May/June 2016

RESOURCE

engineering and technology for a sustainable world

Biomimicry Explained

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UAS series: Part 2

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from the President

Partnerships Work!

As I thought about this month's column, I wondered, "Is my 'Partnership' theme getting old? What can I say that is new?" Then I realized that I don't have to say something "new" about partnerships, because I am constantly reminded about the need to work together to effect change and improve the quality of people's lives.

I participated in the Tri-Societies (Agronomy Society of America, Crop Science Society, and Soil Science Society of America) Congressional Visit Day in March in Washington, D.C. The event included one day of preparation followed by one day of visits to offices of senators and congressional representatives. This year's focus was on support for increased funding of the USDA Agriculture and Food Research Initiative (AFRI). The authorized level of support for AFRI is $700M, while the FY2016 appropriated level is $350M, the highest level appropriated since AFRI was authorized in 2009.

An inspiring part of the preparation day was a presentation by Sonny Ramaswamy, Director of the USDA National Institute for Food and Agriculture (NIFA), focused on the critical need for increased funding for AFRI. He emphasized that while many are looking ahead to the challenges of feeding a growing population in the future, we have critical needs right now to provide nutritional security to the approximately 850M people worldwide, including about 45M in the U.S., who go to bed hungry each night. He also talked about the related health issues, including the huge healthcare costs associated with preventable chronic disease and the new phenomenon of adult-onset diseases occurring in children born this century. Dr. Ramaswamy said that creative, innovative research can find solutions to nutritional insecurity. He described the research that AFRI funds support as "user-inspired science that transforms lives" with the built-in linkage between research and extension through USDA.

I thought of the meaningful research and extension work that so many ASABE members do through USDA funding that does, in fact, transform lives. Additional AFRI funding will be able to support more of the excellent proposals that ASABE members and others submit to AFRI each year; only about 30% of the proposals recommended for funding by review panels over the past two years were able to be funded.

The visits to congressional offices were conducted by teams of four to six people comprised of Tri-Societies staff members, graduate students, Certified Crop Advisors, and researchers from one or two states. My two-state team met with staff members of three senators and one representative and met one representative himself (on a street corner as he was going to the Capitol for a vote). These visits reinforced what was emphasized during the preparation day: "Tell your story." The staffers and the representative wanted to hear about the impact of AFRI-funded research on the people and the economy in the specific state or district of the congressional office holder.

This experience reinforced for me that an effective strategy is to tell the story, work in teams, and involve both students and professionals. This strategy is applicable to much of what you and I do every day. I also learned that ASABE should partner with the Tri-Societies on Congressional Visit Day.

I look forward to hearing from you!

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events calendar

ASABE CONFERENCES AND INTERNATIONAL MEETINGS

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2016

July 17-20	**ASABE Annual International Meeting.** Orlando, Fla., USA.
Sept 6-9	**10th International Drainage Symposium.** Minneapolis, Minn., USA.
Oct. 24-27	**Engineering and Technology Innovation for Global Food Security.** Cape Town Stellenbosch, South Africa.
Dec. 3-9	**21st Century Watershed Technology Conference and Workshop.** Quito, Ecuador

2017

July 16-19	**ASABE Annual International Meeting.** Spokane, Wash., USA.

ASABE ENDORSED EVENTS

2016

May 17	**Food Engineering for Life.** Boston, Mass., USA
Aug. 14-17	**AgriControl 2016.** Seattle, Wash., USA.
Aug. 23-25	**Third International Conference on Agricultural and Food Engineering.** Kuala Lumpur, Malaysia.

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ON THE COVER

RossmannT4. A frame from a Seyet LLC-generated visualization based on research by Michael G. Rossmann, the Hanley Distinguished Professor of Biological Sciences, Purdue University. The image depicts the T4 virus as it penetrates the cell membrane of the *E. coli* bacterium, which the virus infects.

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FEATURES

UPDATE

DEPARTMENTS

Equipping Farmers to Test for Severe Cattle Diseases

Suresh Neethirajan, P.Eng.

Photo by Scott Bauer, courtesy USDA-ARS

When their cows experience a drop in milk production, dairy farmers are often hindered in their ability to determine the cause. One reason is subclinical ketosis (SCK), which means that the affected cow appears healthy and only becomes observably ill when under stress. When SCK becomes full-blown ketosis, major organs can be affected. Other metabolic diseases can also affect milk production and animal health. Until recently, the only reliable method for detecting these abnormalities involved drawing vials of the cow's blood, sending the samples off to a lab for diagnosis, and then waiting for the results. The BioNano Laboratory at the University of Guelph has improved this process by placing the diagnosis of animal health in the hands of farmers, saving crucial time in detecting diseases, and thereby allowing earlier treatment.

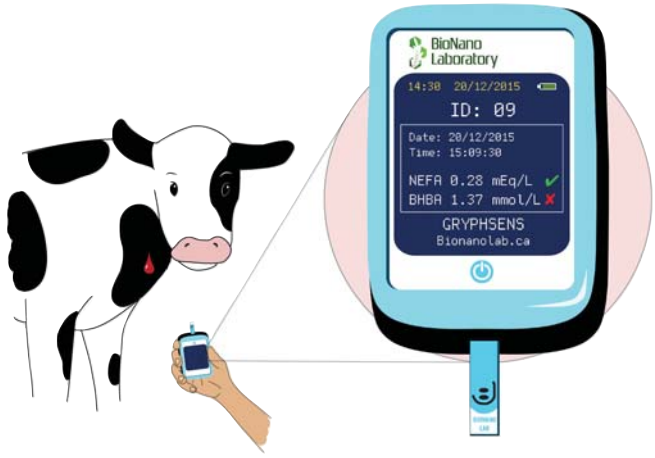
Using a handheld biosensor, a dairy farmer can rapidly detect whether a cow has SCK or other metabolic diseases. The analysis can be conducted in real-time, using a smartphone to access the Internet. This technology allows dairy farmers to rapidly determine the cause of a reduction in milk production, and it allows early detection of diseases that can then be quickly treated, helping the cow return to her normal production level in a shorter time.

How the biosensor works

By detecting certain enzymes in blood, our newly developed device—called GryphSens—identifies biomarkers that are present in miniscule amounts and that indicate the presence of diseases. The device's unique electrode composition, a plant enzyme, and the correct amount of electric current were discovered to be the winning combination for the design.

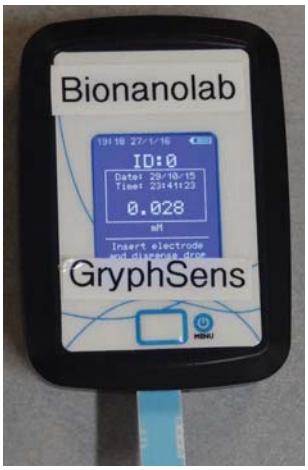
Specifically, the biosensor detects minute electrochemical activity in biological fluids that indicate biomarkers for certain irregularities. These biomarkers flag slightly elevated levels of non-esterified fatty acids (NEFA) and a ketone prevalent in cows—hydroxybutyrate (BHBA)—that at higher levels can signal the early onset of ketosis and other metabolic diseases. Dairy farmers are well aware that charting a cow's NEFA and BHBA levels is the litmus test for the animal's overall health.

Calving is a particularly stressful time for cows. It is a time of negative energy balance (NEB), when the onset of ketosis and other metabolic diseases is most common. Although the levels of NEFA and BHBA are miniscule at first, early detection can reduce complications and allow faster recuperation. Delayed detection can lead to fatty liver, displaced abomasum (twisted stomach), inflammation of the uterus, or a retained placenta.



Some challenges to overcome

While human medicine offers similar devices for measuring glucose levels for diabetics, cows present a challenge by having eleven major blood groups, compared to the four blood groups in humans. An additional challenge was developing an electrode that can simultaneously detect both NEFA and BHBA under variable metabolic conditions that may include a number of interfering components, which can alter the test results.



The GryphSens dual-electrode biosensor.

Disposable screen-printed carbon electrodes were used for their affordability and for their compatibility with handheld and in-line robotic milking devices. Based on previous research, the electrodes were fabricated with redox-active hybrid graphene oxide (GO) material, which has proven very effective in biochemical applications. However, we had to overcome the insulating property of the GO material, which hindered the electrochemical function of the biosensor. A particular enzyme from the soybean plant was integral to solving this problem, and this soybean-based enzyme was layered onto the GO material. This proved to be the defining chemical for detecting NEFA and BHBA, as it had superior and durable redox properties for the critical biomarkers compared to untreated GO electrodes.

Specifically, although lipoxygenase is found in both animal and plant species, soybean lipoxygenase-1 (SLO) was used for catalyzing direct electrochemical oxidation of NEFA in conjunction with [Ru(bpy)3]2+. In this application, SLO breaks down the fatty acids found in metabolic lipids to produce fatty acid hydroperoxide. When used in conjunction with electrochemistry, NEFA becomes oxidized and detectable by the electrode.

The biosensor's other electrode, for detecting the ketone BHBA, uses another enzyme (HBDH) that is produced naturally by organisms under stress and that can be detected through electrochemical oxidation. The isolation that enabled BHBA to be detected uses the electrochemical oxidation of the coenzyme NAD+ to produce NADH. Because HBDH is dependent on the coenzyme, the electrode can readily identify the enzyme through covalent bonding at the molecular level.

Determining the correct microvoltage supplied to the electrodes further enhanced the efficiency and reliability of the device. The result is a biosensor that can detect both NEFA and BHBA in less than a minute from a single drop of cow blood.

Farmers and their cows will benefit

Using our biosensor for on-farm testing for dairy cow diseases significantly reduces the stress on the animals, as it requires a only drop of blood (instead of a vial), and it provides rapid results. This ability to detect multiple disease biomarkers from a single drop of blood by untrained farmers is a unique advantage.

In addition, the cost savings provided by early detection would be substantial for both small and large dairy herds. For large dairy operations, this technology can be combined with in-line robotic milking machines to monitor the herd collectively, avoiding the time-consuming method of testing each cow separately.

Dairy cattle are an investment, and they must be kept healthy to maintain optimal production levels. Our new biosensor is the latest tool for dairy farmers to use in monitoring the health of their herds. This biosensor can be an important part of routine screening in dairy operations, and its ease of use and convenience will significantly enhance the management of dairy herd health.

ASABE member Suresh Neethirajan, P.Eng., Program Leader (Biological and Biomedical Engineering), BioNano Laboratory, and Assistant Professor (Bioengineering), School of Engineering, University of Guelph, Ontario, Canada, sneethir@uoguelph.ca.

"This patented technology from the BioNano Laboratory at the University of Guelph detects two bovine disease indicators (metabolic NEFA and ketosis BHBA) from a single drop of blood within two minutes," says ASABE member Suresh Neethirajan. "Real-time simultaneous detection of multiple diseases is the trend for the livestock sector. Instruments based on nanotechnology, on-line diagnostics, and rapid treatment will significantly enhance the management of dairy herd health."