NABC news

Fall 2009 No. 39

Providing an open forum for exploring issues in agricultural biotechnology

NABC'S PRINCIPAL OBJECTIVES ARE TO:

- *provide an open forum for persons with different interests and concerns to come together to speak, to listen, to learn, and to participate in meaningful dialog and evaluation of the potential impacts of agricultural biotechnology*
- *define issues and public policy options related to biotechnology in the food, agricultural, biobased industrial product, and environmental areas*
- *promote increased understanding of the scientific, economic, legislative, and social issues associated with agricultural biotechnology by compiling and disseminating information to interested people*
- *facilitate active communication among researchers,administrators, policymakers, practitioners, and other concerned people to ensure that all viewpoints contribute to the safe efficacious and equitable development of biotechnology for the benefit of society*
- *sponsor meetings and workshops and publish and distribute reports that provide a foundation for addressing issues.*

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Letter from the Chair....

MARK R. MCLELLAN
NABC CHAIR 2009-2010

Is there opportunity ahead? After a year of wondering how agriculture could be missed as an economic stimulus opportunity, many of us in the research trenches were dazed. As billions were piled on to the acronyms of NIH, NSF, DOE and many others, primary agricultural research was simply stepped over. Our food system is a victim of its own success in producing more with only 2% of our population involved, and, thus, many think that food comes from the grocery store with no knowledge of, nor interest in, the varied sources of our agricultural food supply. This is hard to believe when, in many communities this past year, agriculture helped hold the fabric of state economies together—a pillar, a foundation, upon which all could count[1][2][3].

As many of our best scientists eyed the opportunity for funding away from their passion of agricultural issues, a new USDA undersecretary for Research, Education and Economics and chief scientist has been appointed, Dr. Rajiv Shah[4]. He brings a keen eye to research, honed in the heady halls of the Gates Foundation where a "can do" attitude is coupled with jump-start funding focused on the principle of getting to a solution. Not shackled to old ways and old ideas, Dr. Shah has already shaken the soil we work on with clear expectations of high science not for the sake of science but rather for the accomplishment of far-reaching goals. Dr. Shah has in his team the presidential appointment of Dr. Roger Beachy as the first director of the US National Institute of Food and Agriculture[5]. Bringing extraordinary experience as a scientist to agriculture's corner of Washington power, Dr. Beachy will add to Dr. Shah's ability to steer the ship and demand reasonable funding for research supporting the agricultural fabric of America and the fundamentals of all people: access to a safe, abundant and affordable food supply. Does this change in Washington bring a sense of opportunity? Maybe. Maybe not. But it surely kindles the fires of hope in our finest agricultural researchers across the United States and the world.

We have an opportunity for a golden age for agricultural research as the primary engine behind achieving a doubling of global food production by 2050 to nourish 9+ billion people. In addition, ag research will make major contributions to energy production, human healthfulness, global-climate stabilization and improved efficiency of water use, with maximum sustainability and minimum environmental footprint. The twenty-first century multifunctional role of ag research will position it as a high-priority public-sector investment.

It struck me with the preparation of this column that many do not know of NABC and the leading role it has played in delivering this message over the past decade. Formed in 1989 by senior management of major public-sector ag-research institutions in the United States and Canada to provide an open forum for

continued on Page 7

1 http://edis.ifas.ufl.edu/FE800.

2 http://www.boston.com/news/local/articles/2009/08/06/in_tight_economy_small_farms_and_local_produce_gain_favor/.

3 http://www.mlive.com/news/muskegon/index.ssf/2009/02/sat_states_agriculture_economy.html.

4 http://www.csrees.usda.gov/newsroom/newsletters/update09/061009_.html.

5 http://stlouis.bizjournals.com/stlouis/stories/2009/09/21/daily53.html?t=printable.

NABC 22 — Mark Your Calendars
Davis, California, June 16–18, 2010

Promoting Health by Linking Agriculture, Food, and Nutrition

Ann King Filmer
University of California, Davis

The linkages between diet, nutrition, and health are of increasing interest to researchers, the medical profession, healthcare policymakers, and the general public. Much interdisciplinary research is addressing the interactions of food and health, the prevention of disease by diet, and the roles of agriculture and biotechnology in food production, particularly as they relate to health. These topics will be addressed at NABC's twenty-second annual conference, *Promoting Health by Linking Agriculture, Food, and Nutrition*, hosted by the University of California, Davis (UC Davis), June 16–18, 2010.

The interrelationships among agriculture, food, nutrition, and health are a strong focus of research at UC Davis and many other institutions. UC Davis has established a Foods for Health Institute, which comprises researchers in the plant and animal sciences, nutrition and food science, health sciences, engineering, biological sciences, and veterinary science. The institute's core components include research and outreach in the areas of medicinal nutrition, food engineering and processing, quality of life, policy analysis and education methods.

Speakers at NABC 22 will include agricultural, food, and biotechnology researchers, medical professionals, and key industry representatives. The program is geared toward professionals in these fields, along with government officials and NGOs, journalists, and the general public.

The program will include keynote speakers, several sessions with multiple speakers, and breakout groups. Preliminary planned sessions (subject to change) include:

- Agriculture, food and health: the problem and the solution (a big-picture overview of ag, food and health)
- Food for health successes and prospects (the development of foods with health benefits and the role of agricultural research)
- Choosing foods for health (the behavioral, social, cultural, ethical, and religious dimensions of eating behavior and food selection, including nutrition profiling)
- Emerging regulatory frameworks for food-health claims (the directions of the regulatory environment and labeling requirements in the United States and globally)
- Food-for-health strategies and programs (programmatic approaches in the public and private sectors to develop foods for health, including school-lunch programs)

We look forward to presenting a stellar and timely conference. The full program, along with registration and travel information, will be posted at http://nabc.ucdavis.edu as it develops.

The timing and location of NABC 22 will be favorable for family-holiday travel. UC Davis is a 90-minute drive from the San Francisco Bay Area, a 60-minute drive from the Napa Valley, and a 2-hour drive from Lake Tahoe.

Please direct questions, comments and suggestions on NABC 22 to:

Alan Bennett
Program Committee Chair
(530) 752-1411
abbennett@ucdavis.edu.■

Visit the NABC 22 Website at
http://nabc.ucdavis.edu/
for details on the program, registration, accommodations and travel planning.

Overview of NABC 21

Adapting Agriculture to Climate Change

NABC's twenty-first annual conference convened in Saskatoon, June 24–26, 2009, hosted by the University of Saskatchewan. The sixty delegates were welcomed by Graham Scoles (NABC-21 program chair, acting dean of the College of Agriculture and Bioresources), Peter MacKinnon (president of the University), Alanna Koch (Saskatchewan Ministry of Agriculture) and Allan Eaglesham (NABC executive director, for NABC President Ralph Hardy). Plenary sessions were held on the afternoon of June 24, the morning and afternoon of June 25, and the morning of June 26.

The keynote speaker at the June 25 banquet—held at the Western Development Museum—was Sylvain Charlebois (associate dean and director of the Levene Graduate School of Business at the University of Regina, Regina) whose presentation was titled *Opportunities of the Commons: Agriculture's New Frontier*.

The conference was structured in four modules, after each of which two parallel breakout sessions were scheduled (see p. 5). The breakout session after module 2 was cancelled due to over-run of the prior, lively Q&A session. Three panelists reacted to the plenary presentations with brief remarks after Modules 2, 3 and 4, after which Q&A sessions involved audience participation (including Module 1)[1].

Module 1—*Climate Change Overview and Projections*—comprised presentations by Francis Zwiers (Canadian Centre for Climate Modelling and Analysis, Toronto, *Our Evolving Climate*), Raymond Desjardins (Agriculture and Agri-Food Canada, Ottawa, *The Impact of Agriculture on Climate Change*), and Linda Mearns (Institute for the Study of Society and Environment, Boulder, *The Impact of Climate Change on Agriculture*).

In Module 2—*Genetic Approaches to Crop Adaptation*—presentations were made by Tim Sutton (University of Adelaide, Adelaide, *Functional Genomics and Abiotic Stress Tolerance in Cereals*), Malcolm Devine (Performance Plants, Saskatoon, *Enhancing Crop Productivity Through Increased Abiotic Stress Tolerance and Biomass*), and Michael Metzlaff (Bayer BioScience NV, Ghent, *Adapting Crops to Climate Change*).

The speakers in Module 3—*Other Approaches to Adaptation*—were Don Smith (McGill University, Montreal, *Living With It: Adapting Crop-Production Systems to Emerging Climate Change*), Jeffrey White (US Arid Land Agricultural Research Center, Maricopa, *Adapting Cropping Patterns to Climate Change*), and Rattan Lal (Ohio State University, Columbus, *Soil and Water Management Options for Adaptation to Climate Change*).

Presentations in Module 4—*Ethics, Policy, Carbon Credits*—were made by Harold Coward (University of Victoria, Victoria, *Ethical Issues in Adaptation and Mitigation Responses to Climate Change*), Gordon McBean (University of Western Ontario, London, *Adapting to Climate Change: The Challenges and Opportunities in an Uncertain Policy Environment*) and Benjamin Gramig (Purdue University, West Lafayette, *Greenhouse Gas Emissions Offsets from Agriculture: Opportunities and Challenges*).

Points of interest made by speakers include:

- Global warming is unequivocal. The evidence comes from air temperatures and ocean temperatures, from reductions in the amounts of ice and snow on the surface of the planet, and from changes in sea level because additional water is being stored in the oceans and because the oceans are being warmed. Although there is a great deal of natural internal variability in the system, strong evidence suggests that human activity has been driving these temperatures upwards over the past 100 years.
- Agricultural activities can influence climate through land-use change, which can modify the albedo of the Earth's surface. The albedo in an agricultural context depends on a variety of factors including crop type, crop, management practice, surface condition, time of day and time of year.
- Extreme events in agriculture have received particular emphasis in the past 10 years. For example, the drought in the Canadian prairies in 2001–2002 caused losses in agricultural production equivalent to $3.6 billion, with Alberta and Saskatchewan particularly affected. Net farm income was negative for several provinces. However—and this occurs in crop-modeling studies as in reality—adaptation measures could not completely mitigate the drought impact. This demonstrates that, even in advanced western society, increased adaptive capacity will be important.
- In 2007, after several preceding years of drought, Southern Australia witnessed one of the hottest growing seasons on record, with crop losses much larger than expected. This trend of declining rainfall and increasing temperatures is predicted to continue, emphasizing a need for scientific approaches to develop crop germplasm adapted to these hostile conditions.
- Various analyses suggest that increasing temperatures will pose a major constraint to crop production in the future. The warmest summers observed in the tropics and subtropics in the past century may be seen as normal by the end of the twenty-first century.
- Some stress-protection mechanisms in plants appear to confer tolerance of multiple stresses, for example through effects on energy balance or detoxification of reactive oxygen species generated upon exposure to stress. Down-regulation of poly(ADP-ribose) polymerase (PARP) in *Arabidopsis* and canola increased tolerance of heat, drought and high light.
- Canola plants of a particular variety were grown under stress and non-stress

[1] Transcripts of the panelists' remarks and the Q&A sessions will be included in the proceedings volume, *NABC Report 21*.

conditions and separated into good performers (low respiration rate) and bad performers (high respiration rate) over several generations, producing a population with higher energy homeostasis under stress conditions. Analysis revealed that epigenetic variants had been selected, not mutants, with DNA-methylation changes that correlate with good and bad performance. These changes occurred in coding regions of genes involved in stress response. When the superior epigenetic variants were crossed with hybrid lines, heterosis resulted in more leaf material and better growth under a range of stress conditions.

- Increased productivity of crop plants due to increased concentration of atmospheric carbon dioxide may force corresponding increases in fertilizer demand, in order to achieve higher yield potentials. On the other hand, higher nitrogen-use efficiency under elevated carbon dioxide levels may mitigate increased demands for fertilizers. Application of plant-growth-promoting rhizobacteria (biofertilizers) and understanding signaling between bacteria and plants may also lead to improved crop productivity and, as a result, increase sequestration of carbon in roots; some of these signals also have the potential to increase legume nitrogen fixation, reducing nitrogen-fertilizer applications in the long term and, therefore, reducing nitrous-oxide emissions.
- The potential impacts of climate change on cropping patterns are highly researchable, but present significant methodological challenges. These impacts are not simply a question of increased or decreased productivity, but may have dramatic effects on land use as well as cropping practices. Ecological-niche modeling and crop-simulation modeling are powerful, complementary tools for examining the spatial and temporal aspects of climate-change impacts. Their successful application, however, requires effective interdisciplinary collaboration, including participation of plant biologists.
- Crop yields increased by a factor of 3 to 5 during the second half of the twentieth century despite degradation of soil, desertification of land, and depletion/pollution of water resources. This quantum jump in crop yields and the overall increase in agronomic production was brought about by agricultural intensification through adoption of varieties that were responsive to fertilizer and irrigation inputs. However, future increases in irrigation, most likely to occur in Africa and South America, will exacerbate competition for water resources from rapidly increasing demands from non-agricultural (*e.g.* urban, industrial) uses.
- Demands for natural resources will increase drastically during the twenty-first century because of increased need for food production, which may have to be doubled by 2050, and climate change which will further jeopardize the natural resources that are already under great stress. Adaptation to climate change will be essential for human well-being.
- When we think of the effects of climate change on future generations, the need for mitigation via lifestyle change and altered agricultural practices is clear. Predicted rises in sea level, destruction of traditional habitats and industries and loss of biodiversity push ethically acceptable climate policies strongly towards mitigation rather than adaptation.
- In late 2009, the 15th Conference of the Parties under the Climate Convention will be convened in Copenhagen. It will address the directions laid out in the Bali Action Plan that countries agreed to in 2007 at the 13th Conference of the Parties. The Action Plan specified steps to be taken to "enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012," which is after the end of the Kyoto Protocol commitment period. An agreed long-term global goal for emission reductions, to meet the Convention's objectives, is to be one outcome of the 15th Conference of the Parties, as well as interim targets. What those targets will be or even if there will be agreement on them, is uncertain. From an agriculture point of view, there will likely be important terminology, guidance and rules in the details. These details are even more difficult to predict.
- Production of the three main greenhouse gases that can be mitigated through agricultural activities are carbon dioxide, methane and nitrous oxide. Agricultural management practices can be altered in many ways to reduce emissions, to enhance the removal of carbon dioxide from the atmosphere (C sequestration), or to displace emissions from fossil fuels by using crops or residues as sources of energy. Displacing fossil-fuel emissions with bioenergy from crops represents an important opportunity for agriculture and remains a fertile topic for research as governments continue to rely on renewable fuel standards as an important component of energy and climate-change policies.

Demands for natural resources will increase drastically during the twenty-first century because of increased need for food production.....Adaptation to climate change will be essential for human well-being.

More points of interest will be available in the overview chapter of the proceedings volume, *NABC Report 21*, which will also include the speakers' manuscripts. ■

Summary of the Discussions at the NABC-21 Breakout Workshops

Three breakout sessions were held at NABC 21, comprising five workshops[1], at which the major issues raised during the plenary-session modules were enumerated and discussed. Some of the key points are provided below.

Module 1—*Climate Change Overview and Projections*

- Improvement in computer-simulation models and protocols for uncertainty.
  —Uncertainty is inherent in available computer-simulation models that predict the effects of climate change. Improvements in these models must continue, with the objective of producing quantitative data. On the other hand, the lack of precision is sometimes overstated, and more emphasis is needed on development of protocols for managing uncertainty. Some participants felt that there is too much emphasis on climate models and too little on decision-making protocols. Such protocols, as used in medicine, may have utility, underscoring the need for interdisciplinary effort.
- Population increase and improvement in living standards.
  —Population increase must be factored into predictions of the results of climate change. Also important are improving living standards in China, India and elsewhere that will lead to dietary changes, in particular increased meat consumption.
- Stakeholder engagement and education.
  —All available means of communication regarding climate-change effects on agriculture and food production need to be employed: extension agents, the Internet, "traditional" media and the scientific literature. In particular, scientists must reach out to policymakers.
- Scientific education of policymakers.
  —Policymakers must be given the knowledge-base to weigh the issues and the options.

Module 2—*Genetic Approaches to Crop Adaptation*

- Dynamic systems approaches.
  —Dynamic systems approaches are needed in making genetic improvements for resistance to or avoidance of the biotic and abiotic stresses that will become more severe with climate change.
- Non-molecular skills.
  —Concern was expressed over the lack of availability of plant breeders. Non-molecular skills are being lost also in other disciplines.
- Roles of breeders and molecular biologists.
  —The relative roles and contributions of breeders and molecular biologists need to be examined and better defined.
- Improved water-use efficiency and photosynthesis.
  —Moisture relations will be increasingly important as pressure increases on water resources and warming trends exacerbate evapotranspiration. There is potential to breed for improved efficiency of water-use and of photosynthesis in crops as well as for moisture-stress resistance and avoidance.

Module 3–*Other Approaches to Adaptation*

- Soil organic matter and fertility.
  —Depletion of carbon (*i.e.* organic matter) from soils, and concomitant loss of fertility, are issues of major importance, particularly in view of the fact that soil has huge potential as a sink and reservoir for carbon. Tillage and other farm-management practices need to be modified so that organic matter is replenished and fertility—including water-holding capacity and nutrient retention—thus maintained or improved.
- Improved analytical methods.
  —Methods of soil-carbon monitoring need to be improved, and quantification of nitrous-oxide emissions made more precise. These factors are sensitive to even small fluctuations in temperature and soil moisture and will be affected by climate change.

Module 4—*Ethics, Policy, Carbon Credits*

- *Ethics.*
  —Applying ethics to practical situations can be difficult for non-ethicists. Providing opinion must be viewed differently from weighing ethical considerations. Ethics are derived from principles and not from social mores. Unequal distribution of wealth is not necessarily unethical. Critical considerations are how we treat others, future generations, and plants and animals. Good examples are the Enviropig, produced for profit, which benefits the environment, and genetically engineered crops that will adjust to climate change.
- Science-based policy.
  —The science of mitigation of climate change is now being elucidated, but there has been little progress on the policy side. Since the scientific basis for policymaking has considerable uncertainty, it is recommended that policies be adaptable to accommodate improved data. To transfer science into policy will require engagement of politicians to ensure that their decisions are based on sound scientific data.
- Cap and trade/carbon tax.
  —Cap and trade is the policy most embraced, but much is to be said for a carbon tax.

Fuller coverage of the workshop discussions will be provided in the proceedings volume, *NABC Report 21*. ■

[1] Duties were shared as follows:
Discussion facilitators—Colin Kaltenbach (University of Arizona) and Bruce McPheron (Pennsylvania State University).
Recorders—Allan Eaglesham (NABC) and Tom Wilson (Pennsylvania State University).

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Join our mailing list and receive *NABC Report 21* as soon as it is published at
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The Student Voice at NABC 21

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Gopesh Chandra Saha
Washington State University

Tom Wilson
Pennsylvania State University

To increase graduate-student participation at NABC conferences, the *Student Voice at NABC* initiative was launched ahead of NABC 19. Feedback from those involved was positive, therefore the program was continued for NABC 20 and 21. Grants of up to $750 were offered to graduate students at NABC-member institutions (one per non-host institution) to assist with travel and lodging expenses. Registration fees were waived for the grant winners.

Student Voice delegates are expected to attend all of the plenary sessions as well as the breakout workshops then to meet as a group to identify current and emerging issues relevant to the conference subject matter.

Thirteen graduate students, listed above, participated in the *Student Voice* program at NABC 21.

Introduction

Attendance at NABC 21 by the private and public sector, researchers and professors, students and professionals, exemplified the importance of collaboration amongst disciplines to solving problems related to climate change. It was inspiring to see so many heads together in discussion, and, as students, to have the opportunity to share our ideas.

We offer feedback, as follows, from our various areas of expertise:

Plant Science

Plant breeders go between biotechnologists and the needs of growers and consumers. As such, breeders can define technologies that are most needed. This responsibility can be met by the "21st century plant breeder": a plant scientist who is focused on breeding, but who has the capacity to help develop plant biotechnologies. Tunnel vision from specialization can be combated through collaborative grants that would group biotechnologists and plant breeders.

Education

Climate change needs to become a top issue discussed in the classroom, and scientific educators and the scientific community need to advocate its inclusion in course curricula. Public discourse on climate change requires education on the increasingly important scientific theory. Courses that expose the student to the biotech industry, plant breeding, and product development would convey how combining these sectors can contribute to developing solutions. Future plant-biotech researchers should learn how techniques and disciplines can be combined to address climate change from various angles. In addition to scientific approaches to achieve adaptation to and mitigation of climate change, lifestyle and behavioral adaptations, such as responsible consumer choices and sustainable management practices, should be highlighted. This type of course could be taken early, and would enable students to place subsequently gained knowledge in context.

Climate Modeling

Uncertainty causes the misinterpretation of climate data, which can confuse and misdirect policy decisions. Increased resolution in climate forecasting will determine biotechnological approaches and performance targets. Accurate models are also imperative in developing appropriate risk-assessment strategies. With a better idea of which meteorological changes are coming, we can create better risk-management products and insurance plans to protect producers. In addition to changing temperatures, models for future crop zones must take into account suitable growing conditions including water availability, topography, and expected changes in biogeoclimatic zones.

Soil Science

Within the climate-change debate, it is important to see soils as more than a sink for carbon; soils are the base upon which any biotechnology or plant breeding is made possible. Accordingly, we need to think not only of replacing the nutrients we remove, but also of conserving soil as a resource and, through sustainable management practices, reducing its loss. Efficient energy and nutrient use go hand-in-hand in combating the effects of climate change; if we focus on nitrogen, carbon will follow. The energy and carbon currently needed to create chemical fertilizers are unacceptably high and innovative techniques based on traditional knowledge for returning organic matter to the soil need to be adopted.

Economics and Policy

In the climate change debate, the policy levers most often considered are an

continued on page 8 "Student Voice..."

[1] This is a short version of a summary of the *Student Voice* discussions provided by Ms. Sullivan. The full version will be published in *NABC Report 21*.

continued from Page 1 "Letter..."

constructive dialog on agbiotech issues, NABC has become—and continues to be—a respected source of balanced information in this area. In 1998, the council broadened NABC's activities to include ag research in general in addition to biotechnology in particular; our "vision statement[6]," which communicated the expanded roles of ag research and agriculture for the twenty-first century, produced several positive impacts. In large part, it was the basis for Executive Order 13134—*Developing and Promoting Biobased Products and Bioenergy*—signed by President Clinton in 1999. In 2000, NABC 12 in Florida was the first conference to explore benefits from, and concerns about, the biobased economy. That meeting catalyzed the initiation of the annual *World Congress on Industrial Processing and Biotechnology: Linking Biotechnology, Chemistry and Agriculture to Create New Value Chains*, co-organized by the Biotechnology Industry Organization representing biotechnology, the American Chemical Society representing chemistry, and NABC representing agriculture. The sixth World Congress convened in Montreal in 2009 and the seventh will meet in Washington, DC, in 2010.

NABC has continued to provide leadership in biofuels and bioproducts. The 2007 NABC white paper, *Agriculture and Forestry for Energy, Chemicals and Materials: The Road Forward*[7], states that agriculture can provide both food/feed and bioenergy provided that investment is made in research for economic energy products from non-food crops so that they become the main source of biofuels (75–85%) and food crops become the minor source (15–25%). This opportunity is being recognized with multi-billion-dollar public- and private-sector investments in research and development. Furthermore, NABC's nineteenth and twentieth conferences provided additional information/recommendations: *Agricultural Biofuels: Technology, Sustainability and Profitability* in South Dakota in 2007, and *Reshaping American Agriculture to Meet its Biofuel and Biopolymer Roles* in Ohio in 2008.

The important role of agriculture in terms of human health is less fully recognized than that of energy at this time. In March of this year, NABC published a white paper titled *Food and Agricultural Research: Innovation to Transform Human Health*[8], which documents the many seminal contributions of agricultural research to human health, from vaccines to antibiotics to HIV, and it projects future contributions in functional foods, toxin-allergen reduction, probiotics, nutrigenomics, taste and flavor enhancement, and diet-related chronic diseases. A full partnership of agriculture in the human-health endeavor is recommended. Previous NABC conferences have addressed this area: *Agricultural Biotechnology, Food Safety and Nutritional Quality for the Consumer* in New York in 1990, *Integrating Agriculture, Medicine and Food for Future Health* in Minnesota in 2002, and *Beyond Food and Energy to Health and the Environment* in Tennessee in 2005. *Promoting Health by Linking Agriculture, Food and Nutrition* will be held at the University of California, Davis, June 14–16, 2010 (see p. 2). Much work remains to be done to elevate agricultural research to a full partnership in the human-health endeavor. Contributions from ag research to low-cost prevention of chronic diseases should be key components of the current debate on healthcare and cost containment. Ag research has the potential to be a major provider of solutions or, as we say in Florida, *Solutions for Your Life*.

Global climate change is another societal problem where agriculture and agricultural research should be recognized sources of solutions. There are opportunities for agriculture to adapt to, and to mitigate, greenhouse-gas accumulation in the atmosphere and climate change. NABC's twenty-first conference in June of this year in Saskatchewan initiated dialog on *Adapting Agriculture to Climate Change*, focusing on plant-based agriculture; the full report on NABC 22 will be available in early 2010. The importance of this issue suggests that we may have similarly focused future meetings and/or produce a white paper on this topic. Animal agriculture as well as plant agriculture are challenged in this area.

The other major twenty-first century issue in which agriculture is a major player is water. About 70% of fresh water is used by agriculture. Crops genetically engineered for improved drought tolerance are projected for commercialization in 2011. NABC is exploring a white paper on water and agriculture and many of our membership organizations have mounted major efforts in this area. These efforts have helped push the science of both water quantity and water quality, create forums for discussion involving parts of society that differ in their views of acceptable water solutions, educate our citizens about water and extend our knowledge to all who will listen.

Clearly, agriculture and ag research can be major contributors to providing solutions to the huge challenges that confront us in the twenty-first century. Much of the necessary infrastructure already exists. The primary need is for broad recognition of ag research's expanded role coupled with the necessary public and private investment. It is up to us in the ag-research community to communicate the opportunity to society and government. ■

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[6] Vision for Agricultural Research and Development in the 21st Century: Biobased Products Will Provide Security and Sustainability in Food, Health, Energy, Environment, and Economy (1998). Ithaca: National Agricultural Biotechnology Council.

[7] http://nabc.cals.cornell.edu/pubs/The_Road_Forward.pdf; Hardy RWF Eagleshan A Shelton A (2007) Agriculture and forestry for energy, chemicals, and materials: The road forward. Industrial Biotechnology 3 133–137.

[8] http://nabc.cals.cornell.edu/pubs/AgFood_web.pdf.

continued from page 6 "Student Voice..."

emissions tax or a marketable permit system, *i.e.* cap and trade. Each of these mechanisms functions as a price signal to the consumer, designed to account for market failures or externalities. Only through price signals can we hope to change human behavior as a whole. Further, it is essential that the policy mechanism allows for offsets to be provided by industries "outside the cap" that will reduce emissions at lower cost.

Conclusion

Fundamentally, climate change, food security, and, by extension, global stability, hinge upon the ability of the human race to support itself in a sustainable fashion. This will be facilitated by the collaboration of economists and social and natural scientists in a manner that focuses on solutions that are applicable to society. Agriculture is a perfect reflection of society's approach to caring for itself; it is the act of humans cultivating the Earth upon which we depend. It is clear that agriculture will be, and is being, affected by climate change and by using a systems approach we can create life-cycle analyses to properly assess the roles of various disciplines in climate-change adaptation and mitigation.■

Are you a graduate student at an NABC member institution and would like to participate in *The Student Voice at NABC 22* in June, 2010, in Davis, CA?
Please visit the Student Voice webpage at
http://nabc.cals.cornell.edu/studentvoice/index.cfm
for application details and deadlines.

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