Exploring genetics leads to big ideas

Kitty MacPherson

As a light rain swept across campus one October evening, 15 freshmen were tucked around a seminar table immersed in a discussion about nature in another form.

With their eyes riveted on their instructor, Princeton president and molecular biology professor Shirley M. Tilghman, they grappled with one of the deepest questions in the natural world: What is at the root of the intricate process that makes us all so different?

In her freshman seminar titled “How the Tabby Cat Got Her Stripes or The Silence of the Genes,” Tilghman, one of the world’s foremost authorities on genetics, is introducing the students to a newer aspect of her subject known as epigenetics. The topic is vast, touching upon any factor not already predetermined in specific genes that affects the behavior of a living being’s collection of chromosomes. Influences as simple as the parent from which the gene was inherited, the chromosomal neighborhood in which a gene resides and even chance, scientists are learning, influence whether the gene will be expressed. Epi-

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Princeton engineers develop sensor derived from frogs to help fight bacteria, save wildlife

Chris Emery

Princeton engineers have developed a sensor that may revolutionize how drugs and medical devices are tested for contamination, and in the process also help ensure the survival of two species of threatened animals.

To be fair, some of the credit goes to an African frog.

In the wild, the African clawed frog produces antibacterial peptides — small chains of amino acids — on its skin to protect it from infection. Princeton researchers have found a way to attach these peptides, which can be synthesized in the laboratory, to a small electronic chip that emits an electrical signal when exposed to harmful bacteria, including pathogenic E. coli and salmonella.

“It’s a robust, simple platform,” said Michael McAlpine, an assistant professor of mechanical and aerospace engineering and the lead researcher on the project. “We think these chips could replace the current method of testing medical devices and drugs.”

McAlpine collaborated on the project with Manu Mannoor, a graduate student who works in his laboratory; James Link, an assistant professor of chemical and biological engineering; and Siyan Zhang, a graduate student who works with Link.

A paper outlining the project was published online Oct. 18 in the Proceedings of the National Academy of Science. The research was funded by the American Asthma Foundation, the Air Force Office of Scientific Research and the National Science Foundation.

The current testing method has a major drawback: It relies on the blood of the horseshoe crab, a species that is roughly 450 million years old. The horseshoe crab population has declined in recent years, and as a result, so too has the population of a bird that feasts on the crab.

The crab became desirable for testing because its immune system has evolved to cope with the constant threat of invasion from its bacteria-rich environment. Its blood contains antimicrobial cells, known as amebocytes, that defend the crab against bacteria — similar to the way the peptides protect the African frog’s skin.

For almost 40 years, an aqueous extract made from horseshoe crab blood cells, called Limulus amebocyte lysate (LAL), has been used for testing drugs and medical devices for contamination.

In the era before the use of these animal extracts for testing, although drugs and medical devices were sterilized, they would sometimes cause patients to develop fevers due to an immune reaction to endotoxins, which are remnants of bacteria destroyed by the sterilization process. When a sample from a drug or device is added to LAL and the solution hardens into a gel, it indicates the sample is contaminated and not safe for human use.

Potential to save animal populations

To produce LAL, the crabs are captured and roughly 30 percent of their blood drained before they are returned to the ocean. There is disagreement on how many crabs die as a result of the procedure, but their estimated mortality rate can be as high as 30 percent, according to the United States Geological Survey.

A conservative estimate puts the number of horseshoe crabs on the Atlantic Coast between New Jersey and Virginia at between 2.3 to 4.5 million, according to the Ecological Research and Development Group. In recent years, the populations of the horseshoe crab and shore birds that rely on them for food both have been in decline, with the red knot, a rust-colored species of shore bird, of particular concern.

Each spring the bird migrates 20,000 miles from the islands of Tierra del Fuego, off the southern tip of South America, to the Delaware Bay on the east coast of the United States. From April to May, the bird feasts on horseshoe crab eggs found on beaches, nearly doubling its body weight to sustain its health for the long flight south. Studies have discovered a precipitous decline in the red knot population. One study by researchers at the University of Toronto found that the Tierra del Fuego population of red nesters has declined by 85 percent in recent years.

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What’s inside?

- Board approves five faculty appointments
- Endowment earns 14.7 percent return
- Holiday outreach initiatives planned
- Trends in U.S. unemployment

Perspective on:
Five new faculty members appointed

The Board of Trustees has approved the appointments of three new full professors and two assistant professors.

The full professors are: Marc Fleurbaey in the Woodrow Wilson School of Public and International Affairs and the University Center for Human Values, effective Sept. 1, 2011; Alison Ienberg in history, effective Sept. 1, 2010; and Richard Rogerson in economics and public affairs, effective Feb. 1, 2011.

The assistant professors, both appointed for three-year terms, are: Nathan Arrington in art and archaeology, effective July 1, 2010; and Andrew Shepard in economics, effective Sept. 1, 2010.

Fleurbaey has been appointed the Laurance S. Rockefeller Professor of Public Affairs and the University Center for Human Values, effective July 1, 2010, and Chris B. Fredericks in ethics and normative economics. He is the author of "Fairness, Responsibility and Welfare." Fredericks will join the Princeton faculty from University of Paris Deschate, where he has been a research professor of the Centre National de la Recherche Scientifique since 2005. Previously, he was a professor at University of Toulouse, where he was a professor of the Centre National de la Recherche Scientifique. Fredericks holds a master’s degree from the University of Toulouse and a Ph.D. from the University of Pennsylvania. Ienberg is the author of "Cost to Women: A History of the Place and the People Who Made It," which received numerous awards including the Ellis Hawley Prize from the Organization of American Historians. She currently is working on two books: "Historical Cities: Antiques, Inheritance and Preservation From the Civil War to the Modern," and "Urban Design Unclotted: Collaborative Landscapes and the Modernist Turn Toward Preservation in the 1950-1970s." Rogerson is a macroeconomist who is particularly interested in labor markets. He has published dozens of articles in major journals — including the American Economic Review, the Journal of Political Economy and the Review of Economic Studies — on topics such as business cycle fluctuations, the effects of labor market regulations, and financing of public education and development.

Board approves five promotions

The Board of Trustees has approved the promotions of five faculty members, all effective July 1, 2010. The faculty members and their departments, by the academic rank to which they are being promoted, are:

Professor — Daphne Brooks, English and American Studies; Usha Dhanvij, philosophy; Michael Laffer, history; and Christopher Tully, physics. Associate professor — Jason Fleischer, history, all effective July 1, 2010.

By the numbers

The Sept. 20 issue of the Bulletin presented a look at Princeton’s incoming undergraduates and graduate students based on figures for the pre-registration period. The following are updated figures based on official opening enrollment data issued by the Office of the Registrar.

The PRINCETON CLASS OF 2014

Number of students — 1,137

Percent on financial aid — 61

Number of applications — 21,847 (record)

Percent admitted — 8.8 (record)

Percent men — 50

Percent women — 50

Number of states represented — 49

Number of countries represented — 61

Students of color — 21

Percent international students — 13.7

Percent students by color — 18.6

Percent men — 57.4

Percent women — 42.6

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Percent students by color — 18.6

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Fall 2010 new graduate students

Number pursuing doctoral degrees — 472

Number seeking master’s degrees — 153

Number of visiting and exchange students — 29

Number of applications — 11,124

Percent admitted — 11

Percent men — 62

Percent women — 38

Percent international students — 39

Percent students by color — 12

Percent in humanities — 16

Percent in natural sciences — 26

Percent in School of Architecture — 5

Percent in School of Engineering and Applied Science — 21

Percent in social sciences — 19

Percent in Woodrow Wilson School of Public and International Affairs — 14

Total graduate enrollment — 2,582

Employee retirements

Effective Oct. 1: in history, professional specialist Lin Ferrand, after 11 years; in the plasma physics lab, senior engineer Lela Raheem, after 20 years; in public safety, head security guard Lewis Randerson, after 24 years.

Effective July 1, 2010: in public and international affairs, to accept a position at Hebrew University; in the history; and physics departments, by the academic rank to which they are being promoted, are:

Professor — Dr. Isenberg, a scholar of American urban history, had been a professor at Rutgers University since 2001. She previously taught at the University of North Carolina-Chapel Hill and Florida International University. She is a graduate of Yale University and earned a Ph.D. from the University of Pennsylvania.

She is the author of "From Town to City: A History of the Place and the People Who Made It," which received awards including the Ellis Hawley Prize from the Organization of American Historians. She currently is working on two books: "Second-Hand Cities: Antiques, Inheritance and Preservation From the Civil War to the Modern," and "Urban Design Unclotted: Collaborative Landscapes and the Modernist Turn Toward Preservation in the 1950-1970s."

Rogerson is a macroeconomist who is particularly interested in labor markets. He has published dozens of articles in major journals — including the American Economic Review, the Journal of Political Economy and the Review of Economic Studies — on topics such as business cycle fluctuations, the effects of labor market regulations and financing of public education and development.

Consultant to the University of Arizona State University, where he has taught since 2004. He has previously taught at the University of Pennsylvania, the University of Minnesota, Stanford University, New York University and the University of Rochester. A graduate of the University of Alberta, he holds a Ph.D. from the University of Minnesota.

Fleischer is the author of "How the Towns: A History of the Place and the People Who Made It," which received awards including the Ellis Hawley Prize from the Organization of American Historians. He currently is working on two books: "Second-Hand Cities: Antiques, Inheritance and Preservation From the Civil War to the Modern," and "Urban Design Unclotted: Collaborative Landscapes and the Modernist Turn Toward Preservation in the 1950-1970s."

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University endowment earns 14.7 percent annual return

Princeton’s endowment earned a 14.7 percent annual return on its investments in the fiscal year that ended June 30, 2010. The Princeton University Investment Co. (PRINCO) manages the University’s endowment.

“The strong performance of the endowment contributes significantly to the financial health of the University in what remains a difficult financial climate,” said Provost Christopher Eisgruber. “As a result of PRINCO’s excellent stewardship of the endowment, the support of the University’s alumni and friends, and the budget cuts implemented by units throughout our campus, Princeton has established a new baseline for its budget and avoided the need for additional reductions in spending.

The endowment’s performance enables us to return to within our target band of spending, but we will need to demonstrate continuing budget discipline to continue the effects of the recent financial crisis and persistent economic uncertainty.”

As of June 30, 2010, Princeton’s endowment was valued at $14.4 billion. At the end of the fiscal year, the endowment stood at $12.6 billion, following an investment return for that year of -23.5 percent. The billion, following an investment return for that year of -23.5 percent. The average annual return on the endowment over the past 10 years is 7.9 percent. This result is in the top percentile of 428 institutional Reports.

In asserting that the endowment’s positive performance for 2010 should place the University’s spending within its target band, Eisgruber explained that the University currently has a spending policy that aims for spending for 4 percent and 5.75 percent of the market value of the endowment. Last year, the spending rate was 6.04 percent, modestly above the upper level of the policy. This year’s favorable returns will reduce the spend rate to 5.1 percent.

Holiday outreach initiatives set

Members of the University community will have the opportunity to share the holiday spirit through a series of community service initiatives and special events planned for December and January.

A “Heros for Heroes” campaign will enable the campus community members to send greetings to soldiers who will be away from home with the effects of the recent financial crisis and persistent economic uncertainty.

A “Holiday A Cappella Jam and Toy Drive” featuring several student performers will be held at 6:30 p.m. Friday, Dec. 10, on the Palmer Square Green. The event is free and open to the public, and attendees are encouraged to bring new, unwrapped toys to be donated to the YWCA Princeton St. Nicholas Project.

A “Holiday Hoops” food drive will provide a $4 voucher off the price of a game-day ticket with the donation of nonperishable food items at the Princeton men’s basketball games. Proceeds from the Princeton men’s basketball team’s campaign will be held on St. Joseph’s at 5 p.m. Sunday, Dec. 5, at Jadwin Gym.

Visit the News at Princeton Web page at <www.princeton.edu/main/news> for other recent stories, including the following:

- U.S. President Barack Obama has named Princeton’s Andrew Houck and Joshua Shavitz as recipients of the Presidential Early Career Awards for Scientists and Engineers (PECASE). The awards are given to young professionals in the early stages of their independent research careers. Houck, an assistant professor of electrical engineering, and Shavitz, an assistant professor of physics and the Lewis-Sigier Institute for Integrative Geomcics, are among 85 recipients who will receive awards at a future White House ceremony.
- The U.S. Federal Trade Commission has named Edward Felten, a Princeton professor of computer science and public affairs, as the agency’s first chief technologist to help guide government policy in an era when technology has a growing influence on businesses and consumers. Felten, the founding director of Princeton’s Center for Information Technology Policy, will take a one-year leave of absence beginning in January.

Strong immunity may play a key role in determining long life, but may do so at the expense of reduced fertility, a study led by Princeton economist Andrei C. Gramm has concluded. An 11-year study of a population of wild sheep located on a remote island off the coast of Scotland that gauged the animals’ susceptibility to infection may give new insight into why some people get sicker than others when exposed to the same illness.


Christmas cheer, Nov. 2010, Princeton University

"During the economic downturn, the University reduced spending by $170 million over two years — the previous record was set in 2000 and the current 2011 year — but sustained its commitment to world-class teaching and research. Princeton also protected key programmatic initiatives, such as its generous financial aid program and family-friendly benefits for faculty, staff and students. This year, a budget of more than $169 million for Princeton’s “no-loan” program provides financial aid to roughly 60 percent of undergraduates in the form of grants that do not have to be paid back.

The University’s long-term annualized growth rate was 6.04 percent, modestly above the upper level of the policy. This year’s favorable returns will reduce the spend rate to 5.1 percent.

Research into the immunity of wild sheep to infection may yield new insights in why some people get sicker than others when exposed to the same illness.

- Princeton scientists have identified genes responsible for controlling reproductive life span in worms and found they may control genes regulating similar functions in humans. The work, led by molecular biologist Coleen Murphy, suggests that someday researchers may be able to develop ways to maintain fertility in humans, allowing women who want to delay having children to preserve that capacity and extend their reproduction, and to prevent maternal age-related birth defects.
- Princeton’s Keller Center and the International Internship Program have developed a new research and teaching collaboration and student exchange Initiative between the University and ConRift, a consortium of three universities in Germany’s Ruhr region. The program aims to expose engineering students to international approaches to technology, research and leadership, while giving them hands-on research experience in their field of study.
- After nine years of scanning the sky, the Wilkinson Microwave Anisotropy Probe space mission, known as WMAP, has concluded its observations of the cosmic microwave background, the oldest light in the universe. The spacecraft not only has given scientists their best look at this remnant glow, but also firmly established the scientific model that describes the history and structure of the universe.
- A surprising level of activity discovered in “sleepy” cells throughout the human body could be a key to good health. Fibroblasts, which are found in connective tissue such as ligaments and tendons, long have been viewed by scientists as crucial but dull, quietly performing their essential function of providing the structural framework for tissue. But now, after years of research, a team of Princeton scientists led by molecular biologist Hilary Coller has discovered that these cells are anything but quiet, and may be key to understanding why some people get sicker than others when exposed to the same illness.

- Publishing ideas in a hard-to-read typeface may make concepts harder to learn but easier to retain, according to a new study. Princeton psychologist Scott Kellogg and colleagues assessed whether changing the font of written material could improve the way people learned and remembered material.

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Though the Great Recession officially ended in June 2009, the U.S. unemployment rate has remained above 9 percent. Though the Great Recession officially ended in June 2009, the U.S. unemployment rate has remained above 9 percent. Though the Great Recession officially ended in June 2009, the U.S. unemployment rate has remained above 9 percent. Though the Great Recession officially ended in June 2009, the U.S. unemployment rate has remained above 9 percent.

I see no signs of a brisk hiring environment and the last thing to come back at the end of a recession is that this recession is so broad-based that individuals generally are holding back from spending; their savings rates are at rather high levels. As a result, firms wonder why should I hire more workers? People aren’t buying things.

In a vicious cycle, where the way to get people to buy things is to hire more workers, and the way to hire more workers is for people to buy more things, which is why we needed and probably still need a very aggressive stimulus package. We just haven’t been able to get the economy into a recovery and the labor market always lags in recessions. It’s the last thing to fall in the beginning and the last thing to come back at the end.

What is the outlook for those workers who have lost jobs during the recent recession? That outlook is not quite a bit worse than in earlier recessions. The latest data, which covers the period from November 2008 to March 2009, shows that the workers who lost jobs in this recession are much less likely to be employed than in any earlier recession than we have data on. Only about half of workers who report having lost a job between 2007 and 2009 were employed in January 2010. In any recession I have data on, and that goes back to the early 1980s, the re-employment rate never fell below 60 percent. The unemployment durations are staggeringly long, twice what they were.

More bad news is that those workers who lose full-time jobs and manage to find another job suffer larger earnings declines on average than in earlier recessions. This is largely because they are more likely than in earlier recessions to have found a part-time job rather than a full-time job.

What does your research show about trends in job security in the United States?

I would say that a decline in job security is one of the issues that has been ongoing for at least 20 years. Companies have moved toward a mode of operation where they have a smaller core of long-term employees. In earlier times, when a recession came, you tended to try to protect your core employees, and in fact you may have less of a core to protect. As a result, they engage in layoffs a bit more systematically than they did in the past. As a result, they engage in layoffs a bit more systematically than they did in the past. As a result, they engage in layoffs a bit more systematically than they did in the past.

What are some of the causes, over the long term, for declining job security?

One cause stems from around 1980, when the U.S. eliminated mandatory retirement. The government made it illegal for employers and employees to engage in a voluntary age agreement, where you’d work for a firm and leave when you were 65. The ability of work-ers to continue working past age 65 can make long-term employment relations hip less valuable to firms because they need renewal where they can hire younger workers and where workers have had a long and productive career can be phased out.

The other part of it is that the world has become more competitive. In 1960, Americans bought American-manufactured goods for the most part, and the firms that produced those goods had a protected market. Now, in a more competitive world, U.S. capital is very mobile and flows all over. In China, U.S. companies own a fair amount of productive capacity and they employ Chinese workers to build things. It’s more profitable for them. What U.S. work-ers have to offer employers is, frankly, less rare than it used to be. They are a very good force in lots of places.

How much does job security differ for various parts of the workforce?

It’s pretty dramatic. Between men and women, the trend in declining job security is most evident for men — it’s just stark. For women, that trend was offset for a long time by their increased commitment to the labor force. Forty years ago, women would routinely leave the labor force to have children and maybe come back later when their children were older. Nowadays, those absences, if any, are fairly brief. Many more women stay and don’t give up their jobs, so the trend for women is to be more stable employment than it was in the past. They have been doing this in the teeth of this storm of declining job structures that are not oriented toward long-term employment, so what we have seen for women was an increase in job security for a while, followed by some minor decreases.

There is another factor, not that declining job security is completely restricted to the private sector. If any-thing, job security is much greater in the public sector than it was 30 years ago. I find that rather remarkable, and it feeds into the current debate about the appropriate size of government.

You are teaching two courses this semester. Have your students become more interested in the labor market and economics over the last few years?

Generally, enrollments in economics are at record levels at Princeton. Our total enrollments in undergraduate economics classes this term is up 26 percent from the same time last year. Enrollments of freshmen and sopho- mores are at record levels. I think the students’ interest is genuine and has been piqued by the recession. Econom- ics is in the news every day. People want to know who’s right and what’s going on. It’s something they can relate to because they see it around them. They probably all know people who have lost their jobs. I have three children, two of whom have lost jobs in this recession. It’s something they can relate to because they see it around them. They probably all know people who have lost their jobs. It’s something they can relate to because they see it around them. They probably all know people who have lost their jobs. It’s something they can relate to because they see it around them. They probably all know people who have lost their jobs. It’s something they can relate to because they see it around them. They probably all know people who have lost their jobs. It’s something they can relate to because they see it around them. They probably all know people who have lost their jobs. It’s something they can relate to because they see it around them. They probably all know people who have lost their jobs. It’s something they can relate to because they see it around them. They probably all know people who have lost their jobs. It’s something they can relate to because they see it around them. They probably all know people who have lost their jobs. It’s something they can relate to because they see it around them.
McCarty to deliver President’s Lecture on political polarization

Princeton political scholar Nolan McCarty will speak on “The Polarization of American Politics” in the next installment of the President’s Lecture Series at 4:30 p.m. Thursday, Dec. 2, in McCosh Hall, Room 10.

McCarty will present research on congressional behavior over the past 150 years to show that American politics has become more partisan and divisive than in the past. He also will explore the causes of rising polarization.

McCarty is the Susan Dod Brown Professor of Politics and Public Affairs and associate dean of the Woodrow Wilson School of Public and International Affairs. He is the author (with Keith Poole and Howard Rosenthal) of “Polarized America: The Dance of Ideology and Unequal Riches.” Virginia Zakian, Princeton’s Harry C. Wiess Professor in the Life Sciences, will present the final President’s Lecture at 4:30 p.m. Thursday, March 24, in the Friend Center, Room 101.

The lecture series was started by President Tilghman in 2001 to bring together faculty members from different disciplines to learn about the work others are doing in a variety of fields. The talks will be webcast; viewing information will be available at <www.princeton.edu/webmedia>.

The exhibit of Green, Amber, Cream: Forgotten Art of a Ceramic Workshop in Shanxi, China will run through Jan. 9 at the Princeton University Art Museum. The exhibition includes this Ming dynasty (1368-1644) glazed ceramic statue of the Buddhist deity Guanyin, which was acquired by the museum in 2005. The sculpture was made in 1500 by the artist Qiao Bin, who was part of a family workshop operating in Yangcheng, Shanxi Province. Research on the Guanyin has led to the discovery of other significant works by Qiao family artisans.

A music event at 7 p.m. tomorrow will feature UM onassis, an Russian choir from the Moscow Conservatory, led by the conductor Alexander Ponomarchuk. The program includes works by Tchaikovsky, Stravinsky and Glinka.

For information on tickets, visit <www.princeton.edu/utickets>.
Balancing constitutional rights with national security

By Ushma Patel

C O N F I D E N T I A L, S E C R E T, T O P S E C R E T.

Diane Snyder, a lecturer in politics and freshman seminars at Princeton and a former senior CIA officer, wrote the words on the chalkboard and then fielded a barrage of questions from her students about the U.S. government’s categories of classified information.

What is the default category of classification? “There is no default,” she said.

If you can’t divulge anything that is classified, why do these distinctions exist? “I think the degree of damage that would occur to national security if the information were made public,” she said. For example, leaks of confidential information such as a parking lot access code likely would cause minor damage, while leaks of highly classified, sensitive information such as codes for accessing nuclear facilities would have more dire repercussions, Snyder noted.

Snyder directed research in artificial intelligence, developed information exchange protocols for arms control negotiations and conducted various assignments overseas during her 12 years with the CIA. She says she came to Princeton to lend a real-world perspective to the freshman seminar “The Rest of the Story: The Six O’Clock News, Intelligence, National Security and You.”

The course explores American intelligence agencies and constitutional rights such as privacy, due process and free speech, which date to the founding of the country and have remained at the center of public debate since the Sept. 11, 2001, attacks.

“Students now only know a post-9/11 world, so their attitudes are more tuned in than the average post-Cold War student whom I taught in 1993,” said Snyder, who has taught the freshman seminar every fall since 2006. She began teaching at the University in 1995.

“Today’s students also have far more access to information or news, and the course is designed to help them be discerning in how they listen to their questions is, ‘We just don’t know!’”

In the weekly course, which is designed to be accessible to anyone who has taken high school biology classes, Tilghman assigns readings of science papers published in leading journals. She walks the students through the questions at the base of the studies, the evidence presented and the legitimacy of the conclusions. The freshmen respond freely to the dynamic mix of ideas.

“We all get a chance to speak, ask questions and have open-ended discussions about various topics that arise each week,” said freshman Michael Moses. “I think that this seminar will definitely leave a lasting impression on all its members.”

In fast-paced, three-hour sessions, Tilghman packs in lessons on the fundamental principles of biology. She teaches lab experiments as though they are logic puzzles, creating opportunities for students to think out loud. She frequently says, “OK, let’s talk this through,” and checks in to ensure that students are retaining details.

For example, during a class when she started to launch into a description of an experiment, Tilghman stopped to ask, “What is it called when genes jump from one chromosome to another?” The class chimed instantly: “Translocation.”

As the class progressed, the students posed Tilghman with a series of their own questions, including why Dalmatians are spotted (not because of epigenetics — they lack a gene that controls pigmentation) and whether Alzheimer’s disease may be caused by an epigenetic change to a neuron (probably not). In response, Tilghman probed their thinking, creating a give-and-take environment similar to a collaborative lab meeting.

“I absolutely enjoy the class: I’m learning a tremendous amount, but it doesn’t feel like work,” said freshman Gitanjali Gnanadesikan. “In fact it’s a lot of fun. Not only is the subject interesting, Professor Tilghman has done a wonderful job in construct- ing the course so that we discuss not only the mechanics of epigenetics, but the ideas behind important scientific papers in the field, how the discover- ies were made and what might come next.”

The focus of a recent class was on two milestone papers in epigenetics published three decades apart. Tilghman pointed out the future paper written by the British scientist Mary Lyon displayed on a screen at the front of the room. The study explains how X chromosomes can sometimes be

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“Plants convert light to sugar — this is chemical energy,” Arnold told students in his freshman seminar on “Science and Technology for a Sustainable Future.” “Cars take chemical energy and convert it to linear motion. We convert electrical energy into visible light by using a light bulb.”

For Arnold, an associate professor of mechanical and aerospace engineering and an associated faculty member of the Princeton Environmental Institute, the intricacies of energy are central to his research. In his freshman seminar, Arnold conveys his fascination with the subject “get students to think. I can make a difference.”

Students said the seminar helps inform their strong interest in sustainability topics today. “I really wanted to be in a course where I could learn about energy issues,” said freshman Emily Eichert. “This class is so relevant and topical. Already I understand things I was only half interested in before.”

Faraday, he said, recognized an effect whereby changes in a magnetic field produced an electrical current. This concept is the basis for the modern-day electrical generator. “By doing so he invented a new kind of physics” and demonstrated a new method that is at the heart of many of today’s discussions about electricity, Arnold said. “These discoveries changed the world.”

Carvalho has a deep personal interest in the topic of the course, which est in the 1820s, the battery had recently been invented and people were just starting to understand electricity. Scientists thought of it like water flowing through a pipe, but did not appreciate that invisible forces occurring around the wires could be important, Arnold explained.

To demonstrate Faraday’s law of induction — if the magnetic field is altered, an electric current will travel through wire — Arnold led the class through a lab in which the students used LEDs, wire, magnets and voltage meters to construct small electric generators.

Field trips are part of the seminar as well. During a visit to the University’s energy plant, which employs a technology known as cogeneration, the students learned how technologies evolve into more sustainable applications.

Kicking off a study of Latin America through soccer

Jennifer Greenstein Aufrmann

Carvalho agreed. The stadium experiences in that period were meant to be “spectacles of order closer to military parades than sports events today,” he said. “They were supposed to civilize” the people, freshman Samuel Lazerwitz pointed out, to show off the country at its most civilized, and here we’re using the word “civilized” with quotations.” “It almost seems the stadium was supposed to civilize!” the people, freshman Samuel Lazerwitz pointed out, to show off the country at its most civilized, and here we’re using the word “civilized” with quotations.”

“[The stadium] provided a model for the challenges facing today’s technology innovators. In the 1820s, the battery had recently been invented and people were just starting to understand electricity. Scientists thought of it like water flowing through a pipe, but did not appreciate that invisible forces occurring around the wires could be important, Arnold explained.

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In 2009, since implementing the measures, the number of red knots visiting Delaware Bay was estimated at 24,000, up from 18,000 the year before, but still far lower than the population of 100,000 to 150,000 of two decades ago. The researchers hope that technology based on their electronic chip will eventually replace LAL, as the standard for contamination testing, obviating the need for horseshoe crab blood and helping both the crabs and the red knots rebound. At the same time, producing this new sensory device would not put pressure on the frog species. “No frogs were harmed in the making of this sensor,” McAlpine said.

**Arnold**  
Continued from page 7

In his paper, Brown emphasized that epigenetics is both intuitive result that opened up a new opportunity for the freshmen to be creative and gain insights into a subject about which they are passionate, Arnold said.

“Which would you do if you got these results?” Tilghman asked.

“One student replied: “I would think that epigenetics is both fascinating and complicated. It is a message reinforced at the end of the class when Tilghman asked one last question, too involved, however, to be answered at that time, despite the students’ expectant looks.

“We’ll see,” Tilghman said. “That’s for our next class!”

**Tilghman**  
Continued from page 6

Inactive in mammals. Tilghman, seated at the table’s head, scanned the students’ faces and asked, “If women have two X chromosomes and men have an X and a Y, what does it tell you?”

“Two X chromosomes was active in any given cell; the other X chromosome must be silent. The stripes, she argued, arose because the decision as to which X to inactivate was a random one and occurred early in development. Thus only some of the cells produced pigment because they had inactivated the X chromosome that contained the mutation, while the cells that had inactivated the X chromosome that had a normal gene could not produce the black pigment. Lyon noted a similar pattern seen in the coats of some cats.

Tilghman uses success stories like these to make a point about progress. “Every once in a while, in science, the sky opens up,” Tilghman said, smiling. “You get a breakthrough.”

She displayed an image on the screen showing large messy splotches of ribonucleic acid captured in a lab technique known as gel electrophoresis. These are experimental results from the second paper she assigned, a 1995 Nature report on work led by Carolyn Brown of Stanford University.

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