

White Paper

Animal Agriculture – Innovation, Technology & Consumer Engagement

Information synthesized from the National Institute for Animal Agriculture's Annual Conference, "Animal Agriculture: Innovation, Technology & Consumer Engagement" conducted April 9-10, 2019, in Des Moines, Iowa. Full presentations are available online at www.animalagriculture.org.

DISCLAIMER: The information provided in this White Paper is strictly the perspectives and opinions of individual speakers and discussions at the 2019 annual conference, 'Animal Agriculture – Innovation, Technology & Consumer Engagement.'

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Background

The conference, “Animal Agriculture – Innovation, Technology & Consumer Engagement”, conducted April 9-10, 2019, in Des Moines, IA, was hosted by the National Institute of Animal Agriculture (NIAA). The conference brought together one hundred forty (140) livestock and technology industry professionals from three countries, and included representatives of technology companies ranging from information technology to biotechnology to identification technology, pharmaceutical companies, innovation management, breed associations, trade associations, and livestock tag manufacturers; as well as producers, veterinarians, university research faculty, and regulatory animal health officials. The goals were to present a range of technologies of emerging importance to animal agriculture; discuss issues addressed by those technologies and potential solutions; review and discuss solutions to challenges relating to consumer communication; and to delve into the relationships between technology, consumers, and the animal agriculture industry.

There's always a need to innovate - to make progress and adopt technology in everything we do. However, given all the noise around agriculture, it's also essential to communicate and engage with the consumer world to ensure they have a balanced understanding of agricultural industry. This conference provided an opportunity for stakeholders to explore innovative technologies, as well as methods for delivering accurate information about animal agriculture to inform and improve consumers' perception of modern agriculture.

The NIAA is a non-profit, membership-driven organization that unites and advances animal agriculture for the challenges facing animal agriculture industries (aquatic, beef, dairy, equine, goat, poultry, sheep and swine). NIAA is dedicated to furthering programs for the eradication of diseases that pose risk to the health of animals, wildlife and humans; promoting the efficient production of a safe and wholesome food supply for our nation and abroad; and promoting best practices in environmental stewardship and animal health and well-being.

The 2019 conference, ‘Animal Agriculture – Innovation, Technology & Consumer Engagement’ was funded in part by USDA, Merck Animal Health, IMI Global, Datamars Inc., Allflex, Y-Tex, BeefChain, Intrexon Corp., Iowa Cattleman’s Association, 6666 Ranch, AgVentures Alliance, American Angus Association, Trust Bix Inc., and Fort Supply Technologies.

Purpose and Design of the Conference

The purpose of the conference was to bring together livestock industry leaders, producers, veterinarians, animal health officials, technology companies and communications professionals to discuss difficult issues in animal agriculture, the technologies that can inform and advance those issues, and communications needed to promulgate positive attitudes and consumer perception. The objective of this conference was to provide insight into evolving technology and innovation to help animal agriculture improve animal health, welfare, production sustainability and cost efficiency. Conference participants also gained unique insight into the convictions, attitudes, and needs of the consumer, providing concrete tools and methods to foster accurate, positive consumer messaging and perception for the advancement of the industry as a whole.

Conference Planning Committee Members

Chelsea Good, J.D., Livestock Marketing Association
Mr. Kevin Maher, VetMeasure, LLC
Mr. Dave McElhaney, Allflex USA, Inc.
Mr. Todd Low, Hawaii Department of Agriculture
Dr. Lucas Pantaleon, Virox Animal Health
Dr. Rick Sibbel, Executive Veterinary and Health Solutions, LLC

Conference Topics and Speakers

(in order given at the conference)

Welcome and Opening Remarks

Daniel L. Grooms, DVM, PhD, Dean of Veterinary Medicine, Iowa State University

Can Agriculture Save the Planet?

Mr. Jack Bobo, Vice President, Global Policy and Government Affairs, Intrexon Corp.

Blockchain: Traceability and Transparency for Supply Chain Effectiveness and Elevated Consumer Trust

Mr. Richard Gordon, North America Blockchain Solution Sales Leader, IBM

Challenges Facing Rural Entrepreneurs

Peter Orazem, PhD, University Professor of Economics, Iowa State University

Science Communication Workshop: Making Your Message Matter

Michael F. Dahlstrom, PhD, Professor, Journalism & Mass Communication, Iowa State University

How Alternative Proteins Can Support the Animal Agriculture Industry

Ms. Renée A. Vassilos, Agricultural Economist and Banyan Innovation Group Founder

Alternative Proteins: Present State and Future Outlook

Rodrigo Tarté, PhD, Assistant Professor, Department of Animal Science, Iowa State University

How Gene Editing Can Be Another Tool in Raising Healthier Animals

Ms. Emily Metz, Director, New Product Marketing, Genus PLC

Cultivating Meaningful Conversations

Mr. J.J. Jones, Co-Founder, Roots and Legacies

Executive Summary

Innovation and technology are constantly developing to help animal agriculture improve animal health and welfare, production sustainability and cost efficiency. Animal agriculture and stewardship go hand-in-hand, and today's technology innovations are aimed at continuing that partnership. Two of the most promising innovations for animal agriculture are Blockchain and gene editing.

Blockchain offers a highly secure and efficient way to connect disparate systems, to create a transparent and trusted network from one end of the supply chain to the other. The three main operational principles of Blockchain are open technology, decentralized control that is able to be employed by every user, and the development of a network of networks. IBM Food Trust is the first Blockchain system to be employed by the food industry, and use of and trust in the system has grown substantially since it was introduced to Walmart in 2016. Additional industries utilizing the power and security of Blockchain technology are Golden State Foods, which adopted Blockchain technology to assure cold chain storage management, and Carrefour, which adopted Blockchain in order to provide consumers with increased information about the products they buy.

Gene editing is a new field, made available and accessible by the discovery of CRISPR-Cas9. Gene editing is the selective removal of specific DNA sequences to enhance qualities about the organism encoded. Gene editing is being employed by the company Genus PLC to create animals that are free of specific diseases. Genus PLC has developed the technology to remove DNA sequences related to infection with the PRRS virus, resulting in pigs that are completely immune to PRRS. Commercialization of these pigs is at least five years away, but the gene edited pigs are alive and well and offer the promise of a PRRS free future.

Innovation outside animal agriculture, such as the development of alternative proteins, can be daunting, but we can work within the system and use these innovations to elevate all of agriculture. Alternative proteins include those that are made of plants or fungi, or derived from animal sources such as cell cultured meat or insect flour. We can fight their move into agriculture, or join them by using the momentum generated by their introduction to the agriculture scene. We need to find the opportunities generated by their introduction to elevate animal agriculture and grow both that industry sector and consumer trust.

Innovations and technologies with the most impact in the coming years will be in the science, engineering, and healthcare sectors. In order for the United States to remain a relevant leader in these and other fields, we must fund basic research, recognize the changing rural landscape and the shifting opportunities such as lower rural cost of living, and strive towards a flexible, responsive labor market.

As we adopt and promote new technologies, consideration of the consumer must be central to the process. People love innovation, but new technologies often generate skepticism, consumer concerns, and fear of change. These concerns must be taken seriously, and introduction and adoption of new technologies affected the food we eat must be transparent and presented with a common message of agriculture's shared values. The changes coming to animal agriculture are innovations that will make

things better, not change for the sake of change or profit, and they must be presented to the consumer as innovations. The average consumer is now multiple generations removed from the farm, and modern food production is often misunderstood or even under assault in the media. It is essential to communicate and engage with the consumer world to ensure they have a balanced understanding of our industry. There is an ever increasing need to provide consumers with accurate information. No matter what your role in your organization, we are all responsible for communication and engagement. As food system leaders, we must engage, especially when it comes to technology and innovation.

We need to talk about change in a way that engages people. We need to tell our story. Stories have power, and the farmers' story is an inherently compelling one. People want to know the why of agriculture – why do we do what we do? That why is our values. This is what you want people to believe in. We need to talk about the challenges and what we're trying to achieve, to meet people on common ground and begin to build trust. If the consumer trusts the farmer, the consumer trusts the food. In many ways, nothing we do has more negative impact on the planet, but is more necessary to our very survival, than agriculture. The next 30 years are the most important years in the history of agriculture. They represent a leveling out of the earth's population, and the maximum human burden for the earth. This is why we need to get this right – to support the people and save the planet.

Building consensus and advancing solutions is the mission of NIAA. This conference brought together representatives of many disparate facets of animal agriculture, from the producer to the researcher to the technology company, to discuss big ideas and move the conversation forward. Technology and innovation will power our future, and the consumer will join us if we give them the chance.

Presentation Highlights

Welcome and Opening Comments

Daniel L. Grooms, DVM, PhD, *Dean of Veterinary Medicine, Iowa State University*

Iowa is the center of agriculture in the Midwest. Iowa generates \$21.5 billion annually in crop production, and \$32.6 billion annual in animal agriculture and livestock processing. Iowa is the center of the pork industry with over 21 million hogs – representing 31% of the US industry – and leads egg/layer production with 60 million layers producing 16.5 billion eggs annually. Production agriculture accounts for 27% of Iowa's total economy.

Iowa state university recognizes agriculture's place in the Iowa economy, and emphasizes the importance of agricultural innovation to move the industry forward. More generally, Iowa State University's mission is to create, share, and apply knowledge to make Iowa and the world a better place. One way of achieving this mission is the recent development of a new student innovation center, designed to give students the tools to enter the workforce and continue to advance the industry.

The Iowa State University College of Veterinary Medicine (ISUCVM) opened in 1879, and is the oldest public college of veterinary medicine in the United States. Currently, veterinary students represent 27 states and three countries. The mission of the College of Veterinary Medicine is threefold: teaching, research, and service. The ISU-CVM Lloyd Veterinary Medical Center serves all species, and the large animal hospital sees the largest veterinary caseload of any veterinary school in the United States.

A recent big innovation for ISU-CVM is the Swine Medicine Education Center (SMEC). Its mission is to collect and synthesize the best practices for clinical swine medicine and to translate and disseminate those practices to stakeholders who can apply them to improve swine health, ensure pork safety, maintain sustainability, and conserve resources. Basically, to be a leader in educating the next generation of swine veterinarians in Iowa, nationally, and globally. SMEC is a public-private partnership between ISU-CVM and Audubon-Manning Veterinary Clinic (AMC). To date, SMEC has educated students from North America, Asia, Africa, and South America, and had a tangible impact in 35 countries.

The ISU-CVM is home to the country's largest animal diagnostic lab. In FY 2017, the VDL saw 85,000 cases and performed 1.3 million diagnostic tests, most of those focused on the food animal industry. Iowa State University is in the process of building a new veterinary diagnostic lab to handle the continuing rapid expansion in veterinary caseload.

Finally, ISU is a leader in funding and research with respect to the animal industry. Relevant research at ISU-CVM is designed to answer important questions to move the industry forward. Focuses in swine medicine include new tests and strategies, managing swine infectious disease, and research into lameness issues. The National Institute of Antimicrobial Resistance Research and Education (NIAMRRE) is another innovation center. Housed in the college of veterinary medicine and representing both animal and human medicine with a consortium of schools, this center is addressing one of the most pressing public health concerns facing the world. Last, the Nanovaccine Institute, a consortium of researchers from 20 different

universities housed at ISU, is developing new vaccine technologies and technology, with the goal of using innovative nanotechnology to drive forward in more precise and efficacious delivery of vaccines to both animals and humans.

Welcome to Iowa!

Can Agriculture Save the Planet?

Mr. Jack Bobo, Vice President, Global Policy & Government Affairs, Intrexon Corporation

In many ways, nothing we do has a more negative impact on the planet, but is more critical for our daily survival, than agriculture. The challenge is to retain and grow the benefits of agriculture while reducing the negatives. Nothing is bigger in terms of land use than agriculture, and 40% of all the land on earth that could be used for agriculture is currently in use for that purpose. Agriculture also uses vast amounts of water – for example, agricultural water withdrawals are largely responsible for the fact that the Aral Sea has been drained to just 30% of its original volume, and the Colorado River no longer flows all the way to the sea. And agriculture affects climate change – 10 to 15% of greenhouse gases come directly from agriculture, and another 10 to 15% from deforestation, most of which is caused by agriculture.

These statistics paint a dire picture of agriculture and the impact it has on the planet. However, for every \$1 invested in agriculture we get \$1.43 back everywhere in the world. There is a huge positive rate of return. For comparison, for every \$1 invested in wind and solar, we get less than \$1 back. Consumers could either pay more for their energy or less for their food to get a cleaner environment.

Population growth is a challenge. 800 million people will go to bed hungry today, and 9 million people die every year of hunger. People feel like the food system is failing us when we talk about 800 million going hungry – this represents 12% of the world population. That sounds like a lot, but thirty years ago, that proportion was 24%, and fifty years ago it was 36%. (Figure 1) Things are getting better – but the question is, are they getting better fast enough?

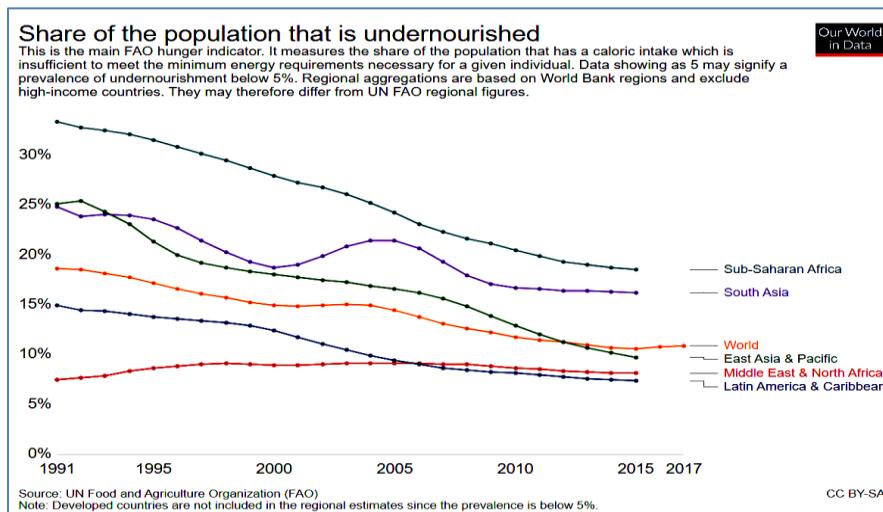


Figure 1. Share of the population that is undernourished.¹

We will need 60 to 100% more food by 2050, and we need to generate more food using less land, less water, and less resources. If we don't change how we produce food, everything will change. Two competing global trends are the slow food movement and the movement towards the intensification of agriculture. We need to find ways of bringing these together. People love innovation almost as much as they despise change. Unfortunately, there is no arena where people despise change more than in the food they eat. The challenge is to help people see developments in food technology as innovations – not change.

Europe has taken a low productivity, low intensification approach to agriculture, largely due to the desire to protect the local environment. But the consequence of this approach is that Europe can't feed itself – it must import 70% of its animal food needs. The import source is largely a high productivity country - Brazil. The unforeseen consequence of this arrangement is that Europe is exporting its agriculture footprint to Brazil, whose high productivity approach has led to increasing deforestation as they strive to enhance production to meet export needs. Europe is in effect marketing a vision of reality that is not consistent with actual reality. But it has a huge impact on how consumers think about the food system – and it means that these consumers don't understand what agriculture really looks like.

A hazard is something that has the potential to harm you. Risk is the likelihood of a hazard causing harm. (Figure 2)

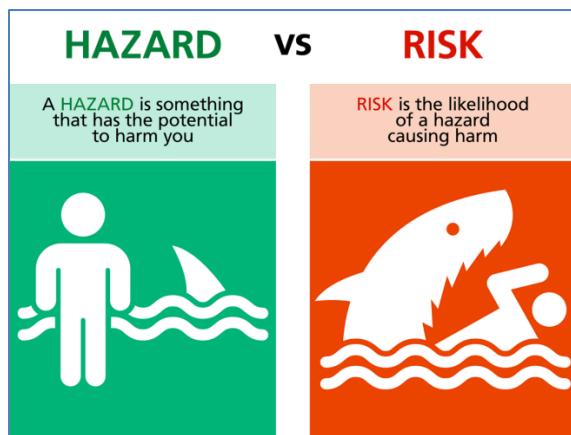


Figure 2. Hazard vs Risk²

We're hardwired to understand hazards, but not to understand risks, and thus our understanding of risk relies entirely on our perception of that risk. Media exposure can significantly sway our perception. In other words, people worry about what they're told to worry about. People worry about chemicals in their food, genetic engineering, and innovations they don't understand. But even though the seedless watermelon has been treated with a highly toxic mutagen to produce three sets of chromosomes, (which is what leaves it seedless) no one worries about watermelons because they've not been told to worry about watermelons.

Perception of risk is inherently intertwined with our biases and experiences. Confirmation bias is the tendency to look for information that is consistent with our beliefs, and avoid information that's not. It isn't ignoring things that are obviously wrong – instead it's digging deeper until you find the one small

thing that allows you to ignore the rest of the information. Understanding our own biases, and how we work in this manner, allows us to understand other people with respect to theirs. Informing our experiences and the perceptions linked to them is the availability heuristic: the tendency to overestimate the likelihood of events with greater availability in memory – e.g. those that are highlighted by the media, and those that are the most recent.

Consumers' perception of risk, biases, and experiences often lead to false beliefs. But instead of eradicating those, the food industry often caters to them. In the short term, this strategy works, because consumers care about the health and safety of their family, and marketing around those false beliefs caters to this. However, in the long term this approach has ultimately backfired. In many cases spurious claims related to past false beliefs have been debunked, and as a result consumer confidence in the food industry has fallen as they've realized they've been misled.

Food fear is real. Names matter, and how we talk about things matter. Take the example of the 'Chinese gooseberry' - otherwise known as the 'kiwi'. Which would you choose to eat? Language is critical to how people respond to us. We need to talk about things in a way that engages people. If you lead with science, you will lose with science. All of us – farmers, scientists, everyone in the agriculture industry – needs to become better storytellers. Farmers and ranchers have a great story to tell, they just need to be able to put it out there, and at the same time be willing to acknowledge and address the consumer's concerns. We need to approach the conversation through the lens of values, because when science and values are inconsistent, values always win. If we can talk about the challenges and what we're trying to achieve, then we can meet on the common ground of values and begin to build trust. If people don't trust you, the science doesn't matter. And if people do trust you? The science doesn't matter! Rather than tell people what you do, you should tell them why you do it.

The baby boom generation was inundated with warnings that population growth was a huge threat, and everyone was going to die of hunger. That didn't happen, mostly because of better nutrition and medicine, but people are still worrying about population growth. The rate of population growth peaked in 1966 and has been decreasing ever since. Our current population growth is occurring for different reasons than it did in the first part of the 20th century – due to the fact that people are living longer, not increased birth rates. By 2050, life expectancy will stabilize – and the population will stabilize. The challenge is to get to 2050 without cutting down our forests, or draining our rivers, lakes and aquifers. The next 30 years are the most important years there will ever be in the history of agriculture. That's why we need to get it right, and why the work we do is so important. But in order to put in place the technologies that will save the planet, we need to build public trust. The science will tell us what we can do. But the public will tell us what we should do.

DISCUSSION

Mr. Bobo mentioned the role of farmer as storyteller. Where do we typically fail?

Storytelling is difficult for everyone. We all have trouble telling our story – from farmers to scientists – because we're not comfortable telling a story, and we're not excited to tell strangers what we do. But

we're in a different world than we were thirty years ago. Transparency is extremely important to the consumer, and for the first time, people are interested in the farmer's story. No one has asked this before! We're not doing a bad job – we've just been asked to do a new job, and we have to learn how to do it.

Blockchain: Traceability & Transparency for Supply Chain Effectiveness & Elevated Consumer Trust

Mr. Richard Gordon, *North America Blockchain Solution Sales Leader, IBM*

When you say 'Blockchain', people often think of Bitcoin. Bitcoin was one of the first applications of blockchain, and thus the application everyone remembers. But Blockchain for business, as has been undertaken by IBM, is different from Bitcoin. Blockchain for business is applying blockchain technology for clients from a business perspective. Blockchain brings traceability and transparency, offering the ability to tell the skeptical consumer where their food really comes from. Big retailers and some big food companies really want to own that relationship with the consumer.

Blockchain allows you to seamlessly join siloed networks to allow the consumer access to the farmer. It harnesses the new paradigm of connecting the brand – in this case, the farmer – directly to the consumer. No longer does the consumer have to trust the label, or ask the employee behind the counter who has never set foot on a farm. Blockchain drives consumer trust.

Blockchain technology offers a highly secure and efficient way to connect disparate systems, to create a transparent and trusted network from one end of the supply chain to the other. This method works due to three overarching principles. First, the system is open by design. Anyone can join the network, made possible by the security inherent to Blockchain technology. Second, no one controls the network. The individual user can control access to the information they enter and make available in the system, secure in the knowledge that other users will see only what the participant wants them to see. Finally, Blockchain strives toward a network for networks, where people can interconnect with different products and processes to seamlessly communicate and do business.

One example of what IBM is doing in the food industry is the IBM Food Trust Network. (Figure 3).



Figure 3. IBM Food Trust Network³

In 2016, Walmart approached IBM with a problem: How to assure food safety with Chinese pork imports. Walmart had a similar issue with imported mangoes. Blockchain developed a system, IBM Food Trust, that improved traceability - in the case of the mango, from 8 days to 2 seconds. With both of these commodities, IBM was able to prove that the network works. In 2017, IBM opened up the Food Trust Network, and several other producers and companies have now joined. In 2018 the network was launched to the public, and as of 2019, consumers using IBM Food Trust are able to locate the source of several products that they buy.

Golden State Foods (GSF) is a second company working with IBM Food Trust to optimize the supply chain. The problem was that cold-chain data were managed in silos by each participant in the supply chain without interoperability. Managing shelf-life, product rotations, and inventory was a challenge due to lack of pertinent information along the chain. The solution was to create a real-time supply chain platform to manage inventory and cold-chain using RFID (a tag on each box- associated with pallet ID), Internet of Things (IOT) sensors, and analytics. The result has been accurate inventory positions and precise determinations of expected shelf-life of each product of each case at all locations. This has given the company insights for better inventory rotation and reduction of waste due to expiration, as well as end-to-date auditable records of cold-chain management.

A European company that has now embraced IBM Food Trust is Carrefour, based in France and operating in Spain. The problem was that there is increased consumer demand for information on the food they buy, but retailers lack easy access to this information or way to share the information they do have with consumers. The solution was to trace select Carrefour products. IBM Food Trusts designed a system to implement QR codes on chicken products that consumers can scan for source and quality information. Due to this innovation, Carrefour has seen improved brand trust and stronger relationships with consumers. Carrefour plans to roll this technology out to all brands globally by 2022.

Who is best equipped to provide information to the consumer? The farmer! The consumer can be assured of sustainability, humane practices, quality of product, and a host of other information as desired by the farmer, the consumer, and the supply chain in between. Blockchain drives consumer trust, and it is that trust that upholds the industry.

DISCUSSION

Where does IBM go next, as we trace backwards from the processor back up the supply chain? Will the technology reach to individual producers?

Blockchain tech is in its infancy – think of it like the internet, 25 years ago., IBM is all about piloting and addressing problems. IBM Food Trust started with WalMart, and has now grown to over 20 large operations. Because most people have a smartphone, this technology can grow throughout the supply chain. IBM sees it going all the way back to the name of the person who picked the mango. The goal is to provide a transparent view for the consumer at every step in the process.

Challenges Facing Rural Entrepreneurs

Peter Orazem, PhD, University Professor of Economics, Iowa State University

The current labor market in the United States is about as strong as it has ever been. Unemployment is less than 4% nationally, and in rural states, the unemployment numbers are even lower. We've seen more than a generation of strong economic performance. However, over that generation, growth in amount paid per hour has not kept pace. That translates to slower growth in purchasing power. The current worker in the United States has an average producing power that is 5 times greater than just after World War II, and much of that productivity growth has translated into a 4-fold increase in worker purchasing power. However, worker productivity growth has slowed considerably since 2000 and that has caused historically slow wage growth over the last 20 years.

Although it may sound counterintuitive, part of the cause of the slowdown is technology. Technological innovation enables economic growth, however, not all technological innovation has been shared equally. There are winners and losers. The economy, bolstered by technological innovation, favors the most skilled workers, and college graduates have been the recipients of the benefits of technological innovations over the past twenty to thirty years. But technology also substitutes for low skill workers. For these low skill workers real wages have fallen, even as the economy has grown.⁴ (Figure 4).

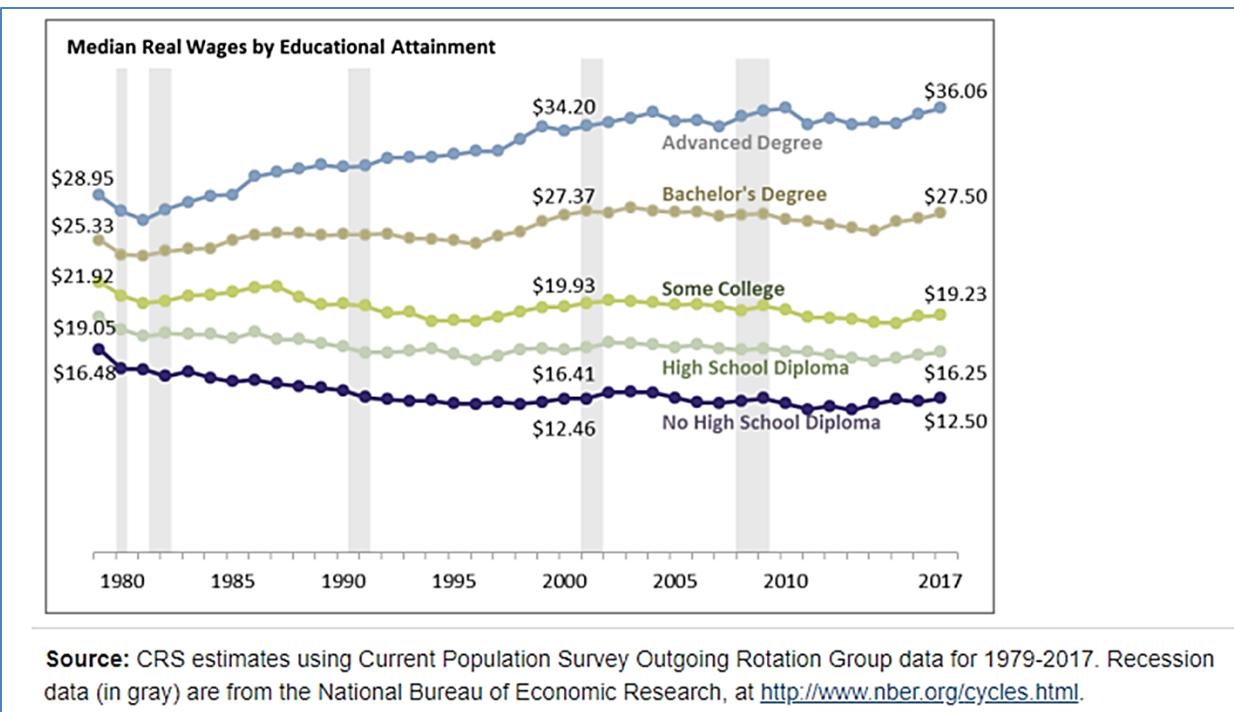


Figure 4. Technologies complement high skill and substitute for low skill workers. Real wages have fallen for those without a bachelor's degree.⁴

It is not only in the United States that technologies affect the labor market. In developing countries, the realities of the economic picture drive technological innovation. As incomes rise, the demand for luxury goods and services has grown more rapidly than income and the demand for necessities, including agricultural products, grows more slowly. The economy shifts to address these demands, favoring services and moving away from agriculture and manufacturing, and technology also shifts to reflect this change. Technological innovation in agriculture has been quite strong, but the resulting growth in agricultural output has outpaced growth in food demand, leading to relative declines in food prices compared to prices in the service sector. The shift in the service sector share of the economy reflects the stronger growth in demand for luxury goods and the slower growth in demand for food.

What is the source of slowing labor productivity growth in the United States? One cause is an apparent reduction in the flexibility of our labor market. Even before 2000 but certainly since then, there has been a reduction in how many U.S. workers are moving across states, across counties, across industries and across jobs in response to changes in society, the economy, and production. In addition, the pace of innovation and entrepreneurship has slowed.

One likely issue is that the United States no longer leads the world in education, and so we are lagging in our development of technically skilled workers. The 20th century was viewed not only as the American Century, but also the Human Capital Century. For most of the 1900s, the U.S. labor force was the most educated in the world. But average schooling attainment stopped growing with the birth cohort of the

1950s, and the United States' advantage has more or less disappeared. In educational attainment, U.S. students now lag the average of industrialized economies, particularly in math education. (Figure 5)

The pace of innovation has also slowed because of cuts in support for basic research. Basic research is a public good. The most impactful new innovations in the coming years will be in basic research – in science, engineering, and the health sciences. The United States still leads the world in the share of GDP devoted to R&D, but that funding is largely private, provided by industry, and focused on applied instead of basic research. The federal government is the main source of basic research funding, but the federal government has cut its commitment in that arena with significantly decreased spending. With nondiscretionary spending (Social Security, Medicaid, Medicare, and Interest Payments on the debt) taking up a steadily increasing share of the federal budget, the prospects for future growth in federal spending on basic research are not good.

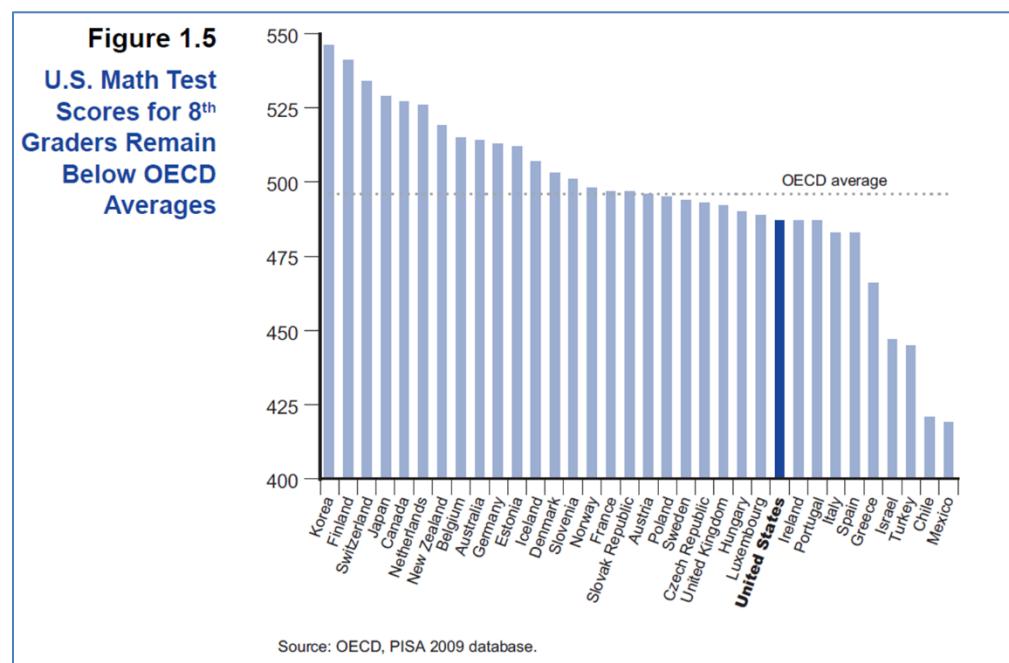


Figure 5. U.S. Math Test Scores for 8th Graders⁵

The United States' ability to maintain our pace of technological growth depends on our ability to attract the best minds. A disproportionate share of new innovation has been fueled by foreign-born residents of the United States. The US has led the world, partly by its ability to access these best minds from all over the world. Will this be able to continue if the U.S. loses its advantage in attracting the best innovators from around the world. Other countries are already increasing their share of these potential leaders as international students increasing go to Europe or Australia or the prominent universities in China and India. If the most impactful innovations are going to be in science, engineering, and health science – where does that leave the US if it is no longer attracting and retaining the best technically trained individuals from around the world and is no longer producing technically trained individuals domestically as well?

Technological innovation has driven the United States from a market dominated by small farms to a market dominated by large ones, but not in all commodities. (Figure 6)

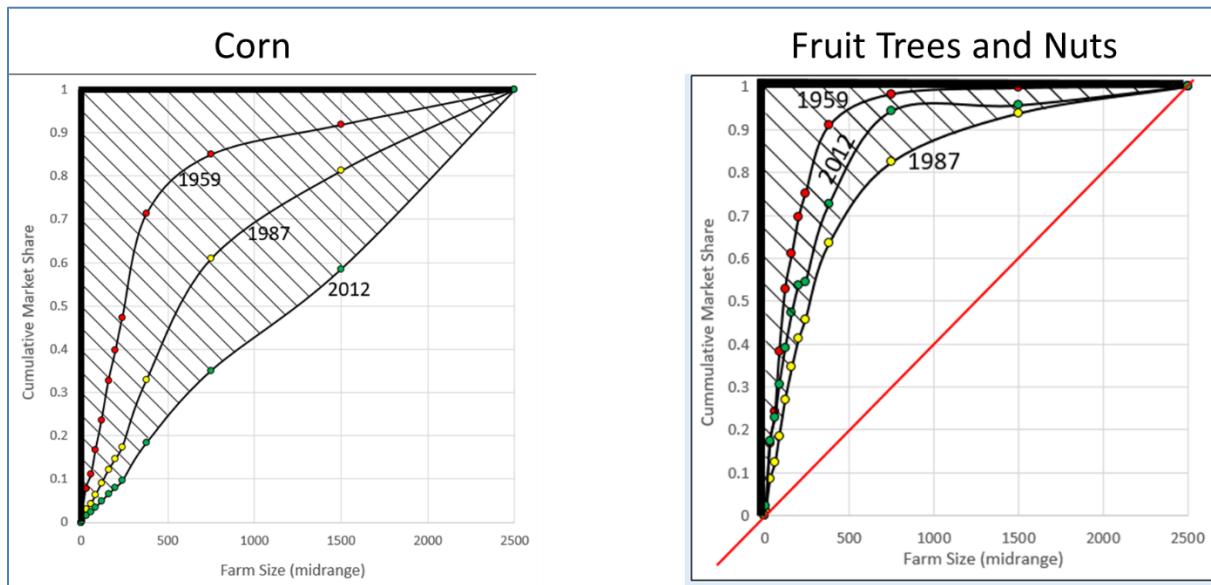


Figure 6. Market Share-Weighted Size Index, 1959-2012.⁶

Farm size is a function of off-farm opportunities and technological means to substitute farm labor. As education of the farmer increases, farm size tends to decrease. This is because the farmer is also working off the farm, and about 80% of farm household income is currently generated off the farm. Due to this dynamic, or perhaps causing this dynamic, many smaller farms are located near urban areas.

Most of the growth in employment in the U.S. since 1999 has been in metropolitan or large urban markets. Employment in rural and small urban markets has shrunk. There are substantial productivity advantages in the denser markets due to better access to skilled labor, venture capital, input suppliers, and customers. As a result, there is a substantial wage advantage in metropolitan markets. In Iowa, non-metro wages lag metro wages by 14%. The need for off-farm labor opportunities to shore up farm household incomes has led to rising use of commuting to shore up the household incomes for rural residents. Improved transportation options allow people to access the higher wages in the metropolitan area, while still benefiting from the lower cost of living in the rural areas. In Iowa, 41% of the workers residing in the least populous counties work in a different county. It is the off-farm income opportunities accessed through commuting that is allowing people to stay in those smaller towns and cities. (Figure 7)

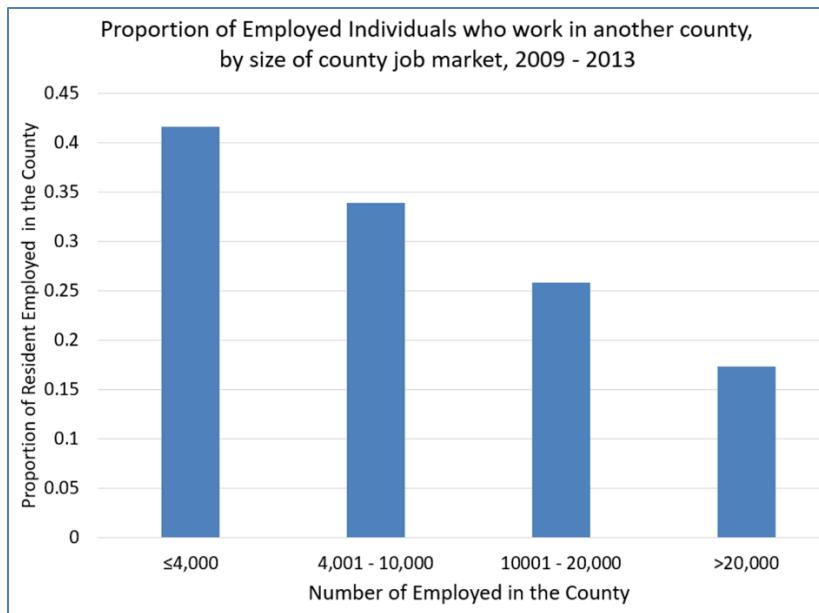


Figure 7. Proportion of employed individual who work in another county.⁷

Entrepreneurship in rural America faces many challenges. Technological innovation, wage and job growth, educational challenges, lack of government funding, and declining productivity growth all contribute to these challenges. The US is moving toward automation because we're finding it hard to attract enough people to work doing labor intensive processes. The United States produces many more manufactured products than in the past – we are just doing it with many fewer people. Moving forward, the type of production process you will observe in rural areas is going to be changing, with many fewer jobs and much more automation. One way to address these dynamics is to focus on the strengths of rural areas. Producing in rural areas enjoys the advantage of lower costs. Small farmers and others are attracted to rural areas due to the lifestyle – the ability to farm, the low cost of living – and transportation enables them to access the job market in urban areas. Rural communities can support the focuses that attract these rural residents, and focus on creative opportunities to support that economy. However, rural entrepreneurs need to be integrated into their nearby metropolitan markets to gain more fully from the advantages of large populations of workers, customers, suppliers, and investors.

Science Communication Workshop: Making Your Message Matter

Michael F. Dahlstrom, PhD, Professor, Journalism & Mass Communication, Iowa State University

The study of science communication is the study of how communication moves from expert to non-expert audiences. Scientific expertise, complexity, and unintuitive results are barriers to communicating, but stories have power – they connect us to each other. The human experience surrounding agriculture builds connections. The goals of this workshop are to demonstrate how storytelling influences audiences, how it intersects with science, how to identify the important decision points when creating stories, and how to get you telling stories.

How do you communicate about animal agriculture? The most common formats are expository, argumentative, and narrative. Expository communication is descriptive or explanatory, similar to what you would find in a textbook or factsheet. In this format, you tell people what's going on. Argumentative communication is employed to support or justify a claim. Journal articles and advocacy messages often take this format. Finally, narrative communication consists of placing information into a story format. Types of communication that take this format are varied, and range from anecdotes to testimonials to simple personal conversation.

What defines a narrative? It's a temporal sequence of events, with cause-and-effect linkages and specific, human-like characters. It's a particular personal experience of a larger phenomenon. The difference in the narrative from expository and argumentative communication lies in how the audience processes the information. Narratives are context-dependent, specific, and present facts that are coherent, in addition to being accurate. Narratives are easier to comprehend, processed faster, recalled more easily, and carry greater weight for decision-making. For example, the chance of shark attacks near White Beach. Suppose the chance of you getting attacked by a shark near White Beach is 0.01%. That's not very high, and you'd probably ignore any shark warnings. However, consider Martha, a shark-attack survivor, who comes to talk to you on White Beach. She lost an arm in a shark attack just off shore. The chances of attack are still the same as before, but you are much less likely to swim after meeting Martha.

Stories are the default mode of human thought. They are what happens when we let our guard down. Stories are how we cognitively structure information to interpret reality. So how can we put science storytelling into practice? Narratives are complex communication structures, and crafting them takes specific attention. A couple of tips can help structure your narratives into compelling, memorable stories.

The first tip is to use anecdotes or exemplars. These illustrations take information from the abstract to the concrete by allowing the audience to identify with the character. They need to be attention-getting, persuasive, and relevant to the audience. One example is neighbor stories. Describe an actual person who has done something and had the resulting experience. These stories bring the science to a human level through someone who has experienced it, and it has a huge positive effect on the audience.

When you want to communicate with an audience, take a couple of minutes and consider:

- Does your topic have obvious anecdotes?
- Will you use real, or fictionalized stories?
- How many anecdotes do you need to demonstrate your topic?
- Who are the most relevant characters?
- Do you want to show success or failure?
- Do you want to show an extreme example or a representative one?

The second tip is to use a story pattern of organization. Organize your anecdotes or exemplars around a challenge. Consider specific character and chronologic order. One way to think about this organization comes from Randy Olson. Often communicators try to organize stories through AAA organization: fact *and*

fact *and* fact *and* fact. This is a clear presentation, but not at all engaging. Drama is good – confusion, doubt, and conflict draw people into a story. Instead of AAA organization, consider using ABT organization: fact *and* fact *but* fact *therefore* conclusion. The ‘*but*’ is where you get your drama – it provides a reason for your character to act, and a reason for your audience to continue listening. (Figure 8)

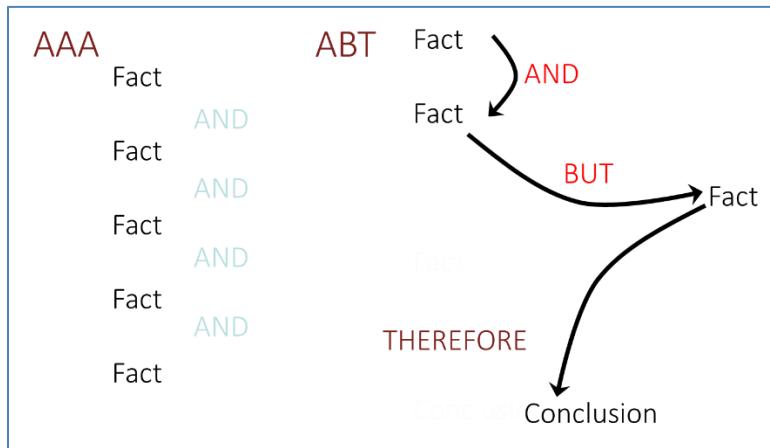


Figure 8. AAA vs. ABT story organization⁸

When developing your story, consider:

- Who is your main character?
- Who is your audience?
- Is there an obvious chronological order?
- Where's your drama? (The ‘*but*’ and ‘*therefore*’ in your story outline)

Storytelling offers informative and persuasive benefits for communicators. Stories are often useful when you need to communicate, as they tell the audience how your information impacts their lives. Consider incorporating anecdotes or exemplars and a story pattern of organization when creating your next message. Have the stories prepared and ready to go, so that they're available when you need them. Find the story hidden in your research!

How Alternative Proteins Can Support the Animal Agriculture Industry

Ms. Renée Vassilos, *Agricultural Economist and Banyan Innovation Group Founder*

Industry disruption is a process whereby a smaller company with fewer resources is able to successfully challenge an incumbent business. Alternative proteins have caused agriculture industry disruption, but alternative proteins can also be viewed as an opportunity: to leverage that disruption to innovate and grow.

Vassilos is an agricultural economist, and has worked as an agricultural specialist for the USDA in Beijing, as an agricultural economist for John Deere in China, India, Southeast Asia and the United States, and finally launched her own agribusiness consultancy two years ago, supporting ag tech startups and the

investor community. She has been looking at the industry and starting to ask questions about where the opportunities are, and how to bring those opportunities to growers and producers.

There are two ways to handle disruption: fight it or leverage it. In the late 1980s, Starbucks' entry into the coffee industry completely disrupted the market. Starbucks offered premium coffee with a new delivery method: European style coffeeshops. As a result of Starbucks' entry into US coffee, the worth of the coffee industry nationally has quadrupled, from \$4.3 trillion in 1991 to \$16 trillion in 2016.⁹

What happened? Starbucks started a chain reaction. As a result of the disruption created by Starbucks arrival on the scene, incumbents in industry started to innovate. Established industry players developed creativity around new products and new ways to deliver products. Coffee industry giant Nestle innovated to develop products at both ends of the coffee spectrum: Nescafe for the entry-level coffee drinker, and Nespresso premium home coffee for the connoisseur. The coffee industry experienced a halo effect, as Starbucks brought solutions, experience, and value to the entire market. In 1990, 3% of coffee was sold at a premium. By 2000, 40% of coffee sold was premium. Starbucks remains a very small share of global coffee consumption, but other players stepped up and innovated to elevate the entire industry.

More recently, Uber and Lyft have completely disrupted the personal transportation industry. Their vision is to revolutionize personal transportation, and challenge the status quo. Unlike Starbucks and the coffee industry, however, the taxi industry chose to fight the industry disruption. The taxi industry had been fairly monopolistic before Uber and Lyft, and fought the change they brought with legislation and regulation. They ignored customers, who supported the innovations finding their way into the industry. The taxi industry chose to fight even though they had the tools to compete: infrastructure, in drivers and cars; the knowledge, as they were already established and trusted in driving routes; and the culture, with customer who already knew how to use the system. Instead of innovating and recognizing the opportunity that was presented to them, they resisted. As a result, the industry has been decimated. New York taxi medallion value, \$2.5 million in 2013, has fallen to just \$205,000 as of 2018 and is in bankruptcy. Meanwhile, from 2012 to 2018 Lyft increased from 40,000 to 500 million rides, and when it went public in 2019, was valued at \$26.5 billion.

Industry disruption provides opportunity – to leverage the disruption to innovate and grow. So, what's happening in the animal agriculture space? Like the taxi industry, animal agriculture has significant advantages that are the envy of any start-up: an established customer base, a product with established domain, proven demand growth, positive revenue, and established distribution channels. However, start-ups bring their own set of advantages. One of the most important is a willingness to fail repeatedly. This open attitude allows start-ups to be creative, innovate, and try a variety of approaches to solve long-standing industry problems. Start-ups attempt to solve problems using a different lens, and through that process are really looking at what the problems are, how to do things better, and creating novel solutions. Because they are small, start-ups are able to be much more responsive when they discover one of their solutions isn't working. They don't have to contend with cumbersome infrastructure or established history and positions. Finally, start-ups are willing to challenge the status quo. They tend to approach a

problem asking why it has been done this way and is there a better way, and a belief that it doesn't have to be the way it's always been.

If there's a way to bring some of this start-up energy and attributes into established industry, it is a tremendous opportunity. Established industry can use the momentum that a competitor is bringing into the space to challenge the status quo and rethink the motives of the supply chain to bring more business opportunity. This is a chance to look at what you can do differently, moderating efficiency with responsiveness. Take this opportunity to take a hard look at the problems that need to be solved, such as consumer concerns. What are the concerns? Why are there concerns? Identify and address the health and environmental questions and lack of trust in big agriculture – and use it to your advantage. Try something different. Start small, focusing first on low cost, minimal impact changes. Communicate with your large customer base. And when you fail, take the lessons learned and try again!

The animal agriculture space is a spectrum of businesses within the industry. Some of those businesses are durable, with the ability to take advantage of growth opportunities and respond to changing demand, and some are vulnerable, often hyper-focused on efficiency with no room to adjust. The opportunity is to evaluate the diversifying opportunities and consider offering products to meet new needs, from new meat consumers to premium meat consumers to possibilities beyond consumer goods.

This sounds like a great opportunity and one where new tools might be an important resource. BeefTrader¹⁰ is a Brazilian livestock technology company that offers such a tool. They recognized that everything at the feedlot is measured by the average – herds are weighed and measured, but there is no animal-level understanding. BeefTrader developed a program with the goal to measure profitability by individual animal. At the feedlot, they employ scales and cameras, collecting 10 different data points on each animal. The feedlot supplies costs and diet composition. BeefTrader compiles and analyzes both sets of information to predict premiums and penalties. The BeefTrader program delivers optimization for profitability to the customer by providing information that identifies the optimal time to send the steer to the processor. BeefTrader is currently running at feedlots in Brazil, and looking to expand to the United States. They really are delivering the 'so what' – significantly increasing profitability. The tool is scalable up and down, offering a solution for producers from the very small to the very large. Many new technology solutions are similarly applicable.

What if you knew which genetics outperform? Knew the market demand? What if you could actually share the story of positive environmental impacts, and could deliver information on environmental impact per individual animal? What if you could predict profit, per animal? There is nothing to fear in this space. The opportunity is to understand.

DISCUSSION

Yesterday we discussed the need for storytelling in agriculture communications. Where does the agriculture industry fail in this arena?

Everyone thinks about how important it is for farmers to tell their story to the customers - but what's missing is information about who is eating the product. Producers need to hear from their customers. This two way communication provides an opportunity for growers to forge a deeper connection to the people, eating their product, as well as sharing the farming story.

What are the things currently happening in the alternative protein space?

Alternative proteins are a big picture landscape. There are hundreds of new proteins, as well as supporters and funders of new proteins. Working in this space is a big departure from working at John Deere, where new products were only generated if they could make a profit. In the venture capital world of alternative proteins, investors provide support to ten or more different companies, with the anticipation that maybe one of those companies will 'hit it big' and give them a 20-fold return. Investors understand that very few of these companies are going to result in a revenue-generating endeavor. These investors aren't necessarily obscure, either. Tyson and Cargill are investing – with an eye toward business diversification. Several of the big players in this space are diversifying their businesses. This is the same opportunity farmers and ranchers have – to diversify away from solely contributing to the commodity meat space.

Farm Bureau has been spending a lot of money to advance regulation of alternative proteins, in order to set a level playing field. They feel it's important to have a level playing field before we start competing against each other.

There is an important position around leveling the playing field. Vassilos thought is that putting the focus on the level playing field puts too much emphasis on regulation and too little emphasis on recognizing and seizing the opportunity created by the entrance of alternative proteins into the market. It is important to level the playing field, but it is also important to figure out what is motivating the change, and how the agriculture industry can profit from it.

Venture capitalists provide the support if significant cash to explore innovative solutions and try new things. Established industry producers don't have this excess capital.

While there is a lot of money being thrown at this space, the actual start-ups are always operating on the edge with barely enough capital. The approach that works is to determine how to challenge the status quo and do things differently from a very low cost, low impact perspective. If you fail in that small change, the losses are not too great to pick up and try again. You need to leverage low cost low impact innovations initially, as you explore the effects on business growth and revenue.

There is a growing trend in social impact investing. What is the difference from a traditional venture capitalist?

Venture capital investments traditionally are high risk dollars in high risk research and development enterprises. Social impact investing is not high risk. Social impact investors usually invest in profitable

companies that are delivering on positive environmental change, good social practices, and good governance. The motivation of the social impact investor is different from that of the venture capitalist.

Alternative Proteins: Present State and Future Outlook

Rodrigo Tarté, PhD, Associate Professor, Department of Animal Science, Iowa State University

What is meat? The USDA definition is:

"The part of the muscle of any cattle, sheep, swine, or goats which is skeletal or which is found in the tongue, diaphragm, heart, or esophagus, with or without the accompanying and overlying fat, . . ." ¹¹

There is a separate USDA definition for poultry meat. A practical definition of meat is the 'edible postmortem component originating from live animals.'¹² Setting the practical definition aside, it's important to note that nothing in the USDA definition says that meat has to come from living animals. The way it's written could be open to interpretation given the new technologies that are coming on board.

If we did away with animal agriculture – basically stopped farming meat – greenhouse gases would decrease by approximately 2.6%, and meeting the nutritional requirements of the US population would be very challenging. Animal-derived foods contribute 24% of energy, 48% of high-quality, bioavailable protein, up to 67% of amino acids, up to 100% of essential fatty acids, and more than 50% of calcium, several vitamins, and choline to the American diet. This source of nutrients would be hard to replace, as no substitute provides such a comprehensive set of nutrients in such a bioavailable package.¹³

A meat protein alternative is a protein source that attempts to replicate the experience of eating meat in its various forms, but without the use of animals. Some of these clearly want to replicate the experience of eating meat, while others just want to be 'close enough' to meat without using animals. Development and adoption of meat protein alternatives are driven by a variety of factors, including animal welfare, health and wellness, vegetarian and veganism, and environmental concerns. These factors are not the same for all people, so different products target different consumer motivations, and various products are delivering on these needs to various degrees. As we discuss and approach this topic, however, it must be remembered that while they are often catering to customers ethical needs, alternative meat protein companies are not altruistic - their main goal is to turn a profit.

There are four main alternative protein categories: plant, fungi, animal, and other. Sources for these range from soy to mycoprotein to seaweed to insects. (Figure 9)

Origin	Sources
Plant	Soy and other pulses, wheat, gluten
Fungi	Mycoprotein
Animal	Cell-cultured meat Insect (crickets, ants, etc.)
Other	Macroalgae (seaweed) Microalgae (unicellular eukaryotes or prokaryotes)

Figure 9. Alternative protein sources¹⁴

The meat substitutes market globally totals \$3.71 billion¹⁵ – not a large market percentage. However, the growth rate of this market is estimated at 7.4% per year, and that is a significant number. It is estimated that the meat substitutes market will total \$7.45 billion by 2020.¹⁶ In the United States, the meat substitutes market totals \$553 million.¹³ Most of this market is dominated by wheat-based protein, soy-based protein, and mycoprotein. It's a small market, but it is growing steadily.

The most mature sub-segment of alternative protein segment is plant-based proteins. These are mostly soy-based products, but also include wheat, gluten, and pea. Recent developments aim to simulate meat more closely than older generation products, and include products like Beyond Meat and the Impossible Burger. Product placement is in the refrigerator case, next to meat. Unlike mature products, which look like cooked meat, these products are made to look red and bleed like raw meat. (Figure 10). They are also highly processed and contain a number of added ingredients.



Figure 10. Beyond Meat plant-based burger patties

Incorporation of leghemoglobin, made from the root of soybean plants, and beet juice are two innovations enabling this evolution in plant based products.

More established mature plant protein products include Kraft's Boca Burger, Kellogg's Morningstar Farms product line, and Mapleleaf Foods Lightlife and Field Roast products. These are just a few examples – there are many other products in what has become a large category of foods with a wide variety of product offerings. And many of the retail giants, including meat companies Tyson and Cargill, are invested in this space.

Among mycoprotein offerings, Quorn is the main product line. The protein source is made from the soil mold *Fusarium venenatum* PTA-2684. Because it is made from a mold, there is some concern regarding allergenicity in consumers, but nonetheless, there are a variety of meat and chicken substitute products.

Insect protein is a growing alternative protein sub-segment, and a number of insect farms are located in the US. Protein is the primary nutritional component of insects, usually accounting for approximately 50% of insect biomass. There are estimated to be 2000 species of edible insects. Crickets have become one of the most popular, through products such as cricket flour. Consumption of insects, or entomophagy, occurs in many world cultures, as insects are very efficient converters of feed, inexpensive, and potentially able to meet protein needs in developing countries. The introduction of this protein to the United States and Europe has been more recent, and faces two main challenges: the first is the "yuck" factor, but the second, and perhaps more important, is that insects are animals. They must be killed, and insects do not satisfy vegetarian or vegan dietary restrictions. Currently insect products are more developed in the United Kingdom than in the US, with a range of products such as cricket flour, mealworm flour, and the Jungle Bar. (Figure 11)



Figure 11. Insect protein products.

Cell-cultured meat is an idea that was first conceived in the 1940s. However, the first cell-culture hamburger wasn't developed until 2013. This initial hamburger cost \$325,000 – costs have come down significantly since then. The process involves taking a biopsy from an animal to obtain muscle satellite cells from which to grow the culture.

There are a number of hurdles and challenges if this technology is to come to market. Fetal calf serum provides the growth factors for the cell culture, and this serum must come from a bovine fetus. The process will require farmed animals. As the products are animal tissue-based, culture contamination must be controlled with antibiotics, and right now the only way to control that contamination is through medically important human antibiotics. Aside from the potential ethical and medical concerns, there is

the difficulty of actually mimicking natural muscle tissue, which includes three dimensional structure, as well as adipose tissue, connective tissue, myoglobin, and natural molecules that provide flavor that are not included in a culture of a muscle satellite cells. Because this product is based on animals, a new regulatory framework may be needed, and it is unclear which agency has oversight of the product. There has been some advancement on the regulatory front, with USDA and USHHS signing an agreement in March 2019, giving FDA oversight of cell banks and USDA oversight at the time of harvest and likely into labels.

Potential benefits of cell-cultured meat are environmental, through potential reduction of greenhouse gas emissions, reduced water and land use, and lower environmental impact. However, the process will call for significant water and energy inputs, so the only way to confirm these potential benefits will be through a thorough life cycle assessment. Additionally, food safety could potentially be increased as animal pathogens are eliminated in a cell cultured product - but it's such a different system that there will likely be challenges we can't anticipate right now. Other potential benefits include product tailoring (nutritional quality and eating profile) and provision of raw materials without undesirable parts – but those advancements are years away from development. The biggest challenge facing this technology may be consumer acceptance. Cell-cultured meat runs counter to current consumer ‘natural’, less processed, and chemical-free trends. The “yuck” factor could come into play as well. And pricing, while greatly reduced from the initial \$325,000 price tag, may not be able to compete with other proteins. However, there are numerous start-ups exploring this protein market, and investors include Tyson, Cargill, and others – development is progressing. But so far, no one has built a plant to scale this technology up to a level to provide a consumer product.

Key long-term success factors in the meat substitute market include financial viability, delivery of a truly meat-like eating experience, and delivery of nutritional attributes similar to meat, in addition to fulfilling ethical and moral promises, and demonstrating lower environmental impact. Consumer acceptance is likely to be niche-based, as different alternative products appeal to a wide and varied range of consumers.

Presently there are more questions than answers with many of these alternative protein products, but the trend is likely here to stay.

DISCUSSION

Have there been meaningful consumer surveys about alternative proteins, particularly around the issue of sustainability?

There have been many meaningful consumer surveys, and many written up in the scientific literature. However, he's not sure if any of them have specifically looked at the issue of sustainability.

Are frozen alternative protein products required to be there, or is this simply a marketing gimmick?

Freezing extends shelf life, so the main reason for placement of these products in the freezer section is to extend shelf life. Some of the frozen products don't hold their integrity at refrigerator temperatures, so must be kept frozen. But placing these products in the freezer case right next to meat is a marketing strategy as well.

Is the Impossible Burger the one we should be most focused on as a source of competition?

From everything he's heard, the Impossible Burger is the closest thing to beef, so yes, it is the most viable source of competition. From what he's read and seen, they are also a very transparent company, which appeals to consumers. While the Impossible Burger may be the most likely competition at the moment, alternative proteins aren't a passing fad – they're here to stay. Cargill and Tyson have figured that out and expanded to encompass alternative products. Animal agriculture is going to have to learn to live with these products. Is it threatening to animal agriculture? People are going to continue to demand and eat meat. However, if products like the Impossible Burger live up to the hype, they could be disruptive to the animal agriculture industry. Their share of the market is very small, but they are debuting at Burger King, and if they get a favorable response there market share could expand considerably. While this is concerning for the ground beef market, ground beef is very different from steak. So far there is no competition for steak.

If you look at the other sources (aside from the Impossible Burger), will there be an issue with amino acid profile and biological value? Would alternative proteins add amino acids to balance nutritional needs?

Biological value is not the same for alternative proteins. Across the board, biological value is lower for these alternatives. If we did away with animal products altogether, we would have serious nutritional issues in feeding our population. Nothing provides more complete protein than egg, dairy, and meat. While vegetarian and vegan diets may work for individuals, it's an entirely different thing to talk about adoption at the population level.

How Gene Editing Can Be Another Tool in Raising Healthier Animals

Ms. Emily Metz, Director, New Product Marketing, Genus PLC

Despite our best efforts, farm animals get sick. Sometimes these illnesses come with no cure or vaccine. Tough diseases don't discriminate. Animals inside barns and outside free range catch disease; domestic and wild animals become ill; and both conventionally raised and organically raised animals get sick. Many of them die. The consequences of disease in animals are decreased productivity, lifelong secondary infections, and death. For the farm there is increased economic impact and increased need to use medications such as antibiotics. The consumer hates that animals suffer, and at the same time wants reduced antibiotic use and safe, affordable food. The food company wants what consumers want, as well as elimination of waste and more sustainable food products. Finally, the environment suffers from increased waste and disease spread.

One of the major disease hurdles facing the swine industry is Porcine Reproductive and Respiratory Syndrome (PRRS). Animals that contract PRRS have huge impact on the system. Many die, and many more lose pregnancies. Those animals that do survive are prone to a lifetime of respiratory infections. Antibiotic use increases to cover affected herds. Economic impact is over \$600 million per year just in the US – and over \$5 billion globally. All of this has trade implications.

This is where Genus comes in. Genus is a world-leading animal genetics company, with an 85 year history of producing genetic lines of pigs and cows. Genus is committed to continuously improving the health of farm animals to produce higher quality milks and meat more sustainably. Genus vision is to breed an animal that is resistant to deadly disease from birth, leading to an animal that leads a healthier life, and as a consequence, a herd that needs much less antibiotics. This vision becomes a reality through specific animal breeding. At its core, Genus is an animal breeding company. Pig farmers have used breeding for generations, to increase efficiency and animal health. Selective breeding has increased pig fertility by 100% and increased feed conversion by 40% since 1960, and has increased meat quality to increase yields: from 75 lbs to 120 lbs per each lean pig. In addition, animals have been bred for better temperament and better overall disease resistance. Genus takes pig breeding to the next step with gene editing.

Gene editing is not the introduction of foreign DNA – and gene edited pigs are not genetically modified organisms or transgenic animals. Rather, gene editing is the process of precisely making a targeted edit in the DNA of an animal, turning on or off a sequence of genes that help make that animal healthier. Genus is focused on the use of gene editing to address diseases that don't have a cure and are very difficult to control. In pigs, the main focus has been on PRRS and African Swine Fever (ASF). Additionally, Genus gene editing technology strictly replicates traits that could be found in nature – it does not create new traits. Genus follows strict guidelines that gene editing will not be used for human amusement – no designer animals will be created – and Genus will not use gene editing to create an animal that can withstand neglect or abuse.

The process of gene editing can be compared to the word processor's 'find and replace' function. It uses the CRISPR-Cas9 enzyme as a pair of 'molecular scissors' to snip a DNA sequence to turn a sequence of genes on or off. Genus uses this technology to remove the gene sequence to which PRRS virus attaches. The result has been complete immunity to PRRS in gene edited piglets. After initial success, Genus partnered with the University of Missouri Roslin Institute, and was able to repeat the result – complete and total immunity to PRRS in piglets. (Figure 12)

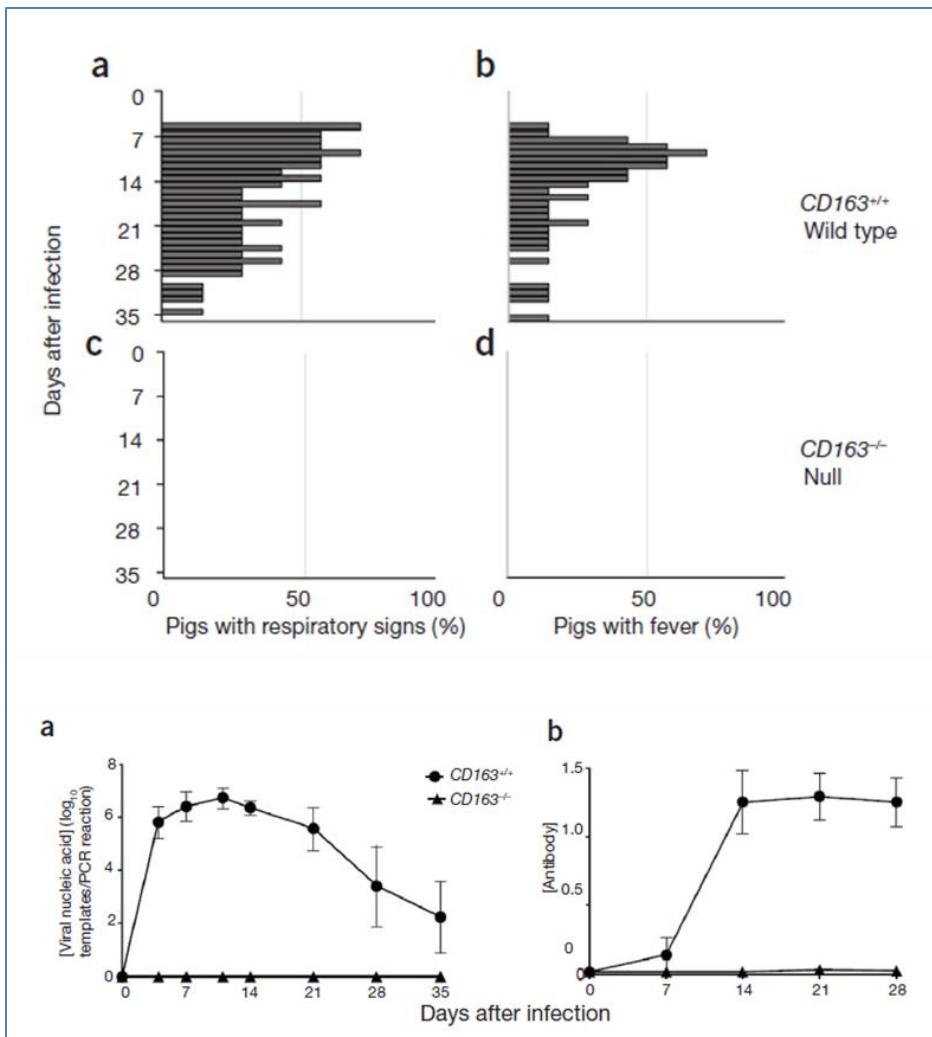


Figure 12. PRRS infection in wild type (CD163^{+/+} PRRS gene active) versus null (CD163^{-/-} PRRS gene inactivated) pigs. No clinical signs or viremia were observed in null pigs.¹⁷

There are currently several generations of litters on the ground now, being raised on Genus farms, that are PRRS disease resistant.

The next step is to bring this technology to commercialization. The timeline is a lengthy one. (Figure 13)

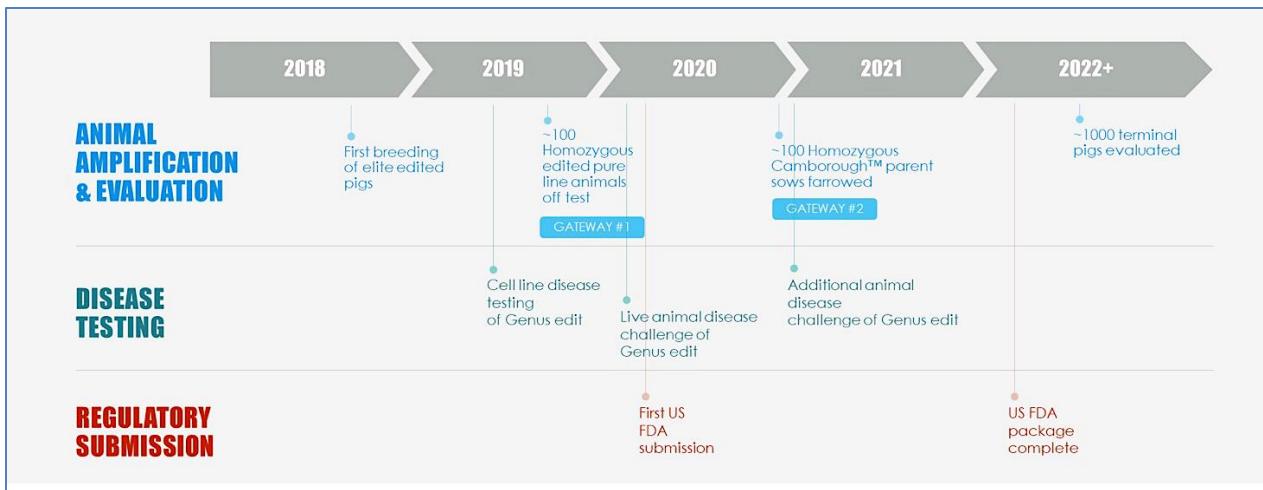


Figure 13. Timeline for commercialization of Genus' PRRS gene editing technology¹⁵

FDA is regulating under the 'new animal drug' format in a multistep process coordinated with USDA and EPA. Completion of the process will likely take approximately five years, and when complete, this will be the first animal product to be released under this process. The regulation as a 'new animal drug' doesn't exactly fit the technology, and it's a challenge to communicate to the consumer, but this process provides significant opportunity to work with the FDA to shape the framework and regulatory authority for gene edited animals. Genus firmly believes these animals should be regulated, especially as the eyes of the global market are on them.

South Korea, Japan, China, Mexico, Canada are the five major countries who work with Genus, and they're watching the regulatory process closely. The opinions of these four, the United States, and other international markets vary widely, from no regulation because the technology is not a GMO, to a full ban on both GMO and gene editing. (Figure 14)

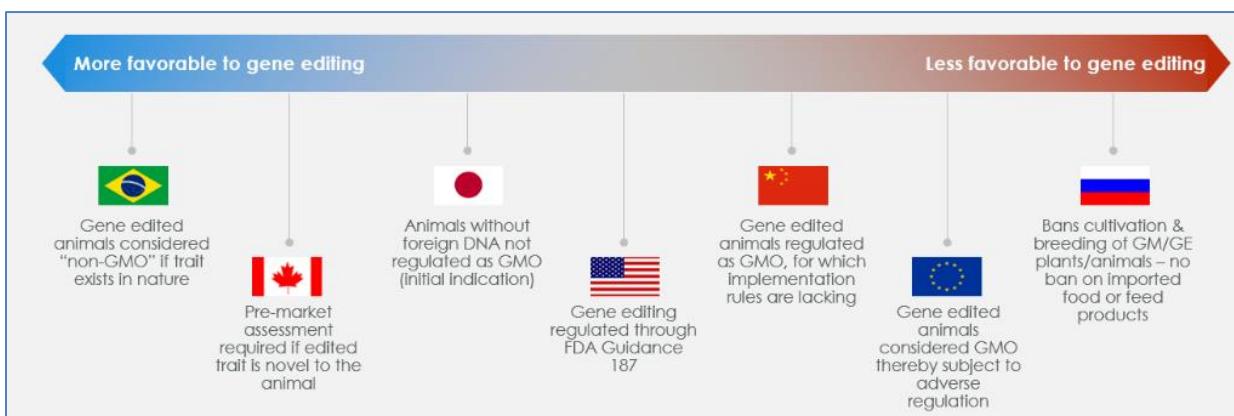


Figure 14. International regulatory opinions on gene editing¹⁵

Genus needs to work with all of them. Two types of regulatory approval that will need to be sought: import of meat and products from gene-edited animal, as well as production in that country of pigs resistant to PRRS.

Genetics is an evolution, not a revolution. Gene editing is a natural evolution of the breeding process. And Genus vision is that making the animal healthier through gene editing will help nourish the world. Agriculture isn't alone – gene editing has wide-ranging application across human medicine and crop development as well. Exposure of the consumer to gene editing has largely been from new outlets, and has been positive. The lack of consumer knowledge in this arena is an opportunity for us to decide the story we want to tell, and drive that story forward. It is very important to approach this positively within the agriculture industry as well. We need to avoid the demonization and competition that often comes with advances such as this one, recognizing that innovation brings more innovation, and we need all the innovation we can get.

Three of the main new technology acceptance gateways for consumers address animal health: prevention of animal suffering, improved animal well-being, and eradicating disease in livestock. The acceptance is there, but tenuous, and consumer concerns must be taken seriously if this acceptance is to become more robust. Consumers want transparency, want industry to seriously consider unintended consequences, require commitment to safety and training, and overall, want industry to do the right thing for the animals. 'Don't worry – we got it' isn't going to work.

Moving forward, there are a number of key disconnects that need to be explored. Consumers love the idea of improving animals' lives and health – but they are skeptical and believe our food system and food companies are creating unhealthy conditions that CRISPR could hide. Additionally, there is a need to re-ground consumers in some realities. First, even animal raised in the ideal environment can become ill. Second, a knowledge of how 'average' farm animal really live. Visuals and videos of how animals on farms actually live, and how farmers support their health and well-being, can help provide accurate information to consumers and foster understanding of real-life animal agriculture.

All animals get sick. Genus is working on getting rid of some of the most difficult diseases. They have the technology for PRRS, and are in the process of commercializing that technology – but first must work out several big issues: regulation, market acceptance, and consumer acceptance. The agriculture industry must remain committed to transparency and doing what's right for the animals, focusing on positive advances, building each other up, and reinforcing the common message of shared values in agriculture.

DISCUSSION

What is the timing for FDA approval?

The fundamental building blocks for regulatory approval comprise 11 steps. Three generations of heritability are required, and for the pig, that's about three years. Officially, Genus has been saying that they are several years away from commercialization. Some international factors, such as Mexican

producers putting pressure on FDA, could accelerate the timeline marginally, but in all reality, commercialization will be at least five years out.

If the genes are inherited, how does Genus continue to monetize and maintain proprietary work?

Genus is investing a huge amount of money, and feels strongly about its process. Once they get regulatory approval, how to bring the product to market boils down to two options, and Genus is exploring both of these pathways. The first is to market by themselves, and the second is to license the technology to competitors. Exploration of these two options is in the very preliminary stages. The most pressing current issue, and focus for Genus right now, is to invest in the regulatory process and market approval.,

Has Genus had any luck finding the gene for ASF?

ASF is more complicated than PRRS, and the University of Missouri Roslin Institute is working on finding the gene or genes that control disease. Currently research is in the discovery phase. Genus is also working on bovine respiratory disease, and that process is further along than ASF research, but neither are anywhere near where Genus has been able to go with PRRS.

Cultivating Meaningful Conversations

Mr. J.J. Jones, *Co-Founder, Roots and Legacies*

Roots and Legacies cultivates ideas, nourishes leaders, and harvests excellence by putting their passions, talents, passions and agrarian values to work. They engage and develop individuals and organizations. Mr. Jones opened discussion by exploring the aha moments we learned from a previous speaker. These included the amazing advances in gene editing; how we are hardwired to understand hazard but not risk; the universe of alternative proteins; that there is a definite timeline for sunsetting the NEUS tag; and that it's important to engage with disruptive technology. Opportunity depends on your point of view.

Mr. Jones is a foodie - he photographs food, makes it at home, takes vacations around food. He also happened to grow up on a farm and ranch in Kansas and was a proud member of the FFA. The key observations he has had during the conference start with the why: Why are we in the animal agriculture space? The concept comes from Simon Sinek's book *Start With Why*, which describes the 'Golder Circle' concept. Many organizations and individuals within organizations talk about what they do and how they do it – but very rarely do they share why they do it. For example, Dell and Apple were competing in the same spaces. Dell took the traditional approach, discussing what they were doing and how they were doing it. Apple, however, wanted to empower their customers to disrupt the world – and they always led with the why: why they do what they do. Apple is the only one left standing. People don't buy into what and how you do something, but they do buy into why you do it. So – back to his question: why are you involved in animal agriculture? The why is your values, and it is very important that we as food system leaders lead with our why.

Both demographics and attitudes of consumers have been undergoing a shift for years. That shift began in 1968. Before that, the authority you held was from the office or title you possessed. Broad social consensus was driven by WASP males, and communication was formal and indirect. Progress was thought to be inevitable, and big was respected. After the shift, authority began to come from relationships. No single social consensus was recognized – but rather that there is a great diversity, with many voices. Communication began to be more informal and direct, and people began to see progress as possible, but not inevitable, and big as bad.

Demographics have been changing along with attitudes. According to the most recent census, 40% of the population is non-white, and more than 80% live in urban areas – trends that began years ago and are expected to continue to grow. The percentage of single-person households has grown from just 13% in 1960 to 28% at the most recent census. We're moving toward a very diverse society, concentrated in urban areas, where the single person household is becoming more and more the norm. But the demographics of food system leaders are largely those of white, rural, family units. This disconnect presents communication challenges. Our audience is usually three or more generations removed from the farm, and has no understanding or basic knowledge of how agriculture works. We need to work hard to determine if our messages are relevant to that population, and if not, how to make them that way.

All around the globe, survey respondents have the same message - they're crying out for companies in every industry to understand them as people: complex, evolving, and unique. We need to align our values, show interest in the consumer as an individual, and really find out what the consumer's concerns are – for themselves, their family, animals, and for the environment.¹⁸ We should not plan to persuade, advocate or educate – we must approach through values.

So the question becomes, how are we going to advocate with individuals and organizations so that they see our values – our why? The answer is that we must be relationship-driven. We must really listen in order to really understand. Our conversations must seek to clarify questions, concerns, and needs, dig deeper, and explore each other's values. Last, we should share our story – letting our audience know what our values are, and let them see how our values align with theirs,

There are many more consumers and interested parties than industry folks to share the story. In the adoption of anything new, there are always innovators and early adopters at the forefront, followed by the majority, and finally, laggards who are the last to adopt. We are appealing to the innovators and early adopters. One such group are peak performer consumers according to the Center for Food Integrity. Their share of voice is 25%, and is much larger than their actual numbers, which hover around 17%. Their outlook is that food is about self-improvement, and is a critical ingredient for looking good and enhancing performance. They are moderately educated about food and food politics, but food is an obsession, because they are obsessed with the physical and professional performance.

Each of us in this room has a role to play, and to play that role we each need a communication strategy. If strategy is mapped out, we are much more successful. The strategy serves as a roadmap – a guiding

document, an opportunity to collaborate, a tool to measure success and a resource. Once in place, the roadmap can be used for communication, crises, major announcements, and special events.

No matter your role in your organization, communication and engagement is all of our responsibility. You're in this room because you are a food system leader. We must engage, especially when it comes to technology and innovation.

DISCUSSION

Rapid advances in technology and innovation fragment the industry and make it harder to tell the story. How do we continue to communicate, build relationships, and tell the story?

We need to look for alignment where there hasn't naturally been alignment between organizations, such as with non-governmental organizations (NGOs) and environmental groups. We need to look outside the network of traditional agricultural organizations and leaders to determine our natural allies, and how to form those relationships proactively. One outside-the-box example is the partnership between the Urban League and the laying industry. This came about because one of the primary consumers of eggs as a primary source of protein are underprivileged customers. Urban League is a natural ally of the industry in this situation, but certainly not a traditional one.

The American Meat Industry has been exquisitely successful for many years in producing very high quality protein very efficiently with a minimum amount of resources. Consumers today need to feel unique when they purchase a product. How does a commodity industry that is commodity-driven make someone feel unique when they buy a high quality product that is 'normal' - not unique?

If you as a producer choose to participate in the commodity business, you need to find the consumers that want normal food – not unique food. This consumer base are comfort-seekers. The market is there, but you will need to be good at operating at a low margin. If you want to target the customers that seek the unique, you need to figure out how to differentiate your product by de-commoditizing.

If we start to differentiate commodities too much, with many producers promoting unique products, doesn't that lead to confusion and mistrust? When we start making too many special products, aren't we going to recreate another problem later down the road?

That is a possibility. But the need for unique food is the new norm we're in. Ms. Emily Metz commented that her view is slightly different. As commodity agriculture, she thinks we need to listen better and provide what consumers are asking for, instead of focusing on development of a unique product. Her impression is that alternative protein producers do a much better job of listening to consumers, and really finding out what they want, than animal agriculture does.

Footnotes

- ¹ United Nations Food and Agriculture Organization (UN FAO)
- ² Graphic courtesy of Dr. Jack Bobo, Intrexon Corporation
- ³ Timeline courtesy of Mr. Richard Gordon, IBM
- ⁴ <https://www.everycrsreport.com/reports/R45090.html>
- ⁵ U.S. Department of Commerce. January 2012. *The Competitiveness and Innovative Capacity of the United States*
- ⁶ Graph courtesy of Dr. Peter F. Orazem, Iowa State University
- ⁷ Graph courtesy of Dr. Peter F. Orazem, Iowa State University
- ⁸ Graphic courtesy of Dr. Michael Dahlstrom, Iowa State University
- ⁹ FAOSTAT
- ¹⁰ <https://techagr.com/eng/>
- ¹¹ 9 CFR § 301.2
- ¹² Kauffman, RG. 2001 Meat composition. In: Hui YH, Nip W-K, Rogers RW, Young OA, editors. *Meat science and applications*. New York: Marcel Dekker. p. 1–19.
- ¹³ White RR, Hall MB. 2017. Nutritional and greenhouse gas impacts of removing animals from US agriculture. Proc. Nat. Acad. Sci. USA 114(48): E10301–E10308. doi: 10.1073/pnas.1707322114
- ¹⁴ Chart courtesy of Dr. Rodrigo Tarté, Iowa State University
- ¹⁵ Grand View research
- ¹⁶ Allied Market research
- ¹⁷ Image provided by Emily Metz, Genus PLC
- ¹⁸ Concept from *How to Win Friends and Influence People* by Dale Carnegie

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