Technology lag: Is there a cost for failing to do it right?

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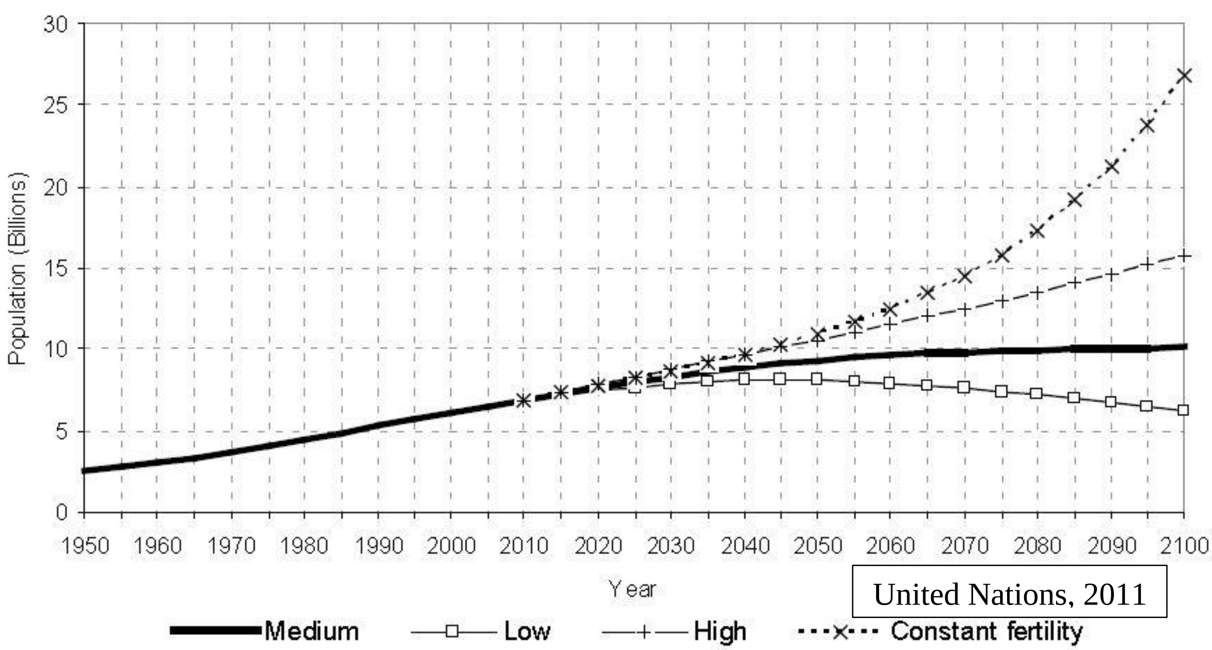
Technological advances should, logically, result in improved efficiency for any industry. The beef industry certainly follows this simple rule. The need for capitalizing upon this opportunity is obvious. The beef industry will be an important contributor to one of the most important tasks of the next 40 years: feeding an expanding population. Future projections in world population vary but many seem to agree that 9 billion people by the year 2050 is a reasonable projection. Projections beyond 2050 vary widely due to different potential scenarios concerning mean fertility rates for the human population.

Population of the world, 1950-2100, according to different projections and variants



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2011). World Population Prospects: *The 2010 Revision*. New York: United Nations.

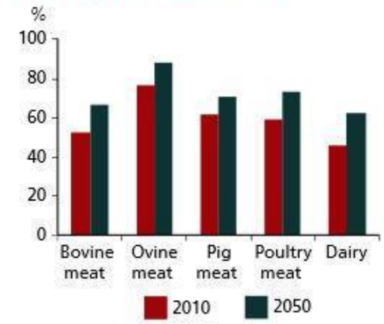
In addition to expansions in world population, there are predicted changes in the types of foods consumed by the growing population. As affluence increases in developing countries there is a projected increase in the proportion of the diet consumed as animal products (FAO, 2011)

PROJECTED TOTAL CONSUMPTION OF MEAT AND DAIRY PRODUCTS

	2010	2020	2030	2050	2050/2010
	(million tonnes)				
WORLD					
All meat	268.7	319.3	380.8	463.8	173%
Bovine meat	67.3	77.3	88.9	106.3	158%
Ovine meat	13.2	15.7	18.5	23.5	178%
Pig meat	102.3	115.3	129.9	140.7	137%
Poultry meat	85.9	111.0	143.5	193.3	225%
Dairy not butter	657.3	755.4	868.1	1 038.4	158%
DEVELOPING COUNTRIES					
All meat	158.3	200.8	256.1	330.4	209%
Bovine meat	35.1	43.6	54.2	70.2	200%
Ovine meat	10.1	12.5	15.6	20.6	204%
Pig meat	62.8	74.3	88.0	99.2	158%
Poultry meat	50.4	70.4	98.3	140.4	279%
Dairy not butter	296.2	379.2	485.3	640.9	216%

Source: FAO, 2006c. Some calculations by authors.
Note these figures are based on World Population Prospects: The 2002 Revision.

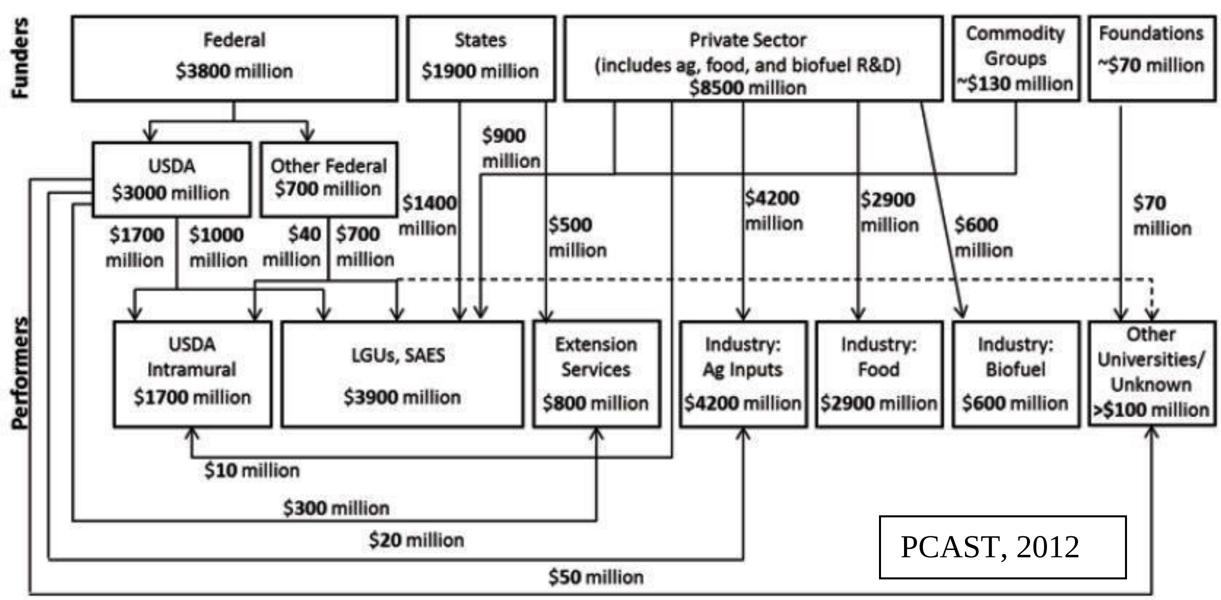
PERCENT OF TOTAL CONSUMPTION IN DEVELOPING COUNTRIES



FAO, 2011

Will the beef industry be in a position to meet these demands for the next 30+ years? First, we must continue to have technological advances. This will require continued investment in research and technology. It is estimated that each dollar invested in agricultural research returns $10 in increased productivity and efficiency (PCAST, 2012). They also showed that

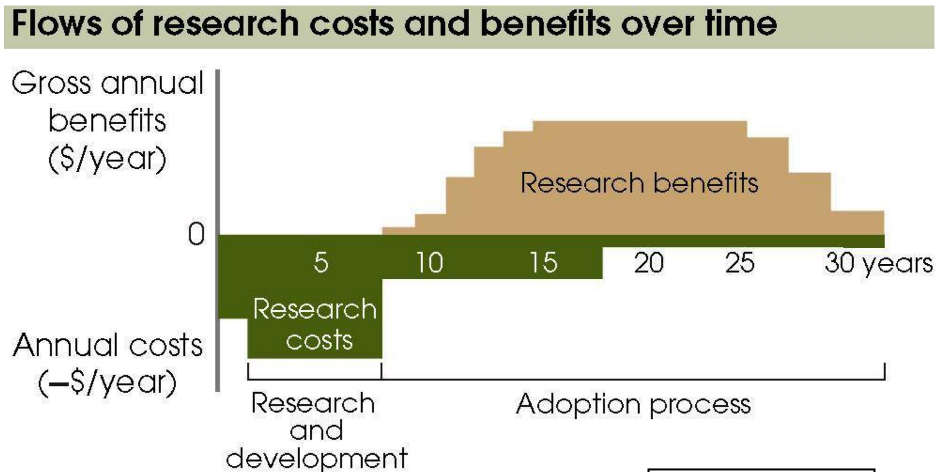
2009 U.S. public and private agricultural research, development, and extension expenditures.



PCAST, 2012

annual investment in agriculture research exceeds $14 billion (PCAST, 2012).

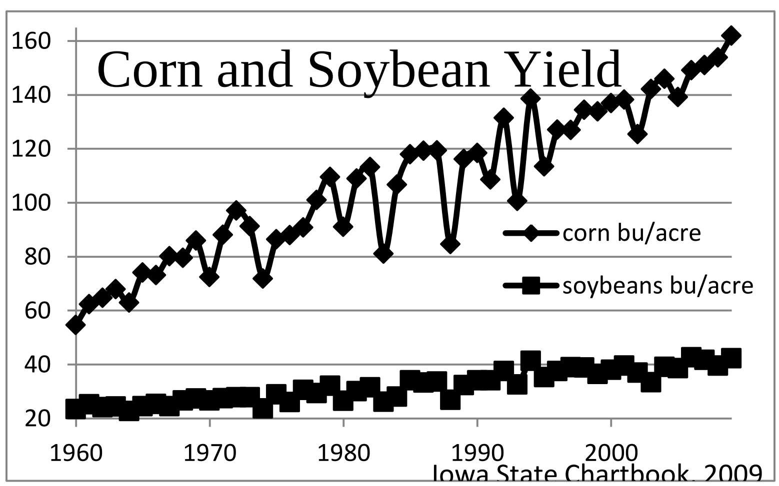
The benefits derived from research do not happen overnight. The research enterprise necessarily includes fundamental research which may not yield benefits for many years while more applied research may have benefit which is immediate. I have had the good fortune to work for universities at which the balance of fundamental and applied research has been good. Some of my colleagues were answering questions about basic biology that set the stage for other colleagues who were doing research that was so immediate that producers were calling to ask them how they thought the research was going to turn out so that they could make management decisions NOW. The time relationship between the cost of research and the resulting benefits are illustrated here.



Source: Alston, Norton, and Pardey, 1995.

Fuglie, 2007

Agricultural research has certainly paid off. The increases in yields of various crops have been very substantial. A near tripling of corn yield and a near doubling of soybean yield over a period of 50 years has been the result of research that contributed improved varieties and management practices. Many other crops have shown similar improvements. Were it not for these improvements, much more land would be required to feed the world.

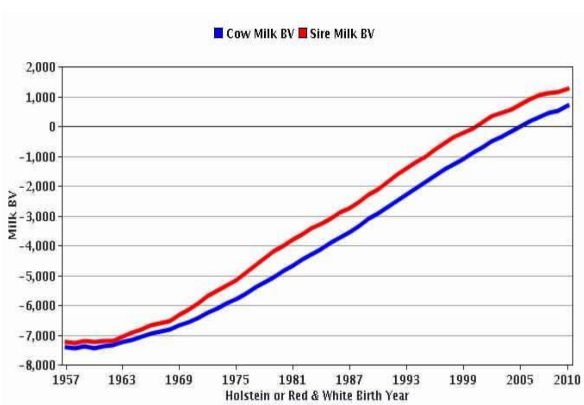


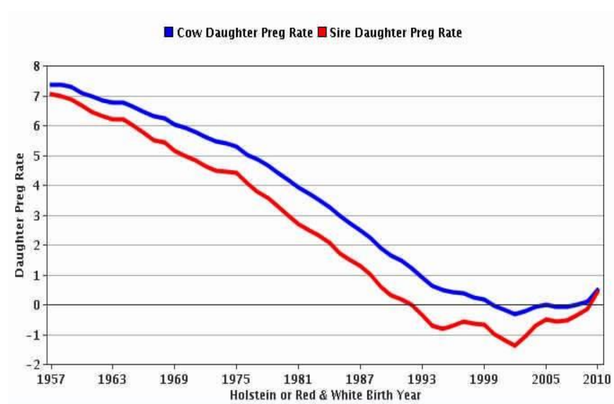
Such changes raise the question: Could it have been more? Development of technology is only helpful if it is used. Research that just sits on the shelf is a waste of resources. The Office of Technology Assessment (eliminated as a Congressional Agency in 1995) examined the potential productivity resulting from different levels of technology adoption in 1992. The study identified several measures of productivity for both plant and animal agriculture from 1990 and predicted productivity in 2000 based upon less, likely or more adoption of technology by 2000. Comparison of the predictions in the table illustrate that both corn and soybean yield actually exceeded the projections for the year 2000. This raises an important question: Is technology being adopted at a rapid enough rate in animal agriculture. Assessment of progress in animal agriculture is a bit more difficult than for plant agriculture because standard measuring sticks, like yield in bushels/acre, are more difficult to identify due to variation in types and locations of production.

Estimates of Crop Yield and Animal Production Efficiency by 2000 (Office of Technology Assessment. 1992. A New Technological Era for American Agriculture

	1990	Less new technology - 2000	Most likely technology - 2000	More new technology - 2000
Corn—bu/acre	116.2	113.8	128.5	141.6
Soybeans—bu/acre	32.4	32.6	33.7	36.4
Wheat—bu/acre	34.8	37.7	42.6	53.8
Beef Lbs meat/lb feed	0.143	0.146	0.154	0.169
Calves/100 cows	90.0	93.75	96.22	102.45
Dairy Lbs milk/lb feed	1.010	1.030	1.050	1.057
Lbs.milk/cow/year	14,200	17,247	19,191	20,498
Pork Lbs meat/lb feed	0.154	0.174	0.181	0.196
Pigs/sow/year	13.9	14.0	15.7	17.8

The number of calves/100 cows has, obviously, not been reached. Improvements in efficiency of production of beef, milk or pork are somewhat difficult to assess, especially for





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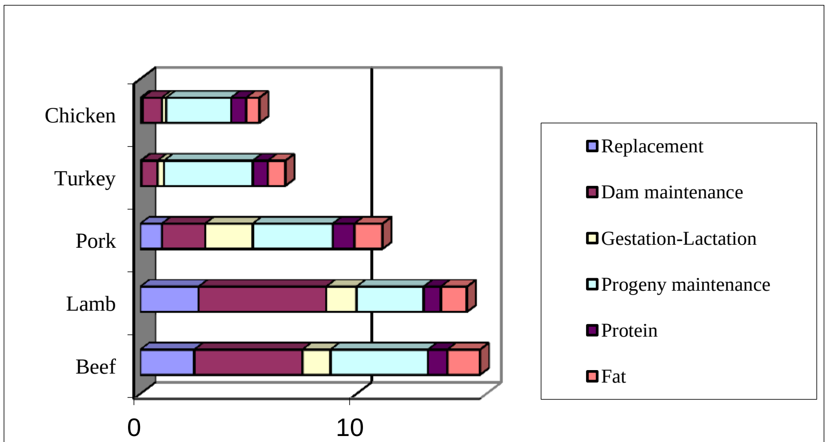
beef because of the variety of ways that beef is finished. The projections seem somewhat reasonable for milk production per cow per year and the commercial pork industry has easily exceeded these projections for pigs/sow/year (National Hog Farmer, 2011). In fact, the 1990 base point for this measure of productivity was probably too low. The dairy industry has certainly achieved an enviable record in improvement of milk production although it has been at a cost in reproductive performance.

The question before us here is whether the beef industry is making full use of the available technology. When asked "what are beef producers breeding for?" at the 1995 Feed Intake Symposium, Dr. Gordon Dickerson replied "for fun!" This tongue-in-cheek response was Gordon's way of telling beef producers that not all of their genetic decisions have always made sense. Harlan Ritchie put together a nice set of information illustrating changes in cattle type across the 20th Century (https://www.msu.edu/~ritchieh/historical/cattletype.html). The meanderings through the short, dumpy cattle of the 1940s-1950s and the changeover to larger-framed cattle, which reached its apex (literally and figuratively) in the 1980s have illustrated that efficiency of production has not always been the central focus of genetic improvement in the beef industry. The Beef Improvement Federation has been at the forefront of genetic improvement for more than 40 years. There have been, of course, tremendous gains in understanding of management of beef cattle as well but the focus of this discussion will be on genetic improvement.

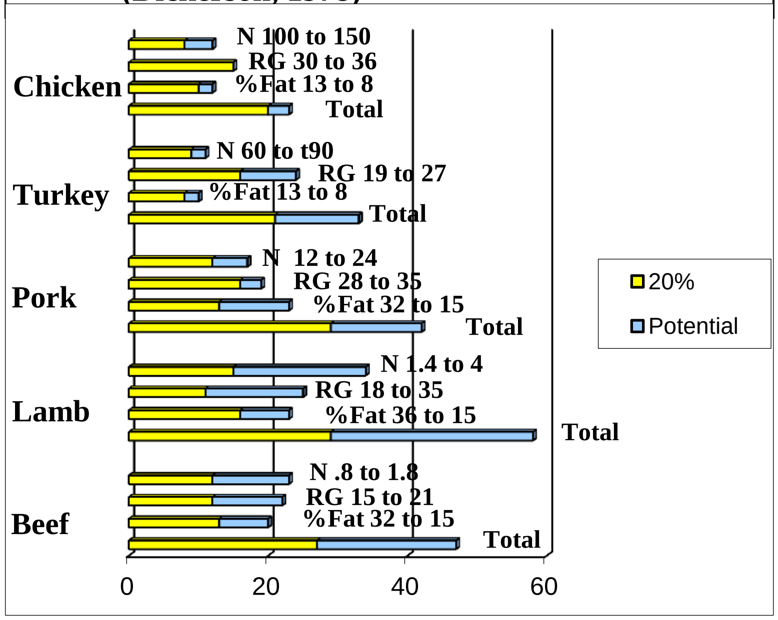
Dr. Dickerson provided some guidance about bioeconomic objective 35 years ago (Dickerson, 1978). He pointed out one of the difficulties in establishing goals for genetic improvement in beef cattle: the costs are spread out over several different phases of production with about half of the costs being associated with the cow herd while the other half are associated with the animal which is going to be used for meat. This division of costs is quite different from the pork industry and extremely different from the poultry industry. Historically, much of the selection emphasis, through the show ring and other aspects of visual appraisal as well as during the early phases of the use of performance information, have probably placed considerable emphasis on traits associated with output and less attention was placed on the costs of production.



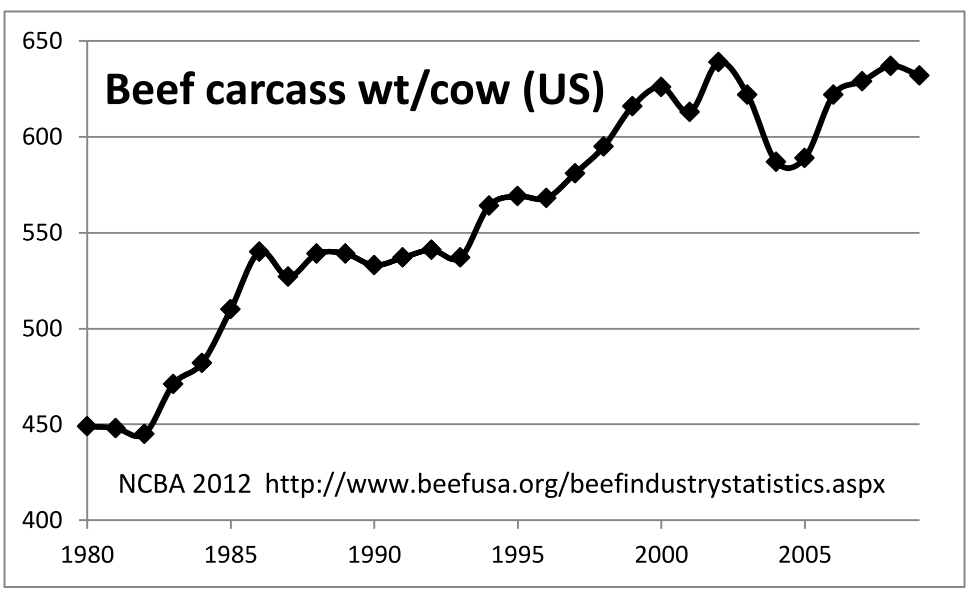
Life cycle cost/kg of edible protein (Dickerson, 1978)

Dr. Dickerson went on to assess the future of the various industries. He projected what would happen to the economic efficiency of the various industries if certain genetic improvements were made. He examined the effects of 20% increases in reproductive rate, and relative growth rate (a measure of efficiency) and a 20% decrease in carcass fat. He further projected amounts of genetic change which he felt were possible with future optimistic advances in technology. For the beef industry, this included an increase in reproductive performance which would include twinning. This is a topic which frequently causes a reaction from beef producers because twin calves are usually viewed as a problem, rather than as an opportunity. When students react negatively to the idea that we might incorporate twinning into beef production, I ask a simple question: “If we could figure out a way for almost all of the cows to have twins, would be build a production system that could take advantage of it?” The answer to that question is, obviously “Yes”.

Potential genetic change in economic efficiency (Dickerson, 1978)



The encouraging thing to note in this graph is that the opportunity for improvement in economic efficiency of beef production in considerable. The disheartening thing to note is that the pork, turkey and chicken industries have, since 1978, met or surpassed the projected improvements proposed by Dr. Dickerson. Genetic improvement in beef production is, to be sure, more time consuming because the lower rate of reproduction and the longer time from conception to production of a carcass which combine to form a



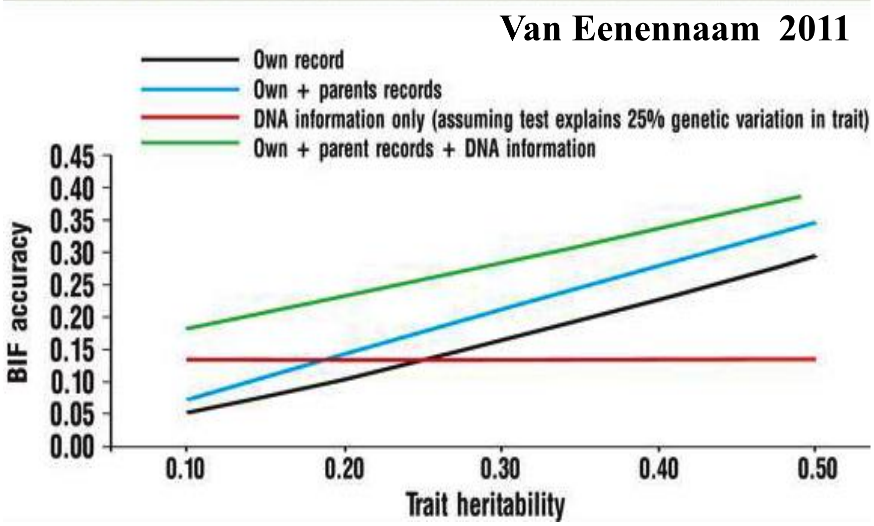
much longer generation interval. However, we must also honestly assess whether we have been doing all that we can do to generate genetic improvement.

Although it is an imperfect means of evaluating progress in the beef industry, the accompanying graph illustrates the pounds of carcass beef per cow in the national beef herd (November 2012). This would reflect change due to both genetics and management since 1980. The genetic component of this change is partially illustrated with the genetic trend values for the traits that are included in the respective genetic evaluation programs of the various breed associations. The changes that have been accomplished during the period in which EPDs have been available have been quite impressive. The degree of change for various traits differs widely among breeds. Some common themes emerge. Size has been emphasized in many breeds, with the exception of some breeds which were already quite large. Several breeds experienced an increase in birth weight, and accompanying increase in calving difficulty for a period of time but there appears to have been a point at which many breeds decided to place some emphasis on improving calving ease and that has been accomplished. Genetic merit for milk production and scrotal circumference has generally increased. Marbling has shown genetic improvement. Interestingly, a breed that has shown above average improvement in marbling is the breed with an already high reputation for marbling: the Angus. Improvements in fatness and muscling have not been uniform across breeds. Although the changes have been impressive and we must keep in mind the complexities associated with the contributions of the various phases of production when evaluating genetic improvement, it is safe to say that we cannot hang our hat on an aspect of genetic change which would be comparable to the tripling of corn yield in the past 50 years. Some of the reasons for the lower rate of genetic improvement are obvious. We are working with a species which reproduces slowly, is part of a very complex system of production in which the animals change ownership multiple times in their life and where the costs of production are highly diversified and are not all incurred by the owner which sells the animal for slaughter. However, we might be wise to heed the warning of Dr. Dickerson. Are we still breeding “for fun”?

It is very encouraging that several breed associations have adopted index or “$ value” EPDs which combine information from various traits. This has several virtues as we move forward. It emphasizes the idea that economic considerations must be included into selection decisions. It also spreads out the selection intensity among several traits which should reduce the likelihood of the emphasis on extremes which have plagued us in the past. It is interesting to note, however, that the genetic trend for the traits associated with $EN (Cow energy) in the Angus breed are in a direction which would suggest that many of the bulls with high $EN values would be older bulls. Indeed, a search of the top end bulls for $EN reveals that only 7 out of the top 26 bulls for $EN were born during the 21st Century. However, the presence of such a tool, including further refinements, and consideration of traits like heifer pregnancy, stayability and calving ease, should enable beef producers to pay additional attention to genetic improvement in the contributors to cost of production in the cow herd.

The beef industry is rapidly moving forward in its evaluation of the use of various molecular biology tools to enhance genetic change. Genomic enhanced EPDs have been introduced. This has tremendous promise for enhancing the accuracy of genetic evaluation (Van Eenennaam, 2011). Rates of genetic improvement should increase when this technology is more fully understood and implemented. We do need to continue to be mindful of Dr. Dickerson's admonitions. Better accuracy associated with genetic prediction is only helpful if we are making decisions which are in line with reasonable production objectives. The industry has demonstrated in the past that it can go too far in pursuit of some genetic improvement goals. More accurate evaluations will only mean that we can go too far more quickly unless proper objectives are established. However, I am optimistic that the changes of the past 30 years have made it more likely that the industry will pursue appropriate goals. The array of traits under consideration is much more broad-based. It includes traits associated with growth, efficiency, maternal ability, reproductive performance and carcass merit. The industry has embraced the concept of the selection index through the various $Value EPDs that have been developed by some breeds. The efforts of the Beef Improvement Federation, and many other organizations, have been a source of education and encouragement for the industry to pursue comprehensive selection objectives.

Figure 1. Effect of DNA information on Beef Improvement Federation (BIF) accuracy of EPDs given different sources of information and trait heritability



New tools for genetic improvement, as well as many management tools, have the potential for raising questions about the societal assessment of various technologies. The beef industry is already under attack for the use of hormonal implants and antibiotics in the feed. It is conceivable that genetic tools will be developed which also generate concerns among consumers. The Aqua-Advantage Salmon (http://www.aquabounty.com/) is a genetically engineered fish with greatly enhanced growth rate. It is under consideration by the FDA for approval to be a part of the food supply. It is also being criticized by many in the anti-GMO movement (http://www.fooddemocracynow.org/). It remains to be seen whether the beef industry will move in a similar technological direction.

We only have to look at our colleagues in the dairy industry to see a technology which is demonstrably safe but is very limited in its use because of consumer concerns. Recombinant DNA derived bovine somatotropin has been available for nearly 20 years but many food companies have adopted practices which have served to diminish its application in the dairy industry (http://news.walmart.com/news-archive/2008/03/24/wal-mart-offers-private-label-milk-produced-without-artificial-growth-hormone).

Failure to use technological advances exerts a cost. The cost is obvious for the producer who lags behind and loses a competitive edge compared with other producers. The cost is, perhaps, less obvious but no less real for an industry which fails to take advantage of technology while competing industries make more rapid improvement in production efficiency. Limitations on use of technology include failure to invest in the necessary research to develop new technology, failure to use the available technology and the prevention of the use of technology due to consumer concerns which may, or may not, have a basis in good science. One might say that the beef industry is "at a crossroads". However, I have been hearing that the beef industry is "at a crossroads" for all of my adult life. So, in lieu of that, I will just conclude by saying that the beef industry has made good use of technological advances, but it could have been better. I am optimistic that, in the future, it will be better.

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