Market Opportunities

Biosensor Technologies in the Food Industry

PUBLISHED BY ASABE – AMERICAN SOCIETY OF AGRICULTURAL AND BIOLOGICAL ENGINEERS
Last week, I was interviewed by a regional business newspaper for a profile in their small business section. Since we are a technology-driven company, the writer kept probing for what makes us more successful than many others. When the appointed time came for her call, I was right in the middle of writing the literature review portion of a federal research proposal. I may have been sensitized to the topic, but I said, “Our success depends an awful lot on the knowledge and ideas we learn from scientists and engineers around the world, those whom we can talk to at conferences and lab visits, and those whom we know only through their published literature.”

The literature review I was working on included about half ASABE conference papers and Transactions manuscripts going back to about 1965. Without the knowledge and insights of our professional peers through the ages, the proposal would have been a shot in the dark at best—our ideas against the ideas in competing proposals. We hope that we demonstrated to the reviewers that our ideas are based on sound science and engineering from respected predecessors.

Each of the scientists and engineers in our company read the literature with the aim of understanding the progression of thought on subjects important to us. Just like reading an old novel from a favorite author, we jump at the discovery of an unread early manuscript from certain ASABE Fellows and pioneers within our membership. As with long-time friends and colleagues, we may not agree with our past and present peers, but we always learn from the conversation.

We know that we can phone or email almost any living ASABE member and enter into a lively and informative conversation about an aspect of technology, a research protocol, or an interpretation of work from mentors long departed. That is the nature of our members. Networking at specialty conferences, the ASABE Annual International Meeting coming up in Reno, and at local section or other meetings provides valuable face time that is rarely considered an imposition. Ours is a Society of members dedicated to the advancement of engineering applicable to agricultural, food, and biological systems. The respect that I have, and that I see in others, for what we know, individually and collectively, is immense. We may work with virtual worlds today, but together we are having a profound, positive influence on the quality of life and sustainability of the real world.

Jim Dooley, Forest Concepts, LLC
jdooley@forestconcepts.com

**Virtual Networks Based on Professional Respect**

**Events Calendar**

**ASABE CONFERENCES AND INTERNATIONAL MEETINGS**

To receive more information about ASABE conferences and meetings, call ASABE at (800) 371-2734 or e-mail mtgs@asabe.org.

**ASABE ENDORSED EVENTS**

2009

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<td>Jun. 17-19</td>
<td>XXXIII CIOSTA CIGR V Conference, Technology and Management to Ensure Sustainable Agriculture, Agro-systems, Forestry and Safety.</td>
<td>Reggio Calabria, Italy; contact Gennaro Giametta, <a href="mailto:gennaro.giametta@unirc.it">gennaro.giametta@unirc.it</a>.</td>
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<tr>
<td>Aug. 23-27</td>
<td>Second Farming Systems Design Symposium.</td>
<td>Monterey, California, USA; contact Jerry Hatfield, <a href="mailto:jerry.hatfield@ars.usda.gov">jerry.hatfield@ars.usda.gov</a>.</td>
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<tr>
<td>Aug. 31-Sep. 2</td>
<td>5th CIGR Section VI International Symposium on Food Processing, Monitoring Technology in Bioprocesses and Food Quality Management.</td>
<td>Potsdam, Germany; contact Da-Wen Sun, <a href="mailto:dawen.sun@ucd.ie">dawen.sun@ucd.ie</a>.</td>
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ON THE COVER

Preparation of a DNA biosensor. (Photo courtesy of Evangelyn Alocilja)
Although America’s food supply is unmatched in quality and quantity, we face new challenges involving biological threats to the food supply chain from intentional and natural contaminations. Food production and processing are becoming increasingly centralized. Americans eat in restaurants more often and eat more imported foods, some of which come from across the globe virtually overnight. Furthermore, novel pathogens are emerging, and familiar ones are growing resistant to antibiotic treatment. According to a report by the Centers for Disease Control and Prevention, foodborne diseases cause approximately 76 million illnesses, including 325,000 hospitalizations and 5,000 deaths, in the United States each year. Researchers at the USDA Economic Research Service estimate that the annual cost of human illness caused by foodborne pathogens is $5.6-$9.4 billion. Hence, foodborne pathogen testing is performed constantly and often by various laboratories, including on-site laboratories at food-processing plants. On-site rapid tests for foodborne pathogens produce results quickly, shortening the length of time that products must be held in inventory and subsequently lowering storage cost. Rapid detection systems will minimize the need for the estimated 60,000 U.S.-based food processors to perform lengthy microbiological testing and expensive immunoassays on materials suspected of carrying foodborne pathogens. Additionally, if a recall is issued, on-site testing provides a rapid response time, thus reducing corporate liability costs.

Newsworthy and market-ready?

A recent development—rapid and on-site diagnosis—has received much attention due in part to its advantages: rapid, sensitive, specific, inexpensive, easy to use, and portable. A biosensor is an analytical device that is composed of a biological receptor in close proximity to a transducer, which is connected to a signal generator that converts the bio-receptor and target interaction into a measurable signal. Biosensors come in many formats: immunosensors, DNA sensors, aptasensors, enzymatic sensors, and cell-based sensors. This month’s Resource cover shows the preparation of a DNA sensor.

The market for biosensor technologies is comprised of five segments: medical, environmental, food and beverage, bio-defense, and pharmaceutical research, with the medical applications overshadowing the other segments. The market size for global medical biosensor-based technologies in 2004 reached about $7.1 billion and is growing at a cumulative annual growth rate (CAGR) of 9.7 percent. It is estimated to reach $11.3 billion in 2009.

The market for pathogen-specific testing is expected to grow for all segments at 4.5 percent CAGR. Based on an estimate of a total market value of $563 million in 2003, a CAGR of 4.5 percent could mean $702 million in 2009. The best overall growth rate is predicted for the food and military segments, at an estimated CAGR of 6.0 percent and 6.8 percent, respectively.
Rapid screening on the rise

Industry analysts expect that as regulations pertaining to pathogen testing continue to be adopted, the shift toward rapid screening methods will continue. The U.S. food industry performed around 144.3 million microbiological tests in 1999, as shown in table 1. The processed food sector accounts for the largest number of tests, with over 52.2 million performed annually. This represents over 36.2 percent of total tests performed and is likely driven by the larger number of processing plants. The dairy sector has the highest testing rate per processing plant, averaging over 630 tests per plant per week. The beef and poultry sectors perform the least number of tests per plant, averaging 369 tests per plant per week. The fruit and vegetable sector is currently the smallest of the four sectors, accounting for only 22.3 percent of all testing in the industry. However, the fruit and vegetable sector is becoming more of a focus by the USDA Food Safety Inspection Service (FSIS) and is expected to result in a substantial increase in pathogen testing in the next few years.

The combined U.S. sales of pathogen, pesticide, and GMO testing products used by food processors are projected to increase from $149.5 million in 2000 to $383.4 million in 2009 at a CAGR of 9.9 percent, as shown in table 2. Of the pathogen tests, bacteria are forecast to have the larger share (82 percent) of sales, as they are responsible for the bulk of illnesses and are routinely tested in food samples. Pathogen tests that screen for toxins are projected to have faster growth quickly and accurately. In 2000, the U.S. market for food testing products was close to $150 million. In 2009, it is estimated to be $383 million at a CAGR of 9.9 percent. These markets are expected to grow annually as legislation creates new standards for microbial monitoring. Products with quicker detection times and reusable features will be much coveted by those interested in real-time diagnostics of disease-causing pathogens. As the world becomes more concerned with safe and secure food, the demand for rapid biosensors will only increase.

To sum it up

There is a growing need for biosensors in the food industry. Potential markets include microbial food safety, food defense, pesticide residue screening, testing for genetically modified organisms, government inspection agencies, and anyone else seeking a diagnostic tool for detecting pathogens quickly and accurately. In 2000, the U.S. market for food testing products was close to $150 million. In 2009, it is estimated to be $383 million at a CAGR of 9.9 percent. These markets are expected to grow annually as legislation creates new standards for microbial monitoring. Products with quicker detection times and reusable features will be much coveted by those interested in real-time diagnostics of disease-causing pathogens. As the world becomes more concerned with safe and secure food, the demand for rapid biosensors will only increase.

**ASABE member Evangelyn Alocilja** is an associate professor, Michigan State University Department of Biosystems and Agricultural Engineering, East Lansing, USA, alocilja@msu.edu.

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**Table 1. U.S. food industry total microbial tests per sector.**

<table>
<thead>
<tr>
<th>Sector</th>
<th>No. of Plants (percent of total)</th>
<th>Total No. of Tests</th>
<th>Average No. of Tests (per plant per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef and Poultry</td>
<td>1,679 (28%)</td>
<td>32,212,471</td>
<td>369</td>
</tr>
<tr>
<td>Dairy</td>
<td>1,388 (23%)</td>
<td>45,887,576</td>
<td>636</td>
</tr>
<tr>
<td>Fruit/Vegetables</td>
<td>652 (11%)</td>
<td>13,981,305</td>
<td>412</td>
</tr>
<tr>
<td>Processed Foods</td>
<td>2,260 (38%)</td>
<td>52,196,282</td>
<td>444</td>
</tr>
<tr>
<td>Total</td>
<td>5,979 (100%)</td>
<td>144,277,634</td>
<td>464</td>
</tr>
</tbody>
</table>

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**Table 2. U.S. market for food testing products (Business Communications Company, 2000).**

<table>
<thead>
<tr>
<th>Segment (CAGR)</th>
<th>2000 (U.S.$ Millions)</th>
<th>2005 (U.S. $ Millions)</th>
<th>2009 (U.S. $ Millions)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathogens (9.4%)</td>
<td>122.6</td>
<td>192.5</td>
<td>302.3</td>
</tr>
<tr>
<td>Pesticides (7.7%)</td>
<td>8.9</td>
<td>12.9</td>
<td>18.7</td>
</tr>
<tr>
<td>GMO (13.6%)</td>
<td>18.0</td>
<td>34.0</td>
<td>64.2</td>
</tr>
<tr>
<td>Total (9.9%)</td>
<td>149.5</td>
<td>239.4</td>
<td>383.4</td>
</tr>
</tbody>
</table>

*Author’s estimate based on segment’s CAGR.
Extending the shelf life of foods by conventional thermal treatment is not only energy intensive but, in most cases, adversely affects the flavor, chemical composition, and nutritional quality of preserved foods. There is a great need for a nonthermal method of inactivating microbes that is safe, energy efficient, economical, socially and environmentally acceptable, and does not adversely affect the nutrition, texture, and flavor of treated foods. The aim in treating foods with thermal and nonthermal methods is to control harmful pathogens and food-spoilage microorganisms and enzymes. The emerging interest in using nonthermal technologies, such as pulsed electric field (PEF), ultrasound, ultraviolet, and high pressure to inactivate microorganisms in foods has led to many studies to investigate their efficacy and their mechanisms of inactivation.

**Pulsed electric field (PEF) technology**

The use of high-voltage electrical pulses in the inactivation of microorganisms suspended in pumpable media consists of using a capacitive electrical circuit that can temporarily store large amounts of electrical energy that can be discharged in a short period of time. Electric field strengths ($E_f$) from 10 to 100 kV/cm with pulse durations of microseconds ($\mu$s) are used to cause irreversible breakdown of cell membranes, resulting in cell death. Pumpable foods contain large concentrations of ions that act as electrical charge carriers and that can therefore conduct a pulse of electrical energy. The difference in electrical potential and the distance between the electrodes will create an electric field.

An electric field applied to a cell will result in an electric potential across the cellular membrane. Under normal conditions for many cells, the natural transmembrane potential (TMP) caused by the presence of ions is approximately 60 to 110 mV. If the TMP is sufficiently great, the membrane will undergo structural rearrangements and experience an increase in conductivity and permeability caused by the formation of pores in the membrane, known as electroporation. However, if a critical field strength ($E_c$) is applied for a sufficient amount of time, the cells may experience irreversible damage to the membrane. This usually occurs when the TMP reaches a value of approximately 1 V.

Since the effects of electrolysis, intense pressure shock waves, and heating of the food are considered undesirable, different research groups have constructed many novel PEF designs that include the use of various pulse waveforms and novel treatment chamber configurations.

**Parameters of PEF processing**

The lethal PEF effect is a function of electrical and food parameters, treatment temperature, and physiological status of microorganisms. The main parameters include the electric field strength, temperature, pulse waveform, shape, frequency, and width; treatment time, target microorganism, configuration and orientation of the treatment chamber; and physical properties of foods.

Most researchers agree that $E_f$ is positively related to microbial inactivation. However, the use of high $E_f$ is constrained to limits stipulated by medium characteristics where...
sufficiently large fields can cause dielectric breakdown of the food. Furthermore, critical treatment times ($t_c$) are necessary above the $E_c$ to cause irreversible pore formation in cell membranes. The process temperature is positively related to cell reductions due to a decreasing elastic modulus and critical breakdown potential in the cell membrane.

The pulse waveforms that have been used to date include square wave, exponential decaying, oscillatory, bipolar, and instant-charge-reversal (fig. 1). Square waves have shown the greatest effect on microorganisms since they operate at a maximum voltage for the duration of the pulse, whereas exponentially decaying pulses only retain the maximum voltage for a very short time. Similarly, oscillatory pulses also showed a lesser effect than square waves since they retain a maximum voltage for a short period of time and prevent continuous exposure at the high voltages. Bipolar pulses were even more lethal than monopolar pulses since the changes in polarity induce an additional stress to cell membranes. Instant-charge-reversal pulses are energy efficient. The amplitude of the reversed charge pulse is not enough to provide cell membrane breakdown, but it produces high alternating stress on the cell membrane, causing structural fatigue.

The treatment time is dependent on both the pulse width and the number of pulses. In general, increasing the treatment time tends to increase microbial reductions. However, an increase in the number of pulses results in a lower killing effect per pulse, and tailing kinetics have also been observed with increased treatment times.

Success in PEF inactivation rates depends on cell morphological characteristics such as cell size and shape. In general, yeasts (a prokaryote) are more sensitive to PEF than bacteria, while Gram-negative bacteria exhibit greater sensitivity than Gram-positive genera. Variability in the sensitivity to PEF among different strains of the same microbial species has also been seen. In general, microorganisms are most resistant to PEF in their lag and stationary phases of growth and are most sensitive during exponential growth phases.

In general, the inactivation of microorganisms by PEF is more difficult in real foods than in buffer solutions. The pH also has an effect on inactivation rates. The presence of bivalent cations reduces the lethal action, where they are assumed to play a significant role in membrane integrity.

**Inactivation of microorganisms and enzymes**

Many studies using PEF to inactivate microorganisms include a wide variety of microorganisms targeted in real foods or other suspending media using different treatment configurations. Numerous studies have achieved significant microbial reductions, others have found little or no success.

PEF-processed fruit juices have retained many of the characteristics of fresh juices while still achieving low microbial level. Vitamin C losses in orange juices have been minimal, with over 97 percent retention. The activities of polyphenol oxidase in apple cider and pectin methyl esterase in orange and tomato juices have also been reduced significantly. Lipase, glucose oxidase- and heat-stable amylase exhibited a vast reduction of 70 to 85 percent; peroxidase and polyphenol oxidase showed a moderate 30 to 40 percent reduction, while alkaline phosphatase only displayed a slight 5 percent reduction at 20°C ($68°F$) and 30 pulses of 80 kV/cm.

![Figure 1. Different waveforms of electric pulses that can be applied in PEF treatment: (a) exponential decay, (b) square, (c) oscillatory, (d) Instant charge reversal, and (e) bipolar exponential decay.](image)

![Figure 2. Common electrode configurations in pulsed electric field treatment chambers: (a) parallel-plate and (b) coaxial.](image)
The combination of different hurdles such as moderately high temperatures—<55°C (<131°F), antimicrobial compounds, and PEF have also been explored.

**Typical system components**

PEF systems typically contain a high-voltage pulse generator and a treatment chamber. Several treatment chambers have been designed. They can be categorized as two types: parallel plate and coaxial (fig. 2). Parallel plate chambers have been typically used in batch (or static) modes, while coaxial designs have been used in continuous modes where the medium is pumped through at a known flow rate and pulses are applied at a known pulse frequency. Other peripheral components include a heat exchanger to control process temperatures and an oscilloscope to observe electrode voltages, pulse waveforms, and pulse widths.

A general schematic of the components in the PEF system is shown in figure 3. A data acquisition system is needed to record waveform, electric field, number of pulses, flow rate, temperature, etc. In a typical pulse generator (fig. 4), the 110 V AC power supplied to the system is stepped up by a transformer and rectified to high-voltage direct current. The high voltage supplied to the capacitive circuit is discharged through the 40 kΩ resistors and the food cell load at a certain pulse frequency controlled by the pulse generator and thyatron switch.

Thus, to retailers, PEF offers longer shelf life due to lower initial microbial count. To consumers, PEF provides minimally processed, microbiologically safe, nutritious, fresh-like foods. Overall, foods retain their physical, chemical, and nutritional characteristics. To make this process commercially viable, innovations are needed to increase the capacity to treat large amounts of food, drastically reduce the equipment costs, and reduce energy per pulse to make PEF cost and energy effective.

**ASABE member Gauri S. Mittal** is a professor of food engineering, University of Guelph School of Engineering, Guelph, Ontario, Canada, gmittal@uoguelph.ca.
Challenge your friends, colleagues, and fellow students to a friendly 18 holes of golf at the ASABE Annual International Meeting in Reno, Nevada. Washoe County Golf Course—affectionately nicknamed “The Shoe”—has undergone many changes, but remains one of the most beautiful, playable tracks in the Truckee Meadows a favorite for its members, locals, and visitors alike.

Cost is $100 per person (portion tax deductible). Price includes 18 holes, cart, lunch, as well as gift packages, trophies, and prizes. Individuals register at www.asabe.org. For sponsorship information, visit the ASABE website.

The 3rd Annual Gale A. Holloway Memorial Golf Outing
Sunday, June 21, 2009

Following the prestigious Fellows Induction Ceremony, join us for dinner and an evening of musical entertainment at the Nugget Casino Resort. It is a short 5-minute ride from the Convention Center.

Dinner will be served in the lovely Poolside Terrace Room, followed by The New Christy Minstrels, an American folk music, Grammy-winning group that came to prominence in the 1960s. Formed by Randy Sparks, the group had several Top 40 folk music hits, including “This Land Is Your Land,” “Green, Green,” “Today,” and “Ramblin.”

Cost is $90 per person (portion tax deductible). Register at www.asabe.org.
Sponsored in part by Claude Brown, Ag Industrial Manufacturing, Inc.
Compared to manufactured products, it has been difficult to trace agricultural products in Japan due to the country’s complex logistical system. However, with consumers’ increasing demand for safe food, especially after breaking news about pesticide residues on imported vegetables and manipulated country-of-origin labels, information disclosure will be the key to solving these problems. A new on-line catalog for vegetables and fruits, called SEICA, may be able to ease consumer worries, and it may even revolutionize farm product logistics in Japan.

The added value of information

The internet promises to be an important tool for food traceability. The great strength of the internet is that anyone can retrieve on-line information for free or at low cost. The ability to sort and catalog vast amounts of information is another important feature of the internet.

With that in mind, the National Food Research Institute (NFRI) of Tsukuba City, Ibaragi Prefecture, initiated the SEICA project (http://seica.info) in the summer of 2002 as an on-line catalog of the vegetables and fruits produced and sold in Japan. SEICA is an official database developed in collaboration between government agencies, including the Organization of Food Structure Improvement (OFSI) and the NFRI. The most significant characteristic of the system is its free and open-access information, which significantly differs from conventional closed systems.

Food traceability is important for two reasons. First is the role it plays in product recalls and in tracking the supply chain in the event of food-related incidents. In addition, traceability provides added value, such as manufacturing information that promotes sales and ensures product quality. A typical example of the first role is beef, with its risks of contamination and spoilage, and an example of the second role is organic products.

SEICA focuses on this second role and aims to provide consumers with information as an added value.

Farm products that are carefully grown with the least amount of pesticide are inevitably expensive. However, consumers’ attitudes have shifted in recent years, and they are willing to accept higher prices for safe food. SEICA was created as a means for distributing such products and measuring their acceptance.

Increasing access to information

Producers register the place of origin, product classification, and cultivation method of the fruits and vegetables that they produce. An 8-digit catalog number is then automatically issued. Producers can then ship their product with this catalog number on the label. Consumers and logistics agencies, such as shippers and wholesalers, can access the SEICA website and search on the catalog number for the product specifications, history, and other production information.

For instance, let’s say you purchased lettuce that has a SEICA label and catalog number. Using that information, you can access the SEICA website on your PC, or on your mobile phone right in the store, and enter the number to see...
such product information as the region of production, the pesticides used and their purpose, the soil conditions, and the cultivation practices. In addition to text-based information, audio messages can show how the product is handled and packaged for shipping, what the production area looks like, and even who the producers are. Through the SEICA website, consumers can see firsthand the farmers’ passion for their products, their farming wisdom, and their agricultural technologies.

The main purpose of SEICA is to serve as a reference to help consumers choose safe food, but it is also beneficial to producers, as they can advertise their products directly to consumers and wholesalers. In addition, farmers can receive consumers’ feedback directly, so they can respond to consumer’s demands immediately. Wholesalers, shippers, and logistics agencies can also provide consumers with detailed product information as well as manage the supply chain more effectively. In short, SEICA will change the fundamental infrastructure of the fruit and vegetable industry. As of March 2008, the number of registered products exceeded 10,000. At the start of the project, most of the registered farmers were enthusiastic individuals; however, larger organizations, such as Japan Agricultural Cooperatives, have recently joined the system, and more products with the SEICA label will be appearing in stores.

Increasing the credibility of information

SEICA is a radical system in that it establishes an official outlet for disclosing the production history of food to the general public, but how is it actually going to be used? In addition, aren’t there some inherent risks, due to the system’s open-access structure?

These questions present an ongoing concern. In fact, before starting SEICA, an experimental operation called the virtually identified produce system (VIPS) was established by which users could check information on a website using tagged ID numbers. Sample products were selected for their high added value, such as premium soybeans and melons, and multiple experiments were conducted. Throughout the experiments, strong positive feedback was received from the participating consumers. Many producers indicated that they wanted to participate in such a project, so it was decided to apply this system on a larger scale, expanding it to all farm products.

The number of producers and consumers who wanted to access the website was much larger than expected. The catalog now accounts for 5 percent of all shipped food products in Japan, and the access is likely to increase annually. Many consumers also answer on-line questionnaires about product quality, and this information is quite useful to producers, too.

There were opinions that consumers’ main concern was the price, rather than the quality, of food products, and that providing further information would not be useful.
However, with consumers’ growing interest in all aspects of food production, the role of SEICA in ensuring food safety is becoming increasingly important.

There still are some problems to be solved. The most difficult problem is the matter of product disguise or misrepresentation. In order to deal with this, producers can now register up to three photographs of their product packaging and labeling information to prevent farm products from being disguised. As for false information, the system displays each product’s initial registration date and the validity period for its associated information, which is one year from the last update, so viewers can determine if a product’s information is out of date. Of course, since anyone can be a registered user, including not only producers but also wholesalers and shipping agencies, the information is not yet perfectly reliable. For now, we have to trust the registrars.

The fundamental purpose SEICA is the sharing of information. Storing so much information, and making it accessible to anyone at low cost, inevitably requires experimental attempts and readjustments. In consideration of this, SEICA has adopted an interface called XML Web Service to retrieve information from other websites and convert the information to its unique layout. The ideal system is about to be realized, in which official institutes administer basic information free of charge and private companies supply additional services using advanced information technology. SEICA proves that such a system is possible and that everyone, from producer to consumer, can benefit.

ASABE member Junichi Sugiyama is a laboratory head, National Food Research Institute, Tsukuba, Ibaraki, Japan, sugiyama@affrc.go.jp.

External Awards for ASABE Members

Many engineering and scientific organizations sponsor awards for outstanding individuals. Members of ASABE are eligible for nomination for many of these awards, which are external to our Society. The ASABE M-105 Committee on Coordination of Special Awards has compiled a listing of these awards, which is posted on the ASABE website under Awards, External Awards Listing.

This listing identifies the award sponsors and their websites. The name of the award, reason for recognition, nomination deadline, and the nature of the award are also listed. Nomination forms and further information are available on the sponsor’s website.

If you know an ASABE member who you believe is deserving of recognition, review the External Awards Listing on the ASABE website. If you find an appropriate match, proceed with the nomination preparation and submission. Recognition of ASABE members for their achievements brings credit not only to those individuals but to our Society, as well.

Sponsors of External Awards include the AAAS, AAES, ABET, ASEE, CAST, MIT, NAE, NSF, Sigma Xi, RNRF, SWE, SWCS, and the Wolf Foundation.
Unexplained disappearances, a baffling plague, an irreplaceable society crumbling: these are not the musings of a musty history textbook or war coverage from across an ocean. They are essential pieces of a modern-day mystery that spans the globe.

This is the story of honeybees, their struggle to survive and the secret they may have to saving themselves. It’s also the tale of three University of Minnesota College of Food, Agricultural, and Natural Resource Sciences (CFANS) investigators and their team, who hope to learn the bees’ secret and use it to save humans as well.

And it all began with a sore throat

Once upon a time, about seven years ago, a researcher from Ukraine working at the University of Minnesota medical school on lab trials to combat HIV came down with a cold. She, like countless people around the world, had always relied on a traditional treatment for such woes, a substance found in any honeybee hive: propolis.

Propolis, sometimes known as bee glue, is a thick, sticky resin that bees collect from tree buds and use to cement holes in the hive and defend it against invading parasites and diseases. Traditional healers from South America to China, Japan to Eastern Europe, have valued propolis as a remedy for such ailments as gum problems and dental health, skin issues and oral sores, as well as viruses and the common cold.

The researcher tracked down propolis at the Minneapolis, Minn., farmers’ market and made herself a tincture to soothe her viral woes. She brought her cure to work and ran a test: propolis versus HIV. Propolis won.

Propolis demonstrated antiviral activity against HIV, prompting a study on propolis that paired the medical school with a team of researchers from CFANS. That project showed promising results, but propolis is an incredibly complex substance, and the mystery of precisely which elements are active remained unsolved. The researchers involved, though, didn’t stop considering the study’s implications.

Where the bees are

“I started thinking, ‘Wait. If propolis is so good for humans, it’s also got to be good for bees,’” explains Marla Spivak, co-principal investigator in a new two-year project to identify the active compounds in honeybee propolis.

For the past several decades, bees have been stricken by parasites and viruses, introduced by humans and global movement, to the point that wild or feral honeybees have become virtually extinct, explains Spivak, a professor in the Department of Entomology and bee expert. In the past year, entire colonies have mysteriously disappeared, an epidemic bee experts have named Colony Collapse Disorder (CCD), which has decimated some beekeepers’ bee populations.

Spivak speculates that CCD could be the cumulative effect of diseases and parasites that affect only honeybees, new systemic insecticides, crop specialization, and destruction of native plant corridors, among other things. Whatever the cause, CCD threatens the pollinators of one-third of all U.S. food crops.

“Honeybees are a very ancient society. They’ve been closely associated with humans forever. As long as human history has been recorded, we’ve been beekeepers,” says
Spivak, citing the innumerable food crops humans rely on bees to pollinate, as well as honey and other hive products. “Now bees are suffering, and they’re suffering for reasons mostly that we’ve created.”

Spivak reasoned that a study could be designed to address both honeybee and human health. Testing chemical compounds against bee diseases can be done much quicker than with human subjects and could produce results that can quickly be applied to combat bee diseases. Those same results could then be tested against HIV and other human viruses. She enlisted two of her colleagues—Jerry Cohen and Gary Gardner from the Department of Horticultural Science from the university’s original propolis study—to join her on the project, which is funded by a grant from CFANS.

“I went to Jerry and said what would be really cool would be to analyze the components of propolis and to use the bee as a screen to quickly test which are active against bee diseases and bee viruses,” Spivak explains. “So I came up with the idea to use the bees as a screen, and they came up with the methods.”

According to the limited research available on the chemical makeup of propolis, it is composed of between 300 and 500 compounds. But the researchers are interested in things present in very small amounts that may be novel and active, so the number may be closer to 3,000 to 5,000. In order to purify a single compound, the researchers have to be able to analyze literally thousands of compounds. The key to analyzing so many compounds, and fractions of those compounds, is to create a process that can run a large number of tests of many different chemical compounds very quickly. In similar tests, such assays have taken longer because there was no screen with which to score relative antibacterial or antiviral activity.

“One of the limitations of the original project we worked with was that we had no rapid assay for biological activity,” Cohen says. “It involved harvesting cells from patients, so it wasn’t trivial. What makes the bee part of this project very important is that quick screening system for bee pathogens—bacteria that cause the death of bees.”

Using propolis supplied by Spivak’s contacts from countries around the world, as well as from her own hives on the

Marla Spivak harvests propolis from her hives on the University of Minnesota campus, as well as from contacts around the world. (Photos by David Hansen, courtesy of The University of Minnesota College of Food, Agricultural, and Natural Resource Sciences Solutions magazine)
St. Paul, Minn., campus, the study will identify any variations that arise from different plant sources in propolis from different locations, as well as any role the bees may have in altering its chemistry. The three professors collaborate with Lana Barkawi, a post-doctoral biochemist in Cohen’s lab, and toxicology Ph.D. student researcher Mike Wilson to create their new screening process.

The ultimate goal of the rapid assay will be to identify any new compounds—compounds that have not been identified or tested against HIV—that show anti-microbial activity, both toward bacteria and viruses using insect pathogens. Then the researchers will submit those compounds to an external service to do specific anti-HIV tests on enzymes unique to the virus.

“The danger with something like propolis, because it’s been looked at for literally millennia, is that you can move down the line and discover something that’s already known,” says Gardner. “Our focus is on two key terms: active and novel.”

Barkawi, who participated in the original HIV study, says the bee pathogen screen is an entirely practical step, because contract labs aren’t interested in getting huge numbers of fractions to run through their assays. “It’s how many compounds—thousands? And we’re looking for the needle in the haystack. There has to be a selection somehow.”

“We might find something novel that’s never been evaluated on HIV, or we might not,” Gardner says. “But we have this background in propolis and HIV expression, so it’s not like we’re saying we can cure AIDS because propolis is good.”

A broader forecast

“Of course, a long-term hope is that after testing propolis components on bee diseases and viruses, we can find components that would be really helpful to treat human viruses, and particularly an inexpensive treatment for HIV for developing nations,” Spivak says. But hopefully “within two years we’ll have identified fractions that are active against bee pathogens for sure, and hopefully bee viruses. Another application of this research is that beekeepers may be able to diversify their income by harvesting and selling propolis, so this can be lucrative for them.”

The researchers hope this study will have impacts beyond the initial identification of active compounds, like isolating other antimicrobial properties in the plant products, Cohen suggests. “Especially when you run into things like antibiotics with growing resistance. Most of our existing antibiotics come from fungal sources.”

They each credit the grant’s unique opportunity for interdisciplinary cooperation as the motivation for an investigation none of them would be able to perform on their own, and they foresee prospects of related inquiry. Gardner says that he and Cohen would be interested in following the plant agents in propolis back to their sources in individual plant resins.

But Spivak reflects on the dangers to her bees, their colonies, and beekeepers, and hopes for something different. “I really hope that bees change propolis when they collect it, because that leaves bees in the picture,” she says. “I want them to be indispensable, so that people maintain the bees, which are so important.”

Sara Specht is a writer and designer for the University of Minnesota College of Food, Agricultural, and Natural Resource Sciences publication, Solutions, wherein this article first appeared in the Winter 2008 issue, sspecht@umn.edu.
Today, much excitement in the agricultural sector is centered on producing biofuels or alternative “crops” of wind turbines that can provide additional income to farm operations. Yet many opportunities still exist for the sector to become more efficient in its own use of energy. Benjamin Franklin’s fiscal philosophy, “A penny saved is a penny earned,” applies to energy: If you save a British thermal unit (Btu), you don’t have to mine or pump it. Improving energy efficiency and conserving energy are nearly always less expensive than producing, transmitting, and distributing energy from any source—whether from a new coal-fired plant, natural gas-fired plant, or renewable energy facility. In fact, the USDA Resource, Education, and Economics (REE) Mission Area has dedicated one of its four goals to efficiency in its Strategic Energy Science Plan.

Energy efficiency is taking on new urgency in recognition of the serious economic, security, and environmental implications of fossil fuels. The wide fluctuations in the world price for oil over the last 12 months have had a particularly significant impact on farm operations, with farmers and ranchers having to cope with increasing costs of fuel, feed, and fertilizer. Depending on the region of the country and type of farming enterprise, energy-related expenses can range from 10 to 30 percent of operating costs. Rising energy costs place additional pressures on agricultural producers who already face narrow profit margins. In agriculture, the impact of oil and/or electricity price increases are potentially greater (especially for field crop production) than in most other sectors, given the need of farmers and ranchers for timely energy supplies and the limited scope for fuel switching. As cities, states, and regions respond with initiatives to reduce greenhouse gases generated from the use of fossil fuels, there is growing recognition that rural America is an important part of the energy equation and that opportunities for improved energy management have been relatively untapped in rural areas.

Productivity related to energy consumption

The spectacular rise in agricultural productivity in the United States is highly correlated with energy usage. Mechanization, which uses fossil fuels, and energy-intensive farming practices that rely on nitrogen fertilizer and other chemicals, are noteworthy examples. However, agriculturally linked energy is not limited to diesel fuel for tractors, natural gas used to make fertilizer, etc. Agricultural sector energy consumption encompasses the entire food
system—everything from agricultural production, through transport and processing of foods, to the electricity to run refrigerators in consumers’ homes. Although the amount of energy used in agriculture production (2.3 quadrillion kJ or 2.2 quadrillion Btus) is a relatively small percentage of total U.S. consumption, the energy use is much greater when the entire food system is taken into account (10.87 quadrillion kJ or 10.25 quadrillion Btus, or about 10 percent of all U.S. energy consumption).

**U.S. agriculture is using energy more efficiently**

To its credit, the agricultural sector has been using energy more and more efficiently in recent years, essentially producing more with the same amount of energy. Energy intensity (the ratio of total energy input to total output) dropped from 2.1 in 1970 to 0.65 in 2004. A major reason behind this efficiency increase is the shift to minimum tillage, no tillage, and/or reduced tillage on 40 percent of U.S. croplands, which greatly reduces fuel usage. To illustrate the effect of adopting energy-saving practices such as conservation tillage, it is interesting to note that the combined agricultural usage of gasoline and diesel fuel has fallen from a historical high of 29 billion L (7.7 billion gal) in 1973 to 17 billion L (4.6 billion gal) in 2002.

Other conservation practices, such as irrigation water management, have also reduced fuel consumption. In addition to energy savings, these practices provide obvious environmental benefits. By adopting more sustainable farming techniques, farmers are saving significant amounts of soil and energy, and tens of millions of dollars in labor and fuel costs.

**Upgrading equipment and reducing “food miles”**

A recent publication, “Clean Energy Farming” by the USDA Sustainable Agriculture Research and Education (SARE) program, highlights ongoing research and provides examples of farmers and ranchers who are employing energy-efficient practices to save energy as well as protect natural resources. One major focus area involves cutting costs and energy use by upgrading machinery and equipment (e.g., lighting, modifying irrigation systems from high to low pressure, use of variable-speed drives to run pumps in dairies, plate coolers that are simple heat exchangers between the warm milk in dairies and cold well or pipe water) and making buildings more energy efficient through proper insulation and windows. A big, potential energy saver involves reducing “food miles.” According to the Leopold Center for Sustainable Agriculture, food travels an average of 2,414 km (1,500 miles) before reaching the consumer. Community-supported agriculture, where members of a community invest in advance for a share of the harvest; direct marketing to local restaurants; and farmers’ markets and on-farm sales all offer simple ways to reduce energy expended on transportation.

**Saving energy in cropping systems**

The SARE program has funded research demonstrating how more diversified cropping systems could help to reduce fertilizers, pesticides, and other inputs that require energy-intensive production methods. For example, substituting manure for a ton of nitrogen fertilizer saves 1,133 cubic m (40,000 cubic ft) of natural gas and can reduce fertilizer costs by $85 per 0.4 ha (1 acre). Reducing water use through alternative cropping practices can also save significant amounts of energy.

SARE-funded research at Texas Tech University, led by scientist Vivien Allen, showed that farmers can successfully integrate pastures into existing cotton monocultures to reduce demand for water and energy. Instead of growing thirsty cotton on a continuous basis, farmers have started placing some cotton land into pastures for grazing livestock. Compared to continuous cotton, this integrated crop/livestock system requires 23 percent less irrigation, 40 percent less purchased nitrogen fertilizer, and fewer pesticides. Other research by Allen demonstrates, for example, that substituting forage sorghum for corn to make high-quality silage uses about one-half to one-third less irrigation water while netting similar yields and higher returns.

In the future, additional energy cost savings may be brought about as bioengineered crops “stack” multiple traits.
Herbicide- and insect-resistant crops generally mean lower pesticide use, require fewer trips across the field because of reduced spraying, and encourage the use of conservation tillage. Fewer trips mean lower energy costs. Scientists are searching to unlock genetic codes that will protect crops against environmental stresses (droughts, floods, and temperatures) and enhance a crop’s ability to utilize nutrients and water resources.

The USDA is also conducting research on improving the energy efficiency of grain drying, which currently accounts for over one-third of the direct energy used in growing corn. Many agricultural products, like corn and distiller’s grain (a by-product of ethanol production from corn), need to be dried for proper long-term storage or to reduce transportation costs. Most commercial cross-flow grain dryers require approximately 5,577 kJ (5,286 Btu) or more of energy consumption per kilogram (2.2 lb) evaporated. Typical heated-air dryers have warm and humid exhaust air streams. Transfer of thermal energy from the air exhaust streams to raise the temperature of incoming grain can substantially improve a dryer’s thermal efficiency. Researchers funded through a Small Business Innovation Research grant from the USDA Cooperative State Research, Education, and Extension Service (CSREES) are working with rotary drum dryers and have, to date, been able to achieve 1838 kJ/kg (790 Btu/lb) of water evaporated. Their goal is to achieve 1163 kJ/kg (500 Btu/lb) of water evaporated, which will represent a substantial reduction in the amount of energy needed for grain drying.

**Energy saving in animal operations**

Ongoing SARE research also demonstrates how diversifying animal operations can help to reduce dependence on energy-intensive annual feed crops and transportation as well as temperature-controlled livestock housing. Raising livestock on pasture improves animal well-being, water quality, and plant and soil health, while also providing habitat for wildlife.

Iowa State University’s Mark Honeyman advocates “deep straw” systems for hogs as a cost- and energy-saving measure. This system involves huts on pastures, deep bedding in hoop barns, or both. According to Honeyman, these systems are much less capital-intensive than confinement and offer additional efficiency opportunities: bedding compost inside the hoop structures provides natural heat, manure packs can be used as compost, and costly power fans for ventilating confinement buildings aren’t needed with these smaller structures because window and door openings provide enough natural air flow.

**Tools and on-farm audits to save energy**

The USDA has developed new risk management tools to address the costs of energy in energy-related production inputs such as the Energy Estimator. This program allows producers to make better input purchasing decisions, save energy, and even help with operating loan applications. The Energy Estimator was developed by the USDA Natural Resources Conservation Service (NRCS). It can be used to calculate and estimate an individual producer’s energy use and costs under alternative tillage practices. Energy Estimator tools have also been developed to save energy in applying fertilizer, in irrigation, and in animal housing.

The USDA-NRCS is also collaborating with ASABE to develop a new standard for performing on-farm energy audits in North America. The purpose of this proposed ASABE standard is to establish procedures for such audits to determine and document current energy usage. The procedures will also identify cost-effective alternatives and recommendations for energy conservation in the cultivation, protection, harvesting, processing, and storage of agricultural commodities and in the feeding, housing, and processing of farm animals and animal products. The goal is to have the standard completed and adopted early in 2009. (For persons interested in participating in the development of the standard, information is available at the end of this article.)

**Rural utilities can play an important role**

Rural electric utilities are becoming more interested in the potential to improve the efficiency of electricity use. Electricity used in agriculture and in the rural residential and commercial sectors (mainly in motors for compressors, fans, conveyors, irrigation and pumping; lighting; electronics; and resistance heating) provides many opportunities for energy savings. Residential and commercial buildings constitute the majority of rural electric loads in many parts of the country. According to a recent report by the Southwest Energy Efficiency Project on rural electric power efficiency, it is estimated that energy use and costs can be reduced by 20 to 40 percent in many rural areas by employing a range of no-cost, low-cost measures and practices with a payback of less than a year. Such measures include better control of lights, temperatures, and appliances; installing low-flow fixtures and investment-grade energy-efficiency measures such as retrofits of the building envelope; use of Energy Star appliances and high-efficiency heating and cooling equipment; and sealing leaky heating and cooling ducts.

The USDA/REE and the National Rural Electric Cooperative Association are in the final stages of completing a joint Memorandum of Understanding that will facilitate the sharing of energy efficiency information between the two organizations. The intent is to provide USDA Cooperative Extension agents with the most current information to allow them to collaborate with rural electric cooperatives in order to save energy in rural communities.

The USDA has also recently formed a Community of Practice (CoP) related to residential buildings to assist
Cooperative Extension agents in providing information on energy efficiency; purchasing more efficient equipment, materials and appliances; making changes in existing home structures for efficiency; and building more energy- and resource-efficient housing, including rentals. The Home Energy CoP is developing a national research-based website through extension with a focus on reducing energy use in rural and urban homes. Available 24 hours a day, seven days a week, the website will be accessible at the point of need and is planned to be operational within the next six months.

Rural Energy for America Program (REAP)
Grants and loan guarantees continue to be awarded through the USDA's Section 9006 Renewable Energy Systems and Energy Efficiency Improvements program, which began under the 2002 Farm Bill and is now known as the REAP program under Section 9007 of the 2008 Farm Bill. In addition to providing financial assistance to agricultural producers and rural small businesses to support renewable energy projects, REAP also provides support for energy efficiency improvements, helping recipients reduce energy consumption and improve agricultural operations. In August 2008, USDA Secretary Ed Schafer announced that 639 individuals and businesses in 43 states and the Virgin Islands had been selected to receive $35 million in grants and loan guarantees for renewable energy systems or to improve energy efficiency in farm and business operations.

Saving energy in food processing
Food and beverage processing are energy-intensive industries fueled by consumer trends toward highly processed and pre-packaged meals and snacks. The food and beverage industry is the fifth largest industrial user of energy. According to the U.S. Department of Energy, there is a large potential to save energy through the use of combined heat and power (CHP) technology. This technology recovers thermal energy (waste heat) that would normally be wasted in an electricity generator and uses it for processing raw materials or vents it into a chiller or desiccant for efficiencies up to 80 percent, as opposed to grid power at 33 percent. Reliable power from on-site CHP systems can increase productivity by keeping businesses online during power outages, as well as providing peak load reduction during periods of high electricity costs. Analysts have identified 42 sites throughout the United States in the food and beverage industry with 276 MW in CHP potential. Such technology would have a projected payback period of five years.

In short
Energy consumption is pervasive throughout the nation’s food system. Improving energy usage and management practices on farms and ranches, in food-related industries, and at the household level can provide significant cost savings while also stewarding natural resources and increasing sustainability. The adoption of innovative practices, materials, and products that reduce energy use will help to address the country’s serious economic and environmental issues.

For further information
www.usda.gov/ener/index.htm
USDA Energy Portal with comprehensive information on energy-related programs, funding opportunities, and technical support across all USDA agencies and offices.

USDA Resource, Education, and Economics (REE) Mission Area has dedicated one of four goals to efficiency in its Strategic Energy Science Plan.

www.nrcs.usda.gov/technical/energy/
USDA Natural Resources Conservation Service (NRCS) has developed four energy tools designed to increase energy awareness in agriculture and to help farmers and ranchers identify where they can reduce their energy costs. Tools are available for animal housing, irrigation, nitrogen, and tillage.

www.sare.org/about/
Websites with USDA Sustainable Agriculture Research and Education program publication, “Clean Energy Farming: Cutting Costs, Improving Efficiencies, Harnessing Renewables,” as well as a list of grants received by farmers, ranchers, and others who have implemented innovative SARE-funded research on energy efficiency and renewable energy.

http://attra.ncat.org/energy.php
National Sustainable Agriculture Information Service farm energy site listing publications, success stories, and links that explain how to make farm buildings more energy efficient, use the sun’s energy to heat greenhouses and pump water, choose and put up wind turbines, make and use biofuels, and more.

www.swenergy.org/

www.sentech.org/CHP4foodprocessing/potential.htm
Oak Ridge National Laboratory’s website examines Combined Heat and Power technology potential in the food and beverage processing industry.

New ASABE Standard Proposal for Performing On-farm Energy Audits
Persons interested in participating in the development of the standard may contact ASABE Standards Director Scott Cedarquist, 269-439-0300, cedarq@asabe.org. A current listing of all ASABE standards projects can be found on the ASABE website at www.asabe.org/standards/proposed.html.
The topic of “change” has been at the forefront of discussion in recent years. Emerging chaos in the form of rapidly shifting energy costs and the volatility of the financial markets has left us wondering about the future, and rightly so. Are these events isolated occurrences, or are they part of an emerging trend? And if the latter, what can we do to educate ourselves about the overriding forces that will inevitably shape the world around us?

A little background
My interest in understanding change began in 2005 when I participated in an ASABE session where each panelist projected his vision for the next 100 years. What I discovered in preparing for this session greatly excited me; that is, a relatively simple conceptual model seemed to work extremely well in helping me understand and communicate the root causes of change. Afterwards, I was encouraged to further develop the concept into book form. The result is a completed draft as a basis for offering workshops and seminars to a wide range of audiences. In fact, this will be the topic for an ASABE Senior Actives session at the 2009 Annual International Meeting in Reno, Nevada.

Overview of the Latesvology conceptual model
This conceptual model is called “Latesvology,” an acronym for the study (“ology”) of the linkages among technology, economics and societal values.” Latesvology’s premise is that these linkages are connected in the following ways (fig. 1):
- Investment in Technological Wherewithal yields more of it.
- The only purpose for Technological Wherewithal is to generate Affordable Choices.
- Variance in Societal Values increases as Affordable Choices increase.
- Consensus about Investment becomes increasingly more difficult as Variance in Societal Values increases.

Latesvology identifies many types of linkages that tie Affordable Choices to different types of Variance in Societal Values. No judgment is offered as to whether a type of Societal Variance is good or bad. When there’s a change in Variance, Latesvology’s premise is that opposing Societal Segments will arise, some supporting the change and others rejecting it. These differences of opinion will result in a Societal Pressure Point.

Opposing Segments always seek to reduce a Societal Pressure Point by lowering Societal Variance to levels that each views as acceptable. In doing so, each will employ some combination of economic, regulatory, conversion, isolationistic and/or violent actions. The Law of Diminishing Returns also plays a role in reducing Societal Variance by lowering the ability for Technological Wherewithal to generate more Affordable Choices (fig. 2).

Example of a Latesvology Societal Pressure Point
Latesvology closely follows two of the major assumptions of economics: that more is preferable to less, and that the desire for more can never be satisfied. In three of Latesvology’s linkages, increases in Technological Wherewithal yield more Affordable Choices with the following result:
- Material Values increase at the expense of Spiritual Values.
- Consumption associated with Necessities increases.
- Non-renewable resources decrease and costs increase, partly a result of the Law of Diminishing Returns (fig. 3).

Each shift in these balances results in a change in Variance. This change then generates a unique Societal Pressure Point, with certain Societal Segments having opposing views about whether the change is acceptable. Each opposing Segment will use some combination of economic, conversion, regulatory, isolationistic, and violent actions to reduce the source of Variance in the Societal Values to a level...
that it deems acceptable. Eventually, the prevailing Segment will determine the level of acceptable Variance in Societal Variance.

Anecdotal evidence that supports Latesvology

If the Latesvology conceptual model is correct, then it should be supported by a macro-view of world history. To test this hypothesis, a timeline of 7500 historical events related to various types of Technological Wherewithal and Societal Values was assembled. These events were then divided among well recognized historical time periods:

• Early Stone Age (from the beginning until 8000 B.C.)
• New Stone Age (8000 B.C.-3000 B.C.)
• Bronze Age (3000 B.C.-2000 B.C.)
• Iron Age (2000 B.C.-500 A.D.)
• Middle Ages (500 A.D.-1500 A.D.)
• Age of Discovery (1500 A.D.-1700 A.D.)

• Six different periods encompassing the Industrial Revolution to the present with a focus on U.S. history (1700-1775, 1775-1812, 1812-1861, 1861-1900, 1900-1945, 1945-2008).

Changes in the world’s annual population growth rate in each of these periods was used as a surrogate measure of the well-being of people as a whole and compared to advances in Technological Wherewithal. In doing so, it becomes readily evident that Latesvology’s premises are anecdotally true, and chaos is emerging.

Statistical evidence that supports Latesvology

If Latesvology is correct, then there should also be statistical data to support rapidly changing Societal Values, especially in the 20th century United States as the world’s largest economy and largest possessor of Technological Wherewithal. Accordingly, extensive statistical data were analyzed over a wide range of indicators of Societal Values. What is abundantly clear is that the Variance in Societal Values in the United States has greatly expanded in the 20th century, especially since the end of World War II. In fact, change is occurring so fast that it is likely that the world is entering a time of increasing chaos based on evidence that support the following projections:

• World population, consumption of goods and services, mining of resources, and Variance in Societal Values will all increase significantly.
• Environmental sustainability will become increasingly more difficult.
• Technological Wherewithal will increase only moderately as compared to the revolutionary advances of the 20th Century.

Latesvology provides a conceptual framework for understanding the root causes of change. Its value-neutral vocabulary allows those with different backgrounds, expertise, and perspectives to readily communicate in an open non-threatening, fact-based manner.

Validation of Latesvology comes from a combination of world and U.S. historical and statistical data. However, Latesvology’s approach is not limited to world affairs. It is equally valid in helping people of goodwill find solutions to problems facing organizations of all sizes, including governments, communities, businesses/industry, non-profits, families, and individuals.

Join us at the Senior Actives session this summer to learn more!

ASABE Past President Otto J. Loewer is Director and Professor, University of Arkansas Economic Development Institute, Fayetteville, Ark., ojl@uark.edu.
Carnegie Mellon developing automated systems to enable precision farming of apples and oranges

In Brief: Two groups of researchers at Carnegie Mellon University’s Robotics Institute have recently received a total of $10 million in grants from the USDA to build automated farming systems. One is for apple growers, and one is for orange growers, but both are designed to improve fruit quality and lower production costs.

Automated farming systems use sensors on autonomous robotic vehicles or at fixed sites within orchards to gather a multitude of data about tree health and crop status. Robotic vehicles will be used to administer precise amounts of water or agricultural chemicals to specific areas or trees. The vehicles also will be used to automate routine tasks such as mowing between tree rows.

The projects were funded through the USDA’s new Specialty Crop Research Initiative. The Comprehensive Automation for Specialty Crops (CASC) Program, led by Sanjiv Singh, research professor of robotics, received a four-year, $6 million grant to develop systems for the apple industry. The Integrated Automation for Sustainable Specialty Crop Farming Project, led by Tony Stentz and Herman of the Robotics Institute’s National Robotics Engineering Center (NREC), received a three-year, $4 million grant to develop systems for the citrus industry. Both project grants will be matched dollar for dollar by industry, state governments, and other funding sources.

“We are taking automation to a level never before demonstrated in an agricultural setting,” said Herman of the NREC project. “This will provide an early look at how the automated farm may someday operate and promises to deliver insights and lessons far beyond what should be expected from small demonstrations of autonomous scouts.”

“Mobile sensors and computer tracking will enable growers to monitor their orchards in unprecedented detail,”
said Singh. “Growers will receive early warning of diseases and insect infestations, as well as continuous updates on crop status. With this information, growers can make timely decisions that will save them money and improve the quality of their crop.”

Although Carnegie Mellon is not a university traditionally associated with agricultural research, the Robotics Institute’s Field Robotics Center has been involved in agricultural automation since the early ’90s and the NREC has worked with agricultural equipment manufacturers since it opened in 1996. Moreover, both organizations are experienced in managing research programs involving academic, industrial, and governmental researchers working closely with end users.

“This level of collaboration between academia, government, and industry is not at all common in agricultural research,” said Jim McFerson, manager of the Washington Tree Fruit Research Commission. The technologies developed will be applicable not only to apple and orange growers but to producers of all kinds of tree fruits, he added.

“Growers can use the data generated by this new approach to make decisions throughout the year regarding pest management, pruning, fertilization, irrigation, and yield estimates,” McFerson said. “We believe this will result in higher quality fruit at a lower per-unit cost, as well as a more productive and safer workplace.”

The CASC Program will work with apple growers in Pennsylvania, Oregon, and Washington and includes collaborators from Penn State, Washington State, Oregon State, and Purdue universities as well as the USDA Agricultural Research Service. Researchers will use a fleet of automated four-wheel vehicles that can perform multiple tasks, including tree monitoring and chemical spraying. Industrial partners include Toro, Trimble, Vision Robotics, IONco, and Sensible Machines.

The NREC’s Integrated Automation for Sustainable Specialty Crop Farming Project will deploy a fleet of networked, unmanned tractors in the orange groves of Southern Gardens Citrus (SGC), one of Florida’s largest growers. In addition to SGC, collaborators include researchers at the University of Florida, Cornell University, and Deere & Co.

Harvesting remains one of the most labor-intensive operations in orchards, but it also is very challenging to automate because of demanding handling and cost requirements. Both projects will investigate new designs for mechanical harvesters, including a vacuum-assisted device that the CASC will use for apple harvesting, but the emphasis will be on aiding human harvesters, rather than replacing them.

For more information contact Byron Spice, bspice@cs.cmu.edu or go to www.cmu.edu.
Clemson researchers’ EarthBottle made from plants soon in stores

In Brief: Environmentally friendly bottles filled with nutraceutical products made almost entirely from plants will soon be showing up on store shelves. They will be followed by pharmaceutical, functional foods, and body-care products.

The compounded resin formula behind the EarthBottle is the brainchild of Clemson University employees Danny Roberts, researcher and assistant vice president of Public Service and Agriculture, and David Gangemi, director of the Institute for Nutraceutical Research. These natural polymer-fiber bottles are recyclable, biodegradable, petroleum-free, stronger and lighter than glass, and more durable than most other bottles.

The materials have the potential to replace plastic for automotive parts, agricultural and industrial fabrics, and biomedical parts, among other applications.

The natural fibers are combined with polylactic acid, a plastic-like substance made from corn. The bottles are made by injection molding and injection blow-molding processes. Inhibitory agents rich in naturally occurring antioxidants and antimicrobial properties are added to protect the products inside the bottles.

“The concept of the EarthBottle is similar to that of the tissue scaffold used in biomedical engineering and regenerative medicine,” Gangemi said. “Both utilize organic substances to create a container, which is biodegradable and has the physical, chemical, and antimicrobial properties needed for a specific use. The EarthBottle protects contents from spoilage, and the scaffold provides an environment to encourage cells and tissue to regenerate. Neither has a need for or dependency on petroleum or hydrocarbon sources.”

“The development and commercialization of the first-to-market, 100 percent all-natural, biodegradable ‘bio-plastic’ bottle approximating or exceeding the performance characteristics of petroleum-based plastics have set the new benchmark for what is possible and practical,” said Bill Grass of Charleston, S.C., Green Energy Consultants. “EarthBottle is a great example of a leading university working with industry to create customer-driven products that not only make good business sense but are good for our environment.”

“We believe that the EarthBottle will become part of the green movement—a part of which is intended to rid our dependency on petroleum by 2025—and will play a major role in eliminating plastics and the non-biodegradable garbage that pollute our environment,” Gangemi said.

For more information contact Danny Roberts, dannyr@clemson.edu; Diane Palmer, spalmer@clemson.edu; or visit www.earthbottle.com/Home.html.

Nutrients in water may be a bonus for agriculture

In Brief: Agriculture producers may find they don’t have to bottle their water from the Texas Seymour Aquifer in the Rolling Plains to make it more valuable, according to Texas A&I Research scientists.

Researchers John Sij, Cristine Morgan, and Paul DeLaune have studied nitrate levels in irrigation water from the Seymour Aquifer of Texas for the past three years, finding nitrates can be as high as 40 parts per million. Though unacceptable for drinking, the water would benefit agricultural producers who use it for irrigation.

This high concentration of nitrates is a concern because it exceeds the federal safe drinking water standards. The aquifer is used as a municipal water source for several communities as well as some rural families.

“When you get more than 10 parts per million, it exceeds the federal limit,” Sij said. Nitrate levels range from 3 to 40 parts per million in the aquifer. The situation is being addressed by the Texas State Soil and Water Conservation Board, with grant funding from the Environmental Protection Agency.

Also working on the project are the Haskell, Wichita-Brazos, and California Creek Soil and Water Conservation districts, the USDA Natural Resources Conservation Service, Texas AgriLife Extension Service, Texas A&M AgriLife’s Texas Water Resources Institute, the Rolling Plains Groundwater Conservation District, and AgriLife Research.

“We don’t know what percentage of the nitrate is geologic in nature or what percentage is due to farming operations,” Sij said. “But if we take it into consideration in our fertility programs, we can mine the nitrogen and use it as a resource.”

Mining the water for nitrates, instead of putting in additional and sometimes unnecessary nitrogen, may also have the potential to improve water quality from the Seymour Aquifer, he said.
Ninety percent of the water from the Seymour is used for irrigation. For those agricultural producers, it could be a source of nutrients that could reduce fertilizer costs.

“We encourage the installation of subsurface drip irrigation systems where possible,” Sij said. This is thought to improve the water quality by reducing the nitrates, and to allow producers to realize the benefits of those nutrients supplied in the irrigation water.

Assuming a 20 parts per million nitrate concentration and just 30 cm (12 in.) of applied irrigation water per 0.4 ha (acre) over the growing season, approximately 25 kg (55 lb) of useable nitrogen per 0.4 ha (acre) can be applied to a cotton crop, DeLaune said.

This amount of nitrogen exceeds the 22.7-kg (50-lb) requirement for a bale of cotton, Sij said. With drip irrigation, it can be put into the soil around the roots and not lost through denitrification, as might occur through surface application of nitrogen.

“At nearly a $1 per 0.45 kg (lb) for fertilizer nitrogen these days, 25 kg ‘free’ (55 lb) nitrogen can add up to significant cost savings, about $55 per acre or more, for producers who irrigate their crops with high-nitrate groundwater,” DeLaune said.

The 68 kg (150 lb) of nitrogen needed to grow three-bale cotton can be reduced if producers learn to take into account what is already in the soil and, now, what is in the water, he said.

“They need to know both those numbers before planning their fertilizer program,” Sij said. “Of course, other nutrients like potassium and phosphorous must be adequate to take advantage of nitrates in the irrigation water as well as any applied fertilizer nitrogen. Producers should have their irrigation water analyzed for nitrate annually and make allowance for this free nitrogen source when determining crop fertilizer needs.”

For more information contact John Sij, Texas A&M AgriLife Communications, jsij@ag.tamu.edu.

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Waste coffee grounds offer new source of biodiesel fuel

In Brief: Researchers in Nevada are reporting that waste coffee grounds can provide a cheap, abundant, and environmentally friendly source of biodiesel fuel for powering cars and trucks.

In the new study, Mano Misra, Susanta Mohapatra, and Narasimharao Kondamudi note that the major barrier to wider use of biodiesel fuel is lack of a low-cost, high quality source, or feedstock, for producing that new energy source. Spent coffee grounds contain between 11 and 20 percent oil by weight. That’s about as much as traditional biodiesel feedstocks—rapeseed, palm, and soybean oil.

Growers around the world produce more than 2.2 billion kg (16 billion lb) of coffee each year. The used or “spent” grounds remaining from production of espresso, cappuccino, and plain old-fashioned cups of java often wind up in the trash or find use as soil conditioner. The scientists estimated, however, that spent coffee grounds can potentially add 1,287 million L (340 million gal) of biodiesel to the world’s fuel supply.

To verify this, the scientists collected spent coffee grounds from a multinational coffeehouse chain and separated the oil. They then used an inexpensive process to convert 100 percent of the oil into biodiesel.

The resulting coffee-based fuel—which actually smells like java—had a major advantage in being more stable than traditional biodiesel due to coffee’s high antioxidant content. Solids left over from the conversion can be converted to ethanol or used as compost, the report notes. It is estimated that the process could make a profit of more than $8 million a year in the United States alone. They plan to develop a small pilot plant to produce and test the experimental fuel.

For more information contact Michael Bernstein, m_bernstein@acs.org, American Chemical Society, or Mano Misra, Center of Materials Reliability, University of Nevada-Reno.
Food safety developments are in the air

In Brief: An experimental treatment from the Agricultural Research Service (ARS) could one day help protect some fresh produce from potentially dangerous microbes such as Salmonella, Listeria, and Escherichia coli O157:H7.

The treatment relies on cold plasma, which is generated when some form of concentrated energy—in this case, electricity—is introduced into a gas until free electrons are torn from the gas’s atoms.

This plasma-forming process is related to the technology used to create plasma for computer chips. But in addition to increasing conductivity, the process of turning gas into plasma has an antimicrobial effect. ARS researchers aren’t the first to harness this technology for food safety purposes, but their method of production has the potential for increased efficiency and lower costs when applied at a larger scale.

To make plasma, other food safety scientists use gas mixtures that include exotic gases like helium or argon, but the ARS team is using the cheapest gas mixture available: air.

In addition to its economic benefits, air—unlike other gases—doesn’t need to be confined to a closed chamber during plasma production. This means that at a pilot scale, this particular method of plasma treatment could be done continuously, on a conveyor belt, which would translate to better efficiency and increased cost savings.

At the ARS Eastern Regional Research Center in Wyndmoor, Penn., microbiologist Brendan Niemira and engineer Joseph Sites—who are developing the process—exposed Golden Delicious apple samples to various microbial pathogens. Then they treated the samples with plasma.

The scientists observed that any exposure to the plasma resulted in a significant reduction in pathogen numbers without harming the apples. Raising the air flow rate and length of exposure increased the antimicrobial activity.

The research was conducted at a laboratory scale and is still in experimental stages. Future studies will include other types of produce and expand the scale of the plasma-creation process.

For more information contact USDA-ARS public affairs specialist Laura McGinnis, Laura.McGinnis@ars.usda.gov.misra@unr.edu.

Across the Americas, squash and gourd bees are superb pollinators

In Brief: Acorn squash and other winter squashes at the local supermarket likely got their start months ago, when their colorful blossoms were pollinated by hardworking bees. An ongoing, science-based census called “Squash Bees of the Americas” is providing new information about the abundance of these bees and their excellence as squash and gourd pollinators.

Agricultural Research Service (ARS) entomologists Blair Sampson, James Cane, and Frank Eischen are among the researchers and other specialists who document their observations for this international survey of 20 or so wild, indigenous bee species.

With tongue extended, a female Peponapis bee sips nectar from a yellow squash flower. (Photo by Jim Cane, courtesy of USDA-ARS)
Cane, based at the agency’s Pollinating Insects Biology, Management and Systematics Research Unit in Logan, Utah, originated the survey. Eischen, at the ARS Honey Bee Research Unit in Weslaco, Texas, has contributed three years’ worth of data about squash pollinators of the Rio Grande Valley. Sampson, at the ARS Southern Horticultural Laboratory in Poplarville, Miss., has scrutinized bees pollinating pumpkin, zucchini, and crookneck and straightneck squash in fields near his laboratory.

According to Sampson, the pollinators that he studied—primarily *Peponapis pruinosa* and *Xenoglossa strenua*—appear to have all five traits of the world’s most proficient pollinators: they are fast, efficient, competitive, abundant, and consistent in their choice of crop.

These and other bee investigations at the three labs provide new insights into how growers, commercial and hobbyist beekeepers, and backyard gardeners can enhance populations of wild bees that pollinate crop plants. These bees augment the work of America’s top pollinator, the European honey bee, *Apis mellifera*.

Today’s honey bees not only have to deal with the still-puzzling colony collapse disorder, but also face on-going hassles from the usual sources—mites, beetles, disease organisms and Africanized honey bees.

For more information contact Marcia Wood, ARS Public Affairs Specialist, Marcia.Wood@ars.usda.gov.

**ALMANAC may predict crops’ role in bioenergy production**

**In Brief:** Computer model ALMANAC promises to provide answers to a key issue facing agriculture today: the management of crops such as corn and switchgrass for bioenergy production.

ARs Grassland Soil and Water Research Laboratory agronomist Jim Kiniry and his colleagues in Temple, Texas, developed ALMANAC as a crop-management tool, and then updated it as a pasture management tool. Now it is being used to evaluate biofuel crops.

After its development in Texas, the model was tested in northern states. It accurately predicted switchgrass yields in ten fields in North Dakota, South Dakota, and Nebraska. The model’s predicted yields were within 1 to 10 percent of actual yields over all fields.

In another study with northern and southern populations of upland and lowland switchgrass, the model showed realistic simulated yields in Wisconsin, Kansas, and Oklahoma. In these studies, the measured yields ranged up to 6.7 tons per 0.4 ha (1 acre).

Kiniry and colleagues simulated growing corn and four varieties of switchgrass in the southern and northern Great Plains and the Corn Belt. ALMANAC projected that switchgrass would use only half as much water per 0.5 kilo (1 lb) of material produced as corn grown for grain.

ALMANAC’s estimated switchgrass water-use advantage was reduced when model inputs specified that entire corn plants were to be used for ethanol production rather than just the grain. In this way, ALMANAC helps farmers determine the most appropriate crop for their fields under current market and environmental conditions. By predicting outcomes on arid rangeland, marginal lands, and more fertile lands like the Corn Belt, ALMANAC can alleviate concerns about shifting acres from food to fuel.

For more information, ALMANAC is online at www.ars.usda.gov/Main/docs.htm?docid= 16601, or contact Don Comis, ARS Public Affairs Specialist, Donald.Comis@ars.usda.gov.
PROFESSIONAL OPPORTUNITIES

Resource is published eight times per year: January/February, March, April/May, June, July/August, September, October/November, and December. The deadline for ad copy to be received at ASABE is four weeks before the issue’s publishing date.

Advertisements are $125 per column-inch length (column width is 3.5 inches) and include free placement on the ASABE Career Center at www.asabe.org/membership/careercenter.htm. The minimum ad size is 2 inches—approximately 100 words—to qualify for the free online listing. Ads are posted on the Web site within three business days of final approval and remain there for 30 days. If the insertion order is for two months, the cost is $110 per column inch per insertion and includes a 60-day free web listing.

For more details on this service, contact Melissa Miller, ASABE Professional Opportunities, 2950 Niles Road, St. Joseph, MI 49085-9659, USA; 269-429-0300 ext. 317, fax 269-429-3852, miller@asabe.org, or visit www.asabe.org/resource/persads.html.

SUPERVISORY RESEARCH SCIENTIST/RESEARCH LEADER

The USDA-ARS is seeking a Supervisory Research Scientist/Research Leader for the Watershed Physical Processes Research Unit at the National Sedimentation Laboratory at Oxford, Mississippi. The mission of the WPP Unit is to conduct high priority research on erosion runoff and sediment yield from agricultural watersheds, on stream channel stabilization and restoration, identify solutions in high demand by our natural resources users and stakeholders, and to transfer findings and technology to State and Federal agencies working on similar problems in other parts of the country. This research is urgently needed to solve agricultural-related stream degradation and sediment pollution problems that are of concern nationwide. U.S. citizenship is required. Salary range: $95,010.00-$145,290.00 PA. For more details and directions see http://www.afm.ars.usda.gov/divisions/hrd/index.html.

Announcement number is ARS-X9S-0060. Announcement closes March 27, 2009. For questions you may contact Dr. Mathias Romkens @ 662-232-2940 or e-mail: matt.romkens@ars.usda.gov.

ASSISTANT PROFESSOR IN BIOENERGY

The Department of Agricultural and Biological Engineering at Mississippi State University is seeking applications for an assistant professor position in the area of bioenergy. The position will be approximately 50% research and 50% teaching, with a 9-month tenure track appointment. The person will be expected to develop and obtain extramural funding for a comprehensive research program in bioenergy systems which will become nationally recognized. The program could include such applications as biomass gasification, biodiesel development, and feedstock handling/conditioning which are all ongoing research areas in the department.

Interest and/or expertise in bioenergy is required, and supporting expertise in bioprocessing, biochemical/thermocatalytic conversion, or bioenvironmental engineering would be considered complementary and desirable. The individual will be expected to participate in teaching in the Biological Engineering and Agricultural Engineering Technology and Business curricula, to conduct research, and to interact with and advise undergraduate and graduate students. The successful candidate should have excellent communication skills, a strong chemistry background, a demonstrated record of scholarship, and evidence of the potential to secure extramural funding. A Ph.D. in Biological Engineering, Chemical Engineering, Agricultural Engineering, or other related field is required. Submit application letter, vita, brief statement of teaching philosophy, research plans, and contact information for three references to: Steve Elder, Department of Agricultural and Biological Engineering, Mississippi State University, P.O. Box 9632, Mississippi State, MS 39762. Electronic submissions may be sent to: selder@abe.msstate.edu. Application review will begin April 1, 2009 and continue until a suitable candidate is identified. Mississippi State University is an Equal Opportunity Employer. Women and minorities are encouraged to apply.

ASSISTANT PROFESSOR IN WATER RESOURCES

The Department of Agricultural and Biological Engineering at Mississippi State University is seeking a tenure-track Assistant Professor in the water resources area. The position requires a Ph.D. at the time of appointment in Biological, Agricultural, Environmental, or a related engineering discipline. Candidates must be capable of developing and sustaining a strong externally-funded research program in their areas of expertise and should demonstrate a strong interest in teaching undergraduate and graduate courses. Training and/or experience in GIS, water quality modeling, mapping, and land surveying are desirable. Submit application letter, vita, brief statement of teaching philosophy, research plans, and contact information for three references to: Thomas Cathcart, Search Committee Chair, Department of Agricultural and Biological Engineering, Mississippi State University, Mississippi State, MS 39762. Electronic submissions are preferred and should be sent to: tc@abe.msstate.edu. Application review will begin April 1, 2009 and continue until a suitable candidate is identified. This position has an expected start date of August, 2009. Mississippi State University is an Equal Opportunity Employer. Women and minorities are encouraged to apply.

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Assistant Professor of Biological and Agricultural Engineering

Water Resources Engineer

University of Idaho Water Center, Boise, Idaho

1st review begins 3/15/09. Questions may be addressed to Dr. Richard Allen, Search Committee Chair, at rallen@kimberly.uidaho.edu or (208) 423-6601. To apply visit www.hr.uidaho.edu, Current Job Openings, Faculty Job #10001078720. AA/EOE

AGRICULTURAL & BIOLOGICAL ENGINEERING

ASSISTANT PROFESSOR IN BIOENERGY

The Department of Agricultural and Biological Engineering at Mississippi State University is seeking applications for an assistant professor position in the area of bioenergy. The position will be approximately 50% research and 50% teaching, with a 9-month tenure track appointment. The person will be expected to develop and obtain extramural funding for a comprehensive research program in bioenergy systems which will become nationally recognized. The program could include such applications as biomass gasification, biodiesel development, and feedstock handling/conditioning which are all ongoing research areas in the department.

Interest and/or expertise in bioenergy is required, and supporting expertise in bioprocessing, biochemical/thermocatalytic conversion, or bioenvironmental engineering would be considered complementary and desirable. The individual will be expected to participate in teaching in the Biological Engineering and Agricultural Engineering Technology and Business curricula, to conduct research, and to interact with and advise undergraduate and graduate students. The successful candidate should have excellent communication skills, a strong chemistry background, a demonstrated record of scholarship, and evidence of the potential to secure extramural funding. A Ph.D. in Biological Engineering, Chemical Engineering, Agricultural Engineering, or other related field is required. Submit application letter, vita, brief statement of teaching philosophy, research plans, and contact information for three references to: Steve Elder, Department of Agricultural and Biological Engineering, Mississippi State University, P.O. Box 9632, Mississippi State, MS 39762. Electronic submissions may be sent to: selder@abe.msstate.edu. Application review will begin April 1, 2009 and continue until a suitable candidate is identified. Mississippi State University is an Equal Opportunity Employer. Women and minorities are encouraged to apply.
BIOENERGY TECHNOLOGY FACULTY POSITION

Applications for a 12 month tenure track Extension Specialist in Bioenergy Technology are invited. The extension specialist will be expected to conduct research on and to build a nationally recognized program in waste-based/agriculture-based bioenergy technology. The extension specialist will also be expected to contribute to state-wide efforts to build the capacity and infrastructure needed for bioenergy and biorefinery development, particularly in energy from waste-based resources.

The extension specialist will also serve as Director of the Rutgers EcoComplex and will be housed at this off-campus center in Burlington County, New Jersey. The Rutgers EcoComplex, a unit of the New Jersey Agricultural Experiment Station (NJ AES), is a research and outreach center that serves as a university-based resource hub for the state’s environmental and renewable energy industries.

Minimum qualifications or equivalent combination of education & experience: PhD in engineering, plant science, environmental science or similar discipline, with appropriate expertise in biofuels in particular. Must be currently at the associate or full professor level. Must also have a strong desire and ability to meet the Land Grant mission of extending knowledge and research to the people of the state. Must demonstrate a track record of strong leadership and team building skills.

Academic Rank: Extension Specialist (12 month, tenure track, Associate or Full Professor equivalent)

Salary: Highly competitive and commensurate with experience

Benefits: Excellent personal benefits package is provided, including one month of annual leave per year, health insurance, retirement program, and other institutional benefits.

Other information: The search will continue until the position is filled, but applicants are encouraged to submit applications by March 15, 2009.

For more information please contact: Margaret Brennan-Tonetta, Associate Director, New Jersey Agricultural Experiment Station, Rutgers, the State University of New Jersey, 88 Lipman Drive Rm 113, New Brunswick, NJ 08901, phone: 732-932-1000 x569, fax: 732-932-4176, email: Brennan@aesop.rutgers.edu

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Political and economic realities are causing scientists to join forces to fulfill the vision of growing energy and converting agricultural and forestry waste into a viable source of energy. Universities and ARS stations around the country are leading the way in diverse areas of bionenergy research such as ethanol, pyrolysis, combustion, gasification, biomass crops, and methane production. Universities and researchers are trying to showcase their research projects. For example: foresters talk about woody biomass, fermentation scientists discuss the latest fermentation process for ethanol production from lignocellulosic material and the pretreatment of cellulose, and agronomists discuss biomass crops like switchgrass and napier grass, while others discuss algae.

All of these scientists are trying to disseminate their research knowledge while they’re often unaware of others’ work. This not only causes significant confusion in the general public but it also leaves potential biomass growers in a dilemma. asking, “What biomass shall I grow and who will buy and process it?” To get simple answers, growers often look to their first source of knowledge, county agents. For their part, industries often ask, “Which biomass crop has the most potential when processed through various bioenergy platforms like combustion, gasification, ethanol, biodiesel, pyrolysis, or anaerobic digestion?”

This leads to one of the greatest challenges that cooperative extension is facing in every state: How do we transfer knowledge to our clients about processes for the conversion of biomass to energy when complete information on the current technology and research is rarely available or is still under research?

To transfer knowledge, skill, and motivation to the individuals that make things happen in the real world, the very first step in the bioenergy extension program should focus on strategies for community involvement and present basic information about biofuel production. This should include an overview, current status, feedstock production and pre-processing, conversion technology, economics, regulations, environmental impacts, etc. Communities enriched with such basic information will actively participate in later extension activities.

The second step for bioenergy extension should address skill and motivation issues using demonstrations and successful case studies. An example is a demonstration of anaerobic digestion systems for waste treatment to produce biogas, reduce capital costs, develop new value-added products, improve farm nutrient management, reduce greenhouse gas emissions, seek carbon credits, and improve water quality. Included in this should be the development of regional bioenergy teams comprised of local stakeholders from government, the private sector, and universities. These teams can better define a community’s potential for developing a bioenergy project.

Extension programming should also provide communities with the tools they need to take advantage of bioenergy opportunities in an environmentally sustainable manner that maximizes local economic benefits. An example of such a program is developing energy crops with minimum non-renewable inputs, proper supply chain logistics, and low environmental impacts, but maximum fuel production per unit biomass.

The results of such extension programs will lead to rural economic development through alternative enterprises such as Cherry Central, a cooperative of cherry farmers in Michigan. New bioenergy extension programs must also take advantage of existing infrastructure and technologies such as E-extension, state bioenergy conferences, the efforts of DOE, EPA, and ASABE and its publications, and other similar professional platforms.

ASABE members Kaushlendra Singh (ksingh1974@gmail.com), Gary Hawkins, John Worley, and Mark Risse are affiliated with the University of Georgia Department of Biological and Agricultural Engineering, Athens, USA.
ASABE 2009 provides a forum to expand awareness of current industry trends, promotes and acknowledges innovations in design and technology, offers opportunities in furthering education through professional development courses and technical sessions and provides a focus on the economic, political and society impacts facing the industry. Join us for 4 days in exciting Reno, Nevada this June!

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