july/august 2010

FACULTY newsletter

CPMS Physical and Mathematical Sciences

ABOVE : Dr. Richard Watt

Artificial Plant Systems Produce Energy

Plants have long been classified as self-sustaining organisms, meaning they can work with elements from the environment to create their own food. Soon, they may have to share this rare distinction with an artificial photosynthesis system—a creation of Richard Watt, faculty member in the Department of Chemistry and Biochemistry. This new system may prove to be a valuable source of renewable electrical energy in the near future.

Nature thrives on renewable energy. Elements work together in never-ending cycles to produce the power needed to keep plants growing and producing. Photosynthesis is an example of conservative, efficient energy systems at work.

"In photosynthesis, light strikes chlorophyll and an electron gets excited to a higher energy state," Watt explained. "Then another molecule grabs the electron and pulls it away. Now, that electron works like water in a hydroelectric dam. It falls through a molecular energy-level system that creates energy the plant can use. But the original molecule—the one that had the electron that got excited—now wants one back. So some other molecule nearby has to donate electrons to that molecule. They cycle."

Studying this cycle, Watt identified ferritin as an element with properties that could simulate nature's miracle. Ferritin is a round, hollow protein that can fit thousands of iron atoms inside its shell and, just like chlorophyll, light affects the energy levels of its electrons.

"We're trying to build an artificial photosynthesis system by shining light on ferritin," Watt said. "When you shine light on it, electrons get excited just like in photosynthesis. And those electrons can be used for energy or may be transferred into batteries for energy storage."

Like the electrons that keep cycling in plants, ferritin keeps giving and taking electrons in a continuous stream of movement as long as light is present.

The main difference between Watt's system and that of nature is their respective end goals. While plants are

Continued on 2nd page

ABOVE : Dr. John Dallon

Mathematical Models Used to Study Cancer

What is cell-to-cell adhesion? Why does it matter? While many people are not familiar with this term, everyone has heard of one of its more infamous byproducts: cancer.

Tumors form when cells connect, or adhere, to each other and divide uncontrollably for no apparent reason. Some may exist as harmless lumps of tissue, while others may prove cancerous. These cancerous tumors become especially dangerous when portions of their contaminated mass begin breaking off and spreading throughout the body in a process called metastasis.

John Dallon, a faculty member in the Department of Mathematics, conducted computer simulations as he sought to better understand cell-to-cell adhesion—how cells stick together and form groups.

With a better perspective on how cells form bonds, Dallon feels this will lead to a greater vision of how these same cells metastasize.

"To understand how cells adhere to one another is important in understanding how they break apart," he said.

Cadherin proteins are key elements in cell adhesions. These proteins span cell membranes and can move around. Dallon compared them to buoys that can drift according to currents or other conditions. Just as tethered buoys can bob around, cadherins are connected to a cell's inner structure and shift position. The task, then, is to determine what purpose the tethering serves. Is it to tow cadherins around to different parts of a cell? Is it to restrict movement? Or is it something else?

These proteins are not simply wandering pieces of matter. Cadherins are actually what make the adhesion of two cells possible. They reach out towards each

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COLLEGE PUBLICATIONS

Chemistry and Biochemistry

Neven, L., Hansen, L.D., Ann. Entomol. Soc. Am., 2010, 103(3), 418-423. Effects of Temperature and Controlled Atmospheres on Codling Moth Metabolism.

Attavar, S., Diwekar, M., Linford, M.R., Davis, M.A., Blair, S., Applied Surface Science, 2010, 256, 7146-7150. Passivation of aluminum with alkyl phosphonic acids for biochip applications.

Curtis, A.D., Reynolds, S.B., Calchera, A.R., Patterson, J.E., Journal of Physical Chemistry Letters, 2010, 1, 2435-2439. Understanding the Role of Nonresonant Sum-Frequency Generation from Polystyrene Thin Films.

Mathematics

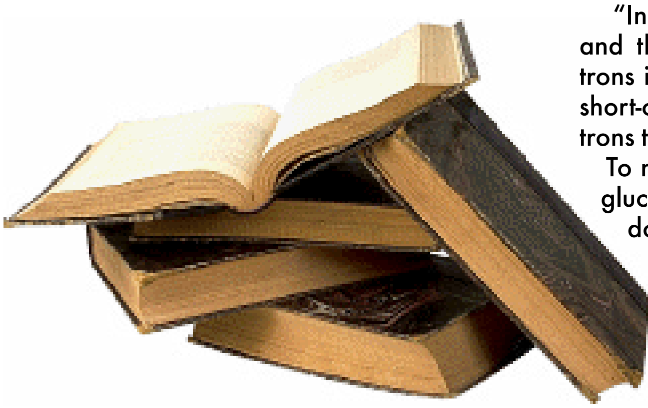
Jared Whitehead, Lennard Bakker, International Journal of Bifurcation and Chaos, 2010, 20(4), 1049-1059, Asymptotic Values, Prepoles, and Periodic Points.

D. Futer, E. Kalfagianni, and J. Purcell, Geometriae Dedicata, 2010, 147(1), 115-130, On diagrammatic bounds of knot volumes and spectral invariants

Jessica S. Purcell, Communications in Analysis and Geometry, 2010, 18(2), 219-256, On multiply twisted knots that are Seifert fibered or toroidal

Statistics

Blades, N.J., Grimshaw, S. D., Pendleton, C.R. , "A Simulation-Based Approach For Evaluating Microarray Analyses," Biostatistics 11(3): 533-536, 2010.



Cancer (cont.)

other when two cells get close and, acting like Velcro, form a bond once they've connected.

In addition to cadherins, actin plays a big role in bringing two membranes together by forming a filament in the cell, which contributes to the cytoskeletal structure. Actin is a part of the cytoskeletal structure, the internal structure of a cell comparable to the bone skeleton of a mammal. When cadherins begin sticking to each other, this internal network of actin begins actively changing.

"It is unclear what happens to actin when cells start to attach," Dallon said. "The internal structures vary in dynamic ways and it is clear that there is a lot of reorganization of the actin filaments near the attachment site."

Some of the questions Dallon sought to answer are: "Why all this reorganization? Why is it important? What's going on here?" He wanted to solve the riddle of actin's sporadic movement and determine if and how it affected cell adhesion.

One theory explaining actin's movements suggested that the actin was restraining the cadherins, acting as an anchor so that the buoy-like proteins could align well enough to grab hold of each other.

"Some people think that the actin filaments act as tethers to limit the mobility of the cadherins, somewhat like a buoy attached to an anchor," Dallon said.

To test this, Dallon used a mathematical model where he allowed some cadherins to freely move while others remained tethered to the cytoskeleton. Results showed that whether or not cadherins were tethered to the cell or free-floating didn't really make much of a difference with cells' abilities to connect, suggesting the tethering theory is not correct.

After further exploration, Dallon concluded that for cells attached to a substrate, at least one major task of this cytoskeleton is to move cell membranes closer together. Pseudopods are protrusions, or little lumps, that stick out along a cell's membrane. Their purpose is to allow two cells to get close to one another, and they are formed when actin pushes against a cell wall to elongate a portion of it.

By pushing outward on a cell's membrane, actin brings cadherins closer together and provides them a better opportunity to attach. According to this research, actin does affect cadherins' abilities to attach. It is not by tethering them in the membrane. Instead, it is by pushing membranes closer together to increase the chances for cadherins to come into contact with each other and bond.

Dallon is optimistic, yet realistic, about the impact this information can have on cancer and other health issues that are based on metastasizing cells.

"The more we know about cell behavior, the better we will be able to control cell-to-cell adhesion," he said. "This project is adding one piece to the puzzle. It's one small tile in a large mosaic. Eventually, we may be able to step back and see the whole picture."

by: Natalie Wilson

Plants (cont.)

working to convert energy into food storage, Watt's model is simply working to harvest raw energy.

"In a plant, sunshine excites electrons and the energy from the excited electrons is used to build sugars. We would short-circuit that system and use the electrons to make an electrical cell," he said.

To make this project even more ideal, glucose can be used as the electron donor to ferritin. This means that waste products from farms, such as corn stalks that are rich in glucose, may be put to good use as natural fuel for an artificial photosynthesis system.

The world consumes large amounts of energy. Many sources of natural power have been and are being developed. With the potential to produce energy more efficiently than other current sources, Watt's project may prove to be a prominent addition to the energy options available.

by: Natalie Wilson

ABOVE : Dr. John Lawson

Professor Promotes Many Research Methods

Man's curiosity has driven him to question and experiment for thousands of years. Through trial and error, standard research methods have evolved that are now an integral part of most science classes. However, some lesser-known techniques have also proven effective.

John Lawson, a faculty member in the Department of Statistics, has years of experience with statistically-designed research strategies and has recently written a textbook on this subject: Design and Analysis of Experiments with SAS. Although these methods were developed early in the second century and have found application in all areas of physical experimentation, they are still not emphasized in general science education.

One research method that has been emphasized in textbooks and curriculum for years, and one Lawson is seeking to diverge from, is the practice of isolating variables.

"This is a traditional approach they use in science classes," Lawson explained. "By holding all the variables constant and varying one, you see how the output you're interested in changes as a function of varying that one. And that's good if you know the relationship exists and if you're just trying to demonstrate it to students in a lab. But if you're trying to do real research and you don't know what relationship it is, then it's very inefficient, time-consuming and subject to all kinds of problems."

Factorial designed experiments eliminate these limitations. Using a design that joins many different factors into various combinations can be useful in marketing situations.

"If you're making something—either a product or a service—and it's composed of different attributes, you want to know what the customers would really like best," Lawson explained. "You want to know if you should use more of one attribute, less of one, take one out, or put one in. You can tell what attributes affect their choice."

Several other factorially designed research methods include: screening designs, response surface designs, designs for mixture experiments, designs for mechanistic models and designs for computer experiments.

Lawson teaches classes in statistically designed experiments and is anxious to collaborate with faculty and students who would like to explore the use of these methods in their research.

by: Natalie Wilson

ABOVE : Dr. Dan Ventura

Computers Research Creativity with Music

What is creativity? How is that spark, so often represented as a luminous light bulb in comic strips and cartoons, turned on in each of us? Dan Ventura, a faculty member in the Department of Computer Science, has launched a research project partially funded by the NSF seeking to find the answers to these and other questions.

"We're trying to figure out what this creativity business is and can we extract the essence of it out and apply it in general to intelligent systems," he said.

Using computer systems as test subjects, Ventura and Tony Martinez's PhD student Kristine Monteith have focused on the musical aspect of creativity to perform their research. With a Bachelor's degree in music therapy, a Master's degree in computer science, and a Ph.D. in computer science in the works, Monteith was able to combine all of her interests and areas of study into one "quite intriguing idea," she explained.

"We're studying things like music because it's the exotic interest," Ventura said. "It catches everybody's eye. It's interesting. It's compelling. It communicates. Everyone can understand music. Everybody can appreciate it to a certain extent."

To begin the study, Monteith gathered nearly one hundred samples of music generally revered as quality compositions, pulling from soundtracks such as Jaws and Gone with the Wind. She then categorized these musical pieces based on the reported emotions they elicited among a group of student listeners. For example, group members reported feeling joy, pain, fear and other emotions while listening to different samples.

Gathering these responses, Monteith then fed them into the computer, giving the equipment its first lesson on musical qualities. Learning from the students' responses, the computer was able to identify patterns that

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CFS & Rank Advancements

Congratulations to all faculty receiving advancements in CFS and/or rank!

Chemistry & Biochemistry

Granted candidacy for CFS
Jeff Macedone
James Patterson
Granted CFS and promoted to associate professor
Allen Buskirk
Promoted to full professor
Adam Woolley

Computer Science

Granted CFS
Christophe Giraud-Carrier
Daniel Zappala
Promoted to full professor
Bryan Morse

Geological Sciences

Granted candidacy for CFS
Summer Rupper
Granted CFS and promoted to associate professor
Randy Skinner

Mathematics

Granted candidacy for CFS
Todd Fisher
Jessica Purcell
Granted CFS
Scott Glasgow
Granted CFS and promoted to associate professor
Lennard Bakker
Promoted to full professor
John Dallon
Greg Conner
Xian Jin Li

Mathematics Education

Granted candidacy for CFS
Doug Courey

Physics & Astronomy

Granted candidacy for CFS
John Colton
Denise Stephens
Granted CFS and promoted to associate professor
Duane Merrell
David Neilsen
Michael Ware
Promoted to full professor
Scott Bergeson

Statistics

Granted candidacy for CFS
David Engler

Music (cont.)

were common in the different, emotion-labeled music groups. For example, certain notes were played more frequently in scary music than in peaceful airs. Now, when the system receives music, it is able to identify and categorize pieces into their proper classifications with impressive accuracy.

In addition to training the system to recognize different sounds and label them with various emotions, Ventura and Monteith hope to expand this creative project from simple discrimination to generation—instead of only being able to recognize musical qualities, the system may begin producing its own work.

While many incredible machines already exist that do produce some original work, their area of specialty is severely limited. Ventura hopes his project will expand the confines of existing mechanical genius.

"We have intelligent systems, artificial systems that are very, very intelligent. But they're a very narrow domain," he said. "I mean, you have these systems that can play chess better than anybody in the world. Literally. But, they can't do anything else. I mean they can't even play checkers, which is pretty darn similar to chess. To get these systems to get more robustly intelligent, I think this creativity is an angle that is going to be important."

Humans are constantly creative as they find ways to solve a variety of problems. While computer systems do not yet possess this same quality, Ventura and Monteith are making progress toward this desired outcome.

by: Natalie Wilson

Professor wins Utah Award in Chemistry

Dr. Juliana Boerio-Goates, a professor for 28 years at BYU, was presented with the Utah Award in Chemistry by Tom Richmond of the American Chemical Society's Salt Lake Section Wednesday, August 4 at an awards banquet in Salt Lake City.

The purpose of the award is to "recognize outstanding contributions to the chemical enterprise as reflected by excellence in research, technology, service to the ACS or its sections, and/or chemical education in any field of chemistry (broadly defined), by chemists working in the state of Utah," the ACS-Salt Lake Section website states. The section established the award in 1958 and has presented it to one qualified nominee every year since.

"It's a prestigious award," Dr. Allen Buskirk, chair of the Central Utah Section of the ACS and BYU professor of biochemistry, said. "All the nominees are outstanding."

Both sections of the ACS in Utah, Central Utah and Salt Lake, work together to determine the recipient. They take turns hosting the awards banquet every year. "This year it was Salt Lake's turn," Dr. Buskirk said.

Dr. Boerio-Goates teaches Physical Science 100 and courses in physical chemistry at BYU. She also does research in thermodynamics—the study of the energetics of chemical and physical processes. "It has important practical applications—you can make predictions about whether changes in temperature or pressure will allow a chemical process to take place," Dr. Boerio-Goates said. She has now been a member of the ACS for more than 30 years and is currently a member of the Central Utah Section.

Only four laboratories in the world can measure S—the entropy of pure materials, a thermodynamic property—and only one of them is in the

Continued on 5th page

ABOVE : Dr. Juliana Boerio-Goates

Faculty Grants

Congratulations to all faculty receiving new research funding!

W. Evan Johnson, Mark Clement & Quinn Snell

Sponsor: NIH
Title: Methods for the analysis and integrations of next-generation sequencing with appl

Timothy Leishman & Scott Sommerfeldt

Sponsor: Caterpillar, Inc.
Title: Advanced Acoustic Modeling and Experimental Verification of Enclosure Insertion Loss

Important Dates to Remember

CHIRP Proposals Due
September 24

HITS Proposal Due
September 30

ORCA Application Deadline
October 29

MEG Application Deadline
November 1

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United States. That laboratory is Boerio-Goates' apparatus at BYU.

Entropy measurements require very accurate, precise heat capacity measurements down to temperatures of nearly absolute zero and up to those well above room temperature on samples that are highly pure and well-characterized. It can take up to two months to make the measurements on one sample.

"Julie is considered to be a leader in her field," said physical chemistry professor Brian Woodfield.

Dr. Boerio-Goates attributes her desire to study chemistry to the teachers she had in high school and college. "I had two very good high school chemistry teachers who were a big motivation to me. Then, my chemistry professors in college were wonderful mentors who encouraged me and continued to provide guidance when I was in graduate school. I still correspond and visit with the professor who is still alive," she said.

Chemistry department chair Dr. Paul Farnsworth said of Boerio-Goates' work, "I think that (she) is motivated primarily by basic curiosity about how the world works more than by any particular application to which her work may be applied. That being said, her work definitely has some immediate practical implications, particularly her work with nanoparticles. The nanoparticles promise to be efficient and cost-effective catalysts for chemical reactions."

CPMS Professors Receive Awards

Seven professors in the College of Physical and Mathematical Sciences (CPMS) received awards at the Annual University Conference of Brigham Young University on Wednesday, Aug. 25.

Statistics professor C. Shane Reese and math professor Michael Dorff received the Maeser Excellence in Teaching Award. The award recognizes superior teaching that is directed toward comprehension and reasoning, meets high student expectations and has a long-lasting influence on students.

During his time at the university, Reese has improved the Stat 221 course and developed a nationally recognized, graduate-level Bayes course. Dorff, the Math Department's associate chair, has helped make mentored math research for undergraduate students a growing trend, both at BYU and nationally.

Dan Ventura, a professor in the Computer Science Department, was awarded this year's Young Scholar Award, which recognizes the contributions and promise of faculty members in the early stages of their professions. Ventura focuses his research on artificial intelligence and machine learning.

Another computer science professor, Chuck Knutson, received the Eliza R. Snow Grant. The grant supports bringing a Latter-day Saint perspective to academia or using that perspective in a creative work. Knutson was recognized for his work on internet safety.

A third computer science professor, Kent Seamons, received this year's Technology Transfer Award. The award recognizes faculty whose research has led to the development of useful commercial products. Together with his students, Seamons developed email security software that was a finalist for the 2010 Utah Innovators Award and was recently licensed to a local startup company.

Barry Willardson, a professor in the Department of Chemistry and Biochemistry, was awarded the Sponsored Research Recognition Award. His study of how information is communicated from the bloodstream to the inside of cells has produced findings helpful in developing new pharmaceuticals.

Professor Matthew Asplund, also of the Department of Chemistry and Biochemistry, received an Alcuin Fellowship, which recognizes faculty members whose work goes beyond their disciplines and includes contribution to the honors and general education program. Asplund teaches introductory chemistry and physical science courses, and is heavily involved in Freshman Academy.

by: Justin Ritter