2012 FAIR
Farm Animal Integrated Research
Introduction

The year 2012 marks the 150th anniversary of the United States Department of Agriculture (USDA). One of the earliest missions of the USDA was the development and delivery of scientific innovations. It is no coincidence that the nation's system of land-grant universities was established at the same time. Over the last 150 years, agricultural research, extension, and education have played a critical role in providing high-quality, safe, affordable, and abundant food for the citizens of the United States and the world. The animal sciences and animal agriculture continue to be important components of that success. Unfortunately, budget pressures, along with shifting priorities, have resulted in stagnant funding for animal science, placing our future success in jeopardy.

Importance of Animal Science and Animal Agriculture

Animal agriculture and its allied industries have a significant impact on the overall economy of the United States. According to the USDA, farm-gate receipts for animal agriculture, including crops used as animal feed, currently total over $200 billion each year. Animal agriculture annually accounts for between 60 and 70% of the total agriculture economy and plays an important role in the balance of agricultural trade. The USDA projects that exports of livestock, poultry, and dairy will reach a record level of $29.2 billion in fiscal year 2012. Animal agriculture also has a major impact worldwide. The Food and Agriculture Organization (FAO) estimates that livestock contribute 40% of the global value of agricultural output and support the livelihoods and food security of almost 1 billion people.

Investments in animal science are critical to the continued success of animal agriculture in the United States and globally. Recent studies show that public investments in agricultural research yield a return of up to 20:1 and are a major driver of increased productivity. However, federal funding for the animal sciences, and agricultural research as a whole, has remained relatively stagnant over the last 20 years. Increased investments in the animal sciences will be needed to meet increasing global demand and maintain the viability and competitiveness of animal agriculture in the United States. The results of FAIR 2012 are intended to focus future investments to maximize the impact of public expenditures and meet critical challenges for the future.

In response to challenges facing animal agriculture and the animal sciences, a yearlong effort titled Farm Animal Integrated Research 2012 (FAIR 2012) was undertaken to identify key priorities and strategies for the future. The FAIR 2012 process brought together scientists, educators, producers, industry, health professionals, and governmental representatives to identify research, extension, and education priorities that will enable the animal sciences to meet key challenges for the future of animal agriculture. The process culminated in a national meeting where FAIR 2012 participants gathered to hear from a broad range of experts in plenary sessions and to engage in breakout sessions to discuss research, education, and extension needs for animal science. Three major themes, or areas, emerged from the FAIR 2012 process, areas in which investments in the animal sciences should be focused to meet future needs: Food Security, One Health, and Stewardship.
One of the greatest challenges facing animal agriculture will be to meet the increased food needs of a growing global population. It is estimated that the world’s population will reach 9 billion by the year 2050, and global food production will need to double in order to meet these food demands. The FAO projects that 70% of this doubling will have to occur through the development and adoption of new technologies. The FAO estimates a 73% increase in meat consumption and a 58% increase in dairy consumption worldwide by the year 2050. Much of this increased consumption will come from developing countries, where people are emerging from poverty and demanding improved diets.

In order to meet increasing demands in a sustainable way, food producers must continue to increase the efficiency with which they use limited natural resources, placing a premium on increased production efficiency in animal agriculture. Compounding the challenge of increased production with limited resources is the diversion of food and feed crops into bioenergy, effectively taking land and resources out of the food security equation. All of these factors point to the need for increased investments in science to increase production capacity and efficiency.

Global food production must increase dramatically during the coming decades because of both a projected increase in the human population and a striking improvement in the purchasing power of many poor people in developing countries, which will increase demand for foods of animal origin. Meeting that increased demand within the constraints of the earth’s resources will require substantial improvements in the efficiency of use of resources. The expected increase in demand for foods of animal origin makes especially imperative a marked improvement in efficiency of use of valuable feed resources in animal production. There are important opportunities to achieve such improvements through research.

Prospects for improving feed efficiency include several nutritional and management factors. For example, measurement systems to match the energy needs of animals and the energy contributions of feedstuffs need improvement, as they limit the ability of nutritionists to use feedstuffs most effectively. For some species, the prevailing energy system is metabolizable energy, which is inaccurate both theoretically and practically. More sophisticated net energy systems are used for some species, but significant questions remain about the quantitative estimates of energy requirements and feed values in those systems. Further research in energy systems could increase the sophistication of diets and thereby increase feed efficiency and reduce the carbon footprint.

Recent shifts in feedstuffs available for use in animal production are expected to continue. For example, the use of low-energy fibrous co-products of grain processing will continue to increase, and the availability of high-energy fats will continue to decrease; both changes will decrease feed efficiency and must be addressed by sound scientific research. Opportunities for increasing the digestibility of fiber are especially promising targets for research, including refinement of supplemental digestive enzymes and exploration of benefits of feed processing.

A growing body of evidence based on residual feed intake shows substantial genetic variation in efficiency of energy use by animals beyond that associated with body composition. This variation appears to offer opportunities for game-changing improvements in feed efficiency, but full exploitation awaits further definition of the physiological mechanisms and of genetic markers for use in practical selection programs. Potential associations of this genetic variation in energetic efficiency with both product composition and disease resistance require special attention.

Basic scientists have made marvelous contributions to our understanding of genomics, proteomics, metabolomics, and related phenomena. The result is a very solid base for further research to apply this new knowledge for improvements in efficiency of animal production. Epigenetics (persistent changes in gene expression) may offer an especially strong opportunity for improvement of efficiency of animal production. The laboratory methods associated with these advances are now being used in applied research, a shift that should be encouraged.

Reproductive performance has a substantial effect on the overall efficiency of use of feeds in livestock production by all species, especially in cattle; recent improvements in reproductive performance are impressive and important contributors to increases in whole-herd feed efficiency. There is a need to further extend these improvements in challenging environments, including those often found in developing countries. Recent increases in litter sizes of pigs provide challenges in optimizing birth weights and postnatal survival and growth. Special opportunities now exist for improvements in reproductive areas such as semen preservation and timing of insemination.

**Focus Area 1: Food Security**

1. **Feed efficiency**
   Prospects for improving feed efficiency include several nutritional and management factors. For example, measurement systems to match the energy needs of animals and the energy contributions of feedstuffs need improvement, as they limit the ability of nutritionists to use feedstuffs most effectively. For some species, the prevailing energy system is metabolizable energy, which is inaccurate both theoretically and practically. More sophisticated net energy systems are used for some species, but significant questions remain about the quantitative estimates of energy requirements and feed values in those systems. Further research in energy systems could increase the sophistication of diets and thereby increase feed efficiency and reduce the carbon footprint.

2. **Energetic efficiency**
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3. **Connecting “-omics” to animal production**
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4. **Reproduction**
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Focus Area 2: One Health

With increases in globalization, the intersection between animal and human health continues to become more and more complex. The One Health concept has evolved in recent years in response to these increased complexities. In its broadest sense, One Health addresses factors affecting animal health, human health, ecological health, and their interconnections, using an interdisciplinary approach. One example of these interconnections is the impact of zoonotic diseases. Zoonoses (diseases that can be passed between animals and humans) are often diseases of major economic and public health importance and account for 58% of currently recognized human pathogens. Of the annually emerging zoonotic infectious disease events, domestic animals account for about 20%. Further complicating this situation is the fact that, in both developed and developing countries, people share their home environments with a variety of animal species, ranging from companion animals to livestock. Poor sanitation and hygiene conditions lead to frequent exposure of humans to animal pathogens and vice versa.

The intersection of human and animal health is also fertile ground for policy and regulatory challenges. For example, the use of antibiotics in animal agriculture has been the source of much controversy in recent years as critics express concerns about antimicrobial resistance. Investments in research will be essential to more clearly understand these issues and provide decision makers with science-based information to develop better-informed policies.

Sound nutrition is another critical aspect to disease prevention and improving human and animal health. The importance of good nutrition is central to preventing disease, correcting physiological imbalances, and providing needed energy. Healthier animals also provide safer and more wholesome products for human consumption. Advances in the animal sciences can play a major role in promoting the One Health concept, resulting in healthier humans, animals, and the environment.

Good animal health is important for the well-being of the animal and as a prerequisite for efficient food production. Maximizing animal productivity and efficiency requires animals to be healthy. Animal health is also connected to human health, largely through the carriage of zoonotic pathogens in animal products for human consumption. The livestock industries have adopted an impressive array of management practices to promote animal health, but the search for additional means of keeping animals healthy continues to be critical.
**Key Topic 2-1: New approaches to vaccine development**

Veterinary scientists and the animal health industry have provided many important vaccines to protect animals from infectious diseases. However, many vaccines fall short of full protection, there are no existing vaccines for some troublesome diseases, and some pathogens mutate so rapidly it is difficult to change vaccines fast enough to keep pace. The good news is that new and more effective approaches to vaccine development promise significant progress in overcoming these challenges. Now is the time to focus research attention on further development and deployment of these new approaches to vaccinology.

**Key Topic 2-2: Understanding and controlling zoonoses with an emphasis on food safety**

The incidence of several foodborne illnesses is declining, thanks to new knowledge and application of the resulting control systems. It is now important to build upon that knowledge, experience, and success by intensifying research and educational programs focused on zoonoses. These programs must be directed at all segments of the supply chain, including pre-harvest, harvest, and post-harvest. Some zoonoses, such as influenza, are transmitted by means other than food and they also demand attention.

**Key Topic 2-3: Improving animal health through feed**

Many dietary components can influence animal health and production to an important extent, creating an abundant opportunity to effect marked improvements in animal well-being and production efficiency. A few examples are probiotics, prebiotics, plant extracts or essential oils, yeast-derived mannans, and functional animal products such as spray-dried plasma. Some of these dietary components alter the immune system or other physiological systems; others change the microbial populations in the digestive tract. The private sector is developing and testing new products at an astounding rate, but there is an urgent need for public financing of research into the underlying biological mechanisms and for objective assessments to guide the industry and inform the public appropriately.
Focus Area 3: Stewardship

Animal agriculture touches many aspects of our society: providing essential nutrition, balancing natural resources, and fostering animal well-being. In order to meet global food demands in a sustainable way, investments in science will be critical to increasing the efficiency with which limited natural resources are utilized. Water quality and quantity are major issues, as competition for this precious resource intensifies. Society also continues to have concerns about climate change and the impacts that animal production may have on climate. These factors demonstrate the need for increased investments in science.

Great successes in resource use efficiency have already been realized through technological innovations. For example, in analyzing the life cycle of beef production between 1977 and 2009, the same amount of beef can now be produced with 10% less feed energy, 20% less feedstuffs, 30% less land, 14% less water, and 9% less fossil fuel energy. Improvements in production systems have also led to an 18% decrease in total carbon emissions. In light of the need to double food production by 2050, science must keep pace with population growth to make even greater strides in resource utilization.

Another important factor of stewardship is animal well-being. Critics of animal agriculture continue to raise concerns about the effects that production systems and increased production capacity have on the well-being of farm animals. Housing systems for farm animals are evolving in response to societal concerns and market demands. Standards for housing and production systems must be based in sound science, and investments are needed to better understand these issues.

Much responsibility for the environment and for animals is borne by the food production system. As the stewardship challenges become increasingly complex, society demands new knowledge to meet those challenges.
Key Topic 3-1: Flow of nutrients and other potential pollutants from animal production systems

The recycling of nutrients from animal manure to soils in order to support the growth of the next crop is arguably the most important recycling program ever, but opportunities to further refine its management must be identified and captured. For example, dietary changes can alter excretion of nutrients by animals, but quantitative estimates of the changes need refinement. Animal production facilities or land application of manure can result in traces of drugs, zoonotic pathogens, antimicrobial resistance genes, and other contaminants escaping into the environment. The amounts are likely insignificant in most cases, but more data are needed to direct management programs.

Key Topic 3-2: Estimation and reduction of greenhouse gas production

Concern about global climate change has focused attention on greenhouse gas production in all segments of the economy, including animal production. Research attention must be focused on rumen function to find new ways to reduce methane production by cattle and other ruminants. Much of the greenhouse gas production of the supply chain for foods of animal origin is associated with feed production, so improvement of feed efficiency will reduce the carbon footprint of the industry. Limitations in our ability to estimate greenhouse gas production from the supply chain must be addressed to properly evaluate new technologies and to monitor progress.

Key Topic 3-3: Impacts of housing systems on animal well-being

The public has become interested in the well-being of animals used in food production, with an emphasis on housing systems such as cages for laying hens and stalls for gestating sows. Sound judgments concerning such systems require a fuller understanding of the animals’ physiological and behavioral responses to them. Alternative systems must be developed and thoroughly evaluated to ensure they actually improve animal well-being and are practical. Other aspects of animal well-being, including pain management, also need vigorous research attention.
Crosscutting Issues

Increased investments in the priority areas identified by FAIR 2012 will be critical for the animal sciences and animal agriculture to successfully meet the challenges of Food Security, One Health, and Stewardship. However, increased investment alone will not be enough. A number of crosscutting issues must also be addressed to help ensure success:

• **Balanced Portfolio** – One of the strengths of the US agricultural system is the “three-legged stool” of research, education, and extension. It is critical that this balanced approach be maintained. Support for research should span from fundamental to applied, with adequate resources dedicated to the extension of new technologies into the field. It is also important to maintain the capacity of both intramural and extramural programs. The educational component must not be neglected because the success of animal agriculture depends on a robust pipeline to develop new scientists, producers, and industry professionals.

• **Size and Scope of Projects** – A current trend at the USDA is to fund large, multi-institutional grants over extended periods. Although there is value in these large awards, it is important to maintain a balance in the size and scope of projects. Without such balance, there is a risk that research driven by single investigators or new investigators will be neglected because of inadequate resources. This could have the unintended consequence of driving new scientists away from agriculture, further jeopardizing the development of new leaders in the animal sciences.

• **Enhanced Collaborations** – Enhanced collaborations on issues important to the animal sciences can play an important role in meeting future challenges. The USDA, universities, and others should increase links with federal research agencies such as the National Institutes of Health, National Science Foundation, the Department of Energy, and others to leverage limited resources and drive innovation.

• **Increased Public Awareness** – Animal agriculture suffers from a perception problem. A critical need exists to better inform consumers about the importance of farm animal production and the value of agricultural research.

• **Regulations** – The issues surrounding animal agriculture are fertile ground for regulations, including issues related to the environment, animal drugs, and trade. The future success of animal agriculture will depend on the consistent and predictable use of sound science by policy makers.

• **Data Mining** – As research priorities are set and agendas developed, it is important that comprehensive mining of historical data be conducted, to understand what is already known, to prevent unnecessary duplication, and to provide a better base on which to build future research. Data mining will reveal information that can be converted into knowledge about historical research, and these data can be used to predict future trends to be used in research planning to support guidelines and policies.
Conclusions

One hundred and fifty years after the creation of the United States Department of Agriculture, the agricultural research, extension, and education system has many successes of which to be proud. Looking ahead, scientific achievements in the areas of Food Security, One Health, and Stewardship will likely be the means by which success of the animal sciences will be measured. Increased public investment in the priorities identified by FAIR 2012 will be important in feeding an increasing global population in a way that maximizes the efficient use of limited resources and promotes human, animal, and ecological health. To achieve the greatest impact of these investments, attention must be paid to crosscutting issues related to the structure of research programs, enhanced collaborations, science-based policies, and increased public awareness of the importance of animal agriculture and the role of science. There is no doubt that the challenges facing animal agriculture in the future will be significant, but with wise investments in science, success is achievable.
Farm Animal Integrated Research (FAIR) 2012

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