

ANIMAL NUTRITION RESEARCH PRIORITIES FOR A HEALTHY SOCIETY

National Animal Nutrition Program, National Research Support Project-9



National Animal Nutrition Program
Leveraging Resources, Linking Researchers



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STATEMENT OF PURPOSE

One of the most pressing issues we face as a global community is feeding the world's growing population, one expected to climb to 9.5 billion by 2050. The food we consume is integrally tied to the cultivation of crops and animals. These activities depend on sensible human stewardship that takes into account an understanding of climate, animal welfare, environmental impacts, and societal and economic needs.

As demand increases, weather patterns shift, and environmental assets shrink, a collaborative effort will be needed to transform the existing nutrition network into a robust and sustainable global food and agricultural system. A sustainable food production system must balance environmental impacts, economic viability, and societal needs. As efforts are made to improve sustainability, developers will face four challenges: 1) food security, 2) food safety, 3) improving human health and nutrition, and 4) effectively communicating across societal sectors.

At the core of each of these challenges are the animals we depend on for nourishment. Ensuring their health and well-being is central to ensuring our health and well-being. To begin building a 21st century nutrition supply chain, those involved with food animal production will need to assess current practices related to animal and crop production, with a keen eye toward improving efficiency while also maintaining or improving animal health.

By strengthening the ecological web formed through the interplay of crops, animals, and humans, we can improve the production of safe and nutritious food, conserve natural resources, and adapt agricultural practices to changing climate conditions. Finally, improving communication between scientists and society, as well as within the scientific community, will be essential to ensuring adequate research capital and that advancements are implemented in the supply chain to the greatest potential effect.

How can those involved in animal nutrition research encourage this transformation? To open a dialogue on this question, the National Animal Nutrition Program, a National Research Support Project (NRSP-9), held a one-day summit in March 2015 in Washington, D.C. Participants included scientists and federal research program managers, as well as representatives from industry and nongovernmental organizations. The overall objective of the meeting was to identify gaps in animal nutrition knowledge for optimal human, animal, environmental, and economic health. A combination of presentations and roundtable feedback sessions provided a lively interchange centered on identifying priority challenges that should be addressed to solidify the role of animal nutrition in future food sustainability.

PRIORITY CHALLENGES

Healthy Environment—Animals affect the environment, but the environment also affects animals. In some locations, climate changes will present challenges to raising livestock, and alternative feeding strategies will need to be developed to ensure that animals receive sufficient nutrition during periods of stress.

Economic Vitality—Growing demand will increase prices, which could present a challenge for low-income populations. New markets will develop; increased production may carry hidden costs that are yet unknown. Economic impacts of animal feeding strategies must be more robustly evaluated.

Consumer Health & Perceptions—Animal nutrition must now include an understanding of public values related to the treatment of animals, concern for the environment, and the increased awareness of animal-borne illnesses that affect humans.

Training Tomorrow's Nutritionists—Expanded education programs are needed to encourage a generation of new scientists to pursue animal nutrition research to help stakeholders with environmental, economic, and societal needs.

Fostering Transdisciplinary Relationships—The animal nutrition community is in a unique position to describe the critical role animals play in our own well-being. The entire nutrition community, both animal and human, should work collaboratively, sharing data and discovering opportunities for joint efforts.

Bolstering Basic Research Capacity—The animal nutrition research enterprise, for application to both livestock and human health, must be reinvigorated; this activity will not only continue to delve deeper into traditional research, but will help expand work in new areas such as genomics, endocrinology, immunology, and stress physiology.

HEALTHY ENVIRONMENT

The current trends of production and consumption will make it difficult to feed 9 billion people in the future. To move forward, it is essential to consider how to produce enough food from the system to meet our needs while also maintaining soil, land, and water resources to meet future needs.

CHALLENGES & NEW DIRECTIONS

Challenge: Future temperature and climate changes will likely impact crop production and animal life. Estimates suggest, for instance, that by 2050, cereal crop yields will be 10 to 20 percent lower than current yields. Geographical locations that currently support livestock may become challenging environments for such activities. As production increases, more waste will be created.

In addition, expanding production of animal-sourced foods without thought to the environmental consequences may diminish natural resources through deforestation, surface and groundwater pollution, soil degradation and depletion, and allocation of more land for feed grain and biofuel production.

New Direction: Those who raise and handle domestic animals can decrease environmental impact in a number of ways. By improving efficiency of the domestic animal population, practitioners can decrease the population's carbon footprint as well as preserve the world's forests. Carefully balanced diets provided to livestock also can decrease greenhouse gas emissions per unit of production.

Challenge: Although innovative products and practices exist to improve efficiency, from a global perspective, many farmers cannot access them. Regions particularly in need are Africa, parts of Asia, and some parts of South America.

New Direction: Livestock production sustainability will benefit from continued improvements in: 1) management practices (optimize diets to improve feed digestibility, water management, high quality grain concentrates, and pasture quality); 2) technologies (manure management, use of by-products for energy production, recycling; and integrated management of mixed livestock-crop systems); 3) genetic resources (harness these to create animals that are more efficient and productive in a variety of scenarios); 4) policy (e.g., strategies on greenhouse emissions, and on water and manure management); and 5) global extension (research capital available in the U.S. can be leveraged to identify strategies for developing nations to reduce environmental impact of livestock production).



NUTRITION SPOTLIGHT

In the U.S., a typical dairy cow lasts almost three lactation cycles, producing over five times her body weight in milk before going to market as a beef cow. Currently, the 9.2 million cows in the U.S. produce 15 percent of the world's milk.

Over the last 60 years, improvements in U.S. dairy management have resulted in substantial environmental gains. Producing milk in 2007 required only 35% of the water and 10% of the land required to produce milk in 1944. Dairy nutrition research was a major contributor to this improvement in environmental impact, and future advancements in nutritional understanding will lead to additional environmental benefits.

KEY RESEARCH DIRECTIONS

Future research harnessing animal nutrition to contribute to environmental health should:

- Characterize biochemical limits to decreasing emissions or pollutants, including the biochemical limits on opportunities to maximize production while decreasing environmental impact.
- Identify regulatory mechanisms for biochemical pathways that produce emissions or pollutants.
- Precisely define energy and amino acid requirements of animals in differing stages of production, including animals undergoing physiological and environmental stress.
- Explore mitigation strategies that account for profitability shifts, spatial and temporal climate heterogeneity, livestock variability, and consumer preferences.

ECONOMIC VITALITY

As the global population grows and the middle class expands, dramatic increases in the demand for animal food products are expected. Farmers must rise to meet this challenge in a manner that does not compromise social acceptability, preserves natural resources for future generations, and maintains the economic viability of their businesses.



NUTRITION SPOTLIGHT

Livestock are a significant global asset with a value of \$1.4 trillion. Livestock industries in developed countries are organized in long market chains that employ at least 1.3 million people. Export of animal products from the U.S. accounts for 25% of agricultural export income. Understanding of animal nutrition requirements has expanded over the last several decades, and livestock diets have shifted accordingly. This improved understanding has helped enhance production efficiency and support more economically viable U.S. livestock enterprises.

CHALLENGES & NEW DIRECTIONS

Challenge: Growing demand will drive up prices for meat over time. Developing countries will experience large increases in net trade or imports of meat, specifically pork and poultry, to satisfy increases in demand.

New Direction: While increasing demand for meat, milk, and eggs offers a significant opportunity for efficient producers, like those in Europe and the U.S., it will require adapting production practices to increase efficiency in other regions. Such improvements to the animal-based food production system will ensure a steady supply of nutritious food at affordable prices.

Challenge: Livestock provides income for the rural poor in developing countries. To support a sustainable food system, however, it may be necessary to consolidate small farms (or assemble into co-ops) in many regions.

New Direction: Farmers may increasingly rely on specialization or niche marketing. Specialization and niche marketing can help improve economic viability.

Challenge: As globalization increases, environmental impact of food production will increase. It is unclear what the true costs of producing food are and who is responsible for those costs.

New Direction: Stakeholders will need to develop the research, technologies, on-farm support, and regulatory controls to build an efficient and productive food production system that fulfills people's nutrient requirements and does not exceed an acceptable level of environmental impact.

KEY RESEARCH DIRECTIONS

Future research harnessing animal nutrition to contribute to economic vitality should:

- Improve understanding of how consumers perceive and value animal protein and livestock production practices.
- Identify and characterize more precise estimates of future food consumption patterns.
- Explore the externalities associated with food production systems and test efficacy and economic implications of different policy strategies to internalize those externalities.
- Incorporate amino acid, mineral, and vitamin demand into general or regional equilibrium models.
- Explore economic impacts of mitigating environmental impact at a farm level, including how small farms are affected differently than large operations.

CONSUMER HEALTH & VALUES

Humans, like all mammals, require energy, amino acids, fatty acids, vitamins, and minerals to survive. Animal food products are essential in efforts to design healthy diets, and animal nutrition research has led to improved understanding of how these nutrients are used within the body, why they are required, and how much of any given nutrient is needed on a daily basis. Although animal-source foods have beneficial human health impacts and animal nutrition research has advanced human health, animal nutritionists do not effectively communicate these benefits to the general public. The historical dogma of public “education” appears to be an ineffective method of fostering this communication. Moving forward, efforts may need to center on reacquainting animal nutritionists with the public and fostering relationships based on mutual understanding. The animal nutrition community should showcase the relevance of animal nutrition in human health through demonstrating responsiveness to the interests of the public.



CHALLENGES & NEW DIRECTIONS

Challenge: Social, environmental, and economic issues now impact the scope of animal and human nutrition.

New Direction: An expanding global middle class will drive the need to increase animal-derived food outputs. To successfully feed the world's entire population within a framework of decreasing or limited resources and competing interests, animal nutritionists will need to develop a deeper awareness of sociopolitical issues around the globe.

Some of these issues include societal concerns about food production related to animals, local understanding of animal welfare, antimicrobial resistance, air quality, nutrient run-off, nutritional security, animal-borne illnesses that target humans, and the causes of hunger and poverty in developing countries. By demonstrating a commitment to conducting research in a socially acceptable, ethical, and humane manner, the animal nutrition community can improve how the world perceives animal production.

Challenge: With 98 percent of Americans removed from farming, consumers do not have exposure to how food is produced, by the way care deeply about it.

New Direction: According to a survey by McDonald's, consumers believe safe food comes from a healthy animal and that healthy animals result from good animal welfare practices. The animal nutrition community should develop a dialogue of its own with consumers. Consumers should be engaged in discussions on topics such as food sustainability. A Green Biz study found that a growing portion of consumers were interested in understanding what food sustainability means and in learning where foods come from. The animal nutrition community needs to discover the degree to which consumers are invested in sustainability and how best to align animal nutrition research with this public interest in food sustainability.

KEY RESEARCH DIRECTIONS

Future research harnessing animal nutrition to contribute to consumer health and perceptions should:

- Use livestock and human systems to better define the role of the microbiome in human and animal health.
- Leverage animal nutrition, immunology, physiology, and other knowledge to help define good animal welfare in a manner that consumers can understand and producers can implement.
- Identify the primary concerns that consumers have about livestock feeding practices in the U.S. and the key progress consumers would identify as acceptable in those areas of concern.

TRAINING TOMORROW'S NUTRITIONISTS

The number of students interested in pursuing advanced degrees in animal nutrition is decreasing over time. This change has led to a shortage of qualified applicants for animal nutrition jobs and a decrease in the available animal nutrition research capital within the U.S.

CHALLENGES & NEW DIRECTIONS

Challenge: Fewer students are interested in animal nutrition.

New Direction: The animal nutrition community needs to consider ways to attract new talent interested in food production and animal nutrition. The current curriculum needs reassessment. Recruitment and retention campaigns for both 2- and 4-year college programs need development. Approaches to introduce animal nutrition curriculum at middle and high school levels should be considered.

Challenge: In many cases, pharmaceutical companies have replaced University extension services as information sources. As a result, public-private partnerships may come with a cost. Rebates and incentives may present a conflict of interest for some farms and ranches.

New Direction: The private sector will play a larger role in the future of animal agriculture and will increasingly drive animal health and nutrition standards. Internationally, big supermarkets are setting quality and food safety standards. By promoting the use of evidence-based studies, animal nutritionists can ensure that decisions are based on scientific outcomes rather than economic concern. This approach could help curb removal of technology based solely on cost. Working groups among farmers that share information and data on animal nutrition would be beneficial.

Challenge: Research programs in some parts of the world are woefully inadequate to address societal needs.

New Direction: The research enterprise abroad needs strengthening. Research efforts in China, Brazil, and India are sufficient, but Africa needs support to develop research on nutrition, breeding, and adaptation that could translate into production efficiencies. The international community has done little to develop these systems and to adapt systems that work in Europe and the U.S. to Africa and parts of Asia.



NUTRITION SPOTLIGHT

Between the years 1987 and 2012, students receiving animal science M.S. degrees declined from 600 to 450 per year. Over the same time period, the number of Ph.D. degrees conferred dropped from 200 to 150 per year.

Steady growth in animal science B.S. degrees (5,000 in 2012), make it one of the largest (7%) of food and agriculture degree programs in the U.S. Between 2007 and 2010, faculty numbers nationally remained flat despite an 8% increase in undergraduate enrollment. Concurrently, full time extension employees in animal sciences have decreased. Thus more faculty time is spent in the classroom rather than developing translational research, training the next generation of animal nutritionists, and facilitating the application of science to the food sector.

KEY RESEARCH DIRECTIONS

Future research to ensure the long-term vigor of the animal nutrition work force should:

- Evaluate the preconceptions that students have about animal science and animal nutrition when they enter college and design high school or middle school educational curriculum to help correct misconceptions.
- Identify strategies to translate animal nutrition education into modern classroom formats (e.g., online, flipped), and maximize hands-on learning opportunities in traditional and modern college classrooms.
- Design innovative and efficient models for partnering with the animal nutrition industry to ensure graduate student training is robust, scientifically rigorous, and globally oriented.

FOSTERING TRANSDISCIPLINARY RELATIONSHIPS

Great advances in research have come from focused efforts in a single area of study. As our knowledge of linkages among biological systems has expanded, it has become apparent that we need more transdisciplinary efforts. Animal nutrition is linked to reproduction, genetics, immunology, farm system economics, and environmental impact. Nutrition research efforts must branch out to foster collaborations with other disciplines.



NUTRITION SPOTLIGHT

Researchers now understand that what a female consumes during gestation has impacts on how the DNA of her offspring behaves. Fields like fetal programming, nutrigenomics, and metabolomics are growing in an effort to better explain how animal nutrition interacts with physiology, genetics, and reproduction.

CHALLENGES & NEW DIRECTIONS

Challenge: Animal nutrition professionals tend to focus on discipline-based approaches rather than solution-based ones.

New Direction: Researchers should work across disciplines and consider areas for collaboration between human and animal health professionals. A dialog should be initiated across disciplines and professional societies to bridge research gaps.

The community should consider creating an initiative modeled after One Health for the animal nutrition community or examine ways that animal nutritionists can get involved in this established concept. Agriculture professionals should also consider ways in which the federal government can partner with private industry to share knowledge and address some of the most pressing issues facing the community. One such initiative, the Foundation for Food and Agricultural Research created by the USDA, leverages public and private resources to address issues including plant and animal health; food safety, nutrition, and health; renewable energy, natural resources, and environment; agricultural and food security; and agriculture systems and technology.

Managers from USDA's National Institute of Food and Agriculture, Agricultural Research Service, and Economic Research Service are working with representatives from the National Science Foundation, the Department of Energy, the Department of Commerce, and others to define areas to jointly issue requests for grant applications. Such requests should address biological mechanisms and interactions between animal and human health and welfare.

Challenge: According to the Centers for Disease Control, about 75 percent of recently emerging infectious diseases affecting people are diseases of animal origin and roughly 60 percent of all human pathogens are zoonotic. Foods of animal origin can be vectors for transmission of disease.

New Direction: It is essential to reinvigorate the dialogue between human and animal science professionals. Programs such as the USDA-NIH Dual Purpose with Dual Benefit initiative offer one avenue for such dialogue. The initiative supports research on domestic animal species to improve human health. These grants typically explore research relevant to both agricultural and biomedical research; yet, many often go to research employing rodent models.

KEY RESEARCH DIRECTIONS

Future research to bridge animal nutrition with other disciplines should:

- Characterize the microbiome and the interrelationships of the food animal microbiome, plant microbiome, and overall human or environmental health affected or mediated through these microbiomes. What is an optimal microbiome?
- Leverage data from across disciplines to improve crop, feed ingredient, animal performance, market, and biological systems models.
- Characterize measurement options to define the immune system as a single endpoint and assess the beneficial outcome of nutrient management on immune function.

BOLSTERING BASIC RESEARCH CAPACITY TO

Federal funding for basic animal nutrition research has been steadily decreasing over time, resulting in decreased capacity to conduct research and limited resources available to train the next generation of researchers. Globally, there is a pressing need for improved quality of education and improved understanding of animal nutrition and its relationship with and relevance to livestock production, but several challenges to advancing nutrition research are evident.

Animal nutrition research seems less prominent in discussions of human and animal health and welfare. A reinvigoration of basic research and improvement in transparency of data, analysis, and interpretation are needed. To identify fundamental research needs not currently addressed, representatives from the animal nutrition community could get involved in analysis and prioritization efforts.

Working Across Disciplines:

Nutrition and the Microbiome

- How can nutrition be used to alter food-chain pathogen transmission?
- How does diet, genetics, and environment modulate the microbiome?

Nutrition and Animal Welfare:

- What is normal animal welfare?
- How can nutrition be an indicator of an animal's welfare status?

Nutrition and Immunology:

- How do the immune system and nutrition interact?
- When does this interaction begin and when can we manipulate it?

Nutrition and Animal Performance:

- How do metabolic modifiers affect how animals are/can be raised?
- How can water and nutrient utilization be optimized through nutrition?

Nutrition and Climate Change

- How can genetics and diet be optimized to adapt animals to climate change?
- How do digestive, absorptive, and post-absorptive processes shift during thermal stress?

Nutrition for Livestock and Human Health:

- How should low birthweight infants be fed?
- What nutritionally modulated mechanisms affect growth and development?
- How does nutrition during critical periods affect future health?

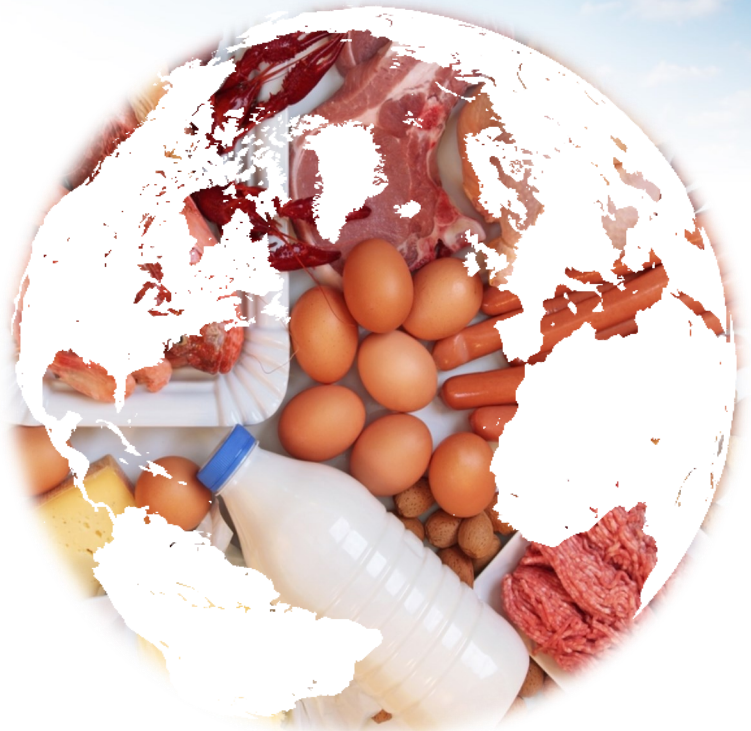
Nutrition and Genetics:

- How does the interaction of genome and nutrition affect health and performance?
- Do genetic and epigenetic effects differ by diet or by species?

Nutrition and Social Science:

- How do consumers perceive livestock feeding practices and animal-source foods?
- How do consumers define good animal health, welfare, and production practices? What are the minimal standards for improvement?

BUILD TOMORROW'S FOOD PRODUCTION SYSTEM, TODAY...



Nourishing the human population requires nourishing the animals that support them. As the population grows and demand for animal food products increases, the animal nutrition community will lead the way in developing a sustainable food chain that supplies nutrition for the globe while humanely caring for the animals that support it and the crops that maintain it. To accomplish these goals, the challenges enumerated in this document must be addressed. Animals

that produce meat, milk and eggs are an integral part of the global food production chain and basic, applied, and systems-oriented research must continue to be conducted to better characterize the role of animal nutrition in promoting a society with healthy people, healthy animals, a healthy environment, and a healthy economy. Animal nutritionists cannot be alone in this effort. Building a sustainable food production system will require collaboration between researchers at basic, applied, and systems-oriented levels. Nutritionists must work together with environmentalists, economists, social scientists, geneticists, animal health and welfare experts, immunologists, and others to generate the knowledge required to design sustainable livestock and poultry production strategies. These interdisciplinary research efforts must be incentivized and promoted by industry, non-governmental, state, and federal funding agencies. Concurrent with research efforts, attention must be paid to how the education system and the general public view livestock and poultry production. Animal production stakeholders must focus on effectively communicating science-based information to the public through educational programs and targeted marketing strategies. By building bridges between research disciplines, industry and governmental agencies, and societal stakeholders, animal nutrition research efforts can move forward to directly enhance the sustainability of the food production system and improve societal health.



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Speakers at the Summit included:

- Dr. Catherine Woteki, Under Secretary for Research, Education, and Economics, USDA.
- Dr. Carlos Saviani, Vice President of Protein, World Wildlife Fund.
- Dr. Daniel Thomson, Jones Professor of Production Medicine and Epidemiology and Director of Beef Cattle Institute, College of Veterinary Medicine, Kansas State University.
- Dr. Marcus Kehrli, Director of the National Animal Disease Center, USDA-ARS.
- Dr. Teresa Davis, Professor, Baylor College of Medicine.
- Dr. Roger Cady, Global Sustainability Lead, Elanco Scientific Affairs Team.
- Dr. Mario Herrero, Chief Research Scientist, Food Systems and the Environment, Commonwealth Scientific and Industrial Research Organization.
- Dr. Mark Rosegrant, Director of Environmental and Production Technology Division, International Food Policy Research Institute.
- Dr. James Womack, Distinguished Professor at Texas A&M University, W.P. Luse Professor of Pathobiology at Texas A&M College of Veterinary Medicine.

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