The role of new technologies in global food security: Improving animal production efficiency and minimizing impacts

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It is regrettable that approximately 870 million out of 7 billion people (12.5% of the global population) are estimated to have been undernourished from 2010 to 2012 (FAO, 2012). As the world population continues to increase, food security on a global scale must become an even greater priority. Along with population growth, economic growth and the rise of the middle class in developing countries are expected to further increase demand for meat, milk, and eggs (FAO, 2009). Although addressing food security on a global scale will require everyone working together to address economic, financial, government, political, and technical issues, increasing production efficiency of livestock and poultry in an environmentally and economically sustainable manner needs to be a priority for animal agriculture.

The wonderfully edited January 2013 edition of *Animal Frontiers* focused on this topic of global food security and explored the relationship between people and animals (including fish) with an emphasis on developing countries. The distinction between food security and nutrition security was made, emphasizing an increased global demand for animal products and the likely increased trade of feed, animals, and their products in the future. The January 2013 edition also looked at the challenge of climate change and considered how pastoralism has evolved to cope with environmental instability. The present edition (Part 2) looks in greater detail at the contribution of technological advances to global food security. During the past 40 years, development and adoption of new technologies has greatly enhanced livestock production by decreasing resource use and output of waste per unit of product produced (Capper and Hayes, 2012). In order to meet the projected food demand by 2050, new knowledge of genomics, physiological processes, nutrient utilization, and animal wellbeing must lead to new management practices that are economically, environmentally, and socially sustainable.

As presented by Johnson et al. (2013), application of growth technologies commonly used in the beef cattle industry has greatly enhanced food security and sustainability. These growth-enhancing compounds, such as steroidal implants and beta-adrenergic agonists, increase production and improve feed efficiency of beef cattle. Long-term use of the growth-enhancing technologies has proven that the compounds are a safe, effective way to enhance lean-tissue deposition in cattle, and the changes in performance result in an economic benefit to both consumers and producers. In addition, land necessary to produce equivalent amounts of food for consumers and the environmental impact of the beef cattle industry is greatly decreased when growth technologies are used. Capper and Hayes (2012) estimated that withdrawal of growth technologies (i.e., steroidal implants, ionophores, in-feed hormones, and beta-adrenergic agonists) would have negative consequences on environmental and economic sustainability of beef cattle production and would increase use of resources, carbon emissions, and production costs per kilogram of beef. Without these technologies, land use required to produce $454 \times 10^6$ kg of beef was estimated to increase by 10% (Capper and Hayes, 2012).

In addition to growth technologies, Hernandez Gifford and Gifford (2013) discuss the role of reproductive biotechnologies in enhancing food security and sustainability. Animal biotechnologies related to reproduction have contributed to many improvements in agriculturally important traits in livestock. While the first biotechnology tool applied to improve reproduction and propagate superior genetics of farm animals was artificial insemination, numerous technologies have been developed over the years. The most recent of these emerging technologies is reproductive cloning and production of transgenic animals. These technologies not only have great potential for improving practical agricultural applications such as resistance to disease, reduced environmental impact, and improved productivity traits, but also for biomedical applications such as those that produce therapeutic proteins in milk or blood or generate organs for human transplant.

Use of technologies have not only increased animal production, but also impacted the global economy related to livestock production and their products. Lusk (2013) discusses the role of technology in the global economic importance and viability of animal protein production. Although food distribution has been a challenge, over the past century, productivity-enhancing agricultural research has led to increased product availability in spite of population growth. The economic benefits of agricultural research have been estimated to outweigh the costs by a factor of 32 to 1. Using the beef industry as an example, technological developments that have occurred in the last 40 years are estimated to be worth over $12 billion annually. It is important to continue to invest in agricul-

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Balchem Corporation is pleased to announce the creation of a new grant-based research program, the Real Science Initiative. The Real Science Initiative was developed to foster innovative research, discover new solutions for enhancing animal performance and health, and build partnerships within the global research community. The program offers funding to university and related research institutes for research in areas that may include but are not limited to:

- Developing new applications of existing protection technologies (e.g., encapsulation or mineral chelation).
- Developing new technologies for increasing the efficacy of nutrient utilization.
- Product applications that enhance newborn, growing, or mature animal immune responsiveness and productivity through improvements in enteric health.
- Increasing the understanding of choline metabolism, including interactions between choline and other nutrients involved in one-carbon metabolism, and the application of this understanding.

Preproposals must be submitted electronically by 5:00 pm EDT on August 1, 2013. Complete program details are available at www.balchemresearch.com.
tural research and develop productivity-enhancing technologies that allow food prices to remain low.

In developing countries, scientific knowledge can be used to match the best management practices with the environmental conditions, and thereby help sustain the livestock industry. For example, significant changes have occurred in global sheep production, and product demand has become oriented mainly towards fine and superfine wools and high quality lamb meat. Montossi et al. (2013) discuss a Uruguayan’s case for the intensification, diversification, and specialization of sheep production systems under pastoral conditions in order to improve the competitiveness of the sheep industry. More profitable and environmentally friendly sheep production systems are linked with producing more high quality products with less sheep. Alignment among researchers, producers and market demand has been the key to being successful at sustaining the sheep industry and its contribution to global food security.

With human demand for animal protein expected to double by the year 2050, livestock must be produced more efficiently considering limited water and arable land. Although livestock production emits carbonaceous and nitrogenous compounds that contribute to air and water pollution as well as climate change, Neumeier and Mitloehner (2013) discuss how livestock technologies have decreased the environmental impact while helping us feed a growing population. In addition, livestock waste treatment technologies such as anaerobic methane digestion can decrease emissions and produce power and fuel. Consumer education on the value of livestock technologies is warranted to allow a more balanced view of innovations that advance livestock production.

Carter and Kim (2013) discuss technologies that reduce the environmental impact of animal wastes associated with feeding for maximum productivity. Animals require specific nutrients in the correct amount and proportion to one another to maximize productivity. Often nutrients, such as N and P sources, are included in excess of the requirement as a safety measure to ensure performance. Matching the nutrients in the diet with those required by the animal can result in marked decreases in excretion and potential environmental impacts. Technologies that can reduce excretion and thereby improve the balance between nutrient import and export from the farm are discussed. Balancing animal productivity with nutrient output will be critical to meeting the demand for animal protein in the coming decades.

The final two articles discuss how demand for animal products has impacted food security in Asia and South America. In Asia, consumption of animal products has been steadily increasing, thus creating a greater demand for feed crops (Cao and Li, 2013). A rapid increase in the demand for animal products, together with changes in international trade, has led to a great expansion of China’s food animal industry. Livestock production has been growing faster than any other agricultural sub-sector in China in recent decades, mainly due to the substantial growth of the pig and poultry industries. China hosts 20% of the world’s population but occupies only 7% of the land area, and an even smaller percentage can be used as farmland. In the next 5 to 10 years, even greater challenges will be encountered in meeting an ever-increasing demand for animal protein products in developing countries. Therefore, there is an urgent need for new technological innovations in livestock production to ensure global food security and the stability of a global economy. As such, China is researching the development of a variety of transgenic crops aimed at producing a higher yield of feedstuffs, and the Meat Quality Modulation Project seeks to significantly enhance animal welfare and quality of animal products.

Finally, Millen and Arrigoni (2013) provide insight into the social implications of changes in animal protein production systems in Brazil using beef cattle as an example. Economic stability in Brazil has brought many benefits to the development of systems of beef production. The establishment of feedlots is partly responsible because they play an important role in shortening the cattle production cycle, improving beef quality, and generating jobs both directly and indirectly. Investments to modernize feedlots, the use of Bos taurus genotypes, as well as feeding younger cattle have contributed to the improvement of Brazilian beef and will consequently increase beef export to help support demand in other countries.

In closing, global food security depends on developing technologies for improving production and production efficiencies of livestock while adapting to and mitigating climate change, protecting crops, livestock, and ecosystems from the threat of pests and diseases and improving the nutritional quality and safety of food products for consumers worldwide.
In addition, vibrant and sustainable livestock production is the basis for economic development and stability. Therefore, developing technologies that can improve livestock production while minimizing environmental impacts, improve natural resource management, and ensure the health and safety of consumers should be our goal.

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About the Author

Clint Krehbiel was raised on a diversified farm near McPherson, KS. His family raises dryland wheat, grain sorghum, and cattle. His mother is retired from a local high school where she served many years as an English and German teacher. Clint holds an A.A.S. degree from Hutchison Community College (1986), B.S. (1988) and M.S. (1990) degrees from Kansas State University, and a Ph.D. degree (1994) from the University of Nebraska. Following his Ph.D., Dr. Krehbiel held a postdoctoral fellow position at the United States Meat Animal Research Center (USMARC) near Clay Center, NE. He then spent 3.5 years on the faculty at New Mexico State University before joining the faculty at Oklahoma State University in the Department of Animal Science in January 2000. Krehbiel holds a split appointment between teaching (~20%) and research (~80%). His research interests include understanding relationships involving ruminal fermentation, gastrointestinal tract metabolism, and whole-body nutrient utilization to improve health, growth, feed efficiency, and meat quality of beef cattle. He teaches graduate courses in rumenology and laboratory techniques in animal nutrition, co-teaches a protein metabolism course, and is the academic adviser for approximately 20 undergraduate students.

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