

# acumen

*A Briefing on Research and Its World Impact • Fall 2009*

*A capitalist path to democracy*

*Astronomy guides Chinese dynasties*

*Harnessing alternative energy*

*Migration as a development strategy*



The Art of  
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ON THE COVER:  
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## UP FRONT

**01 MESSAGE FROM THE DEAN**  
Research, Scholarship and Creative Work

**02 THE ARTS**  
Discovering a forgotten modernism ...  
*Cowboy Jazz ... say word*

**04 THE HUMANITIES**  
Inner peace, world peace ... sexual  
violence in medieval literature ...  
revolutionary Russian art ... metaphysics  
of the mind

**06 THE SOCIAL SCIENCES**  
Lost history, lost democracy ... a capitalist  
path to democracy ... spousal loss ...  
culture and consensus

**08 THE NATURAL SCIENCES**  
Hybrid zones help explain mimicry  
in butterflies ... algae influence gas  
exchange ... the mathematics of  
neuroscience ... speeding up the Internet

## FEATURES

**10 THE ART OF DESIGN**  
Society is looking to design for solutions  
as much as aesthetics.

**14 A CELESTIAL KEY TO CHINA'S ANCIENT PAST**  
From the earliest dynasties, astronomy  
and astrology played a critical role in  
ancient Chinese culture.

**16 POWERING OUR FUTURE**  
Scientists and engineers are trying to find  
new ways to fuel the world's power grid.

**20 HUMAN EXPORT**  
Migrants are becoming flexible labor  
supplies in an increasingly globalized  
economy.

**25 THE LAST WORD**  
Theory Into Practice: Learning, Doing and  
Knowing, by Augustine Ripa, associate  
dean for undergraduate studies and  
professor of theatre

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*Acumen is published annually by the College of Arts  
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consumer recycled paper

**ENVIRONMENTAL SAVINGS:**  
48 trees preserved for the future  
138 lbs. waterborne waste not created  
20,321 gallons wastewater flow saved  
2,248 lbs. solid waste not generated  
4,427 lbs. net greenhouse gases prevented  
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# Message from the Dean



TIME & LIFE PICTURES / GETTY IMAGES

## Research, Scholarship and Creative Work

**This issue of the annual research magazine explores the creativity that inspires research across disciplines.**

Over 40 years ago, the simple image of Earth from space brought our fractured world new attitudes about the fragile beauty and finite limits of our planet. Images such as this profoundly shape our view of the world and ourselves. It also underscores the realization that we are inherently visual creatures. Consciously and unconsciously, we are constantly processing visual cues. These visual cues inform and influence our thoughts and behavior, our sense of safety and security and our sense of self and well-being.

The power of images weaves a common theme between the feature stories in this issue of *Acumen*. Each story presents faculty contributions to research,

scholarship and creative work. Our cover story, *The Art of Design*, examines the transformation taking place in the field of design where aesthetics, psychology and history meet form and texture, in order to inspire. Our second feature, *A Celestial Key to China's Ancient Past*, shows how observations from astronomy and astrology shaped early Chinese culture.

The finite limits of our planet are in the forefront today as we look to provide sufficient clean energy to power the global economy. The feature, *Powering Our Future*, explores the promise and challenges found in alternative sources of energy.

That same image of Earth from space made clear how interconnected we are. We close with an article titled *Human Export*, which surveys the economic and environmental forces driving human migration.

The strength of the College of Arts and Sciences lays in our diversity—in our ability to pursue disciplinary research in a wide spectrum of fields and to bring new knowledge and diverse perspectives to issues that impact our lives. I am pleased to share our contributions and accomplishments with you. I hope you enjoy this issue of *Acumen* and I welcome your thoughts and comments.

**Anne S. Meltzer**

*Herbert and Ann Siegel Dean*



DOUGLAS BENEDICT





A painting by the Czech painter Bohumil Kubišta.

A view of Prague's Ke Hradu Street with Prague Castle and Strahov Monastery in the distance during the early 20th century.

## Art

### Discovering a forgotten modernism

At the beginning of the 20th century, a group of young artists in the Austro-Hungarian city of Prague launched into the forefront of Eastern European art. Central to the development of modern art in Prague, the group was known as *Osmá*, or *Die Acht*: "The Eight." Formed in 1905, it completely reshaped the city's art from a tradition-bound form into one that critics would immediately acclaim for its modernism.

Nicholas Sawicki, assistant professor of art history, examines how the group formed, the work of these artists and their impact on a region that he says traditionally has fallen by the wayside of art historical scholarship.

"Art history, especially in the modern period, has focused on artistic production in cities like Paris, London and New York, where the canon of Western art was formulated," he says. "Other parts of the world, even within Europe, have customarily received little atten-

tion from scholars. Prague's modernism hasn't yet been studied in its context."

Contemporaries and high school classmates of writer Franz Kafka, The Eight's members were left-leaning Czech, Bohemian-German and Jewish painters who studied at Prague's Academy of Fine Arts. They broke from the school to develop their own innovative styles of painting, and in April of 1907 orga-

nized the first independent exhibition of their art.

Modernism in Prague played itself out against national concerns and anxieties in a city comprised of competing populations of Czechs, Germans and Jews. "Whenever an artist came to the fore, his or her work was judged according to certain national conceptions about what art should look like and what the artist's role in society should be. Prague had this continual debate about art in relation to nationality and ethnicity that is very much



SCHNEIDER COLLECTION / CORBIS

specific to the city," he says. The paintings of these artists were challenging enough in their own right, but the group's multiethnic composition also ran counter to cultural norms. For the younger generation in Prague, it was a welcome change.

One of the challenges for Sawicki is the lack of readily available documentation. The Eight's members are not well known internationally, but they would influence and shape modern art in Eastern Europe for decades.

In 1948, communists assumed power, and for the next 40 years progressive and innovative art was suppressed. The work of The Eight was lost. "The artistic legacy that told their story was either destroyed or moved into museum vaults or the back attics of libraries. This chapter of the early 20th century was completely and forcibly buried by the state," says Sawicki.

Modern art came to light again with the collapse of Czechoslovak communism in 1989. Sawicki searches government and private archives and state museums in the Czech Republic, Zagreb, Paris, London, and New York for documents that will shed light on the development of modernism in Prague.

## Music

### Cowboy Jazz

After two years, William Warfield, associate professor of music, is still not comfortable with his jazz composition, *Cowboy Jazz*. It never feels finished, and that's fine with him. A jazz piano concerto that evolved from his impromptu jam sessions with fellow faculty member Eugene Albulescu, *Cowboy Jazz* is an intense, difficult piece that is partially written, partially improvised and pushes performers and audiences alike.

It is designed to cross over for either a jazz pianist who plays some classical or a classical pianist who does some improvising, says Warfield.

*Cowboy Jazz* is a four-movement piece written in remembrance of 9/11. It is the evolution of a piece originally written as a trumpet sonata for a memorial service at



William Warfield, associate professor of music, composed a four-movement piece in remembrance of 9/11.



PHOTO COURTESY OF ZABELLER ARTS CENTER

Lehigh that Warfield performed with Albuлесcu, who is associate professor of music and holder of the Ulrich Chair in Orchestral Music.

A professional composer for 25 years, Warfield writes using an approach developed by the German composer Anton Webern. Taking the mathematical relationship between a three- or four-note pitch, “cell” tones are arranged to take advantage of internal symmetries. A row is generated by extending tones beyond the original cell using only the intervallic relationship between the tones in the cell itself. Using these guidelines, Warfield created a row of 13 tones. Everything written is based on a mathematical relationship between pitches. Harmonies or “vertical structures” were also constructed by using these same intervallic relationships.

The time signatures of the piece are alternating bars of nine and 11, symbolic of the historic date.

The last movement is marked by dual bars of 9/8 and 11/8 time, but it is written in a salsa pattern structure. These intricate rhythms make *Cowboy Jazz* a difficult piece to perform. As an example, Warfield says he took traditional salsa rhythms and altered them. The 9/8 bar is stretched one beat. The 11/8 bar was originally a 12/8 bar that Warfield compressed by one eighth note. Warfield says the effort is challenging but rewarding.

“All of the instincts you have developed after years of writing in the traditional sense are still in use, but this method of composing

takes you places that you normally wouldn’t go as a composer. We’re kind of a slave to our experiences; yet working this way takes you outside your experience level because it’s mathematically generated. It feels weird to play it, but it sounds different than anything I’ve ever heard before.”

Warfield’s composition was commissioned by Kluvers radio orchestra in Arhus, Denmark. Since premiering his work in 2007, he has presented it internationally and played it with his band, the Bill Warfield Big Band. Last year, he presented the work at the International Association of Schools of Jazz annual meeting. Warfield says one of the joys about this piece is every time somebody sits down and plays it, it sounds completely different.

## Theatre

### Say word

Now more than 30 years old, hip-hop has evolved from being a local art form found on the streets of New York’s West Bronx to an international creative inspiration that shapes a generation. Influencing music, art, dance, and theatre, hip-hop is branching out from its fundamental roots of club DJs and graffiti art to create a powerful presence on theatre stages. For artists like Kashi Johnson, associate professor of theatre, hip-hop theatre provides opportunities to discover new voices.

Committed to nurturing new hip-hop talent, Johnson is cofounder of RedSun Productions, a Lehigh Valley, Pennsylvania-based theatrical production company dedicated to cultivating and showcasing original, cutting-edge hip-hop theatre artists for the stage. She works with Touchstone Theatre, a local community-focused professional theatre, to produce the regularly occurring HipHopCollective, an open-mic show that features regional talent and local acts.

Johnson, a trained actor and experienced director, is a self-described product of hip-hop. “I grew up in New York City in the early ’80s, so I was in the room when hip-hop was born and I fell in love,” she says. “I discovered my passion for theatre years later. So imagine how excited I was to learn about the emerging genre of hip-hop theatre. For the first time, there were stories being told by artists who looked like me, performing in regional and national venues that hadn’t traditionally supported this style of theatre. It spoke to me. I felt empowered.

“With Touchstone, it was the perfect opportunity to develop an outlet for a lot of the work I already did. Becoming a producer seemed natural because I know how to put

a show together. What I had to learn was how to negotiate the demands of a performance space, artist needs and audience expectations.”

Booking up to 10 shows per season, Johnson always tries to mix New York artists with acts by local performers in order to fit with Touchstone’s community philosophy. Some events have featured all New York and Philadelphia acts, while others have focused on Lehigh students and their work.

Johnson also works as a consultant to hip-hop artists, many of them New York-based, helping to develop their stage shows. Her professional experiences have dovetailed with her teaching, resulting in a highly popular course that not only examines hip-hop theatre as entertainment, but also asks students to create and perform their original work. She says that whether she is working with professional performers or her students, the enjoyment comes with helping artists find their voice.

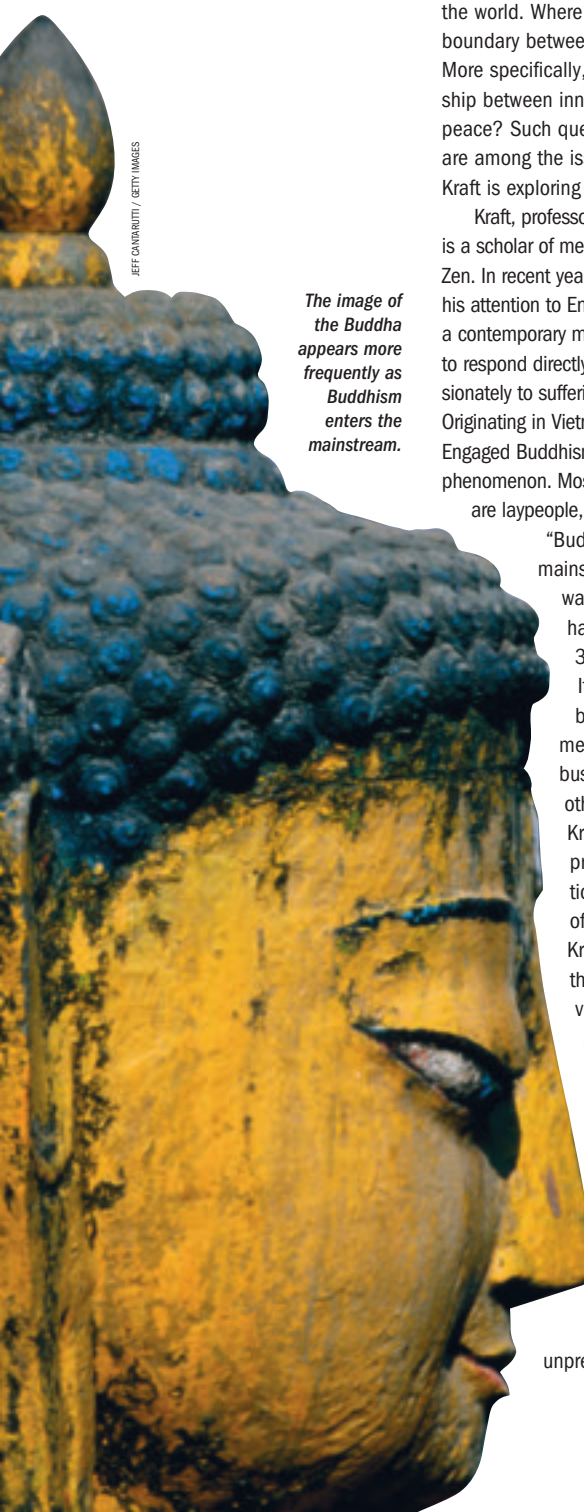
“Hip-hop has been around for some time now and there’s a lot to learn, but 2010 is almost here and students are creating their history in the culture now. I encourage them to define what makes their hip-hop generation different from mine, and what needs to be said that isn’t.”

*Hip-hop is branching out from its fundamental roots to create a powerful presence on the stage.*



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JEFF CANNARUTTI / GETTY IMAGES

*The image of the Buddha appears more frequently as Buddhism enters the mainstream.*

## Religion Studies

### Inner peace, world peace

For more than 2,500 years, Buddhists have been interested in the way the world affects the mind, and the way the mind affects the world. Where is the presumed boundary between mind and world? More specifically, is there a relationship between inner peace and world peace? Such questions, still salient, are among the issues that Kenneth Kraft is exploring in his current work.

Kraft, professor of religion studies, is a scholar of medieval Japanese Zen. In recent years, he has turned his attention to Engaged Buddhism, a contemporary movement that strives to respond directly and compassionately to suffering in the world. Originating in Vietnam in the 1960s, Engaged Buddhism is now a global phenomenon. Most participants

are laypeople, not monks.

"Buddhism is entering mainstream culture in ways that could not have been imagined 30 years ago.

Its principles are being put to use in medicine, education, business, and many other fields," says Kraft. Likewise, the practice of meditation has lost much of its foreignness. Kraft believes that these developments, viewed as a whole, point the way to a more promising future. "This convergence of Asian spirituality and Western social thought—inner freedom meets political freedom—is historically unprecedented."

Buddhism has traditionally emphasized individual self-realization, or awakening. Without abandoning that foundation, today's engaged Buddhists are raising new questions, Kraft notes. "How might we move toward a culture that values awareness, a culture of awakening? What are the links between personal transformation and social transformation? Is awakening possible at a community level?"

Aspects of Kraft's current book project are admittedly utopian. "Used positively, utopian simply means ideal, not 'too idealistic,'" he asserts. "Sustained visualization is a time-honored technique in several streams of Buddhism; in a sense, I'm experimenting with a social version of it. For example, what if the educational system included contemplative approaches to learning—at all levels?"

As for the relation between inner peace and world peace, "How can we work for peace if we are filled with anger or arrogance? In contrast, genuine peace of mind has a kind of ripple effect, in widening circles. Means and ends must accord."

## English

### Sexual violence in medieval literature

Images of sexual violence and ravishment appear in many medieval texts, from the works of Geoffrey Chaucer to less well-known texts like saints' lives, political treatises, and accounts of mystical experience.

Suzanne Edwards, assistant professor of English, is interested in the ways in which legal and literary texts from the 13th through the 15th centuries variously represent and define sexual violence. For example, medieval laws link rape with non-sexual abduction and elopement. Margery Kempe, a mystic, describes her fear of rape with the same language she uses to describe



HP / ART RESOURCE, NY

*Taken from the Sarum Book of Hours, the image is of the fictional St. Margaret of Antioch, who was swallowed by a dragon. Edwards discusses St. Margaret in a new book with the prospective title Beyond Rapture: Pedagogies and Fantasies of Sexual Violence in Late-Medieval England.*

her desire to be ravished by the divine. Edwards's research focuses on how and why the language of sexual violence produces such dense and contradictory meanings.

She argues that these representations of sexual violence capture ethical and epistemological concerns about the will and the body. One of the texts Edwards studies, a guide for religious women, casts reading and marriage as forms of sexual violence. This guide takes an extreme position on sexual violence to explore how human beings can consent to sin, even when they experience that sin as a grave harm. "The imagery and narrative conventions of ravishment tell us about the competing ways in which medieval writers define the limits of bodily experience, human agency, and sexuality," Edwards says.

The philosophical questions about consent and bodily experience characteristic of late-medieval thinking about sexual violence resonated not just with ecclesiastical concerns about sin but also with civil concerns about private property and legitimate governance, another area of interest for Edwards. Imagery of sexual violence reflects ideals about gendered social roles, but often, Edwards argues, in unexpected ways. For example, in some texts the figure of a sexually violated woman models effective masculine rule, the possi-

bility of acting meaningfully in the face of difficult constraints on action.

"There is no single definition of sexual violence in late-medieval England," says Edwards. "It is a contested category that reveals how gender and sex were contested as well. Examining varied medieval accounts of ravishment might help modern readers to re-evaluate familiar concepts, such as consent and violence, gender and sexuality."

#### Modern Languages & Literature

### Revolutionary Russian art

Beginning after the death of Joseph Stalin in 1953 and continuing sporadically through the 1980s, unofficial Soviet art developed outside the public realm and largely beyond the reach of critics, art historians and viewers. A hostile regime set unofficial artists in opposition to those in power, despite the fact that many

study of conceptualism in Russia and an assessment of its overall place in the history of modernism and post-modernism. Her current study concerns visual texts, words painted on canvas that advance the importance of language while de-emphasizing the concrete art object.

This painted word and its replacement of image with text calls visual art itself into question. In the Soviet Union, the conceptualist movement was the most important unofficial art development of the late 20th century. However, establishing what constitutes Russian conceptualism and identifying its main proponents and tenets have been complicated by the fact that the early history of the movement took place "underground," away from the prying eyes of Soviet authorities but also out of reach for most archivists and critics. The complete history of Russian unofficial art is only now being recovered.

"Despite its cultural significance, Russian conceptualism has

history of art and politics. Despite a lack of access to state patronage, museums, mass media and the public, this small and insular group of unofficial artists nevertheless threatened the Soviet system with their powerful critique. Conceptualism, with its shared concern for the communal construction of meaning, provides the ideal workshop in which to chronicle the evolution of Russian art.

"By focusing on this discrete and relatively self-contained movement, we can begin to construct a transnational, cross-disciplinary history of conceptualism."

#### Philosophy

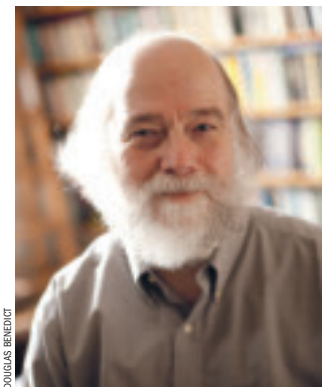
### Metaphysics of the mind

The history of science is a narrative of how humans view the world around them and the reassessment of our assumptions about our place in the world. Mark Bickhard, Henry R. Luce Professor of Cognitive Robotics and the Philosophy of Knowledge, has focused considerable energy trying to understand how minds emerge from, and yet remain continuous with, the world of facts.

This is a problem because the standard understanding holds that we cannot derive norms from facts, yet minds and persons are inherently normative. There is a historic split between the world of minds and the world of facts, and this split is a basic metaphysical division in Western thought. Bickhard explains that "a new metaphysics is needed if we are to develop true models of the normativities of mind. It is only when science studies minds and persons that we run into this fundamental problem of normativity—of true and false, rational and irrational, and so on—in the factual world."

Testing this historic divide between the world of minds and the world of facts, Bickhard is focusing on the evolutionary and developmental emergence of normative

phenomena out of prior forms of process. In addition to challenging the split between substance and mind, Bickhard challenges traditional emphasis on the concept of substance itself. We only really understand the world when we understand it as being in process. His metaphysics is



*Mark Bickhard tests the historic divide between the world of minds and the world of facts.*

process metaphysics, and part of his current research focuses on the central nervous system, trying to explain how different sorts of phenomena of the mind are realized in its processes. This requires an account of how normative mental phenomena are emergent in underlying biochemical processes.

"The world of particles and atoms is a world of facts. The world of thoughts, which can be true or false, and reasoning, which can be rational or irrational, is a world of normativity. I argue that these two worlds of the mind and of facts have been split since the pre-Socratic Greeks. It's not necessary that it be this way. It's possible to think of mental phenomena as emerging from other sorts of phenomena, but to get to that point we have to go back through and undo what I consider to be some errors that go back over 2,000 years. Without an underlying basic process metaphysics, we can't get started on understanding these emergent phenomena."



*A work titled History of the USSR in Slogans 1917-1991 by Russian artists Aleksandr Melamid and Vitaly Komar. Komar and Melamid founded the movement Sots Art, which combines the principles of Dadaism and Socialist Realism.*

of the artists displayed little interest in politics and treated the authorities with disdain or indifference.

Mary Nicholas, associate professor of Russian, recently began a

received little critical attention," says Nicholas. "There is no general work on the subject in English."

Nicholas notes that understanding this movement is important to the



# The Social Sciences

## Political Science

### Lost history, lost democracy

Even after 40 years, the era of the 1960s remains highly contested, as politicians, media and historians struggle to define the meaning and significance of the period. Speculation about the United States “getting over the ’60s” is an almost reflexive media preoccupation that goes back to the end of the ’60s decade itself, says Edward Morgan, professor of political science.

Morgan’s research on mass media during and since the 1960s era finds that the media have revised the meaning of the 1960s era in ways that helped shift political discourse to the right



ROB HOWARD / CORBIS



SANTI VISALI / GETTY IMAGES

*Social and political activist Abbie Hoffman speaks to reporters after arriving in Washington to attend the Un-American Activities Hearings in 1968.*

while simultaneously eroding democratic culture. As a result, Morgan contends, mass media discourse about the 1960s has “domesticated a politically volatile era in the service of a political spectacle that trivializes the kind of empowering democratic awakening that occurred some 40 to 55 years ago.”

Typically, mass media have explained the tumult of the ’60s via a framework that concentrates on characteristics of an unusually “rebellious generation.” The media began to seize upon the generational frame around mid-decade,

Morgan observes, when ’60s movements began to target national institutions and policies and express arguments that lay outside conventional media discourse.

Mass media accounts in and since the ’60s reflect two systemic characteristics: a range of “legitimate” discourse that reinforces system-sustaining beliefs, and commercial imperatives that drive media to maximize the short-term appeal of media content.

During the ’60s, these forces combined to exclude system-critical voices raised by the era’s social movements while simultaneously emphasizing visual, dramatic and violent behaviors—with significant implications for the trajectory of that era.

Similarly, Morgan observes, today’s media culture trivializes political discourse and our understanding of the past. Simultaneously, it maintains the system-reinforcing boundaries of debate at the very time serious questions about the system’s sustainability are being raised.

The task ahead, he argues, is to “build democratic community while simultaneously increasing awareness of the systemic forces that undermine democracy.”

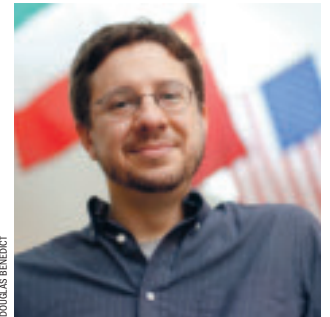
## International Relations

### A capitalist path to democracy

Most social scientists agree that the rise of capitalism leads to democratization because it creates new social classes that conflict with entrenched elites and demand to participate in politics. Kevin Narizny says an alternative possibility, in certain cases, is that democracy developed not due to conflict between social classes, but rather because of a divide between rentier and capitalist elites.

Narizny, assistant professor of international relations, tests

this idea on the origins of England’s Glorious Revolution of 1688–89, which established parliamentary sovereignty over the crown. Democracy developed,



DOUGLAS BENEDICT

*Kevin Narizny, assistant professor of international relations, studies the origins of democracy.*

in part, due to the structure of the English economy, he says.

In a rentier society, individual firms seek favor from the state to establish monopolies. Wealth and power are derived from corruption and clientelism. In capitalist societies, in contrast, elites make their wealth through market competition, which forces them to be more efficient and innovative.

“They don’t need political privilege to succeed,” says Narizny. “In rentier societies, elites had more to lose with the change of a monarch, including the loss of wealth and privilege. That made them unwilling to tolerate democracy. Capitalists are less affected by changes due to elections. It’s easier for the capitalist elites to coexist with democracy.”

Narizny also studies the origins of democracy in Costa Rica. An economic backwater, colonial Costa Rica was excluded from the monopolies that the Spanish Empire created throughout the Americas. Unlike in other Spanish territories, its elites did not rely on the government for their profits and power. The result was a path to democracy that started earlier and developed with less civil conflict than in other states in Latin America.



## Psychology

### Spousal loss

The loss of a spouse or partner poses tremendous risks to one's psychological well-being, yet little is known about the long-term outcomes and processes associated with it.

Christopher Burke, assistant professor of psychology, studies bereavement and how people cope with the loss of a spouse or partner. As stressors go, it's one of greatest a person can experience, he says.

"One of the things that makes spousal loss so difficult is that not only are you going through this stressful experience, but you've lost the person most likely to help you through a stressful experience. You're doubly hit because your partner isn't there to help you through the event."

Studying 800 people who have lost a spouse or partner in times ranging from a few months to 64 years, Burke and his colleagues focused on their emotional recovery, including the nature and frequency of thoughts and memories of the deceased, their emotional and cognitive resolution of the loss, and perceptions of positive change. They found that the grieving process following the loss of a long-term spouse can continue for many years. Even after decades have passed, it is common to have memories and conversations about one's spouse, to sometimes become sad and upset as a result, and at times to experience distress when reminders,

such as the date of the spouse's death, are encountered.

"For many people, the loss remains present tense. Before the loss, they may have discussed everything with their partner. This kind of dialogue is difficult to stop, even if the spouse is not around. Thinking about what the spouse might say to them in a stressful situation might make the situation easier to handle," says Burke.

Each person handles the loss differently and in many ways; widows and widowers may grow psychologically as they redefine how to cope with the world independent of the partner.

"Understanding why it's disruptive for some people but not others may tell us something fundamental about how people cope with stress in general."

*Jacqueline Kennedy had to publicly grieve the loss of her spouse.*



BETTMANN / CORBIS

## Sociology & Anthropology

### Culture and consensus

Once dependent on fishing and sea-salt production, the Turks and Caicos Islands (TCI) have made tourism a mainstay of their economy. In fact, the islands host more than 300,000 tourists a year.

For the mere 12,000 TCI citizens, known as "Belongers," this influx of tourists means they need to carefully plan for their future or risk facing the negative side effects of unplanned growth that other Caribbean countries, such as Jamaica and the Bahamas, have encountered since the 1960s.

Under a National Science Foundation grant, John Gatewood, professor of anthropology, and Catherine Cameron of Cedar Crest College commenced a study to learn Belongers' perceptions of tourism and its impacts on their lives. But rather than just take a survey on tourism, they set out to determine whether Belongers share a common cultural understanding of tourism. To what extent can the diversity of answers among survey respondents be understood as random deviations from a generally shared cultural understanding?

"The intellectual goal of the project is to conjoin cultural model theory with cultural consensus theory," says Gatewood, adding that the method they have developed could be applied to any location. In fact, he has used it in the past to examine employees' perceptions of credit unions.

The cultural models approach involves a fine-grain, qualitative analysis of what people know to build a composite model from diverse informants. By contrast, consensus analysis rests on explicit,



MATTHEW WAKEN / GETTY IMAGES

*Turks and Caicos now hosts more than 300,000 visitors annually.*

quantitative methods and focuses on how knowledge is socially distributed.

"You need to do both," says Gatewood. "Conjoining the two gives you a better grasp of the social organization of knowledge. You get a deeper understanding of both what is known and the extent to which that cultural knowledge is shared and by whom."

Gatewood and Cameron first conducted 31 ethnographic interviews to extract a cultural model of tourism. From there, they 'grew' a 10-page questionnaire that was completed by 277 randomly selected Belongers from TCI's six islands. Questions examined the tourism system, tourism work and opportunities, as well as sociocultural, economic and environmental impacts.

After analyzing data, Gatewood identified two distinct viewpoints—a very pro-tourism, pro-growth perspective and a more cautiously ambivalent orientation—and this contrast is not related to age, sex, education, income or other such personal characteristics. Gatewood then returned to the data and identified the specific subset of questionnaire items on which these viewpoints diverge.

While the findings of the study will assist TCI officials who must manage the growth of tourism in their country, the method itself will have farther-reaching applications. "Some of the analytical techniques we've developed in this study are significant improvements to the anthropological toolkit," says Gatewood.



## Biological Sciences

### Hybrid zones help explain mimicry in butterflies

Most of the approximately 17,600 species of butterflies may be instantly recognized by their wing patterns; however, the butterfly species *Limenitis arthemis* has several guises.

In the northern portion of North America, the *Limenitis arthemis* or white admiral butterfly flies on elegant ebony wings marked with one thick white stripe. Further south, the same species decked in brilliant indigo or aqua is named the red-spotted admiral.

Sean Mullen, assistant professor of evolutionary genetics, explains that the subdued markings of the northern butterflies camouflage them from hungry birds, while the brilliance of the red-spotted admiral mimics the coloration of the pipevine swallowtail, which is found in the same region as the red-spotted admiral. Swallowtail butterflies taste wretched to birds, and predators quickly learn to avoid any big, blue butterfly—including the red-spotted admiral.

The two types of admiral butterflies mingle, interbreed, and produce hybrid offspring in a narrow region that crosses through New England and Pennsylvania. Mullen is particularly interested in such hybrid zones,

because they provide a unique opportunity to observe species formation and natural selection.

"I wanted to really understand why hybridization occurs," Mullen says. "How do these zones originate, how are they maintained? Why do they look different? Why don't they all look like hybrids?"

A cross between the two types of admiral butterflies produces an offspring that is too conspicuous to avoid a predator's detection but cannot be mistaken for a swallowtail. Thus, many of the hybrid offspring become an easy supper for hungry birds, and two distinct subspecies are preserved.

The hybrid zone and the two admiral butterflies also allow Mullen to better understand mimicry. Mullen is mapping the genes that control the differences in wing color and pattern, one piece of a greater project to reconstruct the first butterfly genome. After one butterfly species' genome is mapped, other species' genomes can be more easily determined. Mullen hopes to learn whether the genetic pathways that make one type of butterfly a mimic are the same used by all mimetic butterflies.

If the same genes control mimicry in all butterflies, Mullen believes "we might ultimately be able to predict how the genomes of natural populations respond to natural selection." If different species tweak different genes to become mimics, it "suggests an equally interesting alternative—that essentially the genomes of natural populations are extremely flexible."

## Earth and Environmental Sciences

### Algae influence gas exchange

The voyage Bruce Hargreaves took to the Southern Ocean last year was no pleasure cruise. The waters surrounding the Falkland Islands, off the coast of Chile, were icy during his six weeks at sea. But he and the 30 other scientists aboard the NOAA Ship *Ronald H. Brown* were pleased. Stormy weather was a boon to their work with the Southern Ocean Gas Exchange Experiment, or GASEX-III.

"We succeeded in finding the bad weather we were looking for. We had big storms, high winds, and large waves," says Hargreaves, associate professor of earth and environmental sciences.

Sponsored by NASA and NOAA, GASEX-III aimed to determine how the ocean's physics and the biology of its algae influence the exchange of carbon dioxide between the ocean and atmosphere.

Carbon dioxide (CO<sub>2</sub>) has been implicated as a contributor to the world's changing weather patterns. People and animals expel the CO<sub>2</sub> gas when they exhale, and energy-producing fossil fuels release CO<sub>2</sub> when burned. Scientists attribute recent global warming to an increase in CO<sub>2</sub> and similar gases because these so-called greenhouse gases prevent heat from escaping Earth's atmosphere.

About one-quarter of the world's atmospheric CO<sub>2</sub> is absorbed by the ocean. "The Southern Ocean may be especially important for uptake of CO<sub>2</sub>," Hargreaves says, "but the high winds and large waves in this region typically exceed the conditions previously studied by ocean gas exchange specialists."

Microorganisms called phytoplankton are one of the ocean's two primary means of absorbing atmospheric carbon. (CO<sub>2</sub> also dissolves in ocean water.) Like terrestrial plants, phytoplankton use sunlight and CO<sub>2</sub> to make sugar in the process of photosynthesis.

Even in ideal conditions, a phytoplankton's lifespan rarely lasts more than two days. In that time, it might be digested by a tiny animal near the ocean's surface, which will release its stored CO<sub>2</sub> to the atmosphere, or the deceased phytoplankton might sink into the deep ocean, taking its CO<sub>2</sub> with it. According to NASA, approximately 90 percent of the world's organic carbon can be found in dead biomass on the ocean floor.

Hargreaves's specialized tools measured the amount of light absorbed by phytoplankton. The data, when combined with measurements made by other scientists, can be used to model the amount of carbon absorbed in photosynthesis and the contribution of phytoplankton to the gas exchange process. The



Scientists in the Southern Ocean Gas Exchange Experiment conducted work in the waters surrounding the Falkland Islands. Here, the bright blue-green streaks seen in the sea are blooms of marine phytoplankton.

researchers hope to release a series of scientific papers on how the Southern Ocean's physical and biological processes influence atmospheric CO<sub>2</sub> within the next year.

## Mathematics

### The mathematics of neuroscience

In the field of neuroscience, significant advances are being made as researchers gain a detailed understanding of the complex processes. While biologists make inroads to identify neuronal actions and behaviors, Linghai Zhang and his colleagues are developing mathematical tools to analytically and numerically solve biophysical models of individual neurons and neuronal networks.

Zhang, associate professor of mathematics, uses traveling waves to model the propagation of nerve impulses, the presentation of stimuli in turtle and cat visual cortex, cortical epilepsy and migraine headaches. Zhang uses one-dimensional mathematical models called integral differential equations in his research.

As part of his work, he investigates how wave shape, speed and stability vary as synaptic coupling and the model parameters change. The synaptic couplings may be of pure excitation, lateral inhibition or lateral excitation. Zhang introduced two important concepts to the field: speed index functions and stability index functions, technical tools developed to study the existence, uniqueness and stability of traveling waves. The speed index functions may help to find the wave speed and the stability index functions may help to determine the wave stability. These functions play very important roles in the mathematical analysis of traveling waves in neuronal networks. The analysis and results on the speed, the speed index function and the stability index function

DOUGLAS BENEDICT



*Linghai Zhang develops mathematical tools to advance the field of neuroscience.*

can be applied to dynamic systems and computational neuroscience.

In computational neuroscience, mathematicians work to validate the findings of neuroscientists by checking mathematically the discoveries made by neuroscientists. Mathematicians may also make significant contributions which are not easy for biologists to discover in experiments. The field of neuroscience is always developing, and mathematicians have to always be ready to learn new things, says Zhang.

"As researchers, we need to be familiar with many of the sciences, other than mathematics. We need to know biology and chemistry. We need to know physics as we try to develop the models. We are always re-evaluating our work as science advances."

## Physics

### Speeding up the Internet

It's a 21st-century quest—find a way to transmit and process data faster and faster.

Ivan Biaggio, professor of physics, developed an organic material with an unprecedented combination of high optical quality and the strong ability to mediate light-to-light interaction. Biaggio is part of an international team that has engineered the integration of this material with silicon technology so it can be used in integrated optical chips for optical telecommunication.

The material, which is composed of small organic molecules, covers the silicon waveguides that control the transmission of light beams in an integrated optical circuit. Waveguides are materials such as optical fiber that guide electromagnetic waves in the optical spectrum.

"We have been able to combine the molecules into a material that

is perfectly transparent and flat, and free of any irregularities that would adversely affect optical properties," says Biaggio.

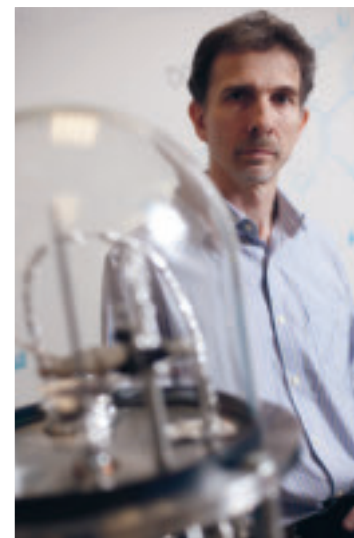
This new material fills the submicron-sized slot where most of the light propagates in a specially designed silicon waveguide. By filling the slot, the molecules add an ultrafast all-optical switching capability to silicon optical circuitry, says Biaggio, creating a new ability to perform the ultrafast light-to-light interactions that are necessary for all-optical data processing. The nanophotonic organic-silicon hybrid has demonstrated the best all-optical demultiplexing rate yet recorded for an integrated optic device on the silicon photonics platform.

As Internet users demand greater bandwidth for ever faster communications, researchers work to increase the speed at which information can be transmitted and routed along a network. They are hoping to achieve a major leap in velocity by designing circuits that rely solely on light-waves to process data. Currently, data must be converted from optical signals to electrical signals in order to manage its progress within an optical telecommunication network. All-optical circuits could unleash the full potential of optical telecommunication and data processing.

All-optical circuits require nonlinear optical materials with high optical properties. A nonlinear optical response occurs in a material when the intensity of light alters the properties of the material through which light is passing, affecting, in turn, the manner in which the light transmits.

"To the best of our knowledge, this is the first time that nonlinear silicon-organic-hybrid slot waveguides were used for efficient ultrafast all-optical switching of telecommunication data streams. We believe that there is a large potential to further develop this silicon-organic-hybrid system on the silicon photonics platform."

*Ivan Biaggio developed a material that covers silicon waveguides that control transmission of light beams in an integrated optical circuit.*



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# The Art of Design

by Tricia Long

Today's culture shows how design resonates with the human psyche

The concept was simple: A basic blue letter “O” partially obscured by five red and white stripes. From the choice of color to the selection of font to its understated simplicity, this basic concept gave aesthetic appeal to Barack Obama’s presidential campaign. But more than a logo, this stylized letter “O” created a brand and connected with an audience. It permeated the public consciousness, appearing on far more than rally signs and campaign buttons. His success is due, in part, to his choices of colors, fonts and logos. His message of change was delivered not only through what people heard, but also by what they saw.

“We are very tied to style, taste, aesthetics and materials,” says Marilyn Jones, assistant professor of design arts. “Graphic design has changed tremendously. It’s about creating an experience. It’s more than a logo and materials—it’s about people and orchestrating behavior.”

Artists working in all media are challenged by a rapidly changing world, in which society looks to design for solutions as much as aesthetics. The field of design is undergoing a transformation that emphasizes the necessity of understanding human behavior. As the 2008 presidential campaign demonstrated, design resonates with the human psyche, and designers are forced to have a greater grasp of how people behave, react, relate and even shop.

“The whole culture has been conditioned into a series of images that we’re accustomed to and acclimated to; they’ve become design icons that are now a part of our visual language,” says Berrisford Boothe, associate professor of art and a founding member of Lehigh’s Integrated





*Marilyn Jones, assistant professor of design arts, has watched the field of graphic design undergo a transformation. Jones believes corporations are now looking to graphic design to help orchestrate behavior and not just create a logo.*

DOUGLAS BENEDICT

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BRIAN HAHN/GETTY IMAGES

Product Development program. “You need to understand sociology when you’re dealing with the nature of how people respond in a consumer-driven marketplace. The Gap became the Gap and Starbucks became Starbucks because of people in my field.”

As a result of this pictorial conditioning, Boothe believes that culture is driven by design. While the hand of an artist can be seen through a painting or an illustration, it is also visible in a watch, an item of clothing or a car.

“There is a misunderstanding about the power and role of the function of art in this culture. We live in a culture where image is king. Don’t believe me? Go for a drive. Look at the billboards, look at the magazines—we are perpetually immersed in the language of design,” says Boothe.

## An interdisciplinary approach

A newly constructed home, the costume worn by an actor on stage, a fork or even a campaign logo can all be created by wedding art with psychology, sociology, history and marketing. As a result, artists from disparate fields are increasing their awareness of one another’s perspectives. They are taking an interdisciplinary approach to their work, extracting from the past and becoming more socially conscious of the world around them.

“Design is a psychology, a way of seeing,” says Boothe, a painter, printmaker, installation artist, lecturer and curator, whose current work is inspired by circles, religion, African-American artifacts and jazz. “It’s a way of being and a way of integrating elements into form. But it’s also about how we, as individuals, go about the business of recognizing and pulling and clashing and integrating experience with the basic tenets of form as we’ve come to know them.”

Jones sees art as the heart and soul of design, necessary for generating ideas and sparking creativity, but adds that as a graphic designer her work is also informed by business and marketing in reaching her audiences. She believes in tapping into the left side of the brain as much as the right side. “Liberal arts education is so important to design,” says Jones. “You have to attack design from many disciplines. You need to have social understanding and global understanding.”

“Fundamentally it’s about lateral interrelationships,” agrees Boothe. “No one field has dominance over the other. An engineer needs to know how to talk to a marketer, who needs to know how to talk to an architect, whose profession it is to define spatial relationships through design.”





Other artistic fields are very much influenced by the greater world as well. Associate professor of theatre Erica Hoelscher, who designs costumes and sets for the theatre, delves into the lives of her characters and their environment before her pencil even touches paper.

Hoelscher has been designing for a production of Eugene O'Neill's *A Moon for the Misbegotten*, which plumbs the depths of the human spirit, locating its beauty in a single, unadulterated moment with tremendous redemptive power. For Hoelscher, her designs must create a world that will speak to someone and connect artist with audience. She taps into anthropology, human behavior and psychology because they help her better understand why a person believes or acts as they do.

In all her productions, Hoelscher also employs a theatrical design teaching method called "scenography"—an old-fashioned term used mostly in Europe to describe the work of the theatrical designer. Here the designer creates the entire world of the play, which includes all visual elements as well as some aural ones. While her work has traditionally focused on costume design, she recently embraced scenery as well in order to exemplify the scenographic model.

"My process in designing *A Moon for the Misbegotten*, and every other play, is a collaborative one," says Hoelscher. "I think the collaborative nature of my design process makes it unique from what other designers and artists do," she adds. "It's exciting to me as a designer when one of the visual elements describes a different aspect of the production than another."

For this production, Hoelscher drew from paintings by German artist Max Ernst to help her envision her concept. "The environment of the play represents, for me, the inner mindset of the characters and prevents them from making intimate connections with others. It is a dangerous, hurtful place."

"It's our responsibility as artists or designers to take what the culture is and reflect it back on them, not to tell them what to do but to say this is what we're noticing is happening in the culture," says Boothe.

## Design for the modern audience

Hoelscher also believes that researching the past influences present-day work. Her research relies heavily on books, images and visual cues that will give direction to where she wants to take her characters and the environment in which she wants to place them. In *A Moon for the Misbegotten*, Hoelscher incorporated photographs of landscapes from the New England countryside, which she discovered in the Library of Congress collection, as well as farm images of decrepit buildings.

"The artist in the postmodern context is pulling from everything known, and everything that's come before it," says Hoelscher, who believes we're conscious of everything around us in the modern world because the world has become so small.

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Berrisford Boothe, associate professor of art, is framed by one of his paintings (top) which sits above his desk (top right). Through her set and costume designs, associate professor of theatre Erica Hoelscher hopes to create a world that speaks to her audience (right). Hoelscher's set design for *A Moon for the Misbegotten* (above).



“The artist in the postmodern context is pulling from everything known, and everything that’s come before it.”

—Erica Hoelscher

“All periods borrow from one another,” she adds. “For designers, all times exist in one space. Any life can be relevant to the modern audience.”

For a graphic designer like Jones, the concept of pulling from the past has more to do with utilizing the techniques that were employed in previous eras of design. The key to understanding this, she says, is that technology is not what innovation is all about. Jones’s students are encouraged to move away from the flat

screen of a computer in order to get a sense for elements such as dimension, texture and form.

“We can’t design in isolation,” says Jones. “We have to keep current, but build on the past.”

More traditional design techniques, including silk-screening, painting, hand drawing and illustration, she says, do not have to be at odds with computers. Instead, the transition between the digital environment and design done by hand should be seamless.

A new graphic design aesthetic is reflecting this, and Jones believes it’s due in part to a backlash against technology and the reliance on things like stock photos, which undermine the role of the designer. Today’s designers are inspired to seek solutions from the past as much as they look to current style and trends.

Boothe adds that not all designers heed the experience of those who came before them, and as a result, the public often accepts bad form as good design.



MASSIMO OSTI / CORBIS



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## Socially conscious design

One of the biggest examples of how the social culture is permeating the field of design is a heightened awareness of issues tied to the environment and sustainability. Today, designers are more conscious of the ethical responsibility to consider the role design plays throughout the life cycle of a product.

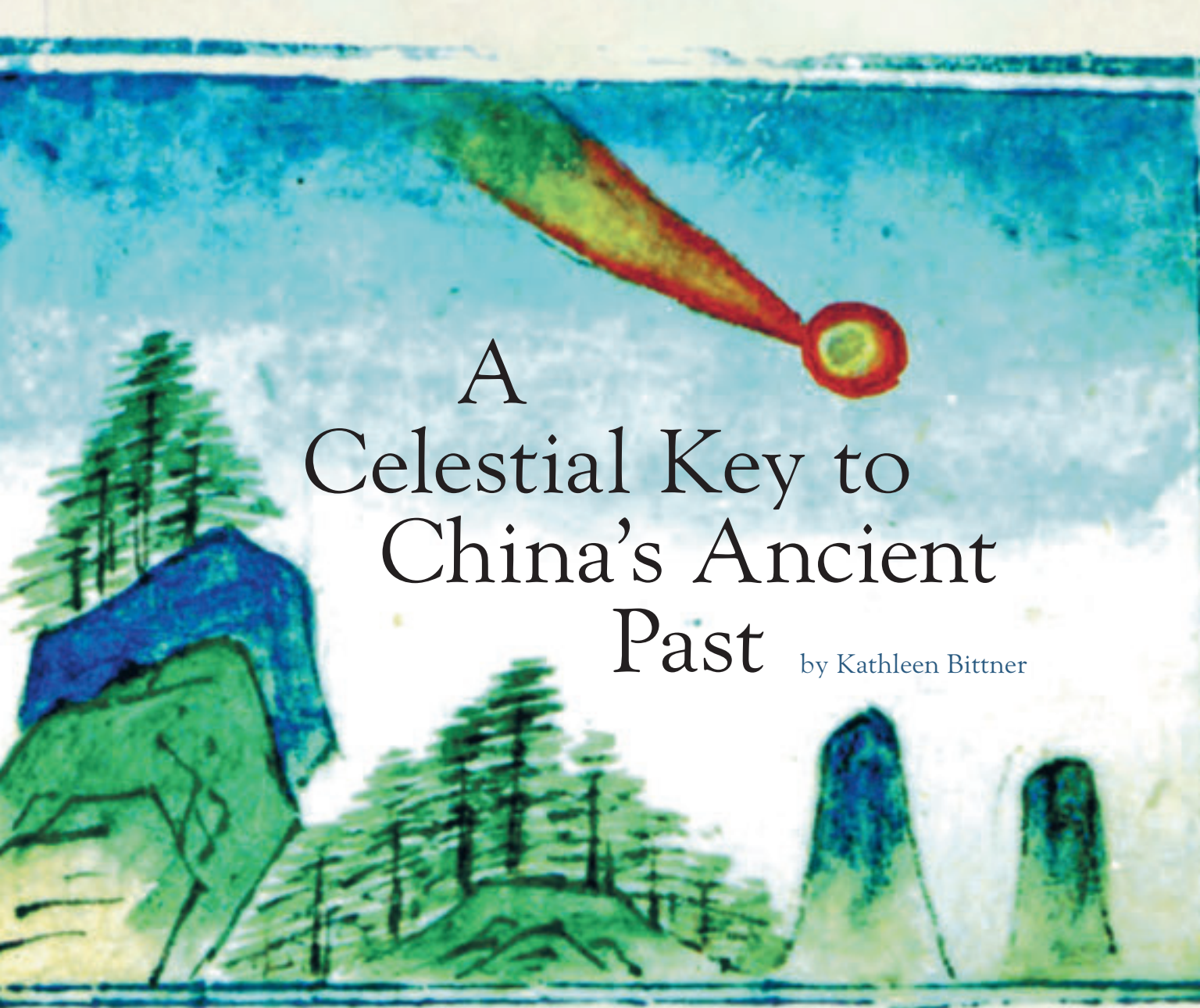
“The critical question is not what happens when you make it or how much fun it is when you use it; the critical question is sustainability and what happens after we use it,” says Boothe, who adds that sustainability issues are critical in training new generations of designers.

Jones agrees that designers no longer simply look at products, but more closely examine their long-term effects. Graphic designers are more carefully weighing the choice of paper, the selection of ink, and the life cycle of a product when they conceive new work.

“Good designers are becoming conscious and aware of things. They are identifying problems and taking on a higher social role in solving problems rather than being market driven,” says Jones. “We live in a time when we have to consume less. For designers, this takes understanding of social needs and empathy.” ●



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# A Celestial Key to China's Ancient Past

by Kathleen Bittner

*Every night, millions of stars illuminate the celestial sea above Earth's atmosphere. These burning beacons, light years away, hold the keys to a culture's past. The Chinese, the keepers of the most complete and accurate astronomical observations in the world, based many of their decisions on what the heavens above mandated during their early dynasties.*

David Pankenier, a professor of Chinese in the department of modern languages and literature, has studied how the Chinese understood the sky and how early astrology manifested itself in different cultures. Recently, Pankenier completed his second book of translations, revolutionizing the history of astronomical observations by translating ancient Chinese, Japanese and Korean astronomical records

from original Chinese into English. Dating back several thousand years, these records of eclipses, comets, auroras, meteor showers and the like could only be comprehended by researchers who could read and interpret them properly.

In collaboration with Zhentao Xu, an astronomer with Purple Mountain Observatory in Nanjing, China, and Yaotiao Jiang,

professor of astrophysics at Nanjing University, Pankenier is responsible for translating and editing 2,500 years' worth of scattered year-by-year Chinese records. "For Western historians and astronomers to interpret the terminology—names of constellations, movements, descriptions of size, appearance and color—required a certain degree of technical expertise," he says.

Pankenier, who began his career at Lehigh in 1986 as its first professor of Chinese language, is also known for his extensive research on the roles astronomy and astrology played in ancient Chinese culture. His research dates back 4,000 years—to the earliest Chinese dynasties.

It took a decade to complete the two-volume *Archaeoastronomy in East Asia*, and geographic distance forced much of Pankenier's and

ILLUSTRATION COURTESY OF DAVID PANKENIER



his astronomer colleagues' collaboration to be completed via the Internet. "Because of these translations, astronomers can now identify orbits of comets and meteor showers to help compute their future trajectories," Pankenier states. "NASA is very interested in these historical records and what impact they may have on the future of Earth."

Pankenier's assemblage of ancient Chinese astronomical translations surpasses other collections in comprehensiveness not only because of the vast span of time it covers, but also because the thousands of original records in Classical Chinese are provided for every observational record translated. It serves as a way for Chinese speakers and those who understand English to be able to collect the same information.

Pankenier's research in Sinology began 40 years ago as a graduate student at the University of Stockholm, Sweden, where he studied Chinese full time for four years before traveling to Taiwan to study privately. Living in Taipei, he studied classical Chinese under Aisin Gioro Yu-yun, a cousin of China's last emperor, Pu Yi. "By the time I got to Taiwan, I could speak, read and write—but I needed full immersion to become fluent," says Pankenier. "I found that writing the Chinese characters was the hardest part to master, as do my students here at Lehigh."

Returning to the U.S. as a graduate student at Stanford University, Pankenier determined that some of the earliest Chinese historical records—dating back to 2000 B.C.—had not been properly understood or dated precisely. As he began looking at questions of early chronology, he made a number of important discoveries, including identifying celestial phenomena, especially planetary events, which corresponded with specific dynasties.

"The Chinese attached a great deal of significance to when the five visible planets—Saturn, Venus, Mercury, Mars and Jupiter—met together in the sky," says Pankenier. "With the help of the historical records and by computing when this actually happened, I was able to date some of the earliest dynasties.

Because of the importance of these astronomical events to the Chinese culture, I began to look more in depth, and research how belief in celestial intervention in terrestrial affairs progressed and manifested itself over time."

"Events in the sky had serious implications for what was happening on the ground and played a crucial part in decision making at the highest levels," Pankenier says. "For early Chinese rulers, observing the heavens and communicating the passage of time to the people were divine obligations, which accounts for a preoccupation with astronomy, astrology and calendrical science throughout Chinese history and explains why the ability to predict celestial events came to be seen as a barometer of a dynasty's legitimacy."

Through signs in the sky, the Chinese believed, the supreme ruler above would show

"Heavenly signs were believed to signal the bestowal of legitimacy on a worthy person who had demonstrated his capacity for benign leadership and a proper respect for divine intentions."

approval or disapproval of the dynasty in power. Rulers who came into power at least as early as the Zhou dynasty in the mid-11th century B.C. were believed to be divinely "mandated" by the heavens above.

Throughout the reign of a dynasty, astrological omens and natural disasters could determine whether they remained in power, or whether their time was up and a new ruler would be selected. "Heavenly signs were believed to signal the bestowal of legitimacy on a worthy person who had demonstrated his capacity for benign leadership and a proper respect for divine intentions," notes Pankenier. "In this way, a spectacular comet or eclipse could, under the appropriate political circumstances, be both ominous for a ruling house and auspicious for would-be usurpers."

While astronomy and astrology played a pivotal role throughout the history of Chinese civilization, there were also many astronomical events in early times that may have been recorded only in imagistic language. Records of these events can be identified throughout different cultures in myths and stories passed down from generation to generation. These vital interpretations of history are important to researchers such as Pankenier. With descriptions of these events, researchers are able to compare them to historical written records and computer simulations, and trace the development of specific cultural traits and practices. Through Pankenier's research and translations, other researchers have been able to identify historical events specific to different cultures.

Working on another book, *Celestial Foundations of Chinese Civilization*, Pankenier continues to be an invaluable resource for professionals in cultural astronomy, astrophysics and the history of astronomy. Through his translations of ancient Chinese astronomical records, scientists may make use of the observations to one day find the means to predict a future asteroidal deep impact. ●



Pre-telescopic illustration of sunspots from the 1425 edition of the Ming dynasty work *Tianyuan baoli xiangyi fu*, Courtesy Nanjing Library (above). Kangxi Emperor, third emperor of the Qing Dynasty, was the longest-reigning Chinese emperor (left).

ILLUSTRATION COURTESY OF DAVID PANKENIER, (LEFT) PIERRE COLOMBEL / CORBIS



# Powering Our Future

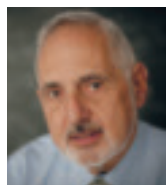
by Carolyn Sayre

Researchers are faced with many challenges in the new millennium, and undoubtedly one of the biggest is finding a cheap and efficient way to harness alternative energy. As natural resources become depleted, scientists and engineers are seeking new ways to fuel the world's power grid.

In the College of Arts and Sciences, basic and applied scientists are working to create new sources of energy while trying to understand the defects that cause existing methods to be ineffective. Designing a new application like fusion has the potential to revolutionize the way society obtains energy, while revamping sources like solar power and fuel cells will make existing models more efficient and economical.

# Fusion fix

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When it was first conceived in the 1950s, it was easy for scientists to dismiss the concept of fusion—a self-sustaining stream of energy—as a pipe dream. Fusion, which

uses magnetically confined plasma to generate unlimited amounts of energy, occurs when hydrogen atoms collide and fuse together under extreme heat and pressure. But in the last decade, a growing body of evidence is starting to show that the once fantastical idea may in fact contribute to the ultimate solution.

“In terms of developing a long-term sustainable form of energy, fusion really is the bright hope on the horizon,” says Arnold Kritz, professor of physics, who has been

Experimental Reactor (ITER), the \$10 billion international project designed to build an experimental fusion reactor, known as a tokamak, in Southern France, won’t be ready for initial tests until 2020. And even after the demo reactor is created and tested, it typically takes 15 to 25 years for any new technology to be adopted into the power grid.

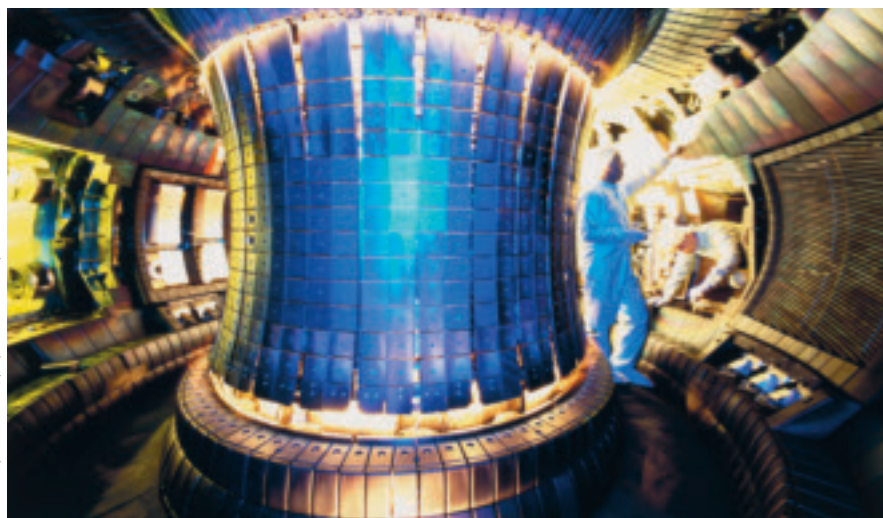
In an energy crisis, there is no time to waste on a concept that could fail. That is why Kritz has spent more than 20 years designing a predictive integrated modeling capability—that simulates the actual physical phenomena that occur inside a tokamak.

“By gaining a deeper understanding of the fundamental phenomenon that governs the behavior of these plasmas, we can simulate exactly what is going on in the tokamak in terms of atomic physics, radiation, energy transport, particle transformation and the flow of heat,” Kritz explains.

“Our simulations have shown that inputting 40 to 50 megawatts of power and outputting 400 to 500 megawatts is a reasonable expectation for the ITER tokamak,” Kritz reports.

Fusion modeling research carried out at Lehigh is essential to ITER’s success. Once the fusion reactor is built, every 400-second experiment will have an amortized cost of \$1 million. As a result, researchers need to know exactly what to expect and be ready to interpret the data.

As a leading researcher in the field, Kritz has monitored fusion research grants for the U.S. Department of Energy. He collaborates with other major fusion centers, like General Atomics in San Diego, the Princeton Plasma Physics Laboratory, and MIT’s Plasma Science and Fusion Center, to verify his results, but the predictive integrative model is unique to Lehigh. Recently, his team was also called upon by the U.S. Department of Energy to work on a hybrid application of fusion research that combines it with fission capabilities, which involve splitting atoms to produce a self-sustaining stream of energy. It is possible that a fusion-fission hybrid may result in fusion contributing to energy production in the next 10 or 15 years.



PETER GUNTER / SCIENCE FACTION, (LEFT) UENTER KOSSENOMCHY / CORBIS

*A vacuum vessel where the plasma used in fusion reactions is created.*

studying fusion for 40 years. “The debate surrounding the concept of fusion isn’t a scientific one—we know that fusion works. The question is whether it can produce energy on a large scale at an economic cost that society can sustain.”

Unfortunately, it is also a question that may take several decades to answer with any certainty. The International Thermonuclear

Tokamaks use magnetic fields to control the location of electrically charged particles, causing the particles to undergo fusion rather than lose their energy to the wall. So far, scientists have proven that fusion is possible by generating 16 megawatts of fusion power in a tokamak in England, but in order for fusion to be self-sustaining, these tokamaks need to generate power without input power from the grid. Kritz and colleagues in the Lehigh Fusion Group have been able to show these conditions are possible using the predictive integrated modeling computer codes.

# Energy economics



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Fusion research, while bright, will take at least another 70 years to develop. Therefore, in addition to creating new sources of energy, researchers must also

maximize the potential of existing forms of alternative energy. At Lehigh, scientists are studying ways to make renewable sources of energy, like solar, more efficient. Solar cells are relatively easy to make, but high price tags have kept them from receiving widespread adoption.

That is where Michael Stavola, professor of physics and associate dean for research and graduate programs, comes in. His laboratory seeks to understand one of the most basic material problems in engineering: making cheap materials function well.



“We have to find a way to make solar cells cheap enough to compete with burning oil or coal, without sacrificing their ability to generate electricity.”—*Michael Stavola*

“Solar energy is a perfect source of energy,” says Stavola. “There are no carbon emissions, pollution or radioactive wastes. The only issue is cost. We have to find a way to make solar cells cheap enough to compete with burning oil or coal, without sacrificing their ability to generate electricity.”

Silicon, the second most plentiful element in the earth’s crust, is used in more than 90 percent of solar cells for power modules. Its most perfect form, single-crystal silicon—which is used in microchips—can be used

nearly 25 years, he and his students have been working to understand the chemistry and physics of the defects that exist in semiconductors. In particular, his team has been studying the role hydrogen plays and its ability to neutralize undesirable defects and impurities.

Adding hydrogen makes solar cells produced from inexpensive, defective silicon materials more efficient. “Hydrogen acts as a Band-Aid of sorts,” Stavola explains. “You get your energy at a reduced price.”

It’s a simple problem, but with a not-so-simple solution. Stavola says it is impossible to make these defects go away entirely. Instead, engineers have learned to live with them. For

production of industrial solar cells that we do not understand.

“After 25 years of fundamental research on hydrogen in semiconductors, we can now apply what we have learned to problems that will help industry create better solar cells.”

## Fundamental thinking



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Fundamental scientists test and troubleshoot the basic principles and ideas that are someday, hopefully, put into application by engineers. Another researcher going back to

the basics is David Moore, assistant professor of chemistry. As a nanoscientist, he manipulates chemical structures on the atomic level. Though still in its adolescence, his research aims to provide the basic understanding that is needed to improve existing alternative energy applications.

“Nanoparticle catalysts have shown great promise in alternative energy applications, but in many cases, that potential has not been realized due to practical difficulties,” he explains. “The exploration of the fundamental science of nanoparticle catalysts provides vital information to scientists and engineers working to develop and improve alternative energy technologies such as hydrogen fuel cells.”

In the lab, Moore studies the interaction between molecules and nanoparticle catalysts, which are used to speed up chemical reactions in fuel cells and show great promise for future alternative energy applications. The problem, however, is that scientists do not always understand the fundamental chemical mechanisms underlying the practical applications. That is why Moore is taking a step back and trying to understand the basic science behind how these nanoparticle catalysts effect chemical changes in reactant molecules. Such low-level interactions between molecules and nanoparticles are studied routinely using computational chemistry, but Moore’s research represents the first direct experimental observation of these processes. “The computational results



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to manufacture solar cells with high efficiencies but is too expensive for widespread use. To keep costs down, manufacturers use a cheaper, less pure form of silicon called multicrystalline silicon. But as a result, these solar cells are less efficient and generate less electricity.

“It is a fairly common problem,” he says. “Lower the quality and cost of the materials and the number of defects increases.”

*Michael Stavola shows a block of multicrystalline silicon, used by engineers to make solar cells.*

“Engineers have learned to make solar cells from multicrystalline silicon, but scientists do not understand the basic chemistry of the impurities that exist in them. There is an entire layer of fundamental science associated with the effect of hydrogen on the



can be extraordinarily useful, but we must be sure that they truly reflect the experimental reality of the system,” says Moore.

Moore’s approach is to trap nanoparticles and reactant molecules in an ultracold environment, in order to study how the nanocatalysts speed up important chemical reactions. His initial experiments aim to elucidate catalytic oxidation of carbon monoxide on gold nanoparticles. Carbon monoxide is a potent poison for the platinum nanocatalysts used in electrochemical hydrogen fuel cells, and thus must be eliminated from hydrogen fuel streams.

“Catalysis is all about improving the speed and efficiency of chemical reactions,” says Moore. “Carbon monoxide oxidation is ordinarily a very slow process, but these gold nanocatalysts speed it up quite dramatically. The problem is that no one knows precisely how they do it.

“Not knowing the mechanism might not be such a big deal if the gold nanocatalysts worked perfectly,” he explains, “but unfortunately that’s not the case. While their initial activity may be very high, it falls off too quickly for practical use.”

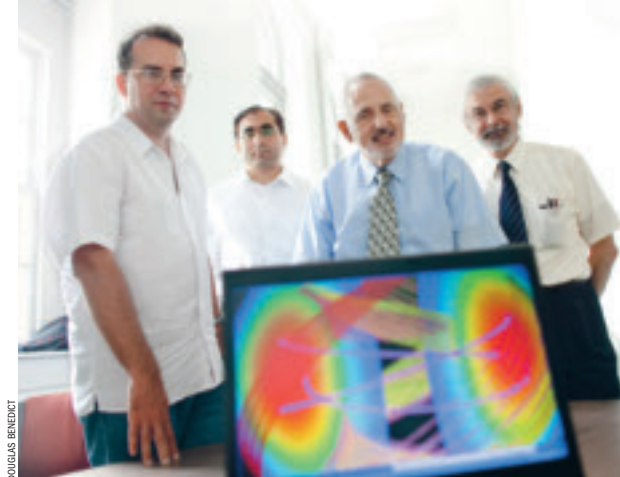


*A hydrogen fuel cell bus in operation in Australia. Hydrogen fuel cells, like solar cells, are based on catalysis.*

Moore hopes that gaining a deeper understanding of the catalytic mechanisms involved will help speed development of improved catalysts. “Once we have a handle on the basic science, we can use our technique to compare and contrast different nanocatalyst materials, to identify those that exhibit similar catalytic properties.” A particular focus is to find alternatives to the use of precious metals, to lower costs and enhance sustainability of these technologies.

Moore’s long-term goal is to use his experimental techniques to bring to light details of the chemistry underlying many different alternative energy applications.

“Hydrogen fuel cells, efficient batteries, solar cells, artificial photosynthesis—all of these technologies are based on catalysis, and there are nanoparticle-based approaches to all of them, yet in no case is the fundamental chemistry completely understood,” says Moore. “If we can help gain this understanding, it should speed development of these vital new technologies.” ●



*The Fusion Research Group includes Alexi Pankin, Tariq Rafiq, Arnold Kritz and Glenn Bateman.*

## The Fusion Research Group

When addressing the significant questions concerning the role nuclear fusion plays in meeting our energy needs, many researchers in the international fusion community turn to the expertise found in Lehigh’s Fusion Research Group. The group is renowned for developing and applying computer codes to predict the evolution of hot magnetically confined plasmas and for research on the control of these plasmas in which fusion reactions occur.

Members of the group include physics professor Arnold Kritz, senior research scientist Glenn Bateman, research scientist Alexi Pankin and research associate Tariq Rafiq. They are each recognized for their significant contributions to fusion science, and they work closely with scientists at the major national and international fusion laboratories. The Lehigh group plays a leading role in using computer simulations that are validated against experimental data. These simulations test and improve theoretical models and are then used to predict and optimize the expected performance of environmentally friendly fusion experiments such as the International Thermonuclear Experimental Reactor (ITER), the international fusion device that is currently under construction. It is expected that the ITER device will produce 10 times as much fusion power as input heating power. Accurate predictions of future experiments are as valuable as careful experimental observations. Members of the group affect the international collaborations that will create the discoveries needed to advance nuclear fusion.

“Predictive modeling helps to avoid costly design mistakes and facilitates the optimization of experimental scenarios in order to make the most effective use of expensive experiments,” says Kritz. “Since each experiment in ITER is expected to cost about a million dollars, there is a compelling need for a reliable simulation capability.”







*In Brazzaville, Republic of the Congo, where fuel is costly and labor abundant, even large orders of goods are transported by hand. The city's hand-truck workers are mostly immigrants from West Africa and from neighboring Kinshasa.*

by Tricia Long

# human export

Migrants become flexible labor supplies in a globalized economy



GETTY IMAGES

When Bruce Whitehouse, assistant professor of anthropology, first began his research as an anthropologist, he landed in a small community in the West African nation of Mali. Mali is among the world's 10 poorest nations, and Whitehouse's host community

reflected the country's hardship.

The community, Togotala (a pseudonym), is bordered by desert and plagued with persistent drought and harsh dry seasons. Farming is the primary means to earn a living, and yet families only have enough money to grow six months' worth of food for the entire year.

As a result, these less-than-ideal living conditions have forced a growing number of Togotala residents to turn to a different export in order to survive—namely, themselves or other family members.

Transnational migrants, including those of Togotala, make up about three percent of the world's population. For many, relocation is a means to offset harsh economic realities. This number, while remaining relatively stable over time, is not perfect. Data are more available for Latin American and South Asian countries than for Africa, where reliable statistics are scarcely kept, even by governments.

"Migrants are flexible labor supplies in an increasingly globalized economy, and their movements are clearly tied to economic patterns,"

PHOTOGRAPH COURTESY OF BRUCE WHITEHOUSE





DIANE GORD AND LEN JENSEN / GETTY IMAGES



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says Matthew Sanderson, assistant professor of sociology and a participating faculty member in Lehigh's Globalization and Social Change Initiative (GSCI). "In developed countries, there's a pull on migrants during economic expansions and a push on them during economic contractions. And that's not unique to this particular time period, but a recurring pattern of how the economic context works."

One reason migrants seek employment is to send money back to the families and communities they've left behind—a practice similar to the one used by early European migrants seeking work in the United States. According to Sanderson, who studies economic migrants and labor movements, around \$200 to \$220 billion was sent back to less-developed countries last year through remittances, but there's evidence that half to 60 percent of the actual total goes unrecorded.

"Migrants see this as a lifeline for their community," says Whitehouse, a participating faculty member in the GSCI, who began anthropological fieldwork in Togotola in 2002.

In Mexico, for example, remittances are the second-largest source of foreign exchange behind oil. Elsewhere, in several countries, remittances make up 30 to 40 percent of the gross domestic product, notes Sanderson.

"Remittances are turning into a development strategy," he adds. "Some countries are reliant on sending people abroad to send money back. This is the state of development in 2009. Social scientists are working to provide empirical evidence on the question of whether remittances promote or undermine development. But the larger normative question is: Should migrants be responsible for bearing the development responsibilities of their country?"

Whitehouse speculates how serious investment in a Malian community could impact migration patterns. "People invest fortunes in trying to cross into other countries," he says. "It's amazing what would happen to development if all that money was pooled."

In the meantime, remittances remain an important economic tool for households in Togotola, nearly all of which have at least one family member working elsewhere in order to support family back home, Whitehouse adds.

### High risk, high cost

What may be surprising is where these Malian migrants seek to relocate. While a few are able to find employment opportunities in growing economies throughout Europe, the United States, Thailand or China, a large percentage migrate to several popular African destinations, places such as Brazzaville in the Republic of the Congo.

At first glance, Brazzaville appears an unlikely host city. In 2003, a survey ranked Brazzaville the worst city to live in the world. Yet between 20,000 and 30,000 Malian migrants and around 100,000 Congo-Kinshasa migrants swell Brazzaville's multi-ethnic, multinational population. Enticed by the promises of a commercial sector, migrants have built a sizable niche in this capital city.

"Migrants would rather be in Europe or the United States, but find Congo profitable and easier to access," adds Whitehouse.

The flux of Malians into Brazzaville to pursue commerce is not necessarily atypical of transnational migration. While most tend to think of migration as people leaving less-developed countries in search of employment in developed nations, migration experts say that's not always the case.

**"In developed countries, there's a pull on migrants during economic expansions and a push on them during economic contractions." —Matthew Sanderson**

"The popular discourse in developed countries centers on immigrants from underdeveloped countries entering in a 'flood tide,' but the most recent figures indicate that actually about half of all those leaving underdeveloped countries end up in other underdeveloped countries," says Sanderson. "Most of the time, these migrants end up nearby in a neighboring country, because the costs of moving are much lower."



PHOTOGRAPHS COURTESY OF BRUCE WHITEHOUSE

(Left to right) A view of Tijuana from the U.S.-Mexican border between Otay Mesa and San Ysidro, California; many migrants send money, known as remittances, back to their families; mattresses are moved by hand truck from the factory in Brazzaville's industrial zone to the Poto-Poto market; a man waters a dry-season garden plot, west of Siribala in Mali.

Sanderson says the high risk and the high cost associated with re-location limit which population is able to migrate where. As a result, many migrants rely heavily on social networks constructed by previous migrants. Middle-income, upwardly mobile migrants with greater resources lay the initial foundation for future—and often poorer and less-skilled—populations to make the move.

“Empirical social science research clearly shows that social networks are a very powerful explanation of why people move and where they move to,” says Sanderson. “Once migration gets started, it has an internal momentum to it known as chain migration, or the friends-and-family effect. Earlier migrants establish links to the local labor market and social support entities that subsequent migrants can use. Once someone is able to become established in the destination country, then the costs and risks of movement are vastly decreased for future movers.”

Migratory flows in nations such as Mali are not unusual and are intertwined to a community’s social and economic structures. As members of migrant-sending communities, many in Mali have devised social networks to help keep themselves closely tied to family, native culture and religion, even as they live much of their lives abroad.

These issues are central to Whitehouse’s work as an anthropologist. He looks closely at what defines a community, how people experience community and how they build it.

Many of the migrants seek to shield themselves from the cultural and religious influences of their host communities. Nearly two-thirds of migrant parents in Brazzaville sent their children home to be raised by extended family members, sacrificing parental rights and privileges in order to help sustain their family.

“In Mali, there’s a strong shared ethos that if you’re not looking after the old or your parents, it puts a stigma on you,” says Whitehouse, who believes these migrants’ interpretations of Islamic values reinforce that ethos within their community.

## Environmental threats

While communities like Togotala demonstrate how migration is ingrained into a community and a nation’s development strategy, some nations are less equipped at handling large out- or inflows of migrants and, as a result, could face dire consequences.

One threat could seriously test these communities and their ability to adapt to abrupt change and significant migrant populations. Climate change has proven a major catalyst for migration, and has piqued the interest and concern of organizations and governments around the globe.

Global environmental conditions such as sea-level rise, intense droughts, glacial melt, extreme heat events and intense regional cooling may unexpectedly force migration, and researchers such as Chad Briggs, associate professor of international relations, say this is something we need to prepare for.

We don’t have to search back far or turn to CNN footage from a far-off land to find an example of migration attributed to environmental change. In 2005, Hurricane Katrina displaced thousands of Gulf Coast residents who fled their homes and community. Cities like Baton Rouge, Louisiana, doubled overnight. In nearby Texas, Houston and Dallas struggled with population increases. Some Gulf Coast residents simply went missing.

Briggs says that while many people may not classify Katrina as environmental migration, political scientists abroad most certainly do. In fact, Katrina is one of the most compelling examples of why further research on climate change and security issues is necessary.

“Legally speaking, the definition of a refugee is someone who left for political reasons,” says Briggs, who studies environmental health risks and vulnerabilities in postconflict regions. “There’s no protection for people who leave for environmental reasons.”

Briggs, who is also a fellow at the Institute for Environmental Security in The Hague in the Netherlands, says that while human environmental





JASON REED / REUTERS / CORBIS

*New Orleans residents rescued by police boats walk away from the floodwaters after Hurricane Katrina.*

pacts will be abrupt, giving relatively little time or warning for adaptive behavior,” says Briggs, who adds that these events would not likely force migration for populations that have adaptation measures, but may impact more vulnerable populations.

Briggs says it will be vital to impress upon lawmakers how these abrupt climate changes could be catastrophic in terms of refugee flows. The military, he says, is not equipped to handle such challenges.

“We need to recognize this ahead of time so that we have the proper mitigation policies for things like climate,” says Briggs. “Or if things are going to happen, then increase the resiliency of these communities to adapt to climate changes when they occur.”

One scenario that could play out after an environmental migration is the flight of wealth and investment, which could destroy any future development in the vacated region.

The resiliency of communities is a concern across the spectrum of those who observe and research migration. Sanderson agrees that persistent outflows drain human capital, creating a “brain drain” effect.

“Persistent outflows of people likely inhibit development in underdeveloped countries. These outflows are essentially siphoning off the very people that could help promote innovation and rising living standards in these countries. This is particularly the case early on in the immigration stream, when the best and brightest are leaving, but this process can be prolonged for decades,” says Sanderson. “Underdeveloped countries invest a portion of their scarce resources into educating and training their citizens. But if these people leave, it is the destination countries that reap many of the benefits from these investments.” ●

## Initiative Helps Students Develop Global Competency

Matt Sanderson and Bruce Whitehouse joined Lehigh’s sociology and anthropology department in 2008, but also came to Lehigh University to take part in a new, yet rapidly growing program that helps students broaden their understanding of an increasingly globalized world.

Created in 2006, the Globalization and Social Change Initiative (GSCI) brings together teaching, research and service on the historical, social, cultural, economic and political changes brought about by globalization.

Participating faculty from the College of Arts and Sciences reflect Lehigh’s commitment to interdisciplinary teaching and research. Faculty from the departments of political science, history, journalism and communication, international relations, religion studies, and modern languages and literature lend their expertise and research related to complex global themes such as global communication, culture and identity, and politics and social structures.

“The research done by GSCI faculty shows the powerful ability of interdisciplinary initiatives to offer depth and breadth to important global issues,” says Jack Lule, director of the GSCI and professor of journalism and communication. “You



have the depth provided by expert scholars who have spent years, sometimes decades, examining subjects in their fields. But you also have the breadth and synergy provided by bringing to-

gether scholars from close to a dozen disciplines involved in the study of global problems.”

GSCI faculty member John Jirik, assistant professor of journalism and communication, examines how power operates in and through the media. His most recent work draws on a case study of a Beijing newsroom at China’s national TV network. Elsewhere in the program, Robert Rozehnal, associate professor of religion studies, researches the history and practice of Sufism in South Asia. Together with other members of the initiative, faculty like Sanderson, Whitehouse, Jirik and Rozehnal are working together to help students develop a core global competency that will help them succeed in today’s dynamic world.

“Lehigh is the perfect size for this kind of interdisciplinary work,” says Lule. “It’s big enough to provide resources and support for internationally known scholars. It’s small enough that those scholars can come together and sit around a large conference table.”



## Theory Into Practice: Learning, Doing and Knowing

**by Augustine Ripa,  
associate dean for  
undergraduate studies  
and professor of theatre**

Creative and original research and scholarship are essential to the experience called knowing. Lehigh undergraduates experience this creation of knowledge directly.

I recall how once, when I was a graduate student, our beloved Professor Scott put down his note cards and looked across the table seriously at the seven graduate

students in our comparative drama seminar. Erudite and wise beyond our ability to comprehend, he read Euripides in ancient Greek, Chekhov in Russian, and Molière in French. He relished ancient puns and rhyme schemes and taught us to understand drama on the page.

But that day, he ruefully admitted that we know things about drama that he would never know—because we stage it. We put the play on its feet, make the words flesh, and by that palpable experience of original creation we advance an art the page can neither contain nor explain. Although it was hard for us to imagine, Professor Scott seemed to envy our way of knowing.

Today, when I'm not the associate dean for undergraduate studies, I am a professor of theatre specializing in drama analysis and performance. Keenly aware that I need to impart a good deal of theory and critical analysis to my students, I am also aware that nothing deepens, clarifies and tests dramatic theory better than the direct experience of making theatre—acting, directing, designing and writing. I and my colleagues strive to engage all students in the active process of undergraduate research for the theatre—making plays—throughout the curriculum and especially in our theatre laboratories in the Zoellner Arts Center.

Undergraduate research and scholarship are hallmarks of a thriving and complete collegiate experience. In the College of Arts and Sciences, all undergraduates have the opportunity to engage in direct research and scholarship under the supervision of and sometimes in partnership with their major professors. Students in the sciences routinely are engaged in the laboratories of chemists, physicists, astronomers, biologists and environmental scientists. They also undertake independent research projects of an advanced nature as their education matures. Undergraduates in mathematics

work with Lehigh faculty on problems no one has solved, even returning in the summer months for uninterrupted focus. Students in social sciences like journalism, political science, psychology, international relations, history, sociology and anthropology engage in research and scholarly explorations of issues of policy, globalization, communication, justice, cultures, society and human nature. They present their papers at conferences and colloquia and contribute original knowledge to the world. Students in the arts and humanities do philosophy, research in religion studies, English, international languages and literature, also presenting at colloquia and conferences. Some paint, sculpt, design, perform and create original works of literary art—poetry, fiction and plays.

Turning theory into practice in order to know and to advance knowledge has a long and venerable tradition at Lehigh. But unlike those in the distant past, undergraduates today are doing creative research in more and more subject areas, and often across disciplinary boundaries. Whether the research is part of the expected outcome of a special program or the expectation of a faculty mentor, all Lehigh students benefit from the research they are asked to do as part of their total undergraduate experience.

Knowing by doing is a time-honored route to the deepest insights and discoveries. Learning the theoretical basics to enable the highest quality research and scholarship is the bedrock of excellent research, and that is one noble goal of the classroom. But beyond the traditional classroom—in the lab, in the field, in the library, in the studio, in rehearsal, on the web, working the equation or composing at the keyboard—the magic of turning theory into the practice of research and scholarship is an experience of the highest order for undergraduates, and we value and foster that in the College of Arts and Sciences.



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**“Legally speaking, the definition  
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for environmental reasons.”**

*see page 20*

