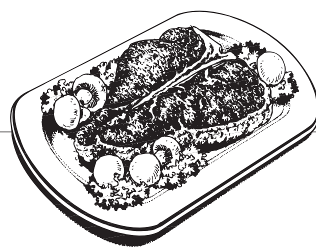
Fifty Years Of Pharmaceutical Technology And Its Impact On The Beef We Provide To Consumers



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EXECUTIVE SUMMARY

FIFTY YEARS OF PHARMACEUTICAL TECHNOLOGY AND ITS IMPACT ON THE BEEF WE PROVIDE TO CONSUMERS

Thomas E. Elam, PhD, and Rodney L. Preston, PhD
July 20, 2004

Through a combination of research, technology development and innovation, the U.S. beef cattle industry has increased beef production per head of cattle by over 80 percent in the last 50 years. Furthermore, the total production of beef has doubled, from 13.2 to about 27 billion pounds, in the same period of time. Pharmaceutical technology, genetics, nutrition, pasture management, stocker management and feedlot production have all played important roles. Increases in grain (corn) yields and a reduction in the real prices of grains have been pivotal in the growth of the feedlot industry, which has enhanced the efficiency of beef production and improved the consistency and quality of the end product. The overall impact of these technologies has been to keep beef cost-competitive in the consumer's market basket while simultaneously improving its quality. Pharmaceuticals have greatly facilitated and enhanced the increased importance of grain feeding in the U.S. beef production system.

The most significant impact of technology on U.S. beef production has been to increase grain-fed beef production and decrease the proportion of non-fed beef production. A synergistic combination of a number of technologies has increased our ability to feed cattle high-grain diets, the most significant contributor to increased beef industry productivity, efficiency and product quality over the past 50 years. Our feedlot technology is what differentiates U.S. beef production from that of the rest of the world. Based on beef production per head of cattle, the U.S. today is the most efficient beef producer in the world.

Compared to beef from pasture cattle, feedlot beef is generally regarded as superior in tenderness, taste and consistency. Thus, a direct effect of progress in technology has been to increase the quality and consistency of the U.S. beef supply. In fact, all of the beef supply increase since 1955 has come from grain-fed cattle. We produced about 7.5 billion pounds in 1955 compared to an estimated 22.9 billion pounds projected for 2005, while the total beef produced from cattle not fed grain has actually declined from about 5.7 billion pounds to an estimated 3.6 billion pounds for the same time period.

The effect on the composition of the per capita beef supply has been just as dramatic. Since 1955, per capita beef production from non-fed beef animals has decreased by 65 percent while per capita feedlot beef production has increased by 71 percent. The increased supply of feedlot beef has revolutionized the consumer beef-eating experience, both in terms of quality and consistency, while at the same time we have also significantly improved overall production efficiency.

None of the technologies alone can account for this increase in overall beef productivity and efficiency. The beef production system has improved and developed into its current form as a result of a number of technologies. If, for example, growth-promoting implants were eliminated from the current technologies, the effects would extend far beyond those of the gain and feed efficiency effects they have in feedlots. It has been estimated that without implants, retail sales of beef would decrease about $1.4 billion, resulting in a reduction of 1.2 million beef cows. Genetics, feeding programs, stocker programs and feedlot management would all have to be extensively modified. It would be very likely that the amount of beef produced in feedlots would fall, negatively affecting beef quality. Lower beef quality could lead to a drop in beef demand and financial losses for producers. Similarly, other pharmaceutical technologies, such as ionophores, antibiotics, repartitioning agents, parasiticides, vaccines and estrus regulators have contributed to improved growth and efficiency, enhanced animal health and well-being, and improved reproductive performance of the nation's cattle herd.

Another major implication of the increase in beef industry productivity has been a dramatic reduction in the industry's overall environmental impact. Had these productivity improvements not occurred, we would need a much larger cattle herd to produce a smaller total beef supply. Those extra cattle would occupy significant amounts of land now needed for other agricultural crops and land now in non-agricultural uses. In addition, the impact of lower cattle productivity would also be felt in the form of increased demand for alternative meats.

The primary benefits of increased productivity have accrued to the cattle industry and to U.S. beef consumers. In 2004, we have a more plentiful, less expensive and higher quality beef supply than we did in 1955. That we have managed to simultaneously increase efficiency, quality and production, while reducing the real price of beef, is a testament to the remarkable work of thousands of men and women involved in this industry over the last 50 years. As a result of their efforts, the industry produces more, and higher quality beef than it would have had these productivity increases not occurred.

As Alan Greenspan recently said "… the phenomenal gains in U.S. agricultural productivity of the past century brought profound benefits to all consumers, regardless of their connection to a farm, in the form of lower prices, better quality and more choices at retail outlets. … Although dislocations are bound to accompany economic growth, we should rise to the challenges that come with innovation, because innovation brings great improvements in material well-being."

The cattle industry of the U.S. can be proud of its record on innovation and technology application. It should continue to look for opportunities to contribute to the U.S. economy, and its own well-being, through continued innovation over the next 50 years.

FIFTY YEARS OF PHARMACEUTICAL TECHNOLOGY AND ITS IMPACT ON THE BEEF WE PROVIDE TO CONSUMERS[1]

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July 20, 2004

Technology is a key factor in keeping beef competitive in the consumer's food basket. Technology improves the efficiency of beef production, reduces the cost of production, improves the health and well-being of beef cattle, contributes to maintaining the availability of beef, and has a significant impact on the overall consistency, quality and wholesomeness of beef, all of which lead to providing the consumer with a consistent supply of beef at an affordable price. In the future, new technology will provide further advances in the production efficiency, animal health and wholesomeness of beef. The benefits from applying technology to providing beef to the consumer can be described in many ways.

Pharmaceutical technology applied by the beef industry over the past fifty years has been a major contributor to providing the consumer with an affordable and wholesome beef supply. This technology has improved the overall efficiency with which beef cattle utilize feed and other resources, has enhanced the health and reproduction of cattle, and improved their welfare.[4]

Annual U.S. beef consumption per person has increased only slightly over the past 50 years (from about 61 lbs. to 65 lbs.[5]) but total beef production increased significantly (from about 13.2 billion pounds to about 27 billion pounds, carcass weight) due to an ever-increasing population. Thus, the total input of feed and other resources needed to produce this quantity of beef has increased, making improved efficiency of resource use in beef production a paramount consideration. Partly as a result of improved efficiency, since 1955 the consumer cost per pound of beef has decreased by 26% after adjusting for inflation. Application of cost-effective technology has been a major factor in the ability of the beef industry to provide this increased supply of beef at an increasingly affordable price.

The leanness of beef has also greatly improved over the past 50 years, enhancing its wholesomeness and reducing the amount of waste fat. Carcass fat content has decreased from about 35% to about 27%. Much of this reduction can be attributed to the introduction of large frame cattle and the use of growth promoting implants.

Because beef cattle grow at a faster rate that they did 50 years ago (about 3.5 vs. 2.2 lb/day in feedlots), they are harvested on average at a younger age (about 16-20 vs. 24-36 months), which has resulted in younger, more tender beef. Growth promoting implants and ionophores used in feedlots have made significant contributions to the higher rate of growth in beef cattle (+15 to

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[1] The findings, opinions, summary and conclusions presented in this paper are those of the authors. We acknowledge support from the Growth Enhancement Technology Information Team that made this study possible.

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[4] Lauderdale, J.W. The facts about beef cattle growth enhancement technology. 19th Annual Southwest Nutrition & Management Conference, pp 61-64. Univ. Arizona. Phoenix, AZ. February 2004.

[5] Consumption per person increased from 61.2 pounds (retail weight basis) in 1955 to 94.6 pounds in 1975. From 1975 to 1990 consumption decreased to about 65 pounds per person, and has been relatively stable since.

20% enhanced growth rate) and improved feed efficiency (+10 to 15%). Antibiotics have helped control death loss and morbidity. Parasiticides have reduced losses to parasites that infest cattle, waste feed and slow growth. Vaccines have reduced disease pressure, further enhancing productivity.

Consistency in the eating quality of beef remains somewhat of an issue for the industry probably due to the many cattle breed types involved. Implants have potentially improved consistency because they decrease the animal's age at harvest. Future pharmaceutical technology may further improve the consistency of beef.

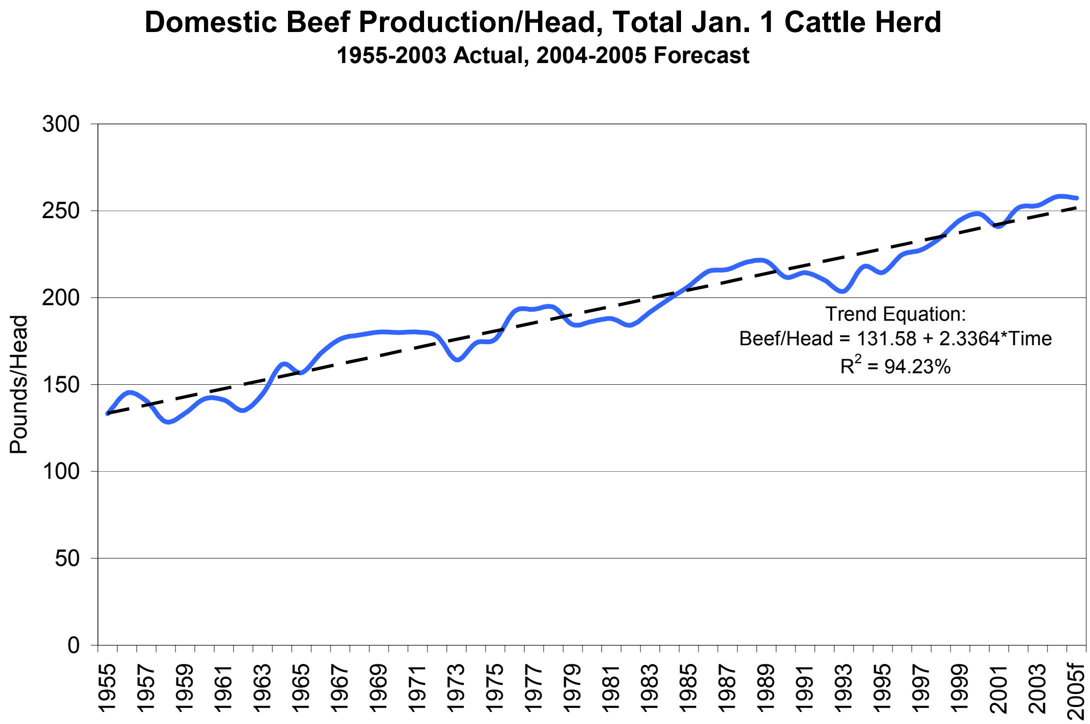
It is important to note that none of these technologies alone is responsible for these improvements in beef production. But taken together they have revolutionized the U.S. beef production system. In the next section we will look at the details of this productivity increase and its effects on the beef provided to consumers.

Cattle industry productivity, value, prices, and land use – 50 years of progress

Over the past 50 years the U.S. beef industry has made significant technical progress. As measured by a simple productivity statistic, pounds of beef produced per total head in the January 1 cattle herd, the efficiency of beef production has increased by over 80%. As shown in Figure 1, production per head was 137 pounds in 1955, and increased to over 250 pounds in recent years. The linear trend line regression indicates that there was an average of about 2.3 pounds (about 1.2%) of additional beef produced per head per year over the 50 years.

Figure 1 [6,7,8]

[6] USDA, NASS. Cattle. 1955-2004
[7] USDA, NASS. Livestock Slaughter. 1955-2004
[8] USDA, ERS. Livestock and Meat Situation and Livestock, Dairy and Poultry. 1955-2004



In this measure of productivity, U.S. beef production was corrected for beef produced from cattle imported live from Canada and Mexico. The numbers shown in Figure 1 thus represent an estimate of beef production from the U.S. herd relative to the total size of that herd. [9]

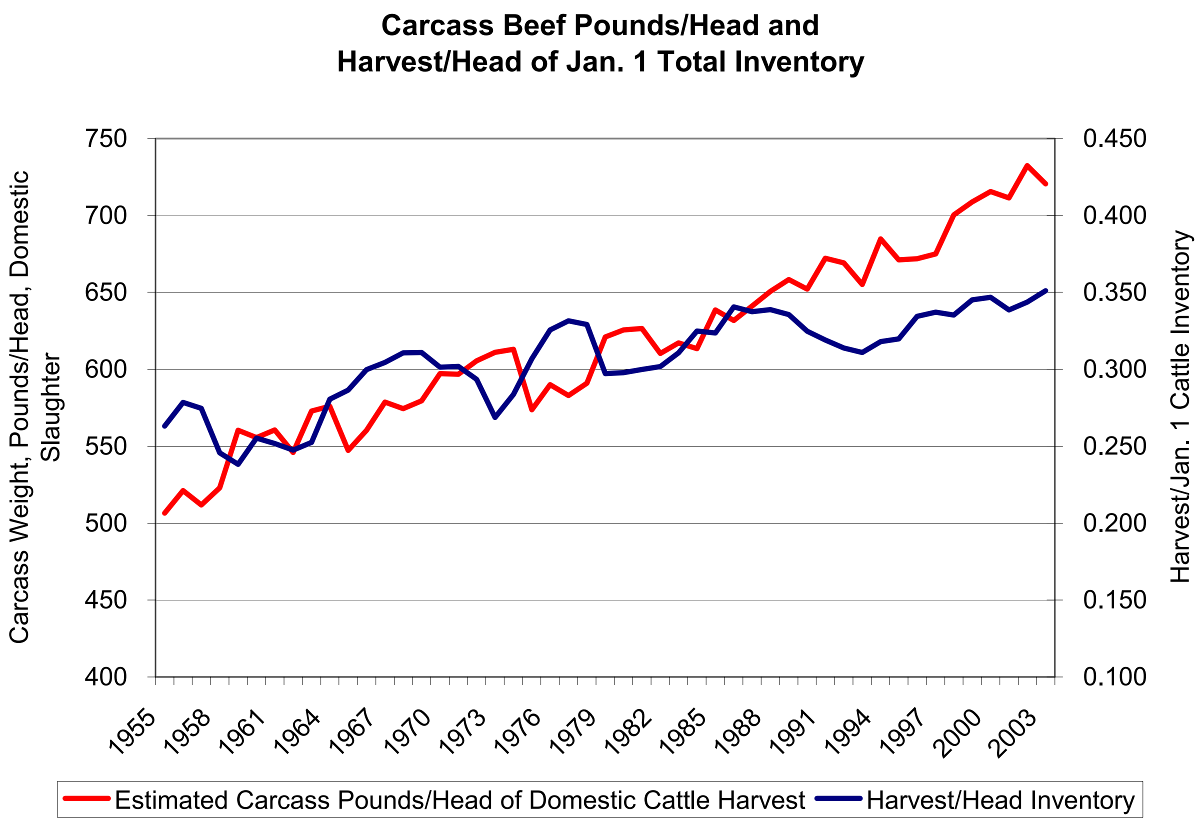
Increases in productivity in Figure 1 come from two sources:

1. Increases in the average pounds of beef per head harvested, and
2. Increases in the number of head harvested per head of inventory.

To estimate the contribution of both sources, domestic beef production was divided by head of domestic cattle harvested (carcass beef production per head) and harvest was divided by total cattle inventory (harvest/head inventory). The results (Figure 2) show that both have contributed significantly to the overall increase in productivity. Since 1955, average carcass weights increased about 42% while head harvested/head of inventory increased by 33%.

Figure 2 [10,11]

[9] To the extent that beef production is corrected for cattle imports, but those cattle were not subtracted from the total U.S. herd inventory, estimates in this study slightly understate the true picture of increased productivity.
[10] USDA, NASS. Livestock Slaughter. 1955-2004
[11] USDA, NASS. Cattle. 1955-2004

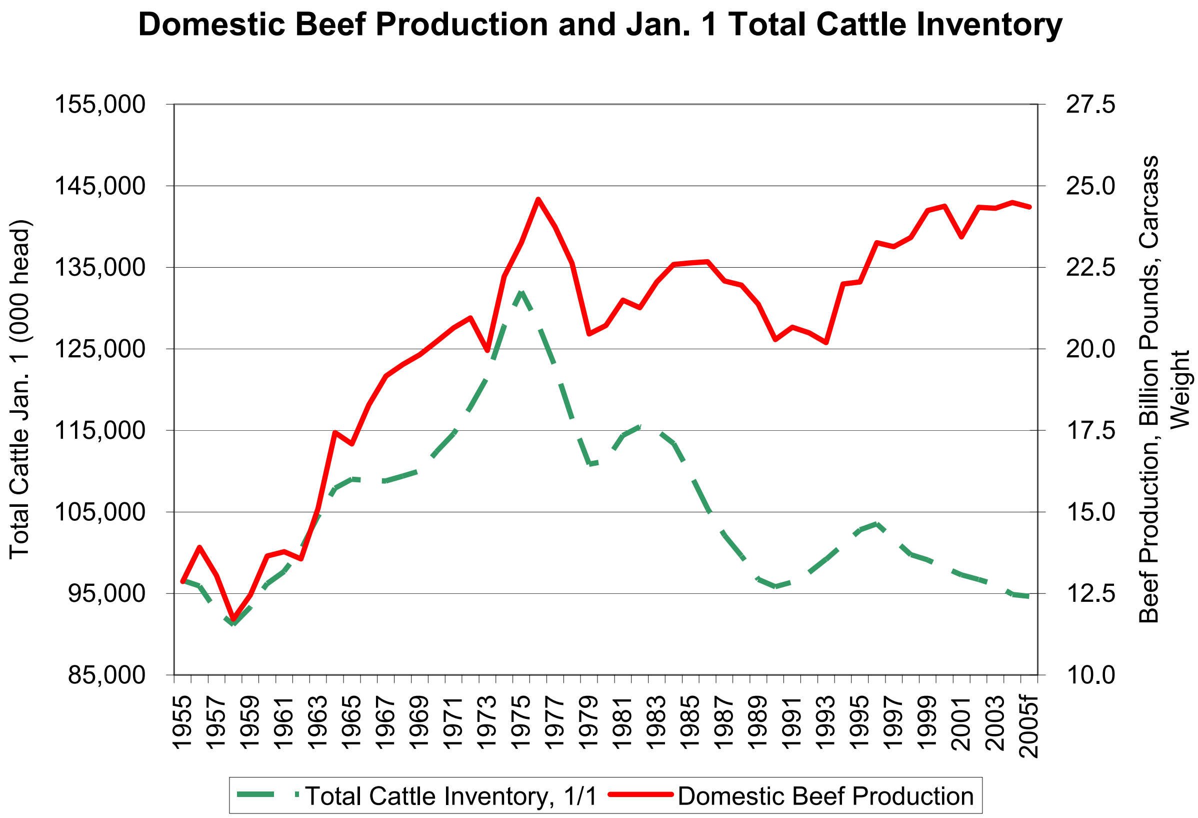


As a result of increased productivity, we have been able to about double total beef production (82% increase) from a herd that is today about the same size as it was in 1955. The major benefits of the increase in productivity are that production costs and prices of beef are much lower and beef production is higher than it would be had technology not advanced. Since animal waste production is directly related to the size of the total cattle herd, the ability to produce more beef per animal also benefits our environment by substantially reducing the amount animal waste produced per pound of beef produced.

As shown in Figure 3, the progress in production efficiency since the late 1970's has allowed increased beef production from a cattle herd that has declined by about 37 million head since 1975.[12]

Figure 3 [13]

[12] The sharp peak in production in the mid-1970s was in part due to herd liquidation, and is not a true indicator of sustainable production levels.
[13] USDA, NASS. Cattle. 1955-2004



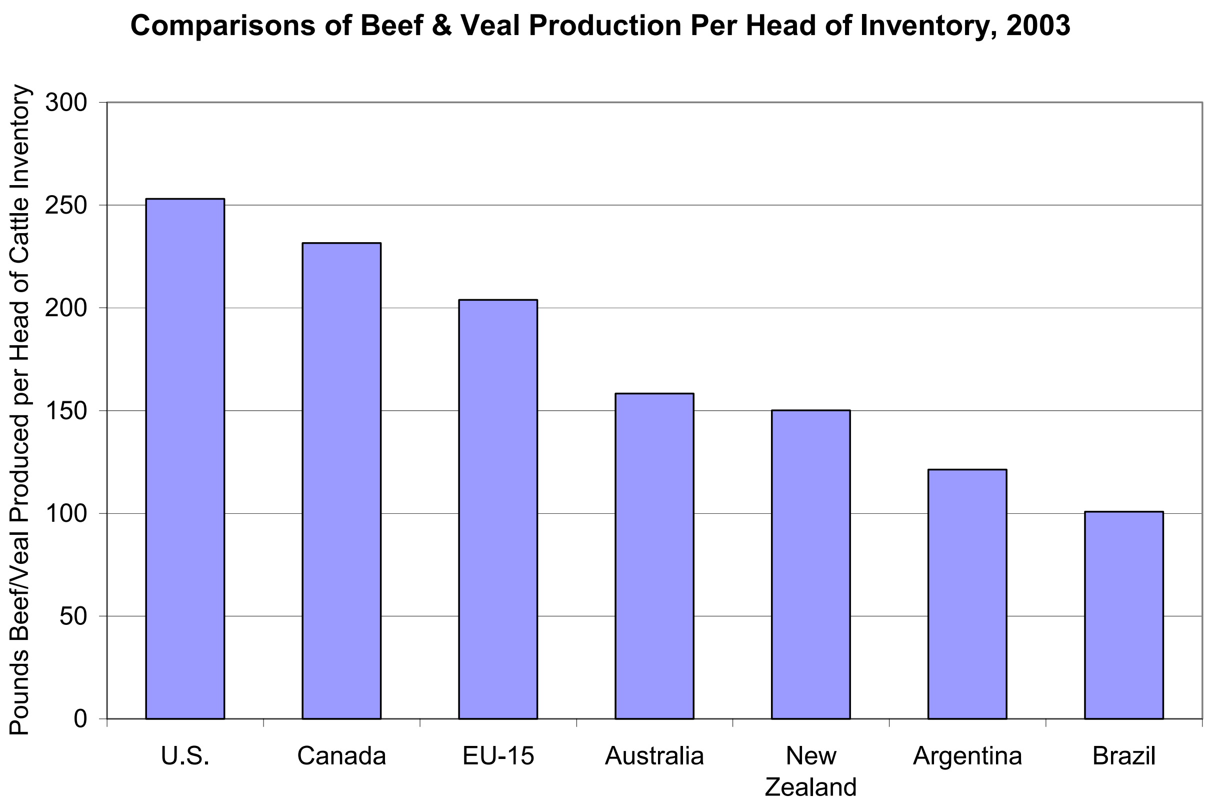
International Productivity Comparison and Implications

The U.S. beef production system is the most efficient in the world when it comes to producing as much beef as possible from each head of cattle in the inventory. As shown in Figure 4, in 2003 we produced about 253 pounds of beef and veal[14] from each head of inventory. Canada, using a system essentially identical to that of the U.S., comes in second. Compared to its major international competitors -- Australia, Brazil, Argentina and New Zealand -- the U.S. is well ahead in productivity.

The productivity of the U.S. beef industry enables us to produce our beef supply using fewer cattle per pound of beef than any other country. In the process, we have reduced the number of animals that are needed for our beef supply to a level lower than that implied by the productivity level of any other country of the world. If one measure of animal welfare is how many cattle have to be born, live and be harvested to produce beef, then arguably, the U.S. is also among the top countries of the world in cattle welfare.

Figure 4 [15]

[14] USDA does not break out beef and veal production in international statistics, therefore to compare across countries the two must be combined. U.S. and Canadian data were corrected for live cattle trade between the two countries.
[15] Data Source: USDA, Production Supply and Distribution Online, 6/7/04



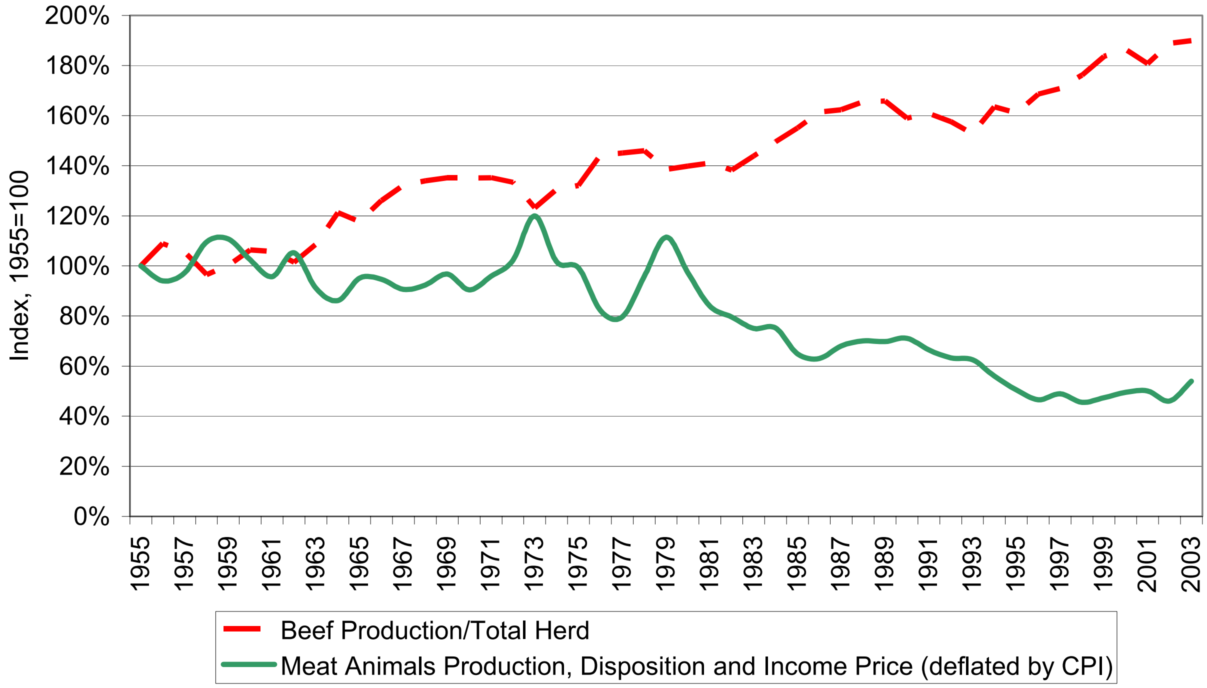
Effects of Productivity Increases on Prices and Economic Welfare

As productivity increases, production costs fall. As costs fall in a competitive industry, some of those lower costs tend to get passed along to consumers in the form of lower prices. This has certainly been true for cattle and beef over the past 50 years. To measure this effect we can look at the productivity measure shown in a prior graph measured against real cattle prices (Figure 5)[16]. To make the data more comparable, both series were indexed to 1955=100. On that basis productivity has increased to over 180% of 1955 while average annual cattle prices, in real terms, have declined by 40-50% since 1955.

Figure 5 [17,18]

[16] Annual average cattle prices from the USDA Meat Animal Production, Disposition and Income (PDI) reports were deflated by the Consumer Price Index (1982-84=100) to correct for the effects of inflation.
[17] USDA, NASS. Meat Animals Production, Disposition and Income. 1955-2004
[18] U.S. Dept. of Commerce, Bureau of Labor Statistics. Consumer Price Index. 1955-2004

Total Cattle Herd Productivity vs. Real Cattle Price Indexes, 1955=100



Effects of Cost and Price on Beef Consumption and Production

Had cattle prices been higher due to higher costs, we know that consumers would have purchased less beef than they did, given the effects of technology on productivity. How much less depends on the price elasticity of beef. A recent USDA study[19] placed the beef price elasticity at -0.35, which means a 10% increase in beef price causes a 3.5% decrease in the amount of beef demanded. If the beef price elasticity is about -0.35, then an 80% increase in retail price (reflecting the absence of the roughly 80% increase in productivity) would cause a 28% decrease in the amount of beef demanded. If that were the case, with 1955 technology and costs, we can say that 2005 beef production would be only about 17 billion pounds of carcass weight versus an estimated actual production of about 24 billion pounds.

However, we also have to consider that, to a great extent, consumers would increase spending on alternative meats to replace the lower amount of beef demanded, so the loss of 7 billion pounds of beef production would be offset by increases in the production of alternative meats. Thus, the higher cost of beef would also result in increased spending on other meats. The extent to which reduced beef consumption would translate to higher consumption of alternative meats would depend on the cross-price elasticities of beef with respect to other meats.

[19] USDA, ERS. Estimation of Food Demand and Nutrient Elasticities from Household Survey Data. Technical Bulletin 1887, August 2000.

For current purposes, we can simply use the estimate of beef production of 17 billion pounds. To produce 17 billion pounds of beef using 1955 productivity would require a cattle herd of about 126 million head. The estimated total January 1, 2005 herd is 94.7 million head, or about 31 million head less than what would be implied by 1955 productivity. Those 31 million extra cattle would need significantly more land, and generate more animal waste, in spite of producing 29% less beef. That would neither be economically nor environmentally sound.

Effects of Productivity on Resource Use – Land Used by Cattle

Cattle are the largest users of land in the U.S. food production system. Pasture for beef cows and stocker cattle, land in feedlots and land in crops used to produce cattle feed account for about 500 million acres[20,21] in the U.S., or about 53% of the total 938 million acres of land in agriculture, including rangeland. The use of this land involves costs to the industry and creates environmental impacts caused by the presence of cattle and associated activities, such as feedlots.

The use of land for cattle is roughly proportional to the number of head of cattle required to produce the beef supply. Technology, by improving the productivity of the cattle herd, has thus helped to reduce the impacts of beef production on land use and the environment. Technology in many other aspects of agriculture, especially grain production, has also improved the efficiency of land use.

As has been pointed out, if we were to attempt to produce the current beef supply with 1955 technology we would need a cattle herd about 80% larger than that of today. Approximately 175 million cattle would be needed, not the current inventory of under 100 million (Figure 5). Even considering the effects of higher beef prices on beef consumption, the total herd would need to be 126 million head to produce 17 billion pounds of beef in the absence of technical progress.

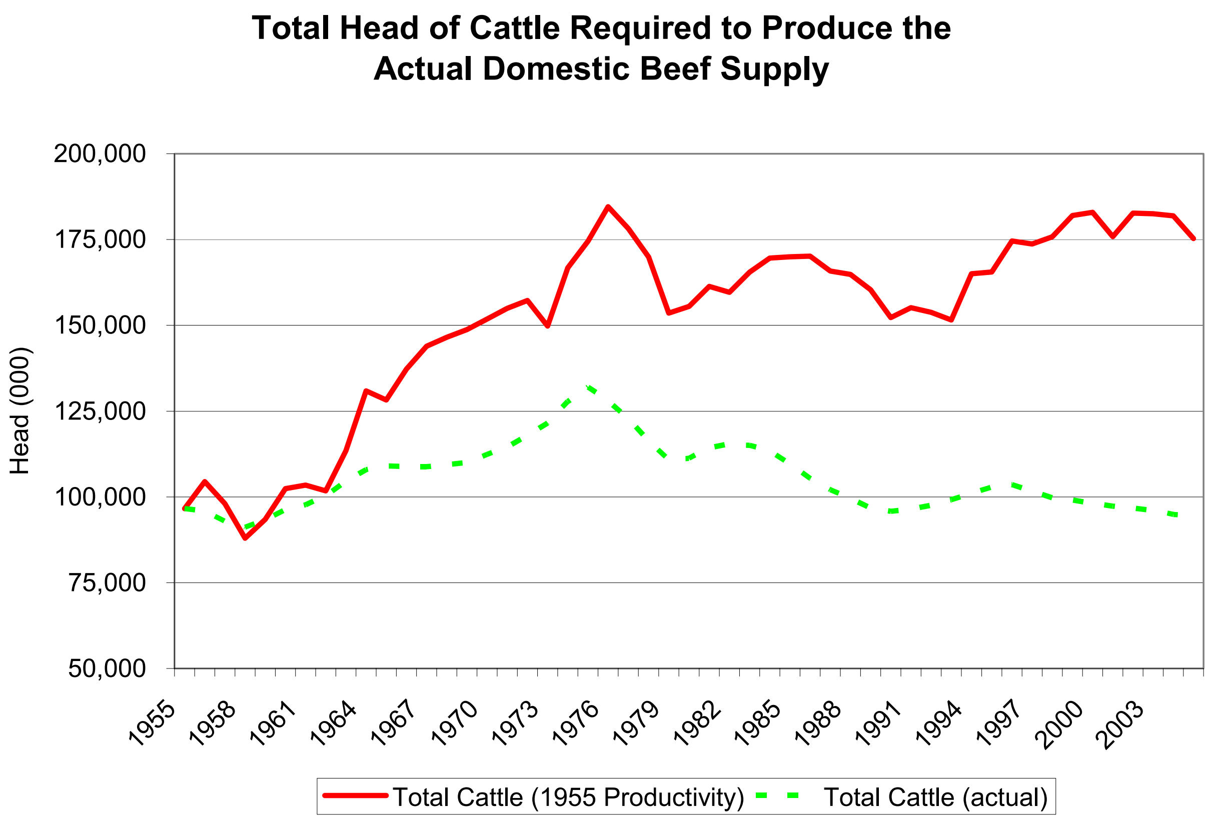
Even if the demand/price adjusted estimate of 126 million head and 17 billion pounds of beef is used, there is still a significant effect on resources needed to produce U.S. beef at 1955 technology levels. Given no increase in stocking rates, the need to pasture and otherwise accommodate a herd of 126 million head, would require us to use about 165 million more acres of land for cattle, or an 18% increase in our total agricultural land use, and that to produce a smaller U.S. beef supply. This would place an incredible strain on our land inventory and the environment. We would need to use large amounts of our forests, wetlands and other wild lands for cattle pasture. The impact on these natural areas would be substantial. Total animal waste production would also be higher, roughly proportional to the increase in the herd size required, or almost 30% more than presently produced. In addition, the land use and animal waste production from increased production of alternative meats would exacerbate the effects of these additional cattle.

[20] USDA. Census of Agriculture. 2002

[21] The 500 million acre estimate consists of cropland used for pasture, woodland used for pasture, all other pasture and rangeland and estimated cropland used to produce beef cattle feed. Some minor amounts of pasture and range may be also used for other ruminants.

Another way to look at the environmental impact is that, since 1975, we have reduced the total cattle inventory by 37 million head. In the absence of productivity increases, the environmental benefits from the reduced cattle numbers would have been largely lost, with no offsetting increase in beef production.

Figure 6 [22,23]



Over the last 50 years, the cattle industry has raised an increasing proportion of the beef supply in feedlots rather than on pasture and range lands. A major impact of agricultural technology has been on the amount of land needed to produce the feed required for cattle feedlots. Given the large increases in the fed beef supply since the 1950's, most would assume that the amount of land needed to produce increased amounts of feedlot feeds has increased, but, in fact, this is not the case.

Table 1 is an estimate of the impact on the land used to produce the corn and roughage used for beef cattle feed. For purposes of this table, it was assumed that all grain used in feedlots is corn and a 50-50 hay/corn silage mixture is used for roughage. Selected estimates from Table 1 are also shown in Figure 7.

Table 1

Estimated Feedlot Beef Production and Land Used for Corn and Roughage[24,25]

[22] USDA, NASS. Cattle. 1955-2004 (actual; 1955 Productivity estimates are the authors)

[23] 1955 Productivity estimates shown do not account for effects of higher beef prices on amounts of beef demanded.

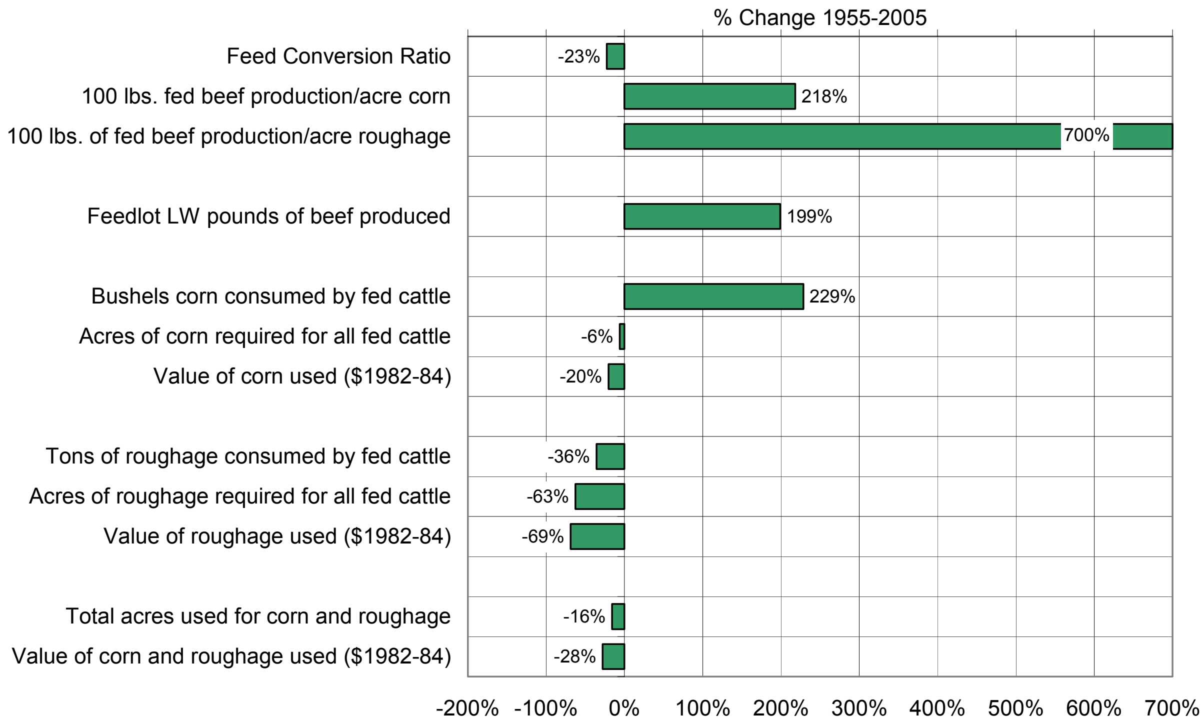
	1955	2005f	%Change
Feed Conversion Ratio	8.0	6.2	-23%
% Corn in ration	62	88	42%
Bu. of corn needed/100 lb. fed beef	8.9	9.7	10%
Corn yield - bu./acre	42	147	250%
Acres corn needed/100 lb. fed beef	0.211	0.066	-69%
100 pounds of fed beef production/acre corn	4.7	15.1	218%
% Roughage[26] in ration	36	10	-72%
Pounds roughage needed/100 lb. fed beef	288.0	62.0	-78%
Roughage yield - pounds/acre	6,581	11,333	72%
Acres roughage needed/100 lb. fed beef	0.04376	0.00547	-87%
100 lbs. fed beef production/acre roughage	22.9	182.8	700%
Fed cattle marketed[27], 000	11,973	28,620	139%
Estimated average pounds gained in feedlot	400	500	25%
Feedlot LW pounds of beef produced, mill.	4,789	14,310	199%
Bushels corn consumed by fed cattle, mill.	424	1,394	229%
Acres of corn required for all fed cattle, mill	10.10	9.48	-6%
Price of corn per bushel	$1.35	$2.25	67%
Value of corn consumed by fed cattle, $mill.	$573	$3,137	448%
Value of corn used ($1982-84 mill.)	$2,137	$1,705	-20%
Tons of roughage consumed by fed cattle, mill.	6.90	4.44	-36%
Acres of roughage required for all fed cattle, mill.	2.10	0.78	-63%
Price of roughage per ton	$15.82	$53.04	235%
Value of roughage consumed by fed cattle $ mill.	$109	$235	116%
Value of roughage used ($1982-84 mill.)	$407	$128	-69%
Total acres used for corn and roughage	12.2	10.3	-16%
Value of corn and roughage used ($1982-84 mill.)	$2,544	$1,833	-28%

The overall impact of technology changes for crops and cattle has been to significantly reduce the land used to meet the feed requirements of feedlot beef production, even though there was almost a 200% increase in the pounds of beef produced in feedlots. Despite the large increase in fed-beef production, the real cost of feedstuffs used was also reduced by about 28%. The reduction in the real cost of feedstuffs is a significant cost savings to the cattle industry and the beef consumer. The reduction in acreage required for beef feedstuffs has made more land available to produce crops for other purposes, including grain exports.

Figure 7

[24] Acreage estimates are based on the exclusive use of corn, corn silage and hay in the diet for concentrate and roughage.
[25] Estimates are based on USDA published statistics and Cattle Fax data on placement and marketed weights.
[26] "Roughage" is a 50-50 mix of alfalfa hay and corn silage.
[27] Steer and heifer slaughter from: USDA, NASS. Livestock Slaughter. 1955-2004.

% Change in Feedlot Performance and Feed Use, 1955-2005



Summary – What would have happened without cattle industry productivity gains?

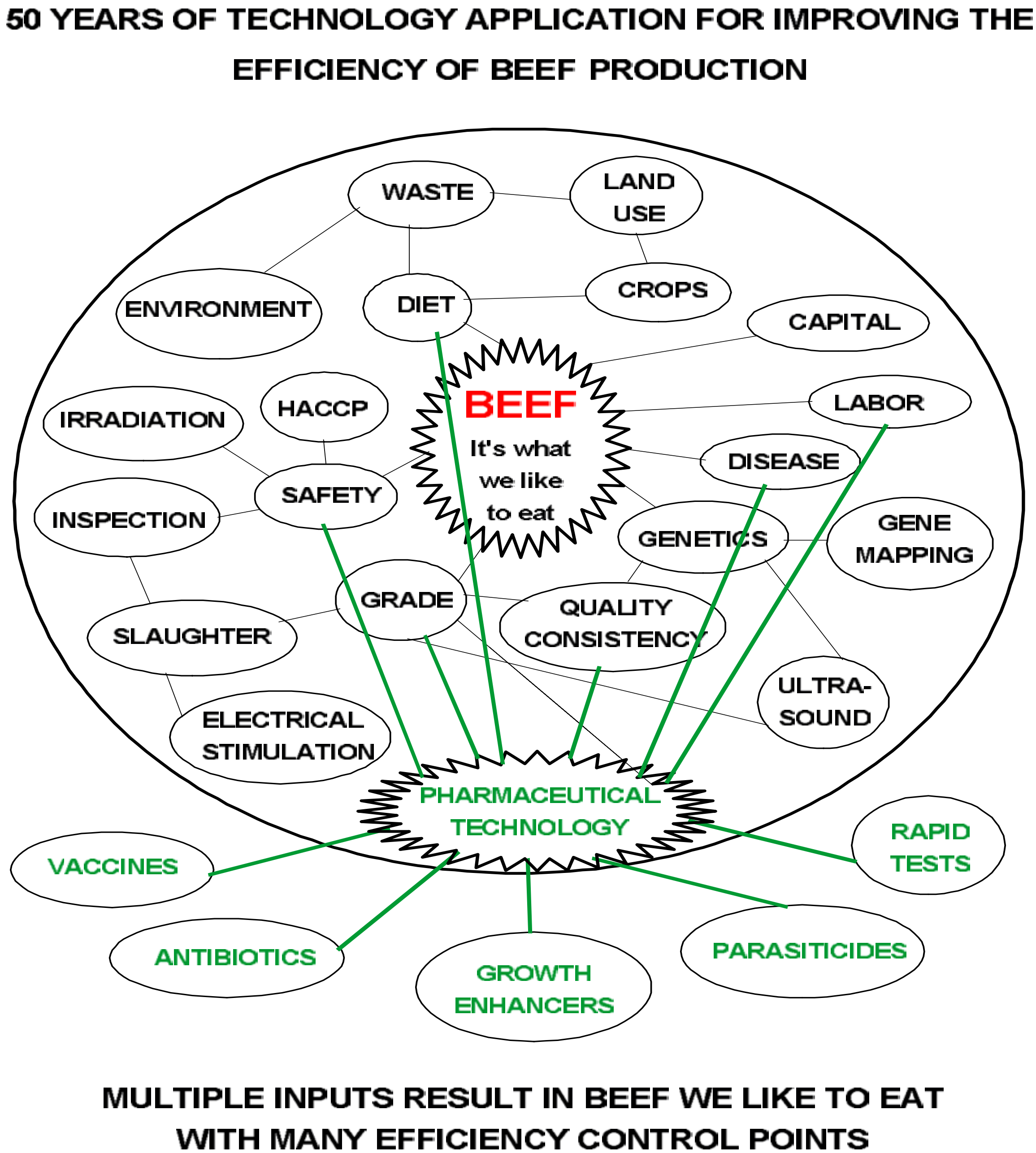
To compare the reality of 2004 to what the world would look like in the absence of cattle productivity gains requires that we know what today would look like without the advances of the last 50 years. This is not an easy task. We do not really know what the total U.S. meat production sector would look like now if the cattle industry had its technology frozen in 1955. But if that had been the case, and alternative meats had continued to improve in production efficiency, we can certainty say that directionally:

1. Beef production and consumption would be significantly smaller;
2. Cattle and beef prices would be much higher;
3. Cattle industry costs per pound of beef produced would be much higher;
4. The cattle herd would likely be larger than it is, but with lower beef production;
5. The environmental load of the beef industry would be greater;
6. Consumers would need to spend more per pound of beef consumed; and,
7. Alternative meats would have a significantly larger share of the total meat market.

The complex relationships among the meats make estimating the magnitudes of these differences, and the size of the effects of technology very difficult. What is clear is that the beef industry of the U.S. has been transformed by changing technology. In 1955, beef production was largely grass-based and beef was produced on small farms. In 2004, beef is mostly produced from cattle that are fed in large operations.

Identifying the effects of technology on the cattle and beef market is also a difficult undertaking due to the many interdependencies in the cattle market itself, among the major competing meats, and among the technologies themselves. A diagram of the major contributors looks something like Figure 8.

Figure 8



The beef industry lost market share over the last 50 years, but it is certain that if technology had not changed it would have lost even more. Despite higher cattle prices in the absence of advancing technology, it is unlikely that the cattle industry would be more profitable today with those higher prices. Higher costs would offset the higher prices, and the industry would likely be no more, and probably less, profitable than it is now.

In the next section we will explore some of the key technologies shown in Figure 8.

Sources and Magnitudes of Cattle Industry Productivity Change

How did we increase beef production per animal by some 80% in 50 years? No one single factor was responsible for this trend. Rather it was the accumulation of many technological changes that have combined over a period of years to give us this more efficient beef production system.

Here is a list of some of the major technological contributors:

I. Pharmaceuticals; other animal health products and programs
   a. Antibiotics
   b. Implants
   c. Ionophores
   d. Repartitioning agents
   e. Parasiticides
   f. Vaccines
   g. Estrus regulation
   h. USDA disease/pest eradication programs
II. Genetics
   a. Beef
   b. Dairy
III. Nutrition
   a. Breeding cattle
   b. Pasture supplementation
   c. Stocker and backgrounder operations
   d. Feedlots
IV. Grain yields, and feed costs

Underlying this list is the fact that the cattle business is a market-oriented, profit-seeking, and price/cost-driven industry that is incredibly competitive. The result has been that cost-reducing technology is sought out and adopted by the industry, especially the feedlot segment. Also, because input suppliers see a large and accepting business for new technology for the cattle industry, significant incentives are present to discover and market new products that save cost and resources in the beef production system.

While the incentives for technology adoption are high, the availability of new pharmaceutical technology has been limited by high costs and long review times for the approval process of the FDA's Center for Veterinary Medicine. In recent years the number of innovative, new drugs for animal agriculture has been a slow trickle. Although cattle have received a high share of the approvals, the total number of truly new animal drugs that have been approved has been less than one per year in recent years. No new compounds were approved in 2000, 2001 or 2003.

Table 2 shows the new, novel, drugs approved for the first time by FDA for use in food-producing animals[28]. Since 1986 only 20 new drugs have come onto the market for use in animal agriculture.

Table 2[29]
New Chemical Entities Approved by FDA/CVM for Food Producing Animals, 1986-2003

Year	Compound Approved	Trade Name	Species	Sponsor
1986	Formalin	Formalin-F	Fish	Natchez
1986	Tripelennamine Hydrochloride	Recovr	Cattle	Solvay
1987	Trenbolone Acetate	Finaplix	Steers/Heifers	Roussel-UCLAF
1988	Ceftiofur	Naxcel	Cattle	Upjohn
1989	Albendazole	Valbazen	Cattle	SmithKline Beecham
1989	Maduramicin Ammonium	Cygro	Broilers	American Cyanamid
1992	Tilmicosin Phosphate	Micotil	Cattle	Elanco
1992	Efrotomycin	Producil	Swine	Merck
1993	Pirlimycin	Pirsue	Cattle	Upjohn
1993	Bovine Somatotropin	Posilac	Cattle	Monsanto
1994	Semduramicin Sodium	Aviax	Chickens	Pfizer
1994	Laidlomycin Propionate	Catalyst	Cattle	Syntex
1995	Sarafloxacin Hydrochloride	SaraFlox	Chickens/Turkeys	Abbott
1996	Florfenicol	Nuflor	Cattle	Schering-Plough
1996	Doramectin	Dectomax	Cattle	Pfizer
1996	Enrofloxacin	Baytril	Chickens/Turkeys	Bayer
1998	Moxidectin	Cydectin	Cattle	Ft. Dodge
1998	Exclusion culture	Preempt	Chickens	Milk Specialties
1999	Ractopamine Hydrochloride	Paylean	Swine	Elanco
2002	Danofloxacin mesylate	A180	Cattle	Pfizer

I.a. Animal Health - Antibiotics

The use of antibiotics in animal agriculture parallels the timeline of their development for human medicine. As new antibiotics were developed for human uses, they were also used in animals. In recent years several products were developed exclusively for beef cattle use. As a result, the spectrum of antibiotic products used in beef cattle today bears little resemblance to that used in human medicine.

Antibiotics are used in two distinct ways in beef production. When included in feed at low dose levels, antibiotics can increase growth rates and improve feed efficiency. Because these products are included in feed, their use is generally restricted to feedlots. Also, antibiotics (generally speaking, injectable products) are used therapeutically to treat sick cattle.

The era of antibiotic growth promotion in U.S. agriculture began in 1946 with the recognition of substantial growth responses to the inclusion of streptomycin in the chicken feed[30]. At the time,

[28] Many of these drugs have received subsequent approvals in other species and for other uses, Optaflexx for cattle for example. The table contains only the first approval of a drug in a food-producing species.
[29] FDA. Veterinarian. 1986-2004

livestock management was changing rapidly from low-performance, high-morbidity, free-range farming to more controlled and intensive husbandry. Post-war demands for increased food production were high, and the discovery of an unexpected way to accelerate growth was received with enormous interest and enthusiasm by scientists and the livestock industry.

The benefits of the antibiotic growth promoters are derived from their principal mode of action, which is the manipulation of the microbial flora of the intestinal tract in most species and the rumen in ruminants. The result of this interaction with the organisms of the gut is improved digestion, metabolism and absorption of an array of essential nutrients, including carbohydrates, proteins, amino acids, minerals and vitamins. In addition, and as a result of enhanced utilization of their diets, supplemented animals need less feed and produce less waste. The benefits of antibiotic growth promoters can be broadly categorized into environmental, performance improvement, disease control, prevention of metabolic and fermentation disorders and a set of other related benefits.

Without antibiotics, cattle divert some of their nutrient intake towards responding to sub-clinical disease challenges that reduce gain and feed efficiency. The magnitude of this response is variable depending on conditions, but can be as large as 5 to 10 % in feedlot cattle[31,32].

Therapeutic uses of antibiotics in cattle result in healthier cattle. Their use in the treatment of cattle disease situations is not unlike their use in human disease. This use overcomes bacterial disease, reduces morbidity and mortality, and thereby contributes to both the welfare of cattle and production efficiency. Examples of this use include various calf diseases, bovine respiratory disease (BRD), and liver abscesses that occur in cattle fed high grain diets. Quantifying the benefit from this use of antibiotics is difficult because these disease situations are sporadic in occurrence; however it is obvious that antibiotics provide a clear benefit in these situations.

The impact of therapeutic antibiotics on beef system productivity should not be underestimated. Without effective therapeutic antibiotics for important cattle diseases, it would be very difficult to maintain large concentrations of cattle in modern feeding operations. Increased feeding of cattle has been perhaps the most important development in the U.S. cattle industry in the last 50 years. Despite the co-mingling of cattle in large feedlots and increased hauling distances, annual death loss (about 4%) is about the same today as it was in 1955. This is largely a testament to the effectiveness of modern antibiotics and vaccines.

Antibiotic use in livestock continues to be questioned by some from the standpoint of antibiotic resistance and postulated human health risks. When quantitative risk analysis procedures are applied to available data, the chance of a human health incidence arising from the use of antibiotics in cattle is so small that it is not different from zero risk. An international panel of medical microbiologists, physicians, veterinarians, animal scientists and risk assessors has

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[30] Page, S. The role of enteric antibiotics in livestock production, a review of published literature. Advanced Veterinary Therapeutics, May, 2003

[31] Rick Stock and Terry Mader. Feed Additives for Beef Cattle. U. Of Nebraska, September, 1984

[32] Preston, R.L. The role of animal drugs in food animal production. In:Proc. Symposium on Anim. Drug Use-Dollars and Sense. Center for Veterinary Medicine, Food and Drug Admin., Rockville, MD. 1987.

recently concluded that, "What has not happened in 50 years of antibiotic use in animals and man, seems unlikely to happen at a rapid rate now."[33]

I.b. Animal Health - Implants[34]

Growth promoting implant products were one of the earliest (1956) and probably the most revolutionary pharmaceutical technology introduced into the beef industry. Over the past 50 years of use, implants continue to be one of the most effective technologies used in the beef industry. They provide benefits for every segment involved in beef production from the cow-calf producer through the feedlot phase and even for the packer. Implant technology can be thought of as hormone replacement, since bulls and implanted steers gain at about the same rate. With the availability of a wide range of doses and combinations of estrogenic and/or androgenic agents, implants have become almost designer products. While implants tend to be most effective in feedlot cattle, implanting strategies have been effectively applied to other beef production phases as well. Estimated returns to cattle producers and packers from implant use range from $30 to as much as $67 per head.[35]

Significant changes in implants and implanting strategies have occurred over time. Prior to 1987, available implants were estrogenic agents, which metabolically enhanced nutrient use to enhance growth. These products improved feed efficiency 2-8 percent and daily gains from 10-15 percent. In 1987, the androgenic (tissue building) agent, trenbolone acetate, was approved for use in growth promoting implants. This compound had an additive effect with existing estrogenic implants. The androgenic implant enhanced muscle growth and added an additional 4-6 percent to the feed efficiency and 5-8 percent to the daily gains.[36]

Typical implant programs in feedlot cattle will increase rate of gain 15 to 20% and improve feed efficiency 8 to 12%. In other words, without implants, feedlot daily gain would be about 2.6 lb per day in steers and 2.4 lb per day in heifers compared to expected gains today of at least 3.1 and 2.7 lb per day, respectively. Similarly, without implants, feed efficiency would be about 7.0 and 7.1 lb of feed dry matter per lb of gain compared to expected efficiencies today of 6.3 and 6.5, respectively. Additionally, implants cause a decrease in fat deposition in the beef carcass, an increase in the rib eye area, and an improvement in lean meat growth. Thus, the cost of gain is decreased, which benefits the cattle producer and carcass improvements are made which eventually benefit both the packer and beef consumer.

Implant programs provide increased management options which help produce a consistent beef supply from the variety of breed types presently used in the industry. Implant programs can also

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[33] Phillips, I., M. Casewell, T. Cox, B. DeGroot, C. Friis, R. Jones, C. Nightingale, R. Preston and J. Waddell. Does the use of antibiotics in food animals pose a risk to human health? A critical review of published data. J. Antimicrobial Chemotherapy, 53:28-52, January 2004.

[34] R.L. Preston. Hormone containing growth promoting implants in farmed livestock. *Advanced Drug Delivery Reviews*, 1999.

[35] Gill, D.R.. and J.N. Trapp. Economics of beef production with and without implants. In: Symposium: Impact of implants on performance and carcass value of beef cattle, P-957. Oklahoma State Univ, Stillwater, OK. May 1997.

[36] Duckett, S.K., F.N. Owens and J.G. Andrae. Effects of implants on performance and carcass traits of feedlot steers and heifers. In: Symposium: Impact of implants on performance and carcass value of beef cattle, P-957. Oklahoma State Univ, Stillwater, OK. May 1997.

be tailored to fit the length of the feeding period. Depending on the final USDA grade target, leaner carcasses are produced that are more in line with consumer demand, there is less waste fat from the cattle carcasses, marbling score may be reduced, but the eating quality of beef produced using implants is unaffected, especially when cattle are fed to the same USDA grade.

The Federal Drug Administration (FDA) and several international health organizations (WHO and FAO) have repeatedly stated that there are no human health effects from consuming beef from implanted cattle.[37,38] Despite their proven safety, implants are banned in Europe, and their use in the U.S. and Canada is used by the European Union as a barrier to importation of beef.

The impact of growth promoting implants on the cattle industry should not be underestimated. If we look around the world, there is no country that feeds cattle in large numbers without using implants. Europe, in particular, produces a large grain surplus and could feed cattle. However, European social programs designed to protect smaller farms, together with an unwillingness to accept some new technology have made cattle feeding very costly. As a result there is only a small cattle-feeding industry in Europe.

I.c. Animal Health - Ionophores

The first ionophore used in cattle was introduced in December 1975. These compounds work by altering the volatile fatty acid balance in the rumen, reducing production of fermentation waste by-products and increasing the amount of net energy available from feedstuffs. In doing so they improve feed efficiency and average daily gain and reduce the amount of feed wasted in rumen fermentation. They work in both feedlot and pasture settings. Ionophores also reduce coccidiosis and, because they reduce bloat and acidosis that can result from the fermentation of grain starch, feedlots are able to feed higher energy-dense rations.

Ionophores are currently used extensively in feedlots, stocker operations and in replacement heifer raising operations. Nearly all feedlot cattle receive an ionophore in the feed from day of arrival to harvest. A high percentage of replacement heifers will also receive an ionophore. Pasture supplements can also include ionophores.

By improving the energy utilization of feeds, ionophores have helped make beef production more efficient and have indirectly aided beef quality by increasing the cost-effectiveness of feeding cattle versus raising them on grass. In feedlot cattle, ionophores will improve feed efficiency by 6 to 8 percent and daily gain by 1 to 6 percent. The efficiency response provides an economic benefit to the feedlot producer of about $12 per head.[39] In stocker cattle and replacement heifers, ionophores improve feed efficiency by 8 to 12 percent and daily gain by 5 to 15 percent.[40]

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[37] Preston, R.L. Rationale for the safety of implants. In: Symposium: Impact of implants on Performance and carcass value of beef cattle, Oklahoma State University, P-957, Stillwater, OK, May 1997.
[38] Lauderdale, J.W. The facts about beef cattle growth enhancement technology. 19th Annual Southwest Nutrition & Management Conference, pp 61-64. Univ. Arizona. Phoenix, AZ. February 2004.
[39] Preston, R.L. The role of animal drugs in food animal production. In:Proc. Symposium on Anim. Drug Use-Dollars and Sense. Center for Veterinary Medicine, Food and Drug Admin., Rockville, MD. 1987.
[40] Rick Stock and Terry Mader. Feed Additives for Beef Cattle. U. Of Nebraska, September, 1984

Ionophores and implants work together well and, in fact, may work synergistically. Ionophores make it feasible to feed higher energy diets, and implants act to direct that extra energy into lean meat production.

I.d. Animal Health – Repartitioning Agents[41]

The first repartitioning agent for cattle was approved in the U.S. by FDA in 2003. Repartitioning agents are used in the last part (typically 4-6 weeks) of the feedlot phase of cattle production. These agents "repartition" the absorbed nutrients towards greater lean meat growth and less fat deposition. While they are being used, rate of gain is increased 17 to 25% and feed efficiency is improved by the same magnitude. Carcass lean gain is improved almost 70% while a repartitioning agent is being fed. Gross returns to feedlot cattle producers are about $10 to $17 per head fed. Net returns will depend on the cost of the drug. The response to repartitioning agents is additive to that expected from implants and ionophores. The percentage effects, measured relative to the entire feeding period of 120-140 days, are less than those measured during the approved period of use (last 28-42 days).

I.e. Animal Health – Parasiticides

The advent of parasiticides in the 1950's also represents a major advance in beef cattle rearing. In their natural, outdoor environment, cattle are subject to infestation by a wide variety of both internal and external parasites. Though very diverse, parasites have one common effect on cattle – they reduce performance. Parasites can also cause disease, reduce the value of hides, and in extreme cases can be fatal.

Internal parasites rob cattle of nutrients from their feed, nutrients that could otherwise be used for growth and development. They can also attack major organs and reduce the health status of cattle. In extreme, but rare, cases internal parasites can be fatal.

Stomach and intestinal worms, tapeworms, liver flukes, lung worms and coccidia are the most common internal parasites of cattle in the U.S. Their effects are usually insidious and subclinical, such as indigestion and poor feed conversion, less than expected weight gain and, for beef cows, decreased milk production and lower conception rates. Lungworms can cause verminous pneumonia and provide an environment conducive for viral and bacterial pneumonia.

Today there is a large array of parasiticides that dramatically reduce the impact of these internal pests on beef cattle performance. However, the evidence on the production effects of this class of products on cattle performance is somewhat scarce. University studies have shown that the use of an effective control program for beef cattle have the following general effects[42,43,44,45]:

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[41] R.L. Preston. Feedlot Management Challenges and Opportunities With β-Agonist Use. 2004 Plains Nutrition Council Spring Conference, April 2004.
[42] W. W. Gill, J. B. Neel, F. N. Hopkins, C. D. Lane, Jr. and D.G. Meadows. Body Condition Score and Internal Parasite Control in Beef Cows.Dept. of Animal Sciences, University of Tennessee, Knoxville, 2002
[43] Steven C. Smith, Kent C. Barnes and Keith S. Lusby. Effect of Deworming on Performance of Grazing Cows and Their Calves in Eastern Oklahoma. Department of Animal Sciences, Oklahoma State University

1. Beef cow weights and body condition scores (BCS) are improved (+20 to 30 pounds and +0.2 to 0.4 BSC),
2. Increases are seen in cow conception rates due to improved body condition scores,
3. Calf weaning weights are increased significantly (20 to 40 pounds), and
4. In heifers there is an increase in growth rate (about 0.1 pounds/day), reduced time to puberty (+33% more reach puberty at 14 months of age) and improved conception rate (25% vs. 56% at 14 months of age),

External parasites of cattle – flies, grubs, lice, and ticks – limit productivity in beef cattle by affecting animals in several ways. They are a serious threat since they feed on body tissue such as blood, skin and hair. The wounds and skin irritation produced by these parasites often result in discomfort and irritation for the animal. More significant, however, is that any blood-sucking or biting parasite may transmit diseases from infected animals to healthy ones. In addition, these pests also may reduce weight gains, cause losses in milk and meat production, produce general weakness, cause mange and severe dermatitis, and create sites for secondary invasion of disease organisms[46,47,48]. They can also damage the hide, a valuable by-product of beef production.

An important economic effect of external parasites on cattle performance has to do with the behavior of cattle as they attempt to avoid them. The irritation caused by flies, lice and grubs can cause cattle to move about and scratch up against any handy object[49]. This behavior wastes energy and can lead to loss of performance.

However, the major economic burden of external parasites is the diseases they may spread. Without effective control, the losses from these parasites and the diseases they spread would be significant.

As is the case with internal parasites, there is today a wide range of products for control of external parasites. Unfortunately there is very little scientific evidence on the monetary value of cattle performance effects of external parasites.

I.f. Animal Health – Vaccines[50,51]

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[44] R. L. Larson, L. R. Corah, M. F. Spire and R.C. Cochran. Effect of Deworming with Ivomec on Reproductive Performance of Yearling Beef Heifers. Report of Progress 651, Kansas State University - Dept. of Animal Sciences and Industry, Page 53, 1992

[45] Tobias L. Stroh, Kris A. Ringwall, James L. Nelson, Keith J. Helmuth, Jon T. Seeger, D.V.M. Efficacy of Spring Time Worming Among Beef Cow Calf Pairs. North Dakota State University - Dickinson Research Extension Center, 1999

[46] Donald R. Johnson, Gus Lorenz, Glenn Studebaker, and John D. Hopkins. Ticks on Beef Cattle (Livestock Insect Series). Department of Animal Sciences, University of Arkansas, 2003

[47] Peggy K. Powell. Cattle Grub Biology and Management. Animal and Veterinary Science Department, West Virginia University, 1995

[48] Lee Townsend. Lice on Beef and Dairy Cattle. Department of Animal Sciences, University of Kentucky, 2000

[49] John Maas. Fly Control for Cattle. Department of Animal Sciences, University of California, Davis, 2002

[50] Clell V. Bagley. Infectious Cattle Diseases and Vaccines. Fact Sheet, 1997, Utah State University - Department of Animal, Dairy and Veterinary Sciences

[51] Dee Griffin, Steve Ensley, Dave Smith, and Grant Dewell. Understanding Vaccines. Fact Sheet, 2002, University of Nebraska

Vaccines used against bacterial and viral diseases, and bacterial toxins are the oldest pharmaceutical technology applied to cattle. The first vaccine was against blackleg caused by the toxin produced by *Clostridium novyi* in cattle.

Over the years, many vaccines have been developed against specific bacterial and viral disease problems in cattle. This technology is prophylactic in nature since the antigens used are for specific disease situations which may or may not be present in a given cattle herd or in the feedlot. Obviously, if the disease entity is not present, there will be no benefit from the vaccine. On the other hand, if the disease is present, or if an outbreak occurs, the benefit can be very great. In addition to blackleg, common vaccines used in cattle production include infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD), bovine respiratory syncytial virus (BRSV), parainfluenza, *clostridium perfringens*, *haemophilus, pasteurella, leptospira* and certain combinations of the above. Several vaccines against *Escherichia coli* O157:H7 are under development and could eventually have major food safety implications for the beef industry.

Due to the nature of their use, it is very difficult to quantify the production efficiency benefits resulting from the use of vaccines. However, a healthy animal will always perform better than one that is, or has been, ill. Vaccine use also reduces the performance variability of feedlot cattle. To the extent that vaccines prevent the onset of clinical and subclinical disease, they contribute significantly to the efficiency of beef production and also to animal welfare.

I.g. Animal Health – Estrus Regulation

There are several products used to regulate estrus in feedlot heifers and breeding female cattle. Melengestrol acetate (MGA) has been shown to improve rate of gain and feed conversion in feedlot heifers. In feedlot heifers the use of an estrus suppression product improves average daily gain and feed efficiency by about 3 to 7%.[52,53] Fed heifers do less riding and bulling when estrus is not present, so there's less dust, less bruising and increased beef quality.

Other products, such as prostaglandins, are used in breeding heifers and cows to bring them into estrus at the same time, thus shortening the calving season and producing more uniform calves at weaning. Use of artificial insemination is also facilitated and genetic improvement is enhanced when estrus is synchronized.

I.h. Animal Health – USDA Disease/Pest Eradication Programs[54]

USDA, with the cooperation of the cattle industry, has helped eradicate or sharply reduce the prevalence of several important diseases in cattle. Contagious bovine pleuropneumonia was eradicated in 1892, the screwworm in 1966, the cattle fever tick in 1943 and foot and mouth disease in the 1930's. Ongoing programs include bovine tuberculosis and brucellosis (37 states

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[52] Rick Stock and Terry Mader. Feed Additives for Beef Cattle. U. Of Nebraska, September, 1984

[53] Duckett, S.K., F.N. Owens and J.G. Andrae. Effects of implants on performance and carcass traits of feedlot steers and heifers. In: Symposium: Impact of implants on performance and carcass value of beef cattle, P-957. Oklahoma State Univ, Stillwater, OK. May 1997.

[54] USDA, ARS, http://www.ars.usda.gov/is/timeline/comp.htm

are currently disease-free). Though several of the programs pre-date 1955, they are all important milestones in the improving health status of the U.S. cattle herd.

Currently, emphasis is being placed on preventing the re-occurrence of BSE. Strict rules have been imposed by the FDA on the feeding of ruminant derived feed ingredients to cattle and USDA is screening selected, older, cattle for the disease.

II.a. Genetics – Beef

The genetics of beef cattle over the last 50 years, as applied by the industry, is probably best described as a directionless process. Early in the past 50 years, three breeds constituted the majority of the beef cattle produced in the U.S., namely Hereford, Angus and Shorthorn. The beef type at that time was described as compact, or compressed. The cattle were of small frame and were quite fat at market weights. The advent of quarter-inch trimming of fat on carcasses brought about an awareness of cattle that were too fat. The benefits of crossbreeding through heterosis began the development of composite lines of cattle (Santa Gertrudis, Braford, Brangus, "black-baldies," etc.). Large frame, exotic European breeds (Charolais, Simmental, Limousine, etc.) were introduced that increased rate of gain, improved feed efficiency, increased mature size and carcass weight. Because of weight limitations, achieving a desired USDA grade without creating a carcass weight that was too heavy to "fit the box" became a major problem for the industry. As a result, the present beef cattle in the U.S. are a diverse population that presents challenges and opportunities in the production of a consistent supply of beef.

Genetic measures have been introduced to improve certain aspects of the production process. Bull test stations identified sires that were above average in rate-of-gain with less fat thickness. Quantitative measures, such as expected progeny differences (EPDs), gave projected performance values for certain traits such as rate of gain and carcass characteristics.

Presently, considerable effort is being directed towards gene mapping and marker technology. This will enable the identification of gene combinations that relate to growth, efficiency and the eating qualities of beef such as tenderness.

II.b. Genetics – Dairy

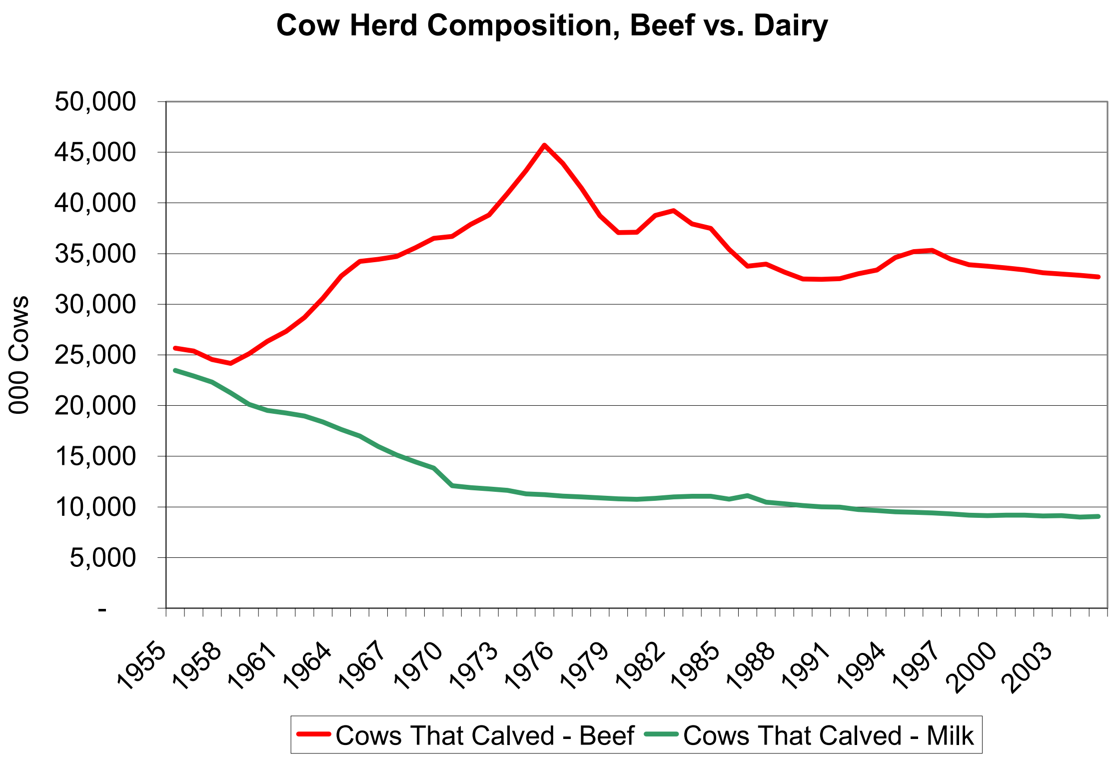
It may not seem obvious that genetic improvement of dairy cattle has helped the productivity of the beef industry, but it has, in fact, been a contributor. Dairy cattle produce beef as a by-product of milk production. If the number of dairy cattle can be reduced via increased milk production efficiency, there will be more specialized resources available for beef production.

Dairy cattle genetics have helped improve milk production from about 6,000 pounds per cow in the mid 1950's to about 19,000 pounds in 2004-2005[55]. By more than tripling the milk-per-cow, we have been able to dramatically reduce the number of dairy cattle required to produce the U.S. milk supply. In doing so, the dairy industry made "room" for a larger beef cowherd. As a result of advances in milk cow productivity since 1955, the dairy herd has shrunk from 23.5 million head to 9.1 million. During that same time period, the beef cowherd grew from 25.7 to 32.7

[55] USDA, NASS. Milk Production. 1955-2004

million head. Figure 9 shows the decline of the dairy cowherd since 1955 and the increase in the beef cowherd.

Figure 9 [56]



Genetic improvement in dairy cattle has proceeded faster than has been the case for beef for a very simple reason. In beef cattle, the genetic traits used for selection are many and complex and results are often unpredictable. In dairy cattle, genetic focus is on one trait – milk per cow – and the results are easy to measure and unambiguous.

III.a. Nutrition – Breeding Cattle[57]

With the introduction of larger, exotic, breeds of cattle, weight at puberty was heavier and cow-calf producers had difficulty getting heifers to calve at two years of age using conventional feeding programs. Research demonstrated the importance of feeding adequate energy to achieve pubertal weights in time for breeding first-calf heifers at 13-14 months. Recently, the beneficial role of fat additions to the diet on reproductive performance has been demonstrated. Furthermore, the importance of achieving a minimum body condition score at calving through dietary energy management and the ability of cows to return to estrus in time to be bred and maintain a yearly calving performance has greatly facilitated the incorporation of larger frame cattle into the national cow herd.

III.b. Nutrition – Pasture Cattle

[56] USDA, NASS. Cattle. 1955-2004

[57] Preston, R.L. Nutrition for optimum reproduction in beef cattle. In: Emerging technology and management for ruminants, pp119-130. International Stockman's School, Winrock International, Westview Press, 1985.

Over the past 50 years there have been major advances in the understanding of the role of nutrition in pasture cattle performance. As a result, the use of pasture supplements containing vitamins, minerals and other nutritional elements missing in natural pastures has become commonplace. In many cases, pasture supplements also contain energy and protein to make up for seasonal deficiencies in grass.[58] Ionophores are also used in some supplements.

The benefits are increased weaning weights in calves and improved reproductive performance in cows. The magnitudes of these benefits depend to a great extent on the effects of weather on forage quality, and are highly variable.

III.c. Nutrition – Backgrounder and Stocker Operations

Over the past 50 years, programs for managing the transition of cattle from a pasture environment to the feedlot have been improved. Known as backgrounding and stocker programs, these management systems are designed to put low cost weight on weaned calves prior to shipment to feedlots. The difference between the programs is that stocker operations are more intensively managed for higher weight gains whereas backgrounding programs maximize the utilization of roughages, pastures and crop residues.

Both of these systems involve feeding hay, grain and protein supplements to young animals on pasture. Vaccines, antibiotics, implants, parasiticides and feed additives, especially ionophores, are commonly used. The normal target is to have cattle gain 1-2.5 pounds a day versus less than a pound that would be gained on pasture alone.[59]

The performance benefit is that cattle arrive at the feedlot, younger, heavier, and in better condition and health than animals that remain on pasture with no supplementation or health management.

III.d. Nutrition – Feedlot Cattle

Feedlot nutrition research, results and application have been taking place continuously over the past 50 years. In addition to better defining the nutrient requirements of beef cattle that have been the source of information for updating the National Research Council (NRC) Nutrient Requirements of Beef Cattle, research has also quantified the relationship between nutrient intake, especially energy and to some extent protein, and the productive performance of beef cattle. Predicted feed and energy intakes, and resulting growth rates translate into live weights, feed efficiencies and harvest weights to achieve USDA grade endpoints. Thus, when cattle are placed in the feedlot, closeouts can be predicted and break-even points determined, facilitating the hedging of cattle to lock in profit margins.

[58] J.E. Sprinkle. Matching Forage Resources with Cow Herd Supplementation. Department of Animal Sciences, University of Arizona, 1996
[59] Kansas State Agricultural Experiment Station and Cooperative Extension Service. Stocker Cattle Management & Nutrition. June 1991.

Nutrition technology has helped convert cattle from roughage/pasture/range diets to high concentrate diets fed in the feedlot. Pharmaceutical products play an important role in making this conversion a success. The ability to feed cattle diets high in grain is a more economical way of supplying cattle dietary energy than via roughage. The feedlot system also permits higher rates of growth that allow cattle to be harvested at market weights when they are younger, and their beef is more tender, than cattle harvested from grass-based systems. Two and three year-old cattle were commonplace at harvest in the early 1950's whereas cattle today are generally between 16 to 20 months of age at harvest.

Vitamin E and vitamin D additions to feedlot cattle diets have recently been shown to extend the shelf life of beef in the retail counter and to potentially enhance the tenderness of beef, respectively.

Arguably the evolution of feedlots and related feeding technologies has been the single most important source of efficiency advancement in the U.S. cattle industry over the last 50 years. The system takes advantage of a wide range of technologies of cattle rearing that all combine to reduce age of cattle at harvest, improve the quality of the end product, and increase beef yields. This system is also what makes U.S. beef a unique and sought-after product around the world.

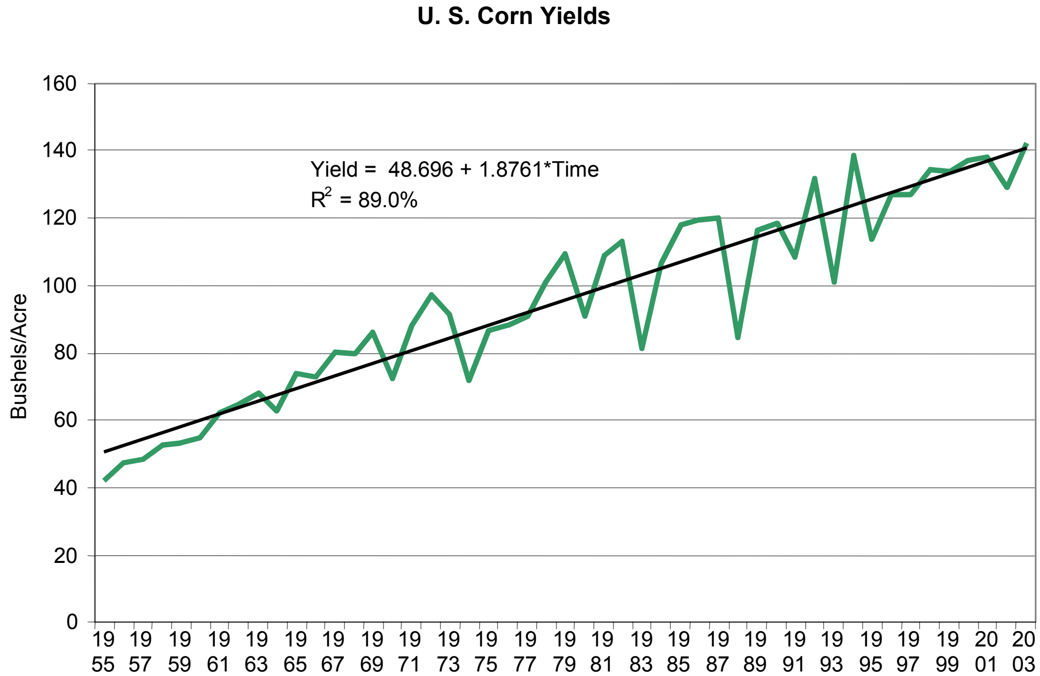
IV. Grain Yields and Feed Costs

Strictly speaking, the progress made in grain production, corn in particular, over the past 50 years is a technology separate from the cattle industry. Yet the effects have been so pervasive that it should be acknowledged that increases in grain yields and the resulting declines in the real cost of grains has had a major effect on the cattle industry.

The major force behind the decline in real corn prices has been increasing yields. Since 1955, the average annual increase in corn yield was almost 1.9 bushels per acre, and as a result the 42-bushel yield of 1955 increased to over 140 bushels in 2003 (Figure 10).

Had corn prices of the mid-1950s simply increased with inflation they would be over $9 a bushel in 2004, not the $2-$3 of recent years (Figure 11). At $9 per bushel, or well over 3 times the current level, the economics of feeding cattle in 2004 would be a very different proposition from what is actually the case. Without the progress in corn production and the resulting declines in the real price of corn, the cattle industry, as we know it today would not exist. More of our beef would be produced off grass, and Figure 1 would show much less progress in terms of productivity of the herd.

Figure 10 [60]



The net result has been that over time cattle prices have increased relative to corn, making it increasingly attractive to produce beef in feedlots. In the 1950's, the ratio of Choice steer prices to corn prices was in the range of 15-25:1. It recent years that same ratio was over 35:1 (Figure 12). The real cost of corn, relative to that of fed beef, has thus been reduced by almost half over the last 50 years.

However, crop production technology alone cannot fully explain the increase in fed beef production. Without the effects of pharmaceutical technologies we would not have been able to feed modern high-energy diets and take full advantage of the developments that have led to lower real prices of feedstuffs.

[60] USDA, NASS. Crop Production. 1955-2004

Figure 11 [61]

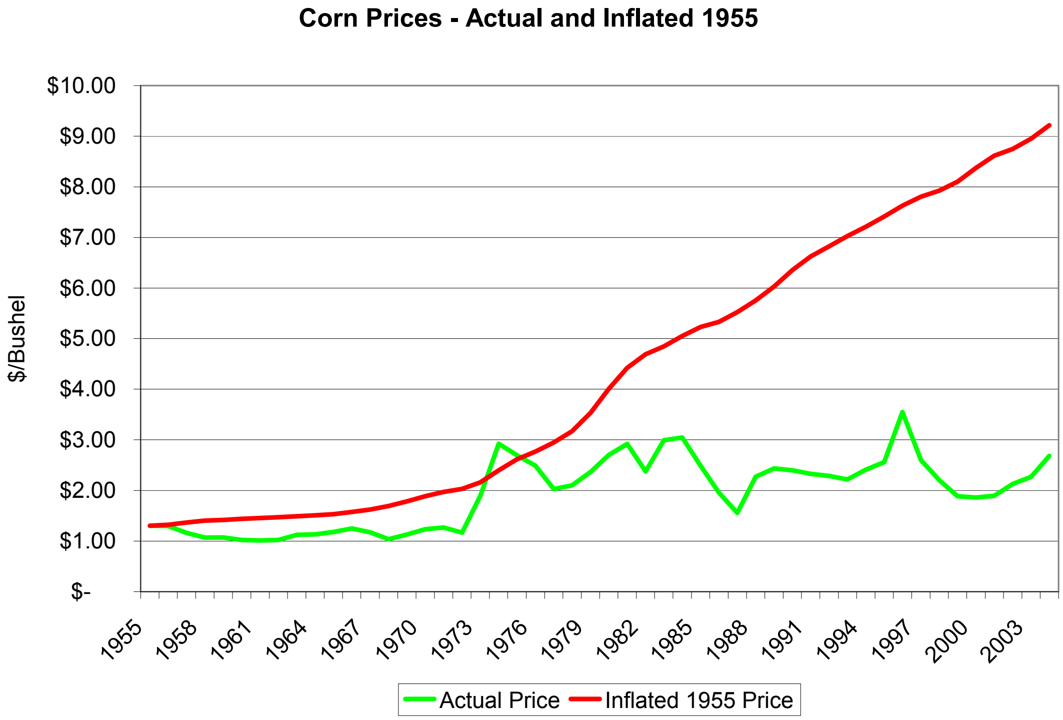
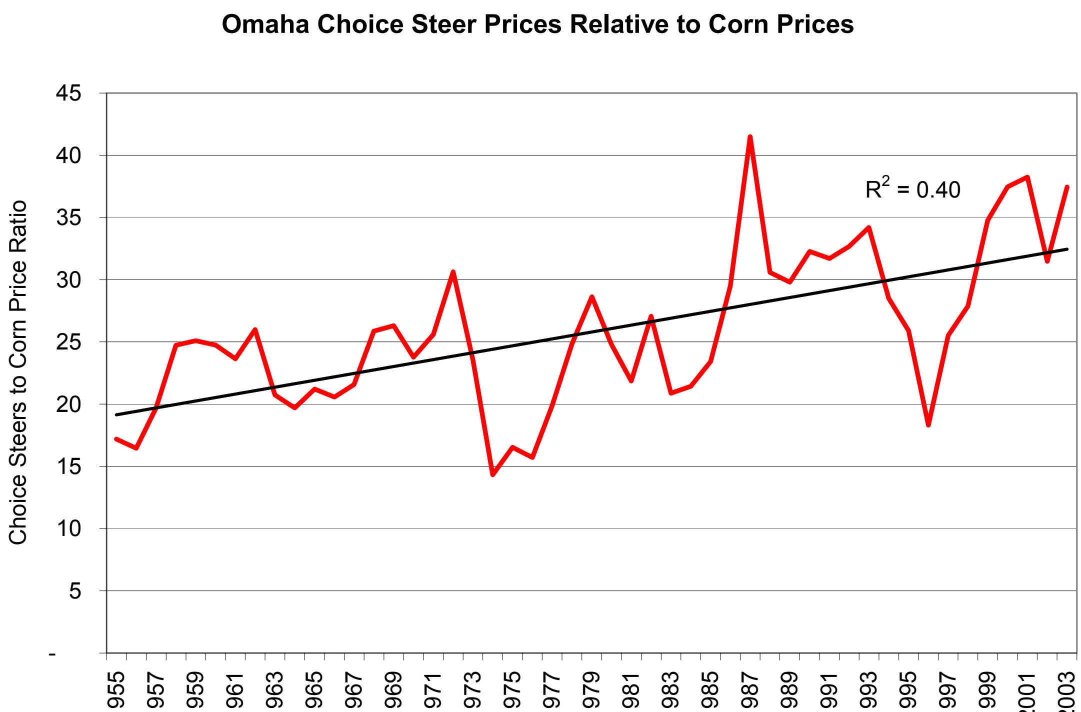


Figure 12 [62]



[61] USDA, NASS. Agricultural Prices. 1955-2004
[62] USDA, NASS. Agricultural Prices. 1955-2004

Summary – Changes in Cattle Performance and Technology

Pharmaceutical technology applied to beef production can explain a significant portion of the advances over the past 50 years. As summarized in Table 2, for feedlot cattle all of the feed efficiency and about half of the average daily gain differences are explained by key pharmaceutical technologies introduced over the last 50 years. There were also significant gains from these same technologies in stockers and calves, but we do not have good estimates in all cases of the typical 1955 values for stocker and calf performance to compare with current performance.

Table 2
Summary Estimates of Performance Gains from Key Pharmaceutical Technologies[63]

					-------------------------Improvement From-------------------------				
Performance Measure	Phase	1955	2004	% Difference	Implants	Ionophones	Antibiotics	Estrus Control	Parasiticides
Feed Efficiency	Feedlot	8.0	6.2	-23%	10%	6%	7%	5%	n/a
Average Daily Gain	Feedlot	2.2	3.5	59%	17%	3%	7%	5%	n/a
Feed Efficiency	Stockers	n/a	n/a	n/a	7%	10%	n/a	n/a	n/a
Average Daily Gain	Stockers	n/a	n/a	n/a	12%	10%	n/a	n/a	n/a
Weaning Weights, lbs.	Calves	400	500	25%	20	n/a	n/a	n/a	30

It is apparent that the use of these pharmaceutical technologies has accounted for a higher proportion of the feed efficiency improvements than was the case for growth rates. Genetic programs, improved feeds and better management have probably contributed more to the increased growth rates than has been the case for feed efficiency.

[63] Percentage improvements for the technologies are the midpoints of their respective ranges.

Beef Quality Improvements – 1955-2005

Contributing factors to changes in beef quality

Cattle performance and efficiency are metrics that can be quantified and evaluated, with a good degree of precision, over time. Beef quality, on the other hand, depends largely on subjective metrics such as flavor, odor, color, juiciness, texture, and tenderness. Consistency of these factors across the entire beef supply and over time is also an important measure of quality. Although there are some objective measurements (ex. - the Warner-Bratzler sheer test for tenderness) for meat quality, it remains to a great extent a very subjective area. Since quality and value are related, a system that measures quality and rewards those who produce a better quality product would seem to be desirable. In the U.S. the USDA beef grading system has been used as a means of evaluating beef carcasses since 1927[64]. The marketplace then has the job of assigning different values to the USDA grades. While not a perfect system, it is the industry standard. However, until recently, little research and technology has been applied to the USDA grading system.

The USDA grading system used by the packing industry is a fee-based, voluntary system. As such, not all cattle that are Federally inspected are assigned USDA quality and yield grades. USDA grades are determined largely by marbling in the rib-eye muscle and the apparent age of the animal. Since marbling was easy to determine in packing plants and was the major factor in the grading system, it became a focus, or target, for beef producers. Choice and Prime beef thus became industry standards for cattle and beef. Most beef that was identified by plant personnel that had marbling scores sufficient to meet Choice or higher was submitted for USDA grading while carcasses with less marbling were usually marketed through "house" grades or as "no roll," ungraded beef. Packers generally found it more profitable to market beef with only a slight degree of marbling under a "house" grade or as "no roll".

From the mid-1950's through the late 1980's, the percentage of federally inspected beef that was USDA graded remained unchanged and ranged from 50 percent to 60 percent. However, during this same period, the percentage of graded beef tonnage that was Prime or Choice, increased from 57% in 1956 to a peak of nearly 98% primarily because the percentage of beef that was voluntarily graded rather than a true change in the percentage of Prime and Choice beef as part of total beef production. This began to change in November 1987, when USDA renamed the USDA Good grade to USDA Select. This name change provided nomenclature that became widely accepted in marketing this grade of beef. Prime and Choice graded beef as a percentage of total beef production has actually changed only slightly since the mid-1960's, ranging between 40 to 55%.

In 1965, to identify beef carcasses with excess waste fat, the USDA also established five "cutability" or yield grades as part of the beef grading system.[65] Yield grade 1 carcasses have about 75-76% whereas yield grade 5 carcasses have 60-61% closely trimmed retail product.

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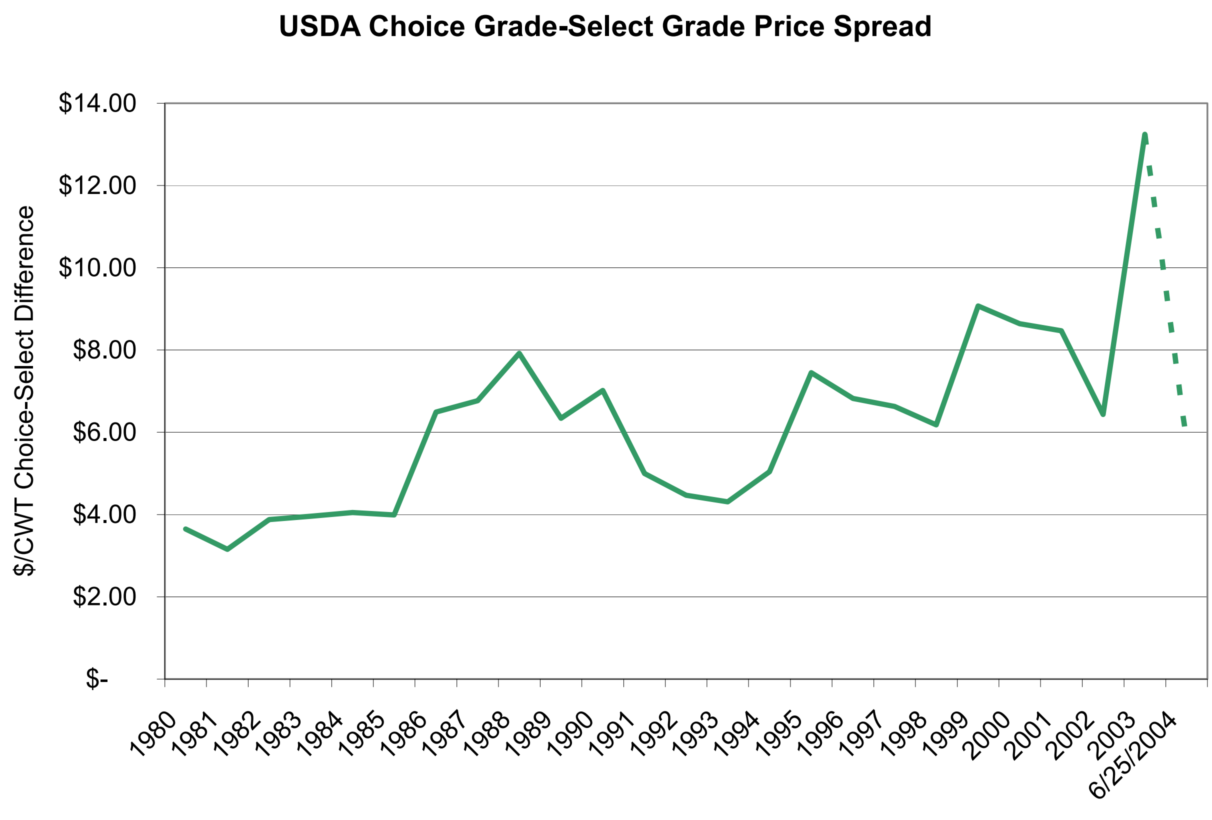
[64] USDA. Official United States standards for grades of carcass beef. Service and Regulatory Announcements C&MS 99. June 1926.

[65] USDA. Official United States standards for grades of carcass beef. Service and Regulatory Announcements C&MS 99. June 1965.

From 1984 to 2003, the percentage of Federally inspected beef that was presented for USDA grading increased from 65% to 96%. USDA grading of beef has become more prevalent for several reasons, including more cattle that are sold on a dressed or formula basis and the fact that the Select grade of beef has become a major portion of the beef sold through retail supermarkets. As a result, from the late-1980s through present time, graded beef has broadened to include USDA Select beef along with the long-standing grades of Prime and Choice. Generally, the price spread between Choice and Select has increased as more Select beef has been presented for grading (Figure 13). The spike in the price premium for Choice in 2003 is likely a result of the unusual conditions surrounding the trade disruptions caused by the discovery of BSE in Canada in May of that year. It is also likely that the recent increase in beef demand has played a role in the increased value of Choice relative to Select grade beef. The view that the extremely wide spread of 2003 was an aberration is bolstered by the fact that the June 25, 2004 Choice-Select price spread was back down to a more typical $5.78.

Figure 13 – Choice-Select Price Spread[66]

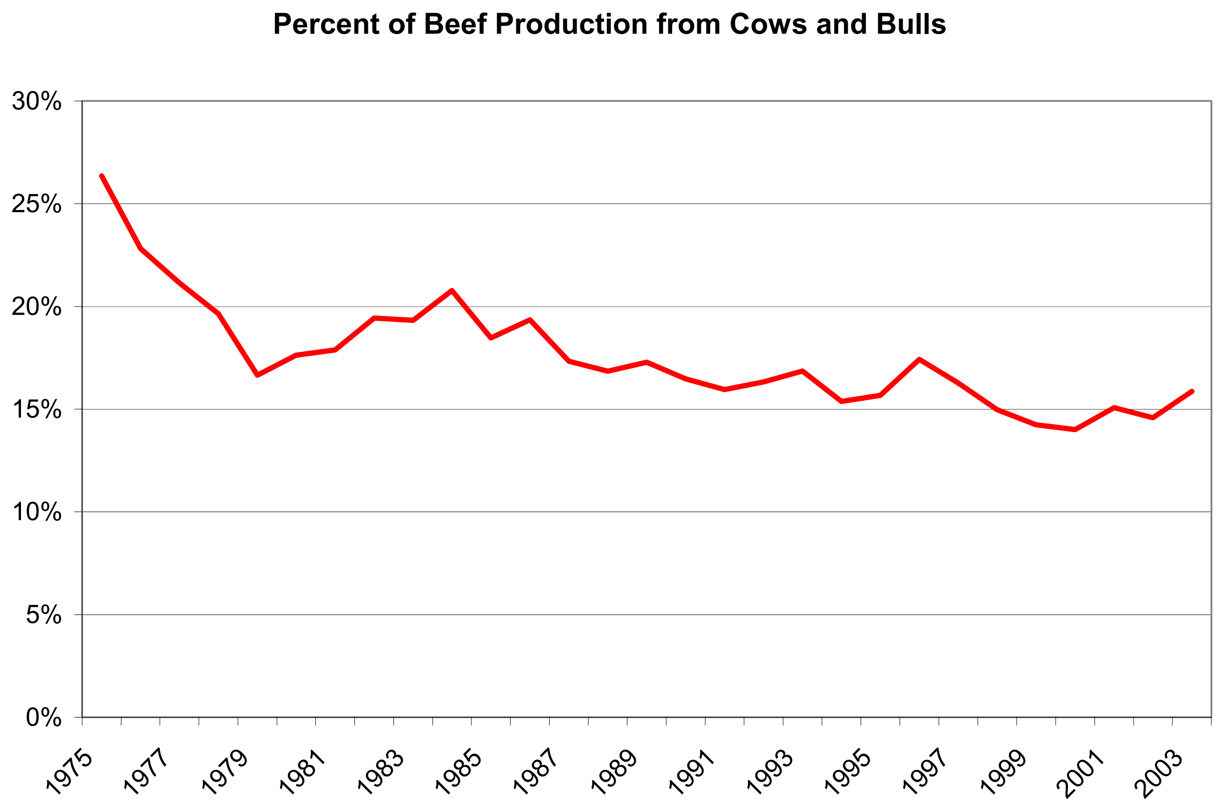


Some of the year-to-year changes in grading percentages can be accounted for by cyclical changes in the proportion of cows and bulls in the total beef tonnage. The majority of beef produced from these two classes of cattle is largely from cattle that are not grain fed. From the peak in total cattle and cow numbers that occurred in 1975, the percentage of beef production

[66] USDA, ERS. Livestock and Meat Situation and Livestock, Dairy and Poultry. 1980-2004

from cows and bulls has declined from 26% during 1975 to only 14% of domestic beef supplies during 2000 and about 16% in 2003[67] (Figure 14).

Figure 14



It became apparent over the years that USDA grades accomplished the objective of differentiating carcasses based on marbling and maturity but the system did not accurately predict which carcasses would produce beef of acceptable palatability and tenderness and those that would not. It became evident that the target needed to change to meet consumer expectations and their perception of quality. While the USDA grades have served to standardize the beef trade in the U.S., their relation to the eating qualities of beef, namely tenderness, taste and juiciness, is marginal at best, especially within the Select and Choice grades.

While increasing USDA grade increases the probability of consumer-acceptable beef (Select, 74%, Choice, 89%, Prime, 94%), the Choice grade still had 11% beef that was unacceptable and 74% of Select was acceptable. If marbling is to remain the basis for USDA grades, then grades should be structured to reflect the "window of acceptability" for fat content in the rib-eye muscle, namely 3 to 7% fat, or slight to moderate marbling, or the lower range of Select to the high range of Choice.[68] Also, there is not good agreement between the subjective estimate of

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[67] USDA, NASS. Livestock Slaughter. 1975-2004

[68] Savell, J.W. and H.R. Cross. The role of fat in the palatability of beef, pork, and lamb. In: Designing Foods; Animal Product Options in the Market Place. Natl. Academy Press, Washington, D.C. 1988.

maturity used in grading beef, namely ossification of the chine bones, and dentition, another accepted measure of an animal's age.[69]

The shift in industry focus from cattle meeting USDA grade specifications to addressing the tenderness and palatability of beef stemmed from industry and university research. Recent research that compared beef tenderness in 1999 to that of 1990 indicates that there was a 20% increase in beef tenderness.[70] Some branded beef programs and alliances are requiring at least a minimum of English cattle breed genetics and some limit the influence of *bos indicus* breeds. These "branded" beef products with various claims of consumer satisfaction have been developed in an attempt to capture market share by providing a specified product. Several large retail supermarkets have already implemented branded beef programs with guaranteed tender beef. Muscle profiling will further aid in the development of beef products with specified eating qualities.

As tenderness measurement systems become faster and more accurate, and DNA testing allows producers to select for tenderness, beef products will become more consistent and will better meet consumer demand. This new technology can only help increase the value of beef by better enabling producers to match the beef they are producing to what the customer is demanding.

We conclude that, as measured by USDA grades, there has been little change in overall grain-fed beef quality over the past 50 years. However, the overall quality of the total beef supply has increased due to significant increases in the proportion of U.S. beef that is produced in feedlots. Furthermore, we cannot find a strong relationship, either positive or negative, between the use of pharmaceutical technologies and the eating quality of beef. Because implants increase lean meat growth, their use will often result in leaner USDA yield grades and somewhat lower marbling. The industry has tended to compensate for this, however, by feeding cattle to an equal degree of finish. Assuming a 10% improvement in feed efficiency but a decrease in the proportion of Choice carcasses from 60 to 40% due to implants, the break-even spread between Choice and Select would have to be $8, $10, $12, $15, or $18 at diet costs of $100, $125, $150, $175, or $200 per ton, respectively[71]. Since the Choice/Select spread has typically ranged between $4 and $8, it is obvious that the feed efficiency improvement from implants more than compensates for any decrease in the percent of Choice carcasses. Many studies have shown, however, that the eating qualities of beef from implanted cattle are not altered by implant use.

Regardless of any impact on USDA quality grades, to the extent that pharmaceutical technologies have enabled us to economically grain-feed an increasing proportion of our total beef supply, they have indirectly increased the overall quality of our beef supply. The ability to harvest most beef animals at a much younger age, and with feedlot finishing, has been significantly aided by availability of these technologies.

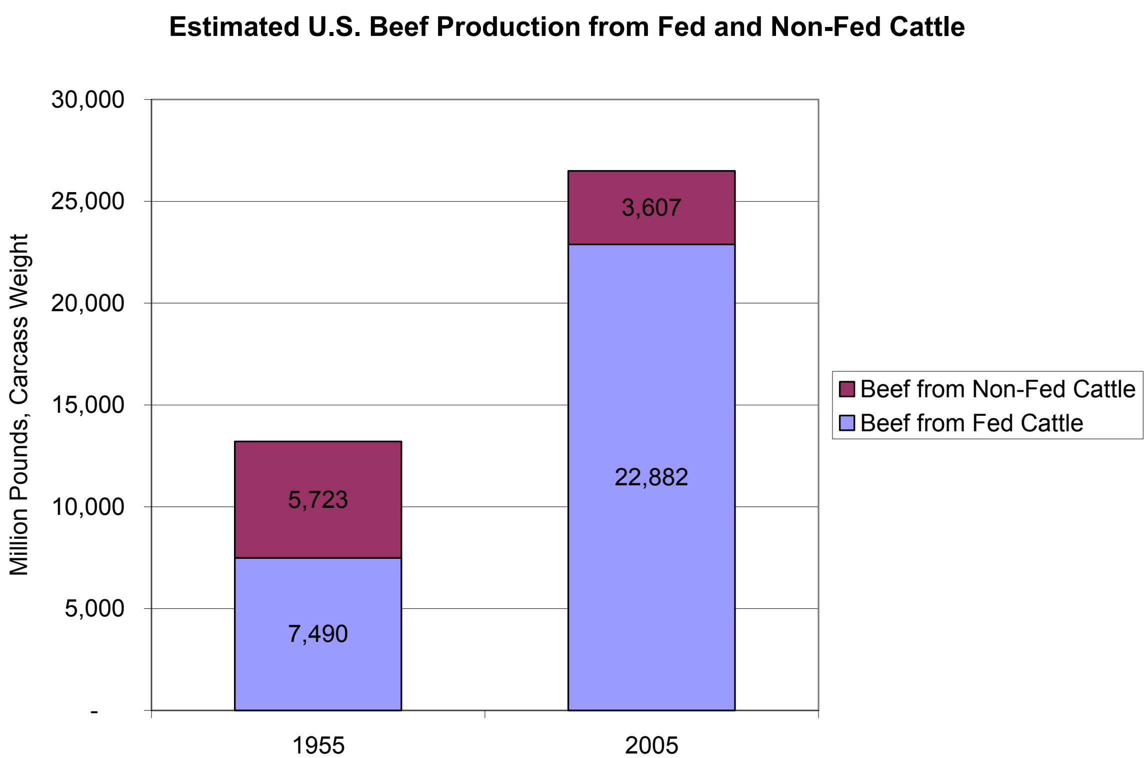
[69] Lawrence, T.E., J.D. Whatley, T.H. Montgomery and L.J. Perino. A comparison of the USDA ossification- based maturity system to a system based on dentition. J. Anim. Sci., 79:1683, 2001.
[70] NCBA. 1999 National Beef Tenderness Survey. 1999
[71] Preston, R. Implant strategies. Nebraska/Colorado Cattle Feeder's Day. December 11, 1996

Summary – Impact of Technology on U.S. Beef Production

The most significant impact of technology on U.S. beef production has been to increase grain-fed beef production and indirectly decrease non-fed beef production. Our ability to feed cattle high grain diets, which has been the result of a synergistic combination of a number of technologies, has been the most significant source of increased beef industry productivity, efficiency and product quality over the past 50 years. Our feedlot technology is what differentiates U.S. beef from that of the rest of the world. Based on beef production per head of cattle, the U.S. is the most efficient producer of beef in the world.

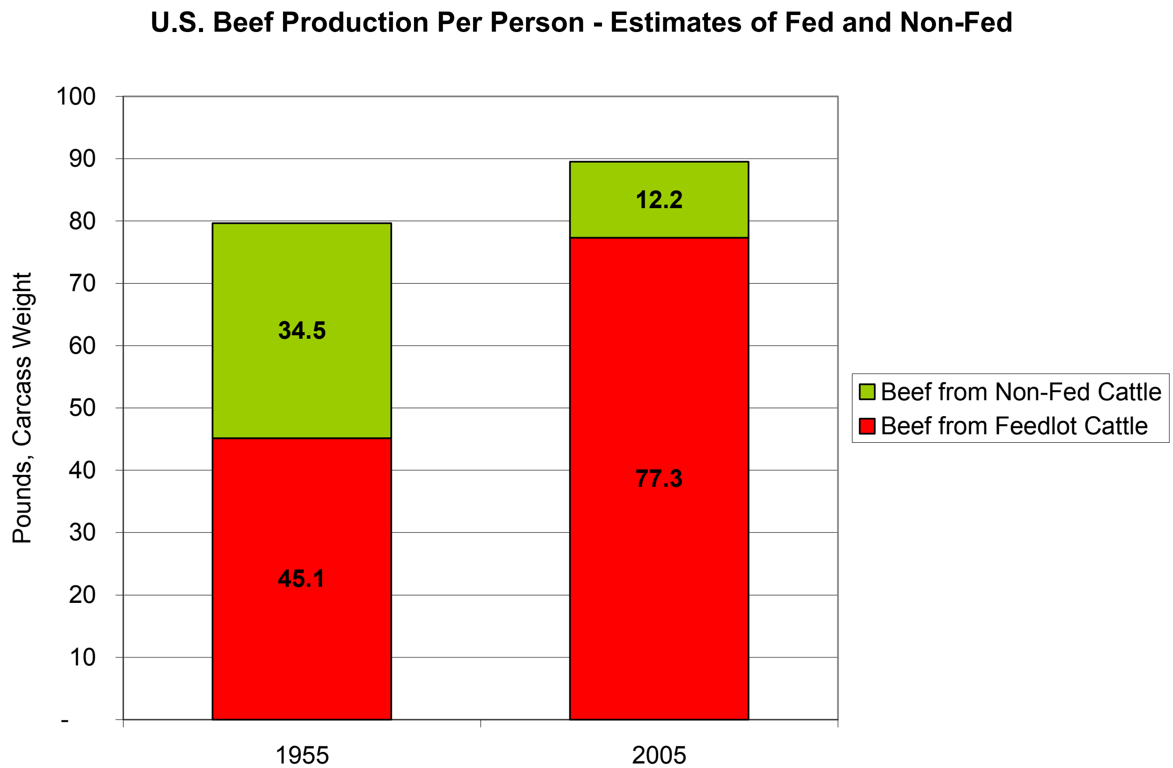
Compared to beef from pasture cattle, feedlot beef is generally regarded as superior in tenderness, taste and consistency. Thus a direct effect of progress in technology has been to increase the quality and consistency of the U.S. beef supply. In fact, as shown in Figure 15, all of the beef supply increase since 1955 has come from grain-fed cattle (about 7.5 billion pounds in 1955 to an estimated 22.9 billion pounds in 2005) while the total beef produced from cattle not fed grain has actually declined (from about 5.7 billion pounds to an estimated 3.6 billion pounds in 2005).

Figure 15



The effect on the composition of the per capita beef supply has been just as dramatic. Since 1955 per capita beef production from non-grain-fed cattle has decreased by 65% while per capita feedlot beef production has increased by 71% (Figure 16). It would be difficult to overstate the importance of these changes. The increased supply of feedlot beef has revolutionized the consumer beef-eating experience in terms of both quality and consistency, while at the same time we have also significantly improved overall production efficiency.

Figure 16 [72]



Conclusions

Through a combination of research, technology development, and innovation, the U.S. beef cattle industry has increased the productivity of its herd by over 80% in the last 50 years. Pharmaceutical technology has been the most important single technology directly applied in the production of beef. Genetics, nutrition, pasture management, stocker management and feedlot management have also played important roles. Increases in feed crop yields and reduction in the real prices of grains have been pivotal in the growth of the feedlot industry. The overall impact has been to help keep beef competitive in cost and quality in the consumer's market basket.

None of the technologies alone can account for the increase in overall productivity. The beef production system has evolved around the entire set of technologies, which has molded it into its current form. If, for example, growth-promoting implants were eliminated from the current technologies, the effects would extend far beyond those of the gain and feed efficiency effects they have in feedlots. It has been estimated that without growth promoting implants, retail sales

[72] These estimates are different from earlier beef consumption estimates. Beef trade is included in consumption but not in these estimated per capita production numbers. Beef trade in 1955 was much smaller than today. We currently export mostly beef from fed cattle and import beef from non-fed cattle, so the differences in consumption versus 1955 are not quite as extreme as the differences in production.

of beef would decrease about $1.4 billion resulting in a reduction of 1.2 million beef cows.[73] Genetics, feeding programs, stocker programs and feedlot management would all have to be extensively modified. Beef produced in feedlots would likely fall, negatively affecting beef quality. Lower beef quality could lead to a drop in beef demand and financial losses for producers.

Another major implication of the increase in beef industry productivity has been a dramatic reduction in the overall environmental impact of the industry. Had these productivity improvements not occurred, we would need a much larger cattle herd to produce a total beef supply that would be smaller than is the case today. Those extra cattle would occupy significant amounts of land now needed for other agricultural crops and land now in non-agricultural uses. In addition, the impact of lower cattle productivity would also be felt in the form of increased demand for alternative meats, implying a higher environmental burden for their production.

The primary benefits of increased productivity have accrued to the cattle industry and to U.S. beef consumers. In 2004, we have a more plentiful, less expensive and higher quality beef supply than we did in 1955. That we have managed to simultaneously increase efficiency, quality, and production, while reducing the real price of beef, is a testament to the remarkable work of thousands of men and women involved in this industry over the last 50 years. As a result of their efforts, the industry produces more, and higher quality, beef than it would have had these productivity increases not occurred.

As Alan Greenspan recently said "… the phenomenal gains in U.S. agricultural productivity of the past century brought profound benefits to all consumers, regardless of their connection to a farm, in the form of lower prices, better quality, and more choices at retail outlets. … Although dislocations are bound to accompany economic growth, we should rise to the challenges that come with innovation because innovation brings great improvements in material well-being."[74]

The cattle industry of the U.S. can be proud of its record on innovation and technology application, and should continue to look for opportunities to contribute to the U.S. economy and its own well being through continued innovation over the next 50 years.

[73] Gill, D.R. and J.N. Trapp. Economics of beef production with and without implants. In: Symposium: Impact of implants on performance and carcass value of beef cattle, P-957. Oklahoma State Univ, Stillwater, OK. May 1997.
[74] Alan Greenspan. Rural economic issues. New Approaches to Rural Policy: Lessons from Around the World, an international conference convened by the Federal Reserve Bank of Kansas City, Organization for Economic Cooperation and Development (OECD), Rural Policy Research Institute, and The Countryside Agency, Warrenton, Virginia, March 25, 2004