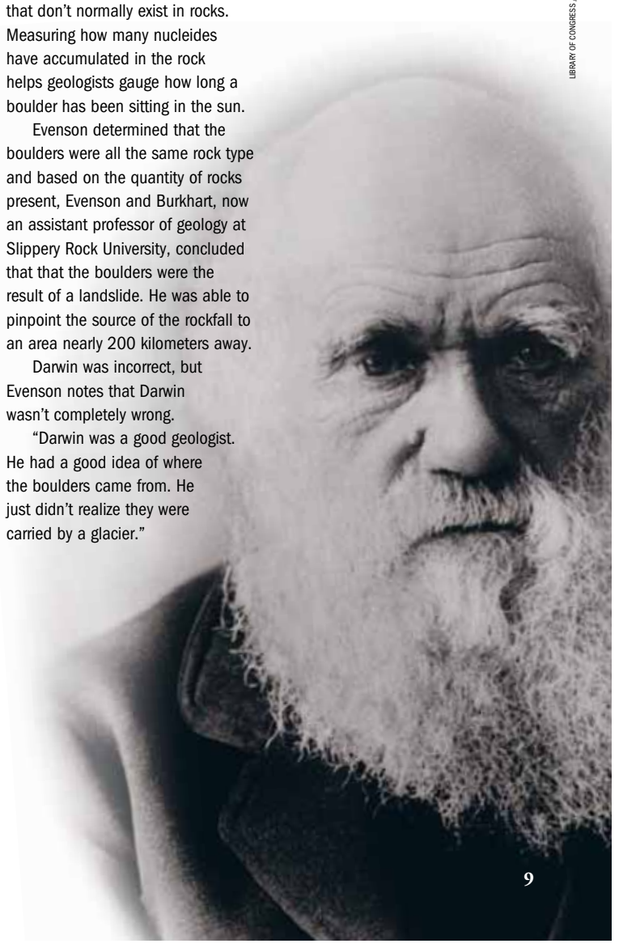
It's logical that those boulders are large granite rocks and they all came from the same spot. You can see they are rather angular. They haven't been eroded. What's happened is they slid on top of a glacier and they rode passively across Tierra del Fuego out onto the plains. As the glaciers retreated, the boulders were all lowered and dropped in one spot," he says.

Taking samples from the boulders, Evenson dated them using cosmogenic nucleide dating. Boulders absorb atomic particles called nucleides, from the sun's rays. These particles go into the rock and cause spallation, a process that produces new isotopes that don't normally exist in rocks. Measuring how many nucleides have accumulated in the rock helps geologists gauge how long a boulder has been sitting in the sun.

Evenson determined that the boulders were all the same rock type and based on the quantity of rocks present, Evenson and Burkhart, now an assistant professor of geology at Slippery Rock University, concluded that that the boulders were the result of a landslide. He was able to pinpoint the source of the rockfall to an area nearly 200 kilometers away.

Darwin was incorrect, but Evenson notes that Darwin wasn't completely wrong.

"Darwin was a good geologist. He had a good idea of where the boulders came from. He just didn't realize they were carried by a glacier."



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History

Napoleon and the Shaping of the Atlantic

In 1804, France enacted the Napoleonic Code, a document that would serve as a major influence on 19th-century legal structures throughout Europe, Latin America and beyond. The Code was meant to be a whole legal system in a single volume, and the standardization of laws it entailed dramatically increased state control over the courts. John

BETTMANN / CORBIS

DOUGLAS BENEDICT

Francois Dominique Toussaint L'Ouverture led enslaved blacks in the struggle for independence from the French (above). John Savage examines how Napoleonic law dealt with enslaved people.

Savage, associate professor of history, explores the invention of the modern sovereign legal subject under Napoleonic law in a novel way, by considering how the civil law system dealt with those deemed unworthy of this subjectivity, the enslaved people of France's colonial territories. The transformation of the French legal system in the early 19th century reveals the unique characteristics of French slavery, while the law of slavery illustrates fundamental principles that guide Napoleonic civil law.

Court cases involving enslaved people provide an extraordinary window onto the social experience of slavery. Civil cases bring out the complex realities of economic life of plantation society, while criminal cases especially reveal the undercurrent of resistance that was often part of daily life. Historians of slavery in the American South have long been interested in how the legal system shaped slavery, by looking at issues like how enslaved laborers often earned wages and a degree of independence while being "leased" by slaveowners, or how criminal acts forced judges to recognize the legal will and intent of slaves and admit slave testimony during court proceedings. But little comparable work existed on the case of the French colonies of the Caribbean. Savage has been piecing together a picture of how French colonies like Martinique, Guadeloupe and St. Domingue balanced the demands of modern metropolitan law with the realities of slave society. "There is a tremendous amount of material that has to be worked through that will tell us about the nature of slave society," says Savage.

While French mandates worked in Europe, colonial bureaucrats throughout the Caribbean ultimately refused to implement them. Savage argues that the demands of the new Napoleonic legal system caused a rift between metropolitan and colonial authorities that led to the gradual implosion of France's slave society, even before the final abolition of slavery in 1848. Savage is especially struck by how, in this period, enslaved people used the legal system in an effort to pursue their own interests. "Even though the odds were against them and they rarely got positive outcomes, we have a whole series of enslaved people who were pursuing lawsuits in civil courts in the French colonies. It gives us a tremendous sense of what their concerns were and what their voice was. You have a more complicated view of slave society."

Slavery was abolished in Martinique, Guadeloupe, French Guiana and Réunion after the revolution of 1848, following slave uprisings in the colonies. Meanwhile, Napoleonic legal forms took hold through the Atlantic world. The co-editor of *Napoleon's Atlantic*, a new volume in Brill's Atlantic World series, Savage is also researching the way Napoleonic models of government, administration, warfare and power became the most copied form of governance among later Latin American autocracies. He shows how Napoleonic law disseminated throughout Latin America and was reproduced and imitated in North America, particularly in Quebec and Louisiana.

"What may be of interest is the way colonial legal systems adapted to local circumstances in a way that often seemed to ignore supposedly fundamental legal principles. Law is largely a product of local social forces, and that tension between social realities and legal texts is one that we can compare in other times and places," he says.

Political Science

The Role of Tipping

Tipping. It's one of life's great social mysteries. Why tip musicians in the subway and not at the Met? Whether it's gratuity for our stylist or the server at our favorite restaurant, we wonder how much is enough or too much.

Holona Ochs, assistant professor of political science, finds that tips are a weak signal of quality and not an effective monitoring mechanism. Her research addresses tipping customs and sheds new light on workplace contentment.

The co-author of *Gratuity: A Contextual Understanding of Tipping Norms from the Perspective of Tipped Employees*, Ochs and Richard Seltzer of Howard University interviewed 425 people in 50 occupational categories, from restaurant staff to adult entertainers. Respondents gave their perspective on their work and compensation. The act of tipping is an act of the client trusting and investing in another's expertise, says Ochs, but she adds that with tips, the price is set by the customer and not necessarily connected to the quality of service but conformity to a social code, reinforcing the existing status hierarchy.

"People appear to obey the rules of tipping norms for social and emotional reasons rather than strictly rational reasons. Tipping demonstrates status and is part of economic redistribution in the market. People adhere to tipping norms because of the feelings evoked by conformity or to avoid social disapproval."

The narratives reveal a general trend in the experiences of tipped employees regarding demographic differences in compliance to tipping norms. In some ways, the most fascinating aspects of these narratives are the perceptual errors themselves, she says. The trend is that tipped employees take more note of demographic differences among clients than they notice differences in service quality.

"One of the ways people act out biases is through tipping. If a person doesn't like you, they don't necessarily have to say it's about race or class. One may dislike a person, tip them less, and say it's because they're not as good with people. In addition, the behavior of different people is classified and judged disparately. When some people barter, they are deemed miserly or shrewd, but when servers expect reciprocity—free drinks for example—from other servers for higher tips, it is described as an 'ethic'"

Because tipping is a poor indicator of performance, management must create an environment of trust with employees, she says. Tipped employees are more contented when they feel they are trusted by managers and that their work quality is not judged on gratuity amounts. The absence of trust contributes to a work environment that imposes unnecessary costs on employees and likely affects the customer experience.

"Management strategies that provide employees with effective training and support are more likely to facilitate a work environment that compensates for the emotional cost of their labor," says Ochs.

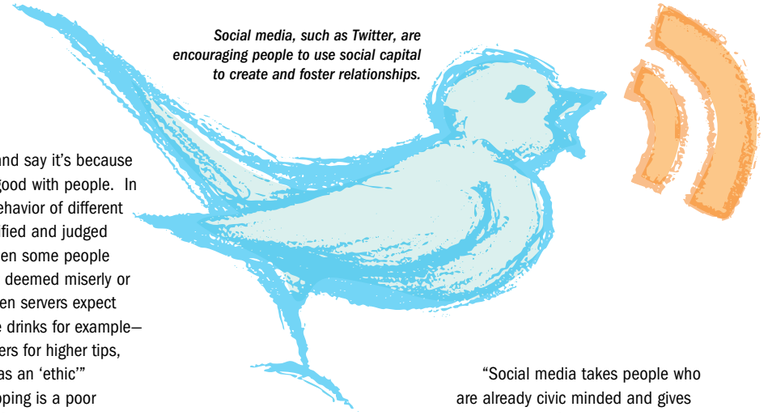
DORLING KINDERSLEY / GETTY IMAGES

Journalism

Digital Civic Engagement

Whether it is Facebook, Twitter, BrightKite or FourSquare, momentum has been gaining for social media as it reshapes the way we communicate. But in the arena of open communication, does social media make us better, more engaged civic citizens? Not according to Jeremy Littau, whose research examines social involvement in online virtual communities.

An assistant professor of journalism, Littau's work reveals a new measure of social capital for users of online communities. Social capital involves the various connections within and among social networks. In these communities, people use this type of capital to create and foster relationships and ties.



Social media, such as Twitter, are encouraging people to use social capital to create and foster relationships.

Littau examined groups of heavy online community users, people who are part of blogging communities, discussion boards or virtual communities that center on topics of common interest. Surveying nearly 2,000 users, he asked about media habits, including use of social networks. From the survey he extracted which social media factors had the greatest influence on people's engagement.

Social media can lead to a more engaged public, but it is limited in scope, says Littau. Being involved in causes over distance, which is facilitated by online involvement, is not linked with involvement in local politics and issues. This "Web-network" social capital that binds communities online thus can spur involvement in faraway causes such as campaign donations or membership in national advocacy organizations. But a better predictor of local activism and civic engagement is someone who has both the Web-network as well as social capital built in his or her local community. Together, they amplify local civic behavior.

"Someone who is just using social media but unengaged with the local community is not going to be politically active locally. It's not going turn people who were previously unengaged into civic actors, but it is a good bridge to help them find other connections with people in their town who want to be politically active.

"Social media takes people who are already civic minded and gives them avenues for participation, but it's not turning a generation into civically minded people."

People use traditional media like newspapers and television to gather information about local issues, while social media gives them another means by which to act on that information. Information seekers might be connected enough in their real-world community, so they do not need the online connection. Yet, users seeking connec-

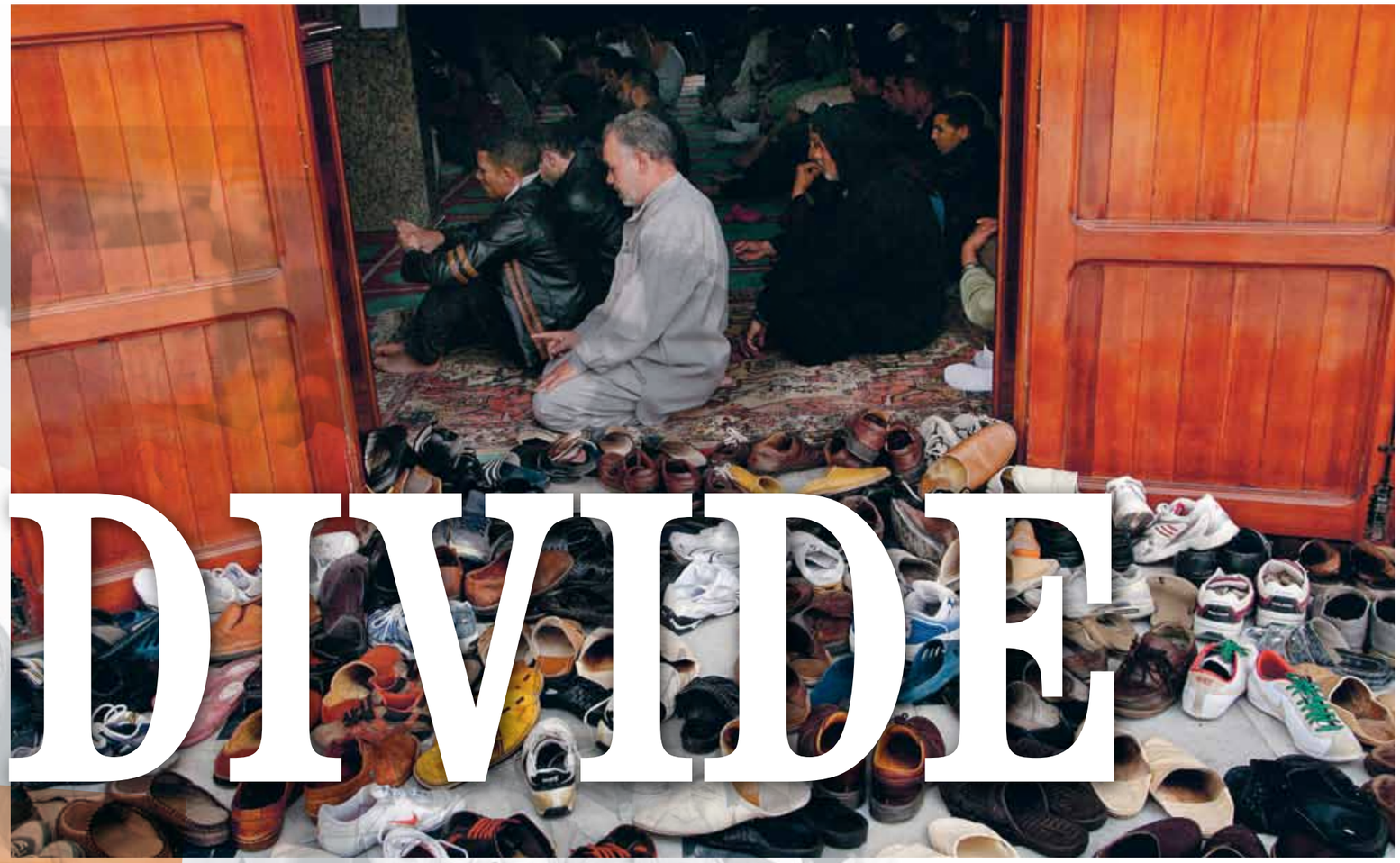
DESMOND BOYLAN / CORBIS

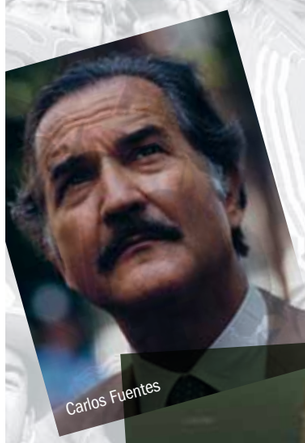
tivity are in search of resources that let them become engaged.

"In essence, social media and traditional media combine to create better and more powerful tools for people to become engaged, but social media isn't creating good civic citizens among people who weren't yet involved," he says.

Social media use generally is tied to desktop and laptop devices that keep people in one place. Littau says mobile social media use might yet help create better citizens as people are freed from those constraints.

How we UNITE, Ways we DIVIDE





Carlos Fuentes

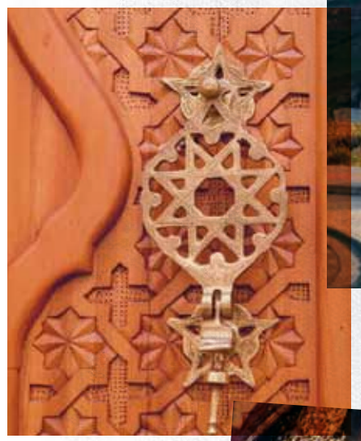
When Spain clinched the 2010 World Cup victory over the Netherlands, soccer fans took to the streets, waving flags, donning official team jerseys and shouting "I am Spanish!" in support of their national team, La Roja or "The Red." This sense of unity is commonplace in many other nations, but the outpouring of national pride in Spain raised eyebrows and added another dimension to a storied history of Spanish identity.

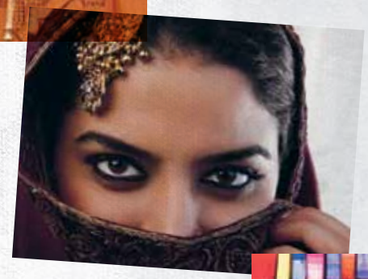
BY TRICIA LONG

Spain faces great challenges in presenting a unified nation outside of international soccer competition. At home, Catalans and Basques seek greater autonomy. Muslims and Jews seek to find their place alongside a Catholic majority. And hundreds of years of history have pitted religious and cultural groups against one another.

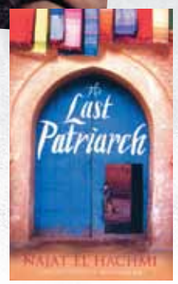
Establishing an identity or feeling a sense of unity is a struggle that is not unique to the people of Spain. How people and groups of people view themselves and those around them in the context of social, political and religious climates has caused personal trauma, shaped history, and altered how individuals, governments and entire nations co-exist. Three Lehigh faculty members are exploring ways in which identity, solidarity, and political and social processes are communicated through literature, media and government discourse. Literature in particular has the power to persuade and shape thought, to expose injustices, and to bring to light cultural fears and concerns.

(left to right) IRA WYMAN / CORBIS; MARIANA FUANO / GETTY; KEREN SU / CORBIS; SEBASTIEN DESARMAUX / CORBIS; ANTON MERES / CORBIS; BACKGROUND IMAGE TO COME





> "Literature affects us in a variety of very meaningful ways. It doesn't just provide information or translate complicated concepts. It has different levels. Maybe it changes the way you look at the next Muslim woman on the street."
>
> —*Edurne Portela*



Writing the Immigrant Experience

Edurne Portela, an associate professor of Spanish in the department of modern languages and literature, has noticed that a relatively young crop of authors are exploring their identities through autobiographies and fictional narratives. While browsing through a bookstore in her native Spain, Portela stumbled upon one book that inspired her latest research project.

The book, *L'últim patriarca*, or *The Last Patriarch*, was written by Moroccan-born author Najat El-Hachmi. El-Hachmi immigrated to Catalonia with her family as a child, and this work of fiction shares her experience of growing up as a young woman in a Muslim immigrant family. El-Hachmi looks at questions surrounding immigration, assimilation, and cultural and religious conflict in modern-day Spain.

Portela, whose own book, *Displaced Memories: The Poetics of Trauma in Argentine Women's Writings*, was published in 2009, found a strong connection between El-Hachmi's work and her latest research project which focuses on memory and trauma in the context of second- and third-generation writers like El-Hachmi. These contemporary authors, many of whom are in their thirties, grew up at the end of Argentina's Dirty War and the fall of Francisco Franco's regime in Spain, and they are reworking their first-generation experience into fiction.

"I want to learn how people are othered and how they react to that process of othering. In this case it's a woman who is not only a woman, but a woman of Muslim background," says Portela, who also serves as director of Lehigh's Humanities Center.

The Last Patriarch expresses the constant tension that arises as a woman of Muslim origin attempts to become part of mainstream Spain at the same time that she becomes conscious of her "otherness" in Spanish society. El-Hachmi also plays off the character of the Muslim father who does not practice his religion because he desperately wants to integrate into society.

El-Hachmi's novel, however, prompted an unexpected reception from the Spanish media. Rather than acknowledging the conflicted feelings these Muslim characters experience during their time in Spain, they held the book up as an example of integration.

"It's a manipulation of the novel, because she's actually criticizing the politics of integration in Spain through different characters in the novel. It's a very current topic in Spain," says Portela. "The media stereotypes the Muslim woman because if she doesn't wear the veil, if she speaks and writes in Catalan, then she's perfect. They appropriate her image and shape it into what they want."

Over the last 15 years, there has been a heavy migration from Morocco to Spain, which has created a lot of social struggles that underscore the tensions between Spain and Northern Africa. Portela says the media's reading of El-Hachmi's novel is a misrepresentation of the current cultural, political and social climate in Spain, where there is still a rejection of the Muslim communities, particularly among Moroccan immigrants.

"There are so many words in Spanish that come from Arabic," Portela adds. There are traces of North African and Arabic culture and history all over Spain. We need to remember that most of Spain was Muslim for many centuries. It's a matter of saying, first we have to know our history and then we have to take responsibility for that history. We can't negate it and say Spain is only a territory for the Catholics and pure Spanish blood, whatever that means."

Through her research, Portela is also investigating the work of another female Spanish author, Esther Bendahan, who as a child immigrated from the Morroccan city of Tétouan to Spain. Bendahan is a Jewish woman, and her story reveals a similar yearning to understand her place and the place of the Jewish people in mainstream Catholic Spain.

A grant from Lehigh's Center for Global Islamic Studies allows Portela to dig deeper into the long and storied history between North Africa and Spain. She spent the summer of 2010 in Spain meeting with some of the authors, like El-Hamchi, who have piqued her interest. Portela also visited Spain's Jewish and Moroccan cultural centers, which provide a place for collaborations and networks to form between groups of people and artists and authors.

"Literature affects us in a variety of very meaningful ways. It doesn't just provide information or translate complicated concepts. It has different levels. Maybe it changes the way you look at the next Muslim woman on the street," says Portela. "If you're a scholar, then you can do a lot with a novel. You know what effect it can have and you can try to get those aspects that have moved you while reading it and do something with it ... maybe use it to explain a complex reality, like what it is to be Spanish today."

Portela's colleague Matthew Bush agrees that narratives can aid in making complex social and political processes understandable. By using particular narrative models, he says, authors have a means to better explain how things happen. These narrative tools also help authors elicit an emotional response from readers in a way other forms of communication may not.

Bush, an assistant professor of Spanish in the department of modern languages and literature, finds it is important for a reader to have a reaction.

"Art produces emotional reactions in us, but what is the purpose of that emotional reaction, or what do we do with an emotional reaction to art?"

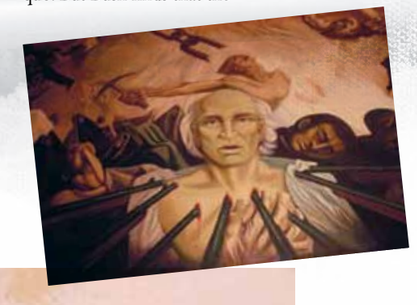
"Literature offers a very rich way of communicating with people and a good novel can really change how you look at others," adds Portela.

Writing Social Crises

Bush's research examines the work of authors who use melodrama—an aesthetic form and narrative structure that uses plot and characters to appeal to readers emotionally—to express the political and social issues of the time. His focus is on melodrama in social narratives written in the first half of the 20th century, particularly from the Latin American countries of Mexico, Venezuela, Peru, Brazil and Argentina.

"With these specific countries, I can connect several different literary genres to illustrate a thematic or aesthetic structure that works across these different schools," he says. "That's an attractive part of the project, to be able to present a paradigm of reading that connects different things that we wouldn't think are necessarily integrated."

Historically, melodrama has been viewed as a conservative genre that celebrates the status quo. But Bush finds that the



(left to right) JEAN-PIERRE LESCOURRET / CORBIS; INDIA PICTURE / CORBIS; ANTON MERES / CORBIS; DON MASON / CORBIS; BUDDY MAYS / CORBIS; BACKGROUND IMAGE: TO COME

form is also used to express a radical narrative or to celebrate revolutionary politics. Bush notes that many of the authors who use this form invert the scheme. For instance, people who are typically viewed as "bad" because they upset a society's traditional power structure are instead portrayed as "good" because they are represented as idyllic models of social rebellion. Essentially, these authors are reworking the classical reading of how melodrama functions.

"The authors in my investigation position characters as either good or bad within the story. Narrative is based on conflict, so I tried to read or discover how these polarized figures are associated with political programs. And those political programs vary greatly," says Bush.

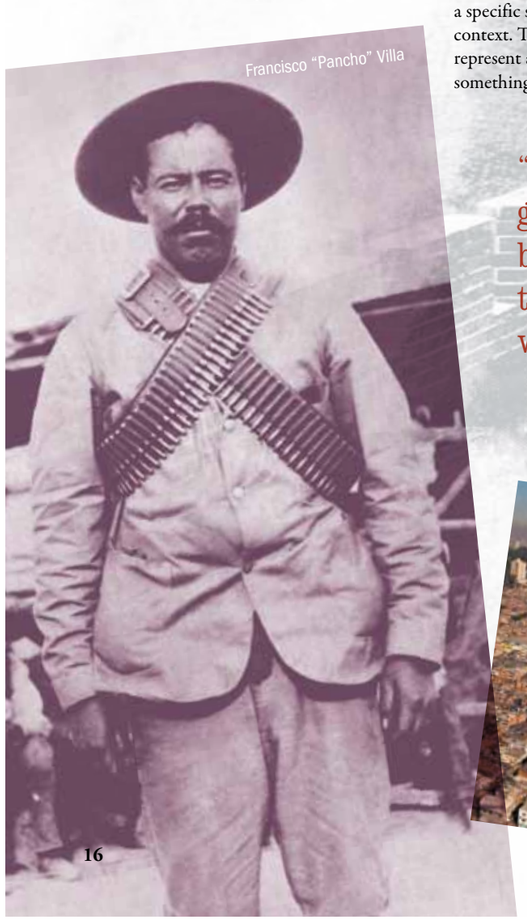
Melodrama figures among specific writing styles that marked the literary history of the first half of the 20th century, as seen in the novel of the Mexican Revolution and the novel of the Spanish American Boom. It is also used to speak to societal problems, such as regional cleavages in Venezuela, the representation of the indigenous people of Peru, socialist realism in Brazil or societal marginality found in urban Argentina. Using these narrative models can help explain things that are politically complicated.

Bush's work focuses on prominent Latin American writers such as Mexican novelist and essayist Carlos Fuentes and Peruvian César Vallejo, along with Argentine author Roberto Arlt, the Venezuelan novelist Rómulo Gallegos, and Brazilian author Jorge Amado.

We see this technique at work in our own contemporary discourse, he adds. In American politics, for example, Republicans and Democrats may hold views on the opposite ends of the spectrum, but each party uses the same techniques in presenting their cases.

"I can be as dogmatic as I want to be on the left or on the right. But in doing that, I'm putting myself in an all-or-nothing type of argument," says Bush. "And that's really a characteristic of melodramatic narrative—this all-or-nothing, good versus evil. Melodrama doesn't do well with gray area. It's black and white.

"The works that I examine are inherently political and they speak in varying degrees to a specific socioeconomic landscape in each context. There is very much an attempt to represent a specific reality and a path to do something about it."


Francisco "Pancho" Villa

Writing a Shared Identity

Communicating a sense of identity and solidarity, however, are not unique to domestic issues. They play into foreign policy issues as well. Political scientist Vera Fennell is looking at how complicated concepts of identity are addressed in the political sphere.

Fennell, associate professor of political science, is conducting research that focuses on identity and the struggle to articulate solidarity between two diverse groups of people that simultaneously acknowledges disparity and difference and has a common political agenda. However, instead of researching literature to explore issues of individual identity, she is investigating the official discourse and narratives that create a unified identity between China and various African nations.

"Here there's a global political arena where you can have political solidarity that explicitly acknowledges race but sees it as something that enhances the solidarity as opposed to how some in the West see it as leading to conflict," says Fennell, who has a joint appointment in Lehigh's Globalization and Social Change Initiative.

China and Africa have a long history of economic and diplomatic ties. For her research, however, Fennell is looking primarily at two events and how they have contributed to a sense of shared identity between China and Africa that continues to evolve today.

The first event, the Badung Conference, also known as the Afro-Asian Conference, brought together representatives from African and Asian nations in Indonesia to promote African and Asian economic coalitions and decolonization. The conference, held in 1955, was one of the first major efforts of African and Asian cooperation.

The other project of interest to Fennell is a railroad built by the Chinese that linked Tanzania to Zambia. The railroad, constructed in the 1970s, linked Zambia to the port of Tanzania, where it could export its goods without having to cross through white-supremacist nations like Rhodesia or South Africa.

By examining these historical milestones, Fennell is better able to understand the strategic partnership between China and Africa that exists today. This political alliance explicitly acknowledges race and uses it to create political solidarity rather than allowing it to create conflict.

"I look at how China conveys this message of what its interests are and the connection among China and various African states and African leaders," says Fennell, who researches newspapers, posters and other forms of visual media to determine how China creates this shared identity with African states. Even movies and songs that come out of China, she says, talk about the "righteous struggle of our African brothers."

Fennell says the common political experience that each shares is one of experiencing colonialism, colonial exploitation and imperialism. Despite the fact that China is one of the fastest-growing economies in the world, the Communist leadership continues to mine this story as what unites them with African states, and what makes their strategic partnerships not exploitative.

"I've begun to think that that may be how the Chinese Communist Party, at least on an ideological level, defines race—as this political experience," says Fennell. "Because China and Africa both experienced colonialism, semi-colonialism and the extraction of resources, they see what that does to the social order, and the economic order, and how it orients your economy to the benefit of someone else and not to the benefit of the people within the nation state. Along with that comes a sense of racial hierarchy and white supremacy. China sees itself sharing this experience with various African states."

During a visit to Shanghai, Fennell spent time in a poster museum that provided information and examples of the artists who have created works to promote unity and mobilize support.

"This is the kind of stuff people dismiss as propaganda," says Fennell. "The more I do this research, the less clear I am on the distinction between propaganda and media. I look at these media representations, which is where the Chinese Communist party presents its official narrative about both domestic and foreign policy. Some of this is for domestic consumption and some of this is for foreign consumption."

Fennell says that from an economic perspective, both China and Africa see the benefits of such an alliance. For those who argue that this is another form of colonialism, Fennell points to Africa's interests in using China as a development aid, which gives them leverage against the International Monetary Fund or the World Bank.

Like Portela and Bush, Fennell recognizes the power in articulating messages in a way that is understandable to the people, be it within a cultural, religious or, in this case, political sphere.

"In order to construct any kind of unity or solidarity, you need some kind of powerful structure or persuasive group to articulate that this narrative of similarity is more important than this narrative of difference," she says. "That's what the Chinese Communist Party was able to do."

> "These authors position characters as either good or bad within the story. Narrative is based on conflict, so I tried to read or discover these polarized figures that are associated with political programs."
>
> —*Matthew Bush*


Premier Zhou Enlai of China at the Badung Conference.

A poster expresses "The Deep Friendship of Chinese and African Peoples".

(left to right) HULTON-DEUTSCH COLLECTION / CORBIS; DANNY LEHMAN / CORBIS; BETTMANN / CORBIS; BETTMANN / CORBIS. BACKGROUND IMAGE TO COME

COLLECTION INTERNATIONAL INSTITUTE OF SOCIAL HISTORY, AMSTERDAM

THE SPECTRUM OF LANGUAGE

by Kathleen Bittner

Language is a fundamental tool in human interaction. It's not only a means of communicating our thoughts and ideas, but also helps forge friendships, relationships and cultural ties. Throughout history, researchers have examined the importance of language. Legend has it that an ancient Egyptian king once had two babies raised in isolation to see what language would naturally emerge. (He was disappointed to find that their first word-like sounds resembled the language of the Phrygians rather than the Egyptians.) More recently, the prominent American scholar Benjamin Whorf proposed that language shapes our thoughts and emotions, influencing our perceptions of the world around us.

Language is not only a vehicle for the expression of thoughts and perceptions; it also represents a fundamental expression of social identity. By using speech, humans are able to use language to convey ideas about the world around them—whether it is in their native language, heritage language, or a learned language. Research at Lehigh addresses a wide sampling of this vital research domain.

The foundation of speech

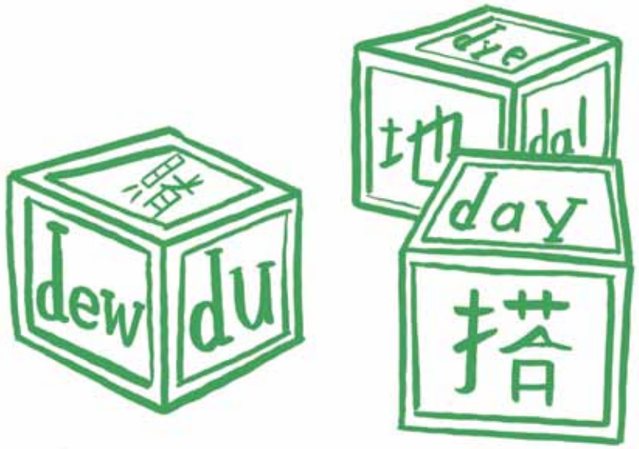
Not only do languages differ in how they encode thoughts and perceptions, they also differ in the basic building blocks they use to map word meanings onto the forms of words. Padraig O'Seaghdha, associate professor of psychology and director of Lehigh's Cognitive Science Program, uses a cross-linguistic approach to explore the role syllables play in producing words in different languages.

Researchers disagree as to how syllables are represented in word memory. To address this and related questions, O'Seaghdha and his colleagues compare performance of the same simple tasks in different languages such as English, Mandarin Chinese, and Spanish. For example, in a set of experiments recently published in the journal *Cognition*, participants rapidly produced words that sometimes shared certain properties, such as beginning with the letter D in English. Participants were familiarized with pictures such as a ball of dough, a dew-covered leaf, or a bowl of dye and asked to name them with single words (dough, dew, dye). The images were shown in a random order so participants did not know in advance which word they needed to say next. Shared elements that helped speakers produce words more rapidly, such as the D in this case, demonstrated that those properties were important for planning and initiating speech. But it turns out that speaking English requires us to prepare to produce words differently than Mandarin.

"English speakers love to have the same sounds in the beginning of their words," says O'Seaghdha. "In contrast, Mandarin Chinese speakers don't show any benefit from words with the same first sound. However they do benefit if the words share the entire first syllable. This suggests that Mandarin is fundamentally different from English. Mandarin uses the syllable as the starting point for turning a word that is in mind into a sound pattern, but English uses individual sounds as the starting points and actually builds the syllables rather than retrieving them directly from memory."

Because English speakers start with the individual sounds of words and then combine them into syllables, the syllables are present in the spoken output, and it may seem that English and Mandarin follow the same procedures. However, the research suggests that this is not the case.

"We are always looking for universal principles, but in practice, theories are actually very language specific," said O'Seaghdha. To resolve this problem, he proposes that theories need to be more abstract, addressing general principles of language processing rather than attempting to fit the same account to all languages. Although the units of language initially retrieved from memory are different in Mandarin and in English, they may serve similar pivotal roles in planning and preparation of speech.



Padraig O'Seaghdha, associate professor of psychology, has conducted research using a cross-linguistic approach, by investigating the role syllables play in language processing.

In his current project, O'Seaghdha is addressing questions of language and thought by exploring conceptions of immediate time with English and Mandarin Chinese speakers. Together with collaborators Jenn-Yeu Chen and Jui-Ju Su at National Cheng Kung University in Taiwan, he is investigating how grammatical differences between English and Mandarin may influence perceptions of the duration of pictured events, and perhaps even the actual experience of the present moment of time by speakers of these languages. English has tenses, while Mandarin does not, and this absence of tense may lead speakers to expand their definition of the present. "If so, what the neuroscientist Michael Gazzaniga calls 'the thin edge of the present' could be a little wider for a Mandarin speaker than for an English speaker," speculates O'Seaghdha.

Language and thought

While much of O'Seaghdha's work is concerned with the how sounds are organized and used in language, Barbara Malt investigates how people use language to talk about the world around them.

"There was a common idea in the literature that humans have mental categories of things

ILLUSTRATIONS BY JOEL HOLLAND/PHOTOS BY DOUGLAS BENEDICT

in the world such as objects that are tables, or objects that are chairs." said Malt, professor of psychology. "The idea was that when you look around the world you perceive things in terms of those categories. There has been a tradition of research in what is the composition of those categories. How do we put things into categories? What makes things be perceived as belonging to a coherent category?"

To explore this concept, Malt developed a project where English speakers looked at a set of 60 pictures and gave each one a name, words like bottle, jar, and container. She then

Barbara Malt, professor of psychology, examines how different languages draw very different boundaries among objects.

shared this project with a student who was a native speaker of Chinese, to conduct in China. The student showed the same 60 pictures to native Chinese speakers.

"Where we had a range of things English speakers called bottle, or jar, or container, the Chinese speakers split them up differently." said Malt. "Later, we found that Spanish speakers had a third way to divide the objects up by name. The things that Spanish speakers called *botella* only partly overlapped with the things English speakers called bottle."

With this, doubts were raised about whether there really are abstract categories of things in the world that everyone simply perceives. Because if Chinese and Spanish speakers are dividing the objects differently than English speakers are, and differently from each other, what does that mean about the objective reality of these categories of things in the world?

Malt's research now looks at speakers of other languages and other sets of objects. Different languages draw very different boundaries among objects or other types of things: body parts, colors, or ways of moving such as walking, running, hopping, skipping, or jumping.

Other than looking at different naming patterns, English, Chinese, and Spanish speakers made additional judgments about the objects. In a recent project, speakers were asked put the 60 pictures in groups according to which items were similar.

"Generally we found that the other kinds of judgments people make about the objects are much more consistent across the speakers than the way they label them." said Malt. "So what they see as being like each other or having similar properties isn't really changed by the fact that they name them in different ways."

"The Whorfian hypothesis suggests that if you have different ways of talking about something, the language itself may create different ways of thinking." said Malt. "That would imply that when you are looking at speakers of different languages, who have different ways of naming things in the world they would have correspondingly different ways of thinking about them. So when we look at the Chinese speakers—their actual way of thinking about the world would fall into these Chinese categories, whereas for English speakers they think about the world in terms of the English categories.

"Our research supports a different perspective, which is that people perceive and understand the world in pretty much the same way. Differences emerge only when a speaker must communicate; then they must use the naming patterns of their language. Our data favor the idea that thought is more universal than Whorf believed," Malt said.

While initially this research studied monolingual speakers, the study expanded to include bilingual speakers. Conducted in Belgium, a geographic region with monolingual Dutch speakers, monolingual French speakers, and bilingual Dutch/French speakers, Malt compared how these speakers named objects.

"If the Whorfian hypothesis is right, when you learn to speak one language it really changes the way you think about things." said Malt. "It is hard to imagine what bilinguals do in that case, because if you have two different languages, and they are giving you two different ways of seeing the world, how do you live with two, or how can you juggle two, or can you really have two different ways of seeing the world? It's easier to think of what a bilingual could do if you think of it in the terms of what we have been finding: Maybe there is just one main way of seeing the world, but two different ways of talking about it."

In fact, bilinguals may not even have totally different ways of talking. If a speaker is bilingual, he or she could follow the same naming patterns of monolingual speakers of each language. Another possibility is that it might be hard to do that, and the bilingual speaker's two languages somehow influence one another. Malt and her Belgian colleagues found the second outcome—Belgian bilinguals used their French and Dutch words in ways that were more similar than the speakers of just one language did.

Bilingual heritage

These findings are important as bilingualism and often multilingualism continue to be the norm rather than the exception in cultures around the world. Another aspect of bilingualism concerns the distinction between native and heritage languages, as children of immigrants encounter the languages of their parents' native countries. Kiri Lee, associate professor of Japanese in the department of modern languages and literature, has been conducting research for the past six years on the role language plays in preserving cultural identities.

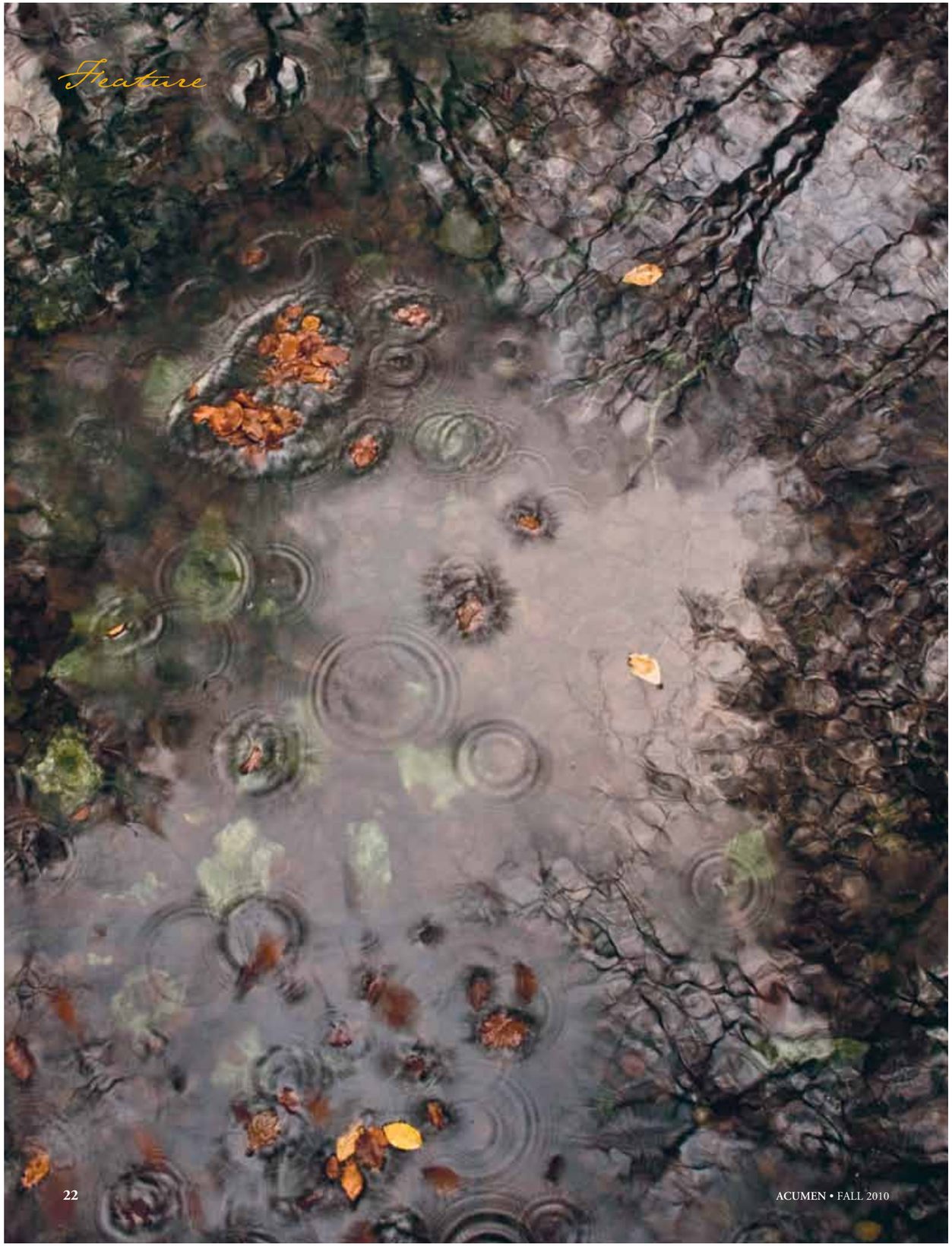
With an extensive background as a linguist, Lee is examining the language proficiency of children for whom English is a second language and how language impacts children's sense of identity and their perception of themselves.

"We are interested in how the children identify themselves—are they a native speaker or are they a heritage language speaker?" said Lee. "Depending on their proficiency in Japanese do they have a low self esteem, and how do they view themselves in this setting?"

Kiri Lee, associate professor of Japanese, conducts research in Japanese heritage schools in New Jersey.

Language proficiency is an important component in remaining connected to one's culture. Studying a group of students at a New Jersey Japanese language school, Lee found that throughout the four years they were followed, students' perspectives on their connection to Japan changed as their proficiency and maintenance of their heritage language increased. Although they weren't "native speakers" they could now be labeled as "heritage speakers" and they found their own identities as heritage speakers. In general, when they become more proficient linguistically and culturally, they feel more connected to their Japanese heritage, notes Lee.

Understanding how we use language is crucial to understanding ourselves and others. Our ability to represent thoughts and perceptions through words possibly makes humans unique among terrestrial species. Questions about the fundamental nature of the human mind form one of the last uncharted frontiers of science. Research on universal principles of language, on language and thought, and on the cultural importance of language is an important part of meeting this challenge.



By Genevieve Marshall

Man or Nature?

Scientists Look to Water for the Answer

In recent months, the BP oil spill has hurt aquatic life, closed recreational beaches and damaged the fishing industry along the Gulf Coast—and its long-range impact remains to be seen.

This is one instance in which human action is clearly the reason for environmental change, and it is easy to pinpoint. But there are many other examples of environmental change in which science can help answer the question "Has nature or human interaction altered an ecosystem?"

Understanding environmental processes provides researchers with needed information as to how humans affect the environment. Donald Morris, an associate professor in the department of earth and environmental sciences, and his colleagues Stephen Peters and Bruce Hargreaves are currently exploring that question as part of several projects, some of which involve their joint efforts.

Petroleum, for instance, is a natural product. It's all organic material—the residue of life that existed millions of years ago.

"But the spilled oil is there because we tapped it. It wouldn't have risen to the surface or spread underwater naturally in such huge quantities without drilling and the application of dispersants," says Morris.

Oil isn't the only contaminant that impacts communities. Peters, an associate professor of earth and environmental sciences whose research focuses on quantifying and understanding geochemical processes in water above and below the ground, studies how unsafe levels of arsenic and other contaminants seep into the water supply through natural degradation of bedrock and human activities such as mining. Working in collaboration with Morris, he is looking at whether the level of mercury transported from unlogged watersheds is higher or lower than that from forested watersheds.

Morris and Hargreaves, also an associate professor of earth and environmental sciences, have combined their understanding of carbon cycling in aquatic ecosystems and ultraviolet light penetration in lakes to study how naturally occurring dissolved organic carbon, or DOC, can influence aquatic ecosystems and climate change. When dissolved organic matter is converted to carbon dioxide (a greenhouse gas) by sunlight or bacteria, the CO2 can enter the atmosphere and contribute to global warming. But if the carbon is buried underground via stream or ocean sediments or transported to lake bottoms or the deep ocean as either organic matter or carbonate rock, it cannot enter the atmosphere, which in turn can help reduce global warming.

What does the work of these three researchers have in common? Morris says it can all be boiled down to a cup of tea.

When it comes down to earth with rainwater, mercury can be emitted back to the atmosphere as a gas or with other particles and re-deposited elsewhere.

The tea that Morris is talking about is not in a mug. It is a metaphor for the dissolved organic carbon derived from decomposed plants and algae that is present in lakes, streams, and oceans.

"Think of plant material and rain filtering through it," Morris says. "The material is worked on by microbes in the soil, then extracted and leached in ground waters or surface waters."

The Link to Mercury

In recent years, the three researchers' interests have converged on projects related to the global mercury cycle, which can be affected by natural processes and human activities.

Conventional wisdom says that most of the mercury in the atmosphere is from the burning of fossil fuels. It can disperse widely and be transported thousands of miles away from its origin. When it comes down to earth with rainwater, mercury can be emitted back to the atmosphere as a gas or with other particles and redeposited elsewhere.

But mercury doesn't travel by itself in water. It binds strongly to DOC. Peters and Morris, with graduate student Tara Redding, are examining the amount of organic carbon and mercury transported during storm events, and how this process affects land use.

"Naturally, that water will have DOC with mercury bound to it," says Morris. "Because this water might be used for drinking water, anything that mobilized the mercury increases the potential to hurt humans."

DOC efficiently absorbs UV radiation, and that's where Morris's expertise comes in. The high-energy light can damage cells and DOC absorbs it like a natural sunscreen, a process known as photobleaching.

Morris has been examining the way that carbon alters penetration of UV light in aquatic ecosystems. His work has taken him from the Poconos in Pennsylvania to Alaska, Argentina and Antarctica, among other destinations. One of Morris's current projects could help scientists understand photobleaching of DOC by UV light, which speeds up microbial processes and makes them a better food source for bacteria. He is attempting to better understand photobleaching, when it might be important, and why some carbon photobleaches faster than others.

(opposite page) MAJA HAUSMEISTER / GETTY IMAGES. (top to bottom) PIER / GETTY IMAGES; NICK KOUDIS / GETTY IMAGES

When bacteria are able to respire carbon molecules more easily, they produce more carbon dioxide, which can enter the atmosphere as a potential greenhouse gas when it leaves the water.

"A lot of people think greenhouse gases only come from the burning of fossil fuels, but that's really not the case," Morris says. "As it turns out, the warming of the earth (natural or through the burning of fossil fuels) makes microbes more active, leading to positive feedback and increasing emissions of carbon dioxide to the atmosphere."

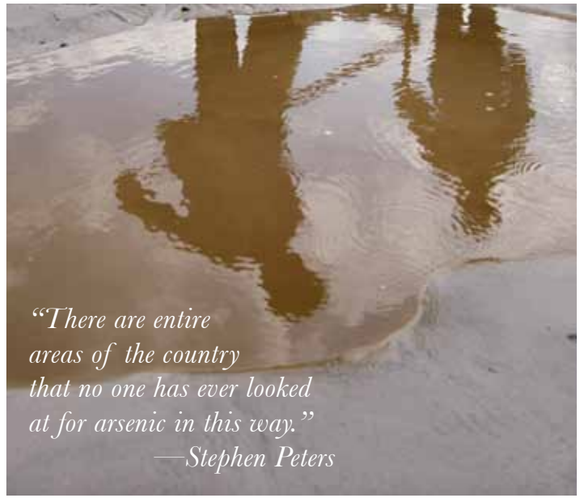
For the past several years, Morris has also been conducting field work in the Poconos, examining the export of DOC from different watersheds. He is comparing forested, agricultural and urban watersheds to characterize the different transport rates and compositions of organic material.

"We've looked at some virgin watersheds that haven't been cut since European settlement," he says. "The trees are very old and very rare. If carbon was once readily stored in these watersheds and not released as carbon dioxide as fast as it is from the cut watersheds, it could help us determine the contribution to global warming from deforestation associated with human settlement."

For Peters, the work has practical applications. Seven years of his research on the low levels of arsenic in the water supply in New Hampshire encouraged the state to change its testing policy. He determined that the amount of arsenic was dependent on the types of rocks and their pH and iron content that came in contact with the water supply rather than landfills or industrial sources. The state now requires all homeowners to test for arsenic.

"There are entire areas of the country that no one has ever looked at for arsenic in this way," says Peters.

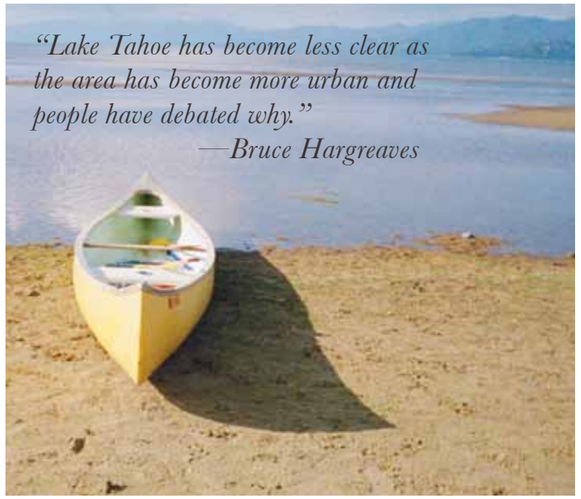
Peters' work also takes him to Lake Lacawac in the Poconos region, where, with Hargreaves, he has been measuring natural mercury emission that occurs when photobleaching turns brown DOC to more transparent water and the altered mercury follows carbon dioxide into the atmosphere



With Morris, he has compared the natural lake output of mercury with the output from experimental chambers set up to mimic the lake's water columns. Some of the chambers were made of a plastic that excludes UV light while others let it enter. The chambers that allowed more UV light in had more bleaching and more mercury emission.

"We're all trying to understand fundamental biogeochemical processes," Peters adds.

The team hopes this might allow them to make more intelligent decisions about how to manage the environment. Understanding these environmental processes helps people make responsible and intelligent decisions.



Hargreaves is developing new electronic field instruments and new research applications for those instruments. As part of his work studying lake transparency in Pennsylvania, Oregon and South America, he has developed new methods for gauging the amount of light absorbed and DOC-produced by algae.

With a California-based company, he is developing a fluorometer sensor that is highly sensitive to algae-produced organic matter. The device measures fluorescence (how much light is emitted by a substance after some light is absorbed) by shining a bit of UV light into water and measuring the amount of longer-wavelength light produced by DOC that comes back to the instrument. It could have commercial appeal to operators of major reservoirs and water treatment plants, and owners of private lakes who value clarity.

Some of Hargreaves' ideas for particle spectrophotometers came as a result of his field work at Crater Lake, Ore., which his research confirmed as the clearest in the world. A decade before Hargreaves' research began, scientists had raised the alarm that a lodge on Crater Lake might be degrading the famously clear blue lake. A federal monitoring program was started in the early 1990s and the lodge's sewage, which was believed to be responsible for the potential degradation, was diverted away from the lake. But Hargreaves' analysis of years of monitoring showed that human pollution was not what affected the water clarity of Crater Lake. Measuring UV-radiation penetration, he determined the culprit was the lake's normal cycles—decades where algae were in greater abundance—and turbidity from rain that stirred up sediment.

More recently, Hargreaves' research has taken him to Lake Tahoe, which local residents are trying to save from destruction.

"Lake Tahoe has become less clear as the area has become more urban, and people have debated why," Hargreaves says. "It has come down to two theories: a lot of fertilizers from lawns and golf courses lead to algal blooms, or clay and sand particles from rivers that used to get trapped before they reached the lake have been diverted into it because of human-built channels to control flooding."

The solution to clearing up Lake Tahoe could be to modify the streams or reduce the amount of fertilizers used on nearby lawns. But Hargreaves is throwing a third hypothesis into the mix. "I think it could be that Lake Tahoe has more colored organic material," he said. "Sometimes nature is the culprit."

Understanding ecological processes provides insights into how humans affect the environment. Peters explained that although their work is primarily focused on ecology, they are always looking for ways to apply their research to social problems.

"We need to understand things," Peters says. "Once you understand a process, you can make predictions. Then you can assess the impact of your actions on what's going to happen down the road." ●

(opposite page) DAVID MAITLAND / GETTY IMAGES; (this page) JIM VECCHI / CORBIS

JOE CRAIG

STEPS: An Interdisciplinary Approach to Meeting Global Challenges

We face significant challenges in gauging the human impact on our environment and in balancing the finite resources of our planet as populations grow and standards of living increase. These challenges play out on local, regional, national, and global scales; they leave no one untouched. They are major factors in determining human well-being and quality of life and will remain so for decades to come.

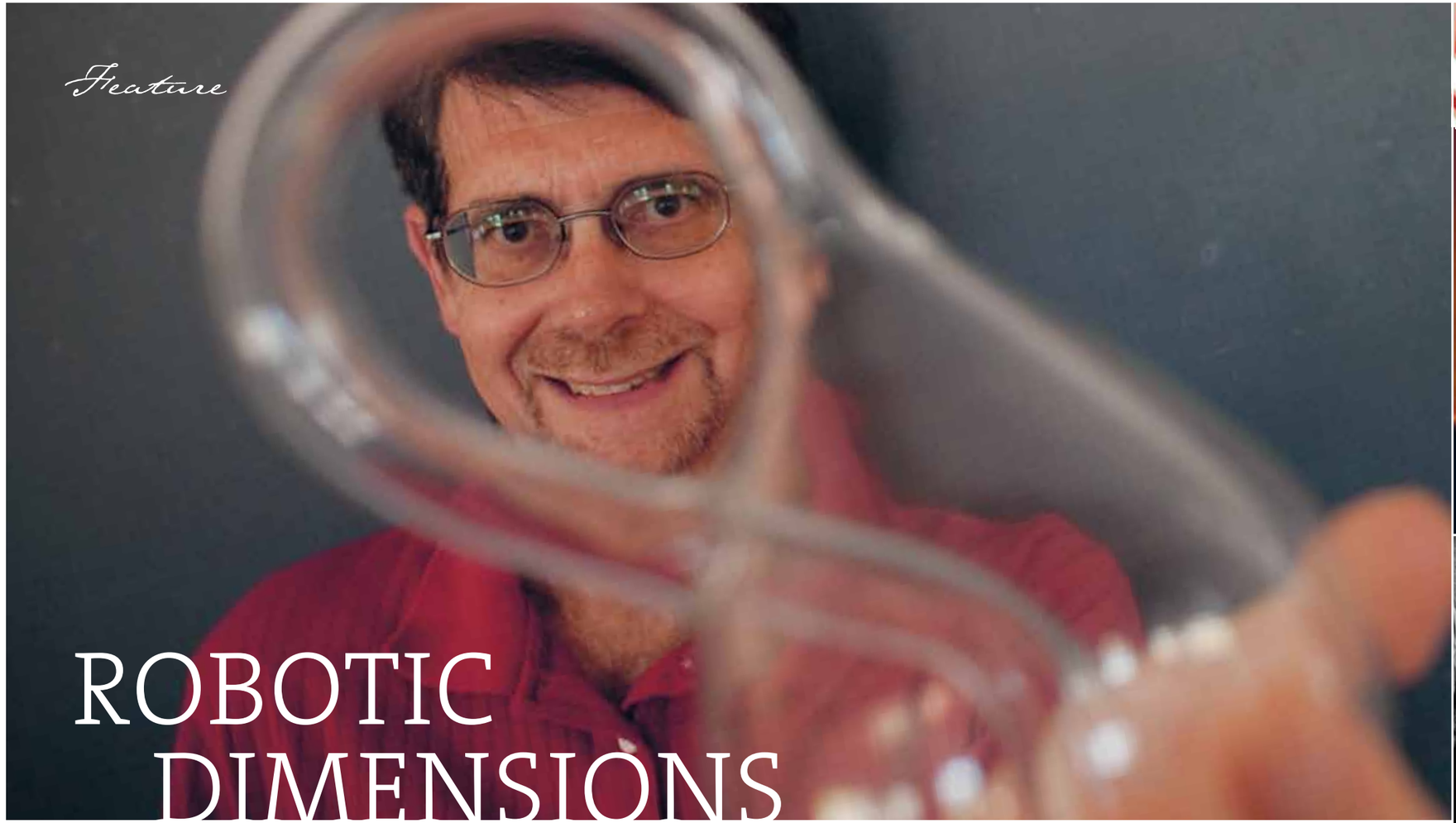
These challenges have extraordinary economic, social, political, and technological implications. In the last decade we have witnessed the geopolitical impact of energy and more recently the human tragedy and economic impact of devastating floods in Pakistan, large earthquakes in Haiti and Chile, and the BP oil spill in the Gulf of Mexico. In the poorest regions of the world an estimated one in five children will not see their fifth birthday because of environment-related diseases. Financial institutions have begun responding to the challenges of energy and climate change, as efforts to find more efficient, clean energy sources and to mitigate and adapt to rising temperatures become growing drivers of global business.

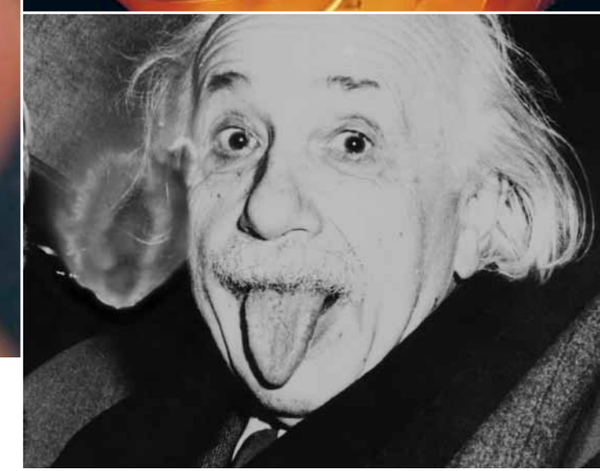
The major challenges we face as a society in the areas of energy and the environment require an interdisciplinary approach that goes beyond traditional boundaries to integrate fields in the sciences, engineering, and the social sciences. In almost all areas, advances are coming at the intersections of disciplines, in a setting where people from diverse perspectives and areas of expertise interact to frame the issues and identify solutions, to view the challenges we face as opportunities, and to turn theory into practice. Through STEPS (Science, Technology, Environment, Policy, Society), Lehigh is catalyzing interdisciplinary research and education in the area of energy and the environment, by bringing students and faculty from diverse fields together and providing them with the programs, facilities, and resources required to address the challenges of today and tomorrow in all their complexity.

The cornerstone of the STEPS initiative is a new 135,000-square-foot building designed to facilitate collaborative interdisciplinary research and teaching. Housed under one roof, faculty and students from the natural sciences, engineering, social sciences, and humanities come together to find innovative solutions to global challenges in the areas of energy and the environment. The STEPS building Incorporates the best principles of green design and in recognizing the power of art to educate, inform, and inspire incorporates original works of art into the structure of the building. Ample public space invites students from across campus to make STEPS their first choice to come and study.

Beyond a building, the STEPS initiative also creates endowed chairs for faculty, fellowships to support graduate research, and programmatic support for research and innovative curriculum. Undergraduate students work closely with faculty and graduate students across disciplines on research projects—inspiring and nurturing a next generation of citizens, innovators, and leaders with invaluable skills in solving complex problems using interdisciplinary approaches.

You can learn more about STEPS online at www.lehigh.edu/STEPS.





ROBOTIC DIMENSIONS

by Erica Klarreich

Back when Don Davis used to teach "Introduction to Mathematical Thought," he liked to emphasize the unexpected applications of mathematics. Again and again, Davis would tell his students, math that was originally done for the sake of its intrinsic beauty turned out to have applications that its creators never dreamed of—to relativity theory, cryptography and fractals, to name just a few examples.

DOUGLAS BENEDICT. (Opposite page, top to bottom) JAC DEFICZIN / GETTY IMAGES; DAN MCCOY-RAINBOW / GETTY IMAGES; ARTHUR SASSE / CORBIS

So when Davis learned that researchers had forged a connection between his own esoteric field of research and robot motion-planning, it was like "a shot in the arm" for his research program, he says.

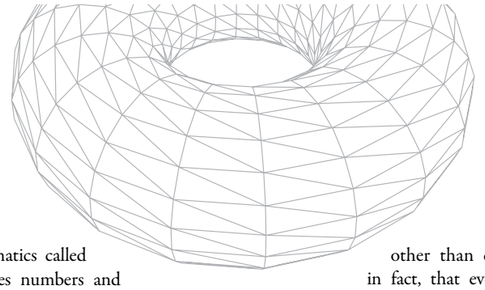
A professor of mathematics, Davis studies a family of shapes called projective spaces, objects that are hard to visualize but are nevertheless defined by elementary rules. The simplest such space, the projective plane (P2), is formed out of a sphere by gluing together each pair of antipodal points. There is no way to do this physically without twisting and tearing the sphere, but mathematicians can nevertheless study the space abstractly, using equations and mathematical functions.

Mathematicians don't shy away from shapes with more dimensions than the three of our physical world. Thus, for any dimension n, they define the n-dimensional projective space, Pn, to be the shape obtained by gluing together antipodal points on an n-dimensional sphere. The projective spaces are among the simplest examples of the mathematical objects called manifolds, shapes that are made by patching together small pieces of ordinary—though possibly high-dimensional—Euclidean space.

Davis's studies focus on one of the most fundamental questions mathematicians can ask about manifolds: What do they look like when sitting inside Euclidean space? More specifically, what is the smallest (that is, lowest-dimensional) Euclidean space that a particular manifold can fit inside nicely?

"Fit inside nicely" could have a variety of meanings. To Davis, it refers to immersions, ways of putting a manifold into Euclidean space that allow the manifold to cross through itself here and there, but don't allow any parts of the manifold to get too crumpled, in a precise mathematical sense. P2, for example, can be immersed in ordinary three-dimensional space (see drawing on opposite page), even though there's no way to place P2 in space without it ever crossing itself.

It's possible to visualize an immersion of P2 in three-dimensional space. But what if you want to know whether, say, P24 can be immersed in 38-dimensional space (currently an unsolved problem)? To tackle high-dimensional projective spaces, Davis



turns to a branch of mathematics called algebraic topology, which uses numbers and algebraic tools to describe the attributes of a shape, such as how many holes, bubbles or higher-dimensional features it has.

Over several decades, Davis has used algebraic topology to prove a wide range of results about the "immersion dimension" of a projective space—the dimension of the smallest Euclidean space in which it can be immersed. In particular, in a key finding, he has established a lower bound on the immersion dimension of certain projective spaces—a dimension below which the projective space definitely cannot be immersed.

The question of a projective space's immersion dimension might seem to belong firmly to the realm of pure mathematics, far removed from any possible application. However, in recent years, mathematicians have connected such immersions to a basic problem in robot-motion planning.

To see how robot-motion planning involves manifolds, imagine a robot arm in the plane with two independent joints at separate spots along the arm. Each joint can rotate through a full 360°, so the possible configurations of that joint are described by a circle. The circles corresponding to the two joints can be seen as the latitudes and longitudes, respectively, on a doughnut shape, or torus (see above). Each point on the torus sits on exactly one latitude circle and one longitude circle, so the point's coordinates specify a particular configuration of the two joints. Thus, the torus is known as the "configuration space" of this robot arm. Each possible motion of the robot arm corresponds to a path between two points on the torus.

A robot arm with more than two joints requires a higher-dimensional manifold as its configuration space. And, depending on the features of the robot, this configuration space may involve shapes other than circles. Mathematicians have proved, in fact, that every manifold defined by equations—including the projective spaces—is the configuration space of some robot. Thus, for a certain class of robots, planning their motion involves understanding paths in projective spaces.

To plan a robot's motion, engineers must specify a collection of rules that tell the robot how to move from any position to any other position. Ideally, engineers would like these rules to be continuous, meaning that small tweaks in the robot's starting or ending position result in only small tweaks in the resulting motion. Otherwise, the program will have instabilities—situations in which if you enter a starting position or ending position with even a slight error, the robot's motion will change drastically.

Unfortunately, robots whose motion can be planned with continuous rules are the exception. For most robots, the best engineers can do is to partition the configuration space into chunks such that each chunk has a continuous rule. A natural question is, how many chunks are needed? In other words, how many fundamentally different rules do engineers have to come up with to program the robot's motion? This number of chunks is called the topological complexity of the robot's configuration space.

> "FOR THESE IDEAS TO BECOME USEFUL, THERE'S GOING TO HAVE TO BE A LOT MORE INTERACTION BETWEEN MATHEMATICIANS AND ENGINEERS."
>
> —DON DAVIS

In 2003, a research team headed by Michael Farber, of the University of Durham in England, proved that for projective spaces, the topological complexity is simply equal to the immersion dimension plus one. "This shows the importance of the immersion dimension of projective spaces, from an applied engineering point of view," Farber says.

The result instantly translated all of Davis's findings on the immersion dimension into facts about robot motion planning. For example, Davis's lower bound on the immersion dimension provides a lower bound on the topological complexity of projective spaces as well. Engineers trying to program a projective-space robot using fewer rules than this lower bound will simply be wasting their time.

A lot of work remains in order to make these findings applicable to real-world problems. At present, projective-space robots are not being used in any actual physical systems, although it's quite plausible that they could prove useful, Davis says. And thus far, his work on immersion dimensions doesn't actually spell out how engineers should program a robot—his findings can only specify, in some cases, how many rules the ideal program would have.

"For these ideas to become useful, there's going to have to be a lot more interaction between mathematicians and engineers," Davis says. Someday, he hopes, his work might indeed prove to be one of the unexpected applications of mathematics in which he delights. In the meantime, he says, "it's a beautiful subject to think about." ●

To plan a robot's motion, engineers must specify a collection of rules that tell the robot how to move from one position to another.

ALBERT KLEIN / GETTY IMAGES; WILLIAM WHITEHURST / CORBIS

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Learning in a Research Environment

by Michael Stavola

Associate Dean for Research and Graduate Programs

An important scientific paper, a new technology, or an elegant work of music or poetry each advances society. But what are the benefits of research to the students at a university where creative work is an everyday activity?

At an institution like Lehigh, the research environment is an exciting, dynamic learning environment for faculty and students alike. I am an experimental physicist, and that was the only viewpoint I really knew before I joined the Lehigh faculty. Having close friends from across the College of Arts and Sciences has broadened my horizons. Similarly, students have their lives enriched by the broad range of activities that they enjoy. The College of Arts and Sciences is a place where a science student can act in a theatrical production or a history professor can host a research colleague whose lecture on city building in Latin America finds students majoring in civil engineering and history sitting side by side.

The classroom environment builds a foundation of knowledge; however, this environment is artificial, and, in many important ways, does not mimic the real world. Students are taught concepts, theories and methods that are central to their discipline. With these tools, students solve various kinds of problems or perform well-directed tasks that exercise their new skills. Problems in textbooks can be challenging, but it is clear from the start that these problems have solutions and involve the lesson just taught. What can be missed is the recognition that the most interesting challenges in real life do not have neat solutions. Sometimes, it is not even clear what the important questions are or from what direction a fruitful strategy for attack will come. Research experiences in any discipline can teach these lessons in ways that textbooks cannot.

An outstanding way to get to know someone is to work together on a shared challenge. Scholarly work creates bonds between professors and their students. The faculty mentor learns the strengths and interests of the student and can offer valuable guidance and advice about career choices. The student can learn how research projects are initiated and conducted. How does someone choose a new creative activity to work on? How do you develop strategies to move forward? What do the results of your work really tell you about the question you have chosen? What remains ambiguous and what is proven? By working as a partner to a faculty mentor, a student can see how these challenges are addressed, and, in the process, develop his or her own unique perspective and skills.

Graduate and undergraduate students are a critical part of the university research enterprise who share and shape the learning environment. For graduate students, interactions with undergraduates in the classroom or research laboratory strengthen their own understanding. Explaining a concept is a terrific way to learn it. Undergraduate students benefit from the synergy that arises from attending lectures crafted and delivered by their professor and then being able to revisit and discuss confusing issues with a teaching assistant who is close to their age. Undergraduates are sometimes less intimidated by their graduate-student colleagues and may be willing to ask questions that they fear might be too simple to ask the professor. These "easy" questions are often central to understanding.

The interactions between undergraduate and graduate students provide windows to the many possibilities for future careers. Some graduate students find that they love helping others to learn, and their experiences as teaching assistants provide a foundation for their future careers as teachers. Undergraduate students, in addition to the assistance they receive with learning course material, can see close up how the next level of the educational process works. The idea of earning an advanced degree suddenly becomes an interesting possibility to consider. Even if this is not the path a student chooses, this choice is made with open eyes.

In a learning environment that is enriched by creative work, students (and teachers) experience what physicist Richard Feynman called the pleasure of finding things out. The excitement that comes with the success of any creative endeavor can ignite the fervor in a student that becomes the inspiration for a lifetime of creative work.

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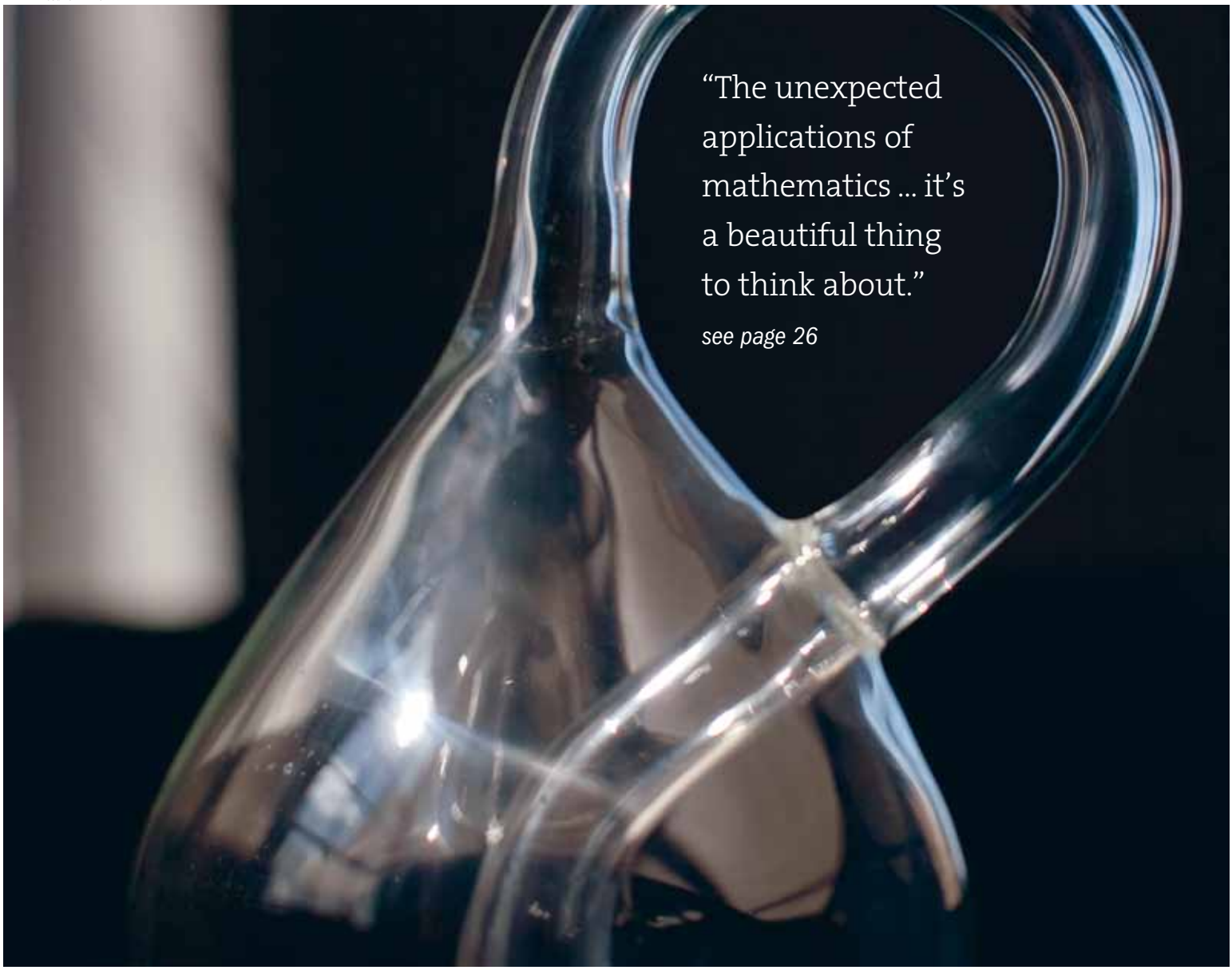

"The unexpected applications of mathematics ... it's a beautiful thing to think about."

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