april 2010

FACULTY newsletter

CPMS Physical and Mathematical Sciences

ABOVE John Prince, who received his PhD in Cell and Molecular Biology from the University of Texas, is one of the newest CPMS faculty members.

CPMS Welcomes John Prince to Faculty

As I walked up to John Prince's office for our interview, I watched a biker coming down the hallway. I was surprised when he stopped in front of the door and welcomed me into his office, still slightly panting from his four-mile ride to work. While Prince modestly identified himself as a novice biker and runner, he is familiar with the many trails in the area and enjoys frequent rides and runs to work.

The Department of Chemistry and Biochemistry recently welcomed John Prince as its newest faculty member. Born in Texas, Prince is the fourth of nine children. While he cherishes Cougar athletics, he is also, like a true Texan, an avid fan of the football team of the University of Texas.

Prince met his wife, Melissa, during his freshman year at BYU, while she was living in Heritage and he in Deseret Towers. Though they did not seriously date prior to his mission to Edinburgh, Scotland, he explained his heightened interest in her when he got back.

"You start spending time with someone and you begin to realize that, wow, this is someone I would like to spend eternity with," Prince said.

The couple now has five boys—Joshua, Hyrum, Matthew, Seth, and Samuel—whose names collectively cover all four LDS standard works, Prince noted.

With all eight of Prince's siblings having either graduated from or currently attending BYU, Cougar blood runs heavily in his family. Prince began his education in Provo, obtaining a Bachelor's degree in Microbiology. He went on to receive his PhD in Cell and Molecular Biology at the University of Texas and subsequently pursued post-doctoral work at the University of Colorado.

Having recently finished nearly 14 years of post-secondary schooling and research, Prince is anxious to start putting his training to professional use. Within his two months at BYU, he has

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ABOVE Jani Radebaugh is one of the foremost experts in the study of the surface of Titan, Saturn's largest moon.

Radebaugh Studies Titan's Sticky Dunes

Imagine a world where mountains are made of rock-solid ice and lakes are full of liquid methane. Sound like a science fiction movie set? If fact, this is a true description of Titan, Saturn's largest moon.

Jani Radebaugh, a faculty member in the Department of Geological Sciences, has dedicated a large portion of her professional career to understanding this heavenly body and the insights it may provide into Earth's own natural processes.

Titan has received special attention because its atmosphere and surface remarkably resemble that of Earth. Unlike any other known planet, Titan's atmosphere contains large amounts of nitrogen, as well as carbon and hydrogen, organized into organic molecules. While the presence of these substances does not indicate there is life on Titan, the body may be a good place to look for life or prebiotic processes. In addition, Titan experiences rain fall and river flow, with methane as the liquid. Because it is the only other known body that sustains such complicated weather systems, Titan has become an important analog to Earth's processes.

Having another world with similar processes is especially convenient when studying the formation of sand dunes, an activity that helps researchers to better understand climate and atmospheric processes - both on Earth and on other heavenly bodies. While it is certain that wind plays a key role in the dunes' creation, it is less evident how this element works with the sand to create large mounds and snake-like patterns. Titan's sand dunes have become a particular source of intrigue for Radebaugh.

"I would like to understand what processes have made these features that are so similar to Earth's, yet made up of

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Prince *continued*

organized a team of graduate and undergraduate students to help him with his research, nearly every one of whom specializes in a different field: computer science, bioinformatics, biochemistry, math and neuroscience. Prince recognizes the benefits of interdisciplinary research, enabling researchers to tackle important problems that might not otherwise be attempted, especially with undergraduate students.

The College of Physical and Mathematical Sciences is proud to welcome John Prince as a member of our faculty. His diligence and various interests promise to prove a great contribution to the BYU community.

by: Natalie Wilson

JANI RADEBAUGH

"I am trying to answer, what are these basic landforms on Earth and other planets, and what processes created them?"

Radebaugh *continued*

such different materials," she explained.

Titan provides certain advantages when trying to solve the riddle of sand dunes. First, it has a larger area of dunes to study. While only 5 percent of Earth's surface is made up of sand dunes, 20 percent of Titan is covered with fine particles of organic material, similar in texture, color, and even chemical makeup to coffee grounds and comparable in size and behavior to sand found on Earth.

The material on Titan also moves more freely because there are no plants anchoring it. Moreover, because Titan's methane oceans are located in its polar regions, fine particles can blow across most of the planet without getting stuck in or obstructed by large bodies of liquid, as is the case on the ocean-planet Earth. With many interfering factors eliminated on Titan, it is easier to identify the impact that wind patterns have on creating sand dunes.

There are several theories about how linear dunes, the type found on Titan and in Earth's largest deserts, are formed. The currently favored model states that opposing, or obliquely angled, winds combine to produce these linear dunes stretched out along the average wind direction. Determining if this model is correct is important because it will allow researchers, like Dr. Radebaugh, to better understand the winds on Titan. Applying this model to Titan suggests that the dominant winds there move from east to west, but it also requires there to be several, perhaps seasonal, wind directions.

Radebaugh's expertise on Titan's dunes has attracted professional attention. The prestigious journal Nature Geoscience recently solicited Radebaugh's educated opinion on a paper by Dave Rubin proposing an alternate theory of how dunes may be formed on Titan.

While studying the dunes of China, Rubin noticed that some were sticky. Instead of dry, fine particles of sand–the material most dunes are composed of–these dunes are formed from bits of clay. When the wind blows, these sticky clay clumps roll along the ridge and attach to the downwind margin, lengthening the dunes in the downwind direction. He suggested that Titan's dunes may possess similar, sticky qualities, and therefore require winds from only one direction.

In her response paper, Radebaugh cautiously noted that one theory may not apply to every situation. However, she optimistically accepted Rubin's theory as viable. This new idea may be another piece to the puzzle of Titan's dunes and serve as a step closer to understanding Earth's functions as well. By comparing Titan and Earth, Radebaugh may make substantial progress in reaching her goal.

"I am trying to answer, what are these basic landforms on Earth and other planets, and what processes created them?" she said.

by: Natalie Wilson

ABOVE Tyler Jarvis received a research grant from the National Security Agency to explore group actions, orbicurves and topological field theory.

Jarvis Studies Math, Physics with NSA Grant

Code-cracking and understanding physics isn't just for the spies and scientists anymore—rather it is the collaborative work of mathematicians driving new research forward.

Tyler Jarvis, chair of the Department of Mathematics, received a research grant from the National Security Agency (NSA) to explore group actions, orbicurves and topological field theory. These topics fall under algebra and algebraic geometry, which are the best means for making and breaking codes. Beyond cryptography, however, Jarvis' work also has implications for the field of physics.

His research into group actions is directed toward understanding the geometric problems that arise from theoretical physics. As physicists study the interaction of particles, they regularly bring questions of geometry to the math department. The mathematicians, in turn, work to understand the symmetry and geometry involved, so they can then provide insight into the geometric structures. This collaborative chain reaction between the disciplines helps determine new approaches to the material involved.

"The ultimate application for the physics I am studying is still unknown," Jarvis said of his work. "But physics gives us deep insight in to the geometric properties of these surfaces."

As he explores these areas, Jarvis contributes to his department's mission to "build a unified and collegial atmosphere" through teaching, research and citizenship. He finds the interdisciplinary nature of the work particularly engaging, and enjoys the

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Jarvis *continued*

opportunity to interact with different faculty members both inside and outside his own department.

"It draws on physically motivated intuition to show that many areas of math are connected in ways we never thought of," he said.

In light of new research, the traditional view of math as "one person in a room thinking" seems to be changing. Jarvis' NSA grant, for example, is bringing graduate and undergraduate students into the cycle of collaboration.

The Department of Mathematics hopes to see more space made for its own labs soon. Currently, Jarvis is working to meet with students in whatever space is available. However, despite the logistical problems, Jarvis still finds great satisfaction in seeing the students do well.

"They're bright and helpful," he said. "I learn many things from them."

by: Katie Pitts

ABOVE Jaron Hansen and his partner, emeritus professor Lee Hansen, are seeking to put everyday waste to use as a renewable energy research.

Hansen Turns Waste Into Renewable Energy

Slaughterhouse waste, manue, algae, sawdust, used cooking oil. What common factor unites these seemingly unrelated materials? They are all, in fact, sources of natural energy.

Thanks to Jaron Hansen, a faculty member in the Department of Chemistry and Biochemistry, and Lee Hansen, an emeritus professor of the same department, waste of all kinds may now be used to produce electricity. To market their innovative system, the pair created their own company called Anaerobic Digestion Technology.

To produce energy, the company first gathers its fuel – garbage. This material is then pumped into a large 14-foot by 30-foot vat filled with bacteria. These bacteria eat through practically anything and produce methane gas in the process. As the methane rises to the top of the vat, it is collected through a pipe that channels it into a cleaning chamber.

This cleaning chamber is called the gas conditioning system and is a breakthrough, patent-pending invention by Hansen and Hansen. Although the gas produced by the bacteria is mostly comprised of methane, other contaminants are present that negatively affect electrical generators. Thus, in order to prepare the gas for entrance into the generator, it passes through a container full of zeolite. These beads soak up all the other gases and contaminants and let the methane gas pass easily through, resulting in 98 percent pure methane gas to be burned and converted into electrical power by the generator.

Currently, 100 homes are being powered by Anaerobic Digestion Technology and their partner company Andigen. The Church of Jesus Christ of Latter-day Saints is also interested in this technology. A Church-owned ranch in Elberta, Utah, which maintains roughly 5,000 cows, faces the challenge of removing a

large amount of animal waste and it has called upon BYU to put their trash to use as fuel for bacteria. The Church and the university are working together to establish a plant in Elberta that will produce 1.2 megawatts of power for over 1,200 homes and save the church $1 million per year on disposal expenses.

In addition to being burned for electrical power, methane may also be compressed to become liquid car fuel. Yet, despite the huge benefits of methane, it is not the only valuable product of bacteria. What is not converted into gas by the bacteria becomes rich compost, which can then be reused to fertilize the fields that the cows graze on or sold for a large profit in gardening stores.

Along with saving fossil fuels and curbing the damage their smoke may inflict upon the earth's atmosphere, Jaron Hansen identifies the best part about using waste to power homes.

"It is a renewable source," he explained with a smile. "We're all going to keep on making solids."

by: Katie Pitts

IMPORTANT DATES TO REMEMBER

- *Summer Institute of Applied Statistics: Bayesian Reliability*
  June 16-18
  For more information, click here.

- *NSF Regional Grants Conference*
  October 25-26
  For more information, click here.

ABOVE Dan Ventura and his student research team have developed an artificial intelligence with the capacity to evaluate and, ultimately, create art.

COLLEGE PUBLICATIONS

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CS Professor, Students Get Artistic

DARCI may be intelligent, creative, sleek, and artistic, but she's no typical co-ed art student.

Actually, DARCI is a computer program, the brainchild of Computer Science professor Dan Ventura and his students. DARCI, which stands for Digital Artist Communicating Intent, is part of ongoing research into what creativity is and its application to artificial intelligence.

Though DARCI is ultimately designed to produce art, the first step in the project was training DARCI to evaluate art. The main concept behind the programming that makes this possible is a neural network, a mathematical abstraction designed to model the architecture of the brain.

With the help of upper level visual arts students and curators from BYU's Museum of Art, selected images were chosen as training example for DARCI. Before being input to DARCI, these images were encoded as a set of low-level vision features measuring aspects of the image, such as color content or texture.

For each picture, the students labeled the image with adjectives, such as «calm» or «painterly», and then corrected DARCI as it applied adjectives on its own. This process was then repeated with images of what the trainers considered to be good and bad art. After using this data for several hundred training cycles involving several million synaptic updates, DARCI was deemed ready to judge an art show.

The "Fitness Function" art exhibit was held during March in BYU's Harris Fine Arts Center. Anyone was allowed to enter the gallery and upload a digital image to DARCI's system. DARCI scored each piece from 0-100. Works that received a score of 70 or above were accepted and printed on-site. Markers and clips were on hand for accepted artists to sign their work and hang it up in the gallery.

In total, over 700 images were submitted, but only 16.8 percent were chosen by DARCI for display, a fairly standard acceptance rate for art shows.

Once the exhibit was closed, the creators revealed that scoring equally weighted between whether DARCI felt each piece was good or bad art and whether or not it was phantasmagorical, an adjective they felt the computer system knew well.

DARCI did have her fair share of critics. Several accepted works were Renaissance masterpieces overlaid with bold text asking, "Do you like this DARCI?" David Norton, a PhD candidate who is working on DARCI, said that these reactions made the show more interesting while furthering their research.

"The idea of evaluation is an important concept when discussing creativity," he said. "We wanted to challenge people's perceptions of evaluation and then see how they would react. Ultimately we want [DARCI'S] art to be something unique and, at the same time, be accepted by the community... Part of the point of the show was to get people to think about the selection processes that occur in exhibits such as this. What makes one work a piece of art and another not? How do we evaluate art, or anything for that matter?"

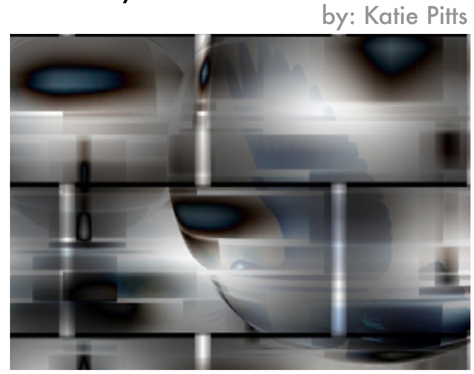
Ventura discussed in an interview how the project reaches into several fields. While they chose art as the medium, they are most interested in how computer science can approximate human creativity in artificially intelligent systems, granting them the ability to adapt knowledge outside of a narrow scope.

"Really, it's not about art," said Ventura. "It's about understanding that underlying creativity... and trying to figure out if that kind of thing is implementable... so we get systems that are intelligent in a better way than they are today."

Since its conception last June, the DARCI project has already resulted in one publication, with another under review. Ventura, Norton, and graduate student, Derrall Heath, will continue their work with the aid of a three-year grant from the National Science Foundation's CreativeIT program.

For those who missed the exhibit, a second DARCI is being publicly trained online. You can participate by visiting darci.cs.byu.edu on the Web.

by: Katie Pitts



ABOVE Art created by DARCI.

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ABOVE Weathered, highly eroded rocks such as those pictured here have traditionally presented a difficult challenge to computer animators. Jones' algorithm aims to smooth that process.

Jones, Students Aim to Change Animation

Despite the incredible leaps digital effects artists have made in the field of modeling for computer animation, many of their methods are often tedious. One of these time-consuming, difficult tasks is the realistic reproduction of weathered rocks. However, with the supervision of Michael Jones, a faculty member in the Department of Computer Science, students Matthew Beardall, Mckay Farley and Joseph Butler have created an algorithm that simplifies the creation of weathered rock surfaces.

"The algorithm is based on estimating the curvature of the rock," Jones said. "It's pretty clever."

Using Utah's Goblin Valley as the model for their project, the students and Jones studied the curvature of real rock surfaces both in nature and in the geology literature.

One explanation for the weathering observed in Goblin Valley is that the weathering rate depends on ratio of exposed surface area to volume.

"Our algorithm estimates this ratio and computes the weathering rate by estimating surface curvature," Jones explained.

The rocks' mean surface curvature can be positive, zero or negative. High positive curvature indicates that the surface has a jutting edge, while zero curvature identifies a flat surface and negative curvature describes a hole in the rock. Using computers to study these findings, Jones and his group confirmed that high positive curvatures weather very quickly while negative ones erode more slowly when modeling spheroidal weathering. Cavernous weathering, on the other hand, happens more quickly in areas with negative curvature.

Understanding these natural processes has allowed Jones to develop a computational program that simplifies the work of animation. Instead of "moving the points of the surface around by hand," as was done with the previous method, animators may now tell a computer what they want their rocks to look like and it will produce them, Jones explained.

Artists sketch a curve that describes the durability of the rock. Using this information, the computer mimics what might realistically happen in nature. Less durable, high curvature areas weather more than the rest of the virtual surfaces. On the other hand, durable rock that has zero curvature experiences very little alteration in its appearance. The final weathered shape is a plausibly weathered copy of the curve sketched by the artist.

The work of Jones and Beardall demonstrates that surface curvature is a potentially productive approach to the long-standing problem of weathering rock in 3D. Their algorithm may relieve much of the modeling effort required to produce natural scenes in the quality entertainment that we all enjoy.

by: Natalie Wilson