17

Dairy Cattle

Key Terms

Babcock Cream Test
Bovine somatotropin (BST)
Condensed milk
Diversified farm
Embryo transfer
Genetic markers
Gomer bull
Herd health
Mastitis
Milk
Pasteurization
Posilac
Silo
Somatic cell count

Learning Objectives

After you have studied this chapter, you should be able to:

- Explain the place of dairy cattle in U.S. agriculture.
- Explain the reasons for the size of the U.S. dairy industry.
- Give a brief history of the dairy industry in the United States.
- Describe the structure of the U.S. dairy industry.
- Give an accurate accounting of where the dairy industry is located geographically in the United States.
- Give a brief synopsis of DHIA and its functions.
- Identify and place in context the role of genetics in the dairy industry.
- Describe the general basis of managing dairy cattle for reproductive efficiency.
- Describe the feed supply of dairy cattle and explain how it affects dairy management.
- Describe the goals of a dairy herd health program and some common diseases that affect dairy cows.
- Discuss bovine somatotropin and its use in the dairy industry.
- Explain the nutritional benefits of milk to humans.
- Discuss trends in the dairy industry including factors that will influence the industry in the future.

SCIENTIFIC CLASSIFICATION OF CATTLE

Phylum:	Chordata
Subphylum:	Vertebrata
Class:	Mammalia
Order:	Artiodactyla
Suborder:	Ruminata
Family:	Bovidae
Genus:	*Bos*
Species:	*taurus; indicus*

THE PLACE OF THE DAIRY CATTLE INDUSTRY IN U.S. AGRICULTURE

Dairy products provide nearly 11% of all yearly cash receipts from agriculture (Figure 17–1). This ranks dairy as third in animal industries behind beef and combined poultry and eggs. The annual cash receipts from dairy products in the United States is approximately $26 billion. Dairy products generally account for approximately 22% of animal agriculture's share of annual farm cash receipts (Figure 17–2). Dairy products rank in the top five commodities for 38 of the 50 states. Nine states exceed $1 billion in yearly cash receipts from farm **milk** sales to milk-processing plants and dealers. An additional six states exceed $0.5 billion. The United States produces approximately 15% of the world's cow's milk. Dairy cattle also produce beef (20–25% of U.S. total) from cull dairy cows and Holstein calves that are fed in commercial feedlots (Figure 17–3). Most veal comes from dairy

Milk The normal secretion of the mammary glands of female mammals.

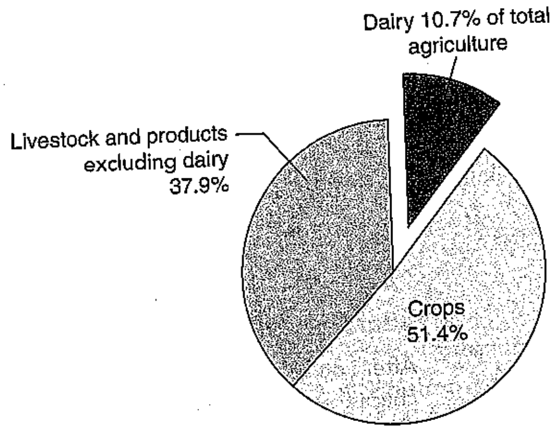

Figure 17–1
Dairy products farm cash receipts as a percentage of total U.S. farm cash receipts, 2000–2009. Source: USDA-NASS, 2011b

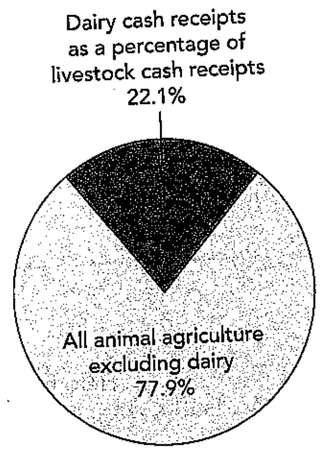

Figure 17–2
Dairy products yearly farm cash receipts as a percentage of total animal agriculture's cash receipts, 2000–2009. Source: USDA-NASS, 2011b.

Figure 17–3
In addition to milk, 20–25% of the beef consumed in the United States each year comes from cull dairy cows and dairy steers, like the animals shown, which are finished for beef.

calves fed all-milk diets and slaughtered when weighing a few hundred pounc
By any standards, the dairy industry is a major industry in the United States, ar
the United States is a major dairy product producer and consumer.

PURPOSE OF THE DAIRY CATTLE INDUSTRY IN THE UNITED STATES

The purpose of the dairy industry is to make use of resources that humans can
use and to produce food that humans can use. As ruminants, most of the feed
ergy consumed by dairy cows is from forages. This forage conversion is their ch
contribution to human welfare (Figure 17–4). In addition to forage, vast supp
of waste material from the agronomic crops of the nation's agriculture (e.g., c
tonseed) and food by-products (e.g., soybean meal, bakery by-products, distill
grains, and citrus pulp) are fed to dairy cattle. Table 17–1 compares relative perc
ages of feed nutrients converted to edible products by livestock species. The d
cow's conversion of feed to food is the most efficient of all the domestic animals

Figure 17–4
The purpose of the dairy industry in the United States is to make use of forage and convert it to milk. They also efficiently use leftovers from agronomic crops, such as cottonseed, and food by-products, such as bakery by-products, distiller's grains, and citrus pulp. (Photo by Tim McCabe USDA Natural Resources Conservation Service.)

Dairy cows have traditionally provided a means for farmers to add value to homegrown feeds. Farm-produced grain could provide more profit if fed to a cow and the milk sold than if the grain was sold. Dairying also provides a way for farmers to distribute labor needs across seasons in diversified operations. Fewer cows can be milked during the planting and growing season for crops, which allows time for the farmer to attend to the land. When the harvest is over, more cows can be milked to use available labor. In this way, dairy cattle help us maximize the use of available resources to the benefit of the whole society. In times of plentiful grain production, dairy cattle can be used to help us make best use of the abundance from agronomic production. In this way, they help to moderate the fluctuations in grain prices that could otherwise disrupt agronomic practices and endanger the agricultural economy and the supply of grain for human consumption.

Although cattle are milked around the world, most are multipurpose cows that produce milk, as well as meat and labor. Historically, only developed economies such as the United States have had a specialized dairy industry. This is changing. Modern dairies are becoming much more common around the world.

Table 17–1
RELATIVE PERCENTAGES OF FEED NUTRIENTS CONVERTED TO EDIBLE PRODUCTS BY ANIMAL SPECIES

Animal Product	Gross Energy Conversion (%)	Protein Gross Edible Conversion (%)
Milk	20–25	30–40
Chicken (broiler)	15–20	20–30
Eggs	15–25	30–40
Pork	15–20	10–15
Beef	4–5	5–8

Source: Voelker, 1978 and Smil, 2005.

HISTORICAL PERSPECTIVE

Until 1850 or so, the history of dairy cattle in the United States varied little from that of beef cattle because there were no specialized dairy breeds in the United States. The cows that were milked were simply the same animals used for all other purposes. Milk production was usually for the producer's own use or for local sale.

After the Civil War, the commercial milk-processing industry began developing and the dairy industry began evolving in earnest. The first cheese factory had actually been established in Oneida, New York, in 1851. However, several developments led to a rapid expansion of the fledgling industry. Gail Borden patented **condensed milk** in 1856 and established a condensery in 1857 ir Burrville, Connecticut. The new product occupied less space and provided a use for surplus milk. Mechanical refrigeration was developed in 1861, which allowec for greater flexibility in shipping and storing fresh milk. In 1864, Louis Pasteu discovered the microbiological fundamentals that would lead to the process o **pasteurization**. Commercial pasteurizing machines were available in 1895. B the 1860s, there were specialty dairy centers near the larger Atlantic Coast cities Cows that would support the industry were needed. Significant numbers of cow of various dairy breeds were imported, and between 1868 and 1880, breed assc ciations were formed.

Condensed milk Milk with water removed and sugar added.

Pasteurization Controlled heating to destroy microorganisms.

The refrigerated rail car was invented in 1871, which allowed shipment c products over greater distances. **Silos** were invented in 1875 at the University c Illinois, which allowed dairy farmers to store high-quality feed for the winter ar gave dairying its year-round dimension. The cream separator was developed in 187 by Dr. Gustav De Lavel. *Hoard's Dairyman* was first published in 1885, and l 1889 was recognized as the most important dairy journal in the country. Dr. S. M Babcock introduced the test for milk fat (butterfat) that would bear his name, tl **Babcock Cream Test**, in 1890. This test provided a basis for the pricing of mil Testing for tuberculosis began in 1890, resulting in this widespread cattle disease b ing all but eradicated. The fledgling industry got its first university curriculum wh the University of Wisconsin established a dairy program in 1891. The first testi and recordkeeping association was formed on August 12, 1905, in Newaygo Coun Michigan. Many similar organizations were formed and, in 1927, the Dairy He Improvement Association was instituted by the American Dairy Science Associati with a rules committee for milk production testing. The first milking machines w assembled in 1903 and were soon manufactured by D. H. Burrell Company in Li Falls, New York. Milk was soon sold in glass bottles. Paper milk cartons were int duced in 1950, followed by plastic milk containers in 1964.

Silo Structure in which silage is made and stored.

Babcock Cream Test Test for determining the fat content in milk.

Tank trucks were first used to transport milk in 1914. In the 1930s, bulk t handling of milk on the farm began in California. Homogenized milk made its de in 1919. Vitamin D fortification began in 1932. Artificial insemination begar dairy cattle in 1936 and was commercially available in 1939. After World Wa artificial insemination techniques caused the genetic improvement of dairy cow take a giant leap. Antibiotics for animal use were developed in the 1940s and 19 which allowed for more efficient treatment of bacterial diseases in cattle.

During the early 1950s, the industry began restructuring. Operations larger, which allowed for economies of scale. Milk production reached its p in 1964 at 127 billion pounds. The all-time high number of dairy cows reached in 1945 at 27.8 million. Numbers of cows and producers have b declining ever since. Production per cow has been increasing. Technolog innovation and consumer demands are creating a very dynamic environm within the industry.

STRUCTURE AND GEOGRAPHIC LOCATION OF THE DAIRY INDUSTRY

Dairying is among the least concentrated of all the major farm enterprises in the United States, with dairy cows found in every state in the union. In large part, this is because of the perishable nature of milk and the costs of shipping it over long distances. Thus, dairy cows tend to be found near the human population. Figure 17–5 gives a full breakout of milk cows by state and region. Among the 10 largest milk-producing states are the 6 most-populated states. An exception to this is Wisconsin, which has many more cows and produces much more milk than its population needs. However, Wisconsin has long had a strong milk manufacturing industry. Idaho is another state whose milk-producing rank (top 5) is quite different from its human population rank, at 39th. However, it ships much of its production to the West Coast states.

The dairy industry restructuring has consistently trended toward fewer operations (Figure 17–6) that have increasingly more cows per operation. As a result, in excess of 60% of the U.S. milk supply is produced in herds of 500 or more cows (Figure 17–7) and that percentage increases yearly. In addition, the activities of the dairy have been changing. They have become more specialized and more likely to be the sole farm activity. Dairy herds were traditionally self-contained family operations with as many cows as the family's resources would allow. The dairy was generally an integral part of a complete, **diversified farming** program. Crops of various sorts were grown on the farm, most of the dairy's feed needs were met on the farm, and

Diversified farm Farm with multiple income-generating enterprises.

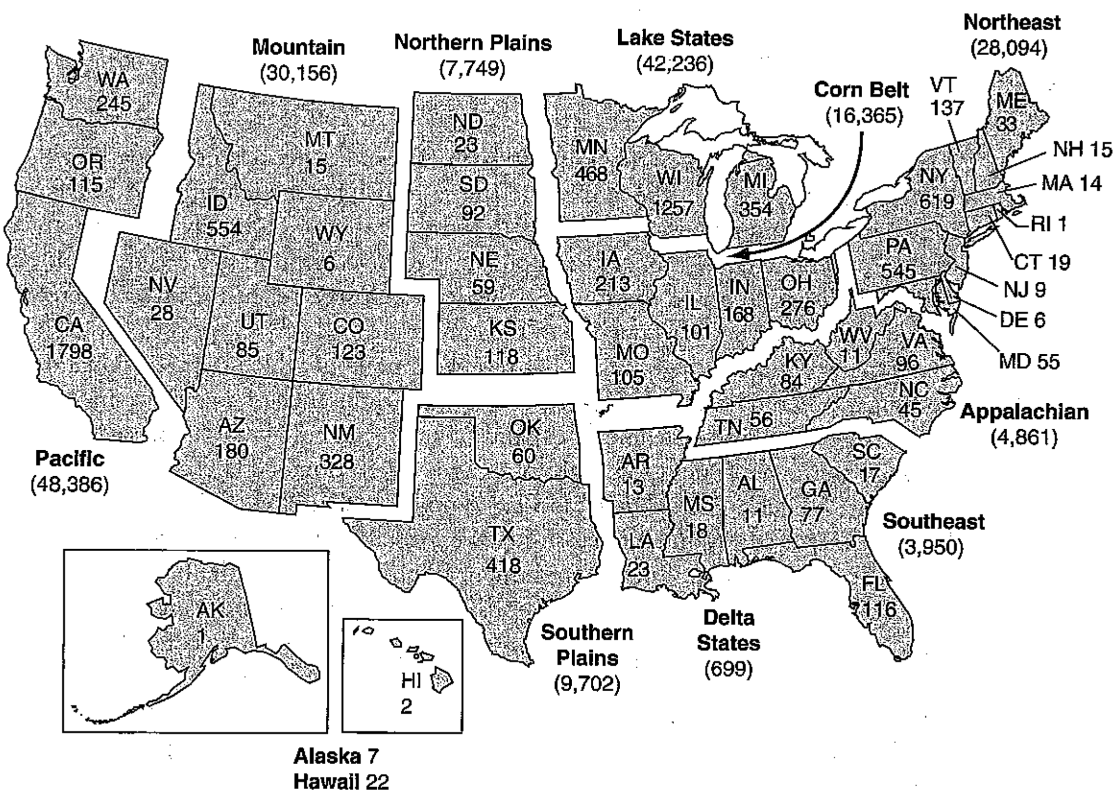

Figure 17–5

Milk cows by state and total milk production by region. The number found within the state represents the number of dairy cows × 1,000. The number beside the region name represents the total milk produced in the region in millions of lbs of milk. All information represents averages for recent years. Source: USDA-NASS, 2011d.

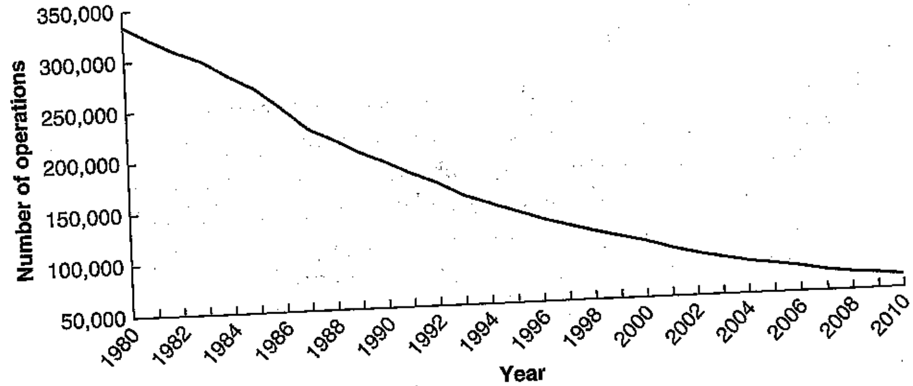

Figure 17–6
Milk cow operations, 1980–2010. The trend since the 1950s has been to fewer total dairy cattle operations. At the same time, the average dairy has gotten larger. Source: USDA-NASS, 2011a.

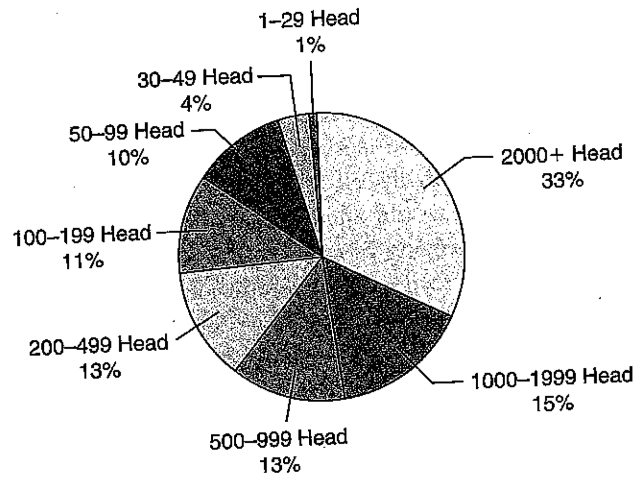

Figure 17–7
Percentage of U.S. milk production by size of operation. More of the cows are in larger herds, and fewer in smaller herds. This reflects the trend of small herds going out of the dairy business. As this is happening, fewer, larger herds are controlling a greater percentage of the cows. Source: USDA-NASS, 2011a.

replacement animals were grown on the farm. The milk check came regularly, wh helped meet the needs of the family and the cash flow for the remainder of the fa ing operation. In many ways, this epitomized the concept of "family farm" to m of the country. Much national farm policy has revolved around protecting this ic Although dispersed across the country, the dairy industry was historically centere regions of the northeastern portion of the country.

The structure of the industry has reached a point at which the traditional c no longer predominates. Large-scale dairies with thousands of cows have increa These large operations are able to expand by taking advantage of labor-saving t nologies that small operations cannot afford. Operations of 100 cows or less exist, but the definition of *small* and *large* are both changing as the overall av herd size increases. Production has shifted west to take advantage of mild dry clir and to accommodate an increasing human population. From the beginning, new, larger western producers adopted business organizations and management egies that reduced milk production costs resulting in a competitive edge. This fa contributed to the westward shift in milk production, and it is still a driving f The top-10 dairy states are listed in Table 17–2. These 10 states produce app mately three-fourths of U.S. milk. California became the largest milk-producing in 1994. Idaho surpassed New York in 2010 to become the third largest dairy st

The dairy cow population declined to less than 10 million co 1990 (Figure 17–8) while the average amount of milk produced per cow has inc (Figure 17–9) and the total milk output from the nation's dairy industry has inc (Figure 17–10). The increase in milk per cow is compensating for the decrease number of cows.

Table 17-2
TOP-10 DAIRY STATES

Total Milk (lbs)		Total Cows (1,000 Head)	
California	40.39 bill.	California	1760
Wisconsin	26.04 bill.	Wisconsin	1260
Idaho	12.78 bill.	New York	610
New York	12.71 bill.	Idaho	550
Pennsylvania	10.73 bill.	Pennsylvania	540
Minnesota	9.10 bill.	Minnesota	470
Texas	8.83 bill.	Texas	410
Michigan	8.33 bill.	Michigan	354
New Mexico	7.88 bill.	New Mexico	318
Washington	5.90 bill.	Ohio	272

Source: USDA-NASS, 2011c.

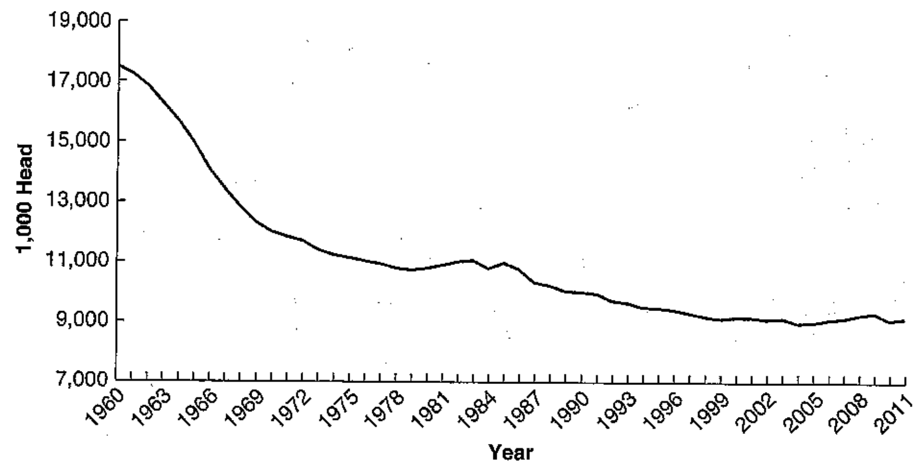

Figure 17-8
The number of dairy cows in the United States. The decrease in cows has not caused a decrease in total milk production because of an increase in average productivity of the remaining cows. Source: USDA-NASS, 2011a.

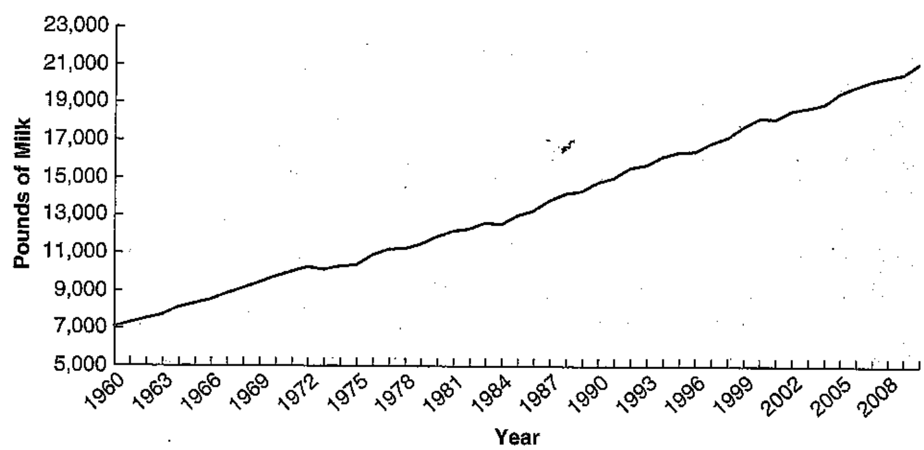

Figure 17-9
Rate of milk production per cow. Improved genetics, management, and use of technological innovations have caused a sustained trend of more milk per average cow. Source: USDA-NASS, 2011c.

Most U.S. dairies fall into one of two major categories. The first category consists of smaller herds of fewer than 200 cows, about as many as the average family could expect to handle and still do a good job. Most of the country's dairies remain in this category. A larger percentage of these dairies are located in the traditional dairy states than in the newly emerging dairy states. Dairies in California, New Mexico,

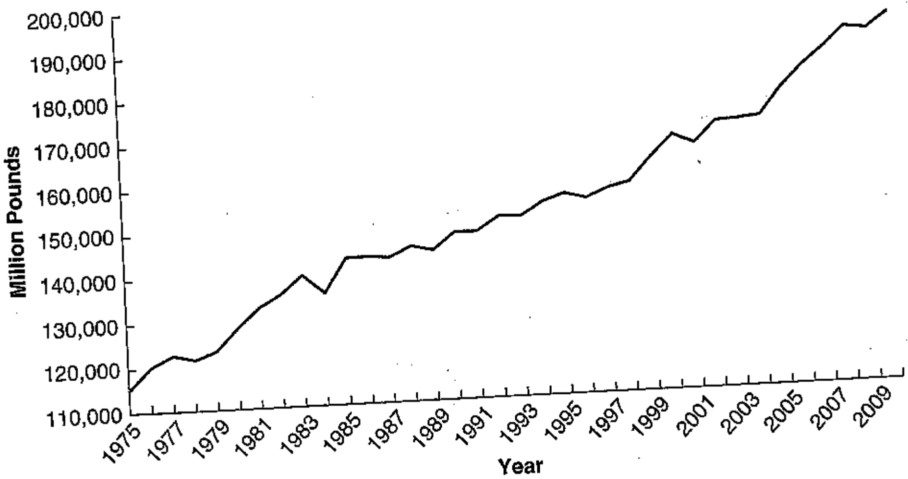

Figure 17–10 *Total milk production has steadily increased in spite of a trend for fewer cows.* Source: USDA-NASS, 2011a.

Arizona, Texas, Idaho, and Florida, especially the newer ones, tend to have several hundred or increasingly several thousand cows. They may still be family farms or family corporations, but they are specialized dairies that more likely do nothing but dairy. These large specialized operations tend to buy all of their feed and may even contract with someone to raise their replacement heifers. Several individual dairies in this category have over 15,000 milking cows.

In contrast to the other animal industries, there is very little vertical integration in the dairy sector, and few people are predicting that will change substantially in the immediate future. The overwhelming majority of dairies, even the large ones, are individual- or family-owned and operated, and many of the family-owned corporations and partnerships are restricted to family members.

DAIRY HERD IMPROVEMENT ASSOCIATION (DHIA)

The National Cooperative Dairy Herd Improvement Program (NCDHIP) wa established in 1965. It is administered at the state and local levels by the Dairy Her Improvement Association (DHIA) and collects and processes information on dair cows. The program provides herd owners with management, production, and co information. Information on DHIA records is collected on the dairy by a DHI representative approximately 12 times each year. Milk weights and milk samples a collected on each cow. Once the information is processed, producers are provide with valuable information to help them determine the profitability of individu cows, make nutrition decisions, manage reproduction, control mastitis, and so o The organization is mentioned here because it can be an integral tool in managing t cow for the needs outlined in the next few sections.

Records compiled by this program are also used by the United States Depa ment of Agriculture (USDA) for sire evaluation purposes. The USDA sire summar provide accurate estimates on the genetic merit of sires. This is accomplished by co paring daughters of individual sires with daughters of other sires in the same her Any producer using artificial insemination in a dairy benefits from this service.

GENETICS AND BREEDING PROGRAMS

The fundamentals of genetics and breeding are discussed in Chapters 8 and 9, wh has a specific section on dairy cows. See those chapters for the fundamentals of d cattle breeding.

Table 17–3
GENETIC CHANGE IN SELECTED DAIRY PERFORMANCE TRAITS FOR DIFFERENT BREEDS FOR COWS BORN IN 1962 COMPARED TO 2008

	Breed					
	Ayrshire	Guernsey	Holstein	Jersey	Brown Swiss	Milking Shorthorn
Milk yield (lb)	4,976	6,548	7,794	7,410	5,943	5,139
Fat yield (lb)	172	240	265	247	207	184
Protein yield (lb)[1]	69	96	132	150	91	63
Somatic cell score[1]	+0.2	+0.1	+0.1	+0.4	+0.2	+0.1
Daughter pregnancy rate (%)	−4.9	−7.6	−6.7	−4.6	−7.3	−4.3

[1]1986–2008.
Source: Interpreted from www.aipl.arsusda.gov, May 2007.

The dairy industry has made tremendous genetic progress in milk production (Table 17–3). Milk, fat, and protein have increased significantly for all of the breeds. Holstein cows born in 1962 averaged 14,319 lbs of milk on a mature equivalent basis, whereas those born in 2004 are averaging 26,219 lbs. About 60% of the increase is related to genetic progress and 40% of the increase to better management.

A disturbing statistic from Table 17–3 is the negative trend for daughter pregnancy rate (DPR). DPR is defined as the percentage of time that a cow would be expected to get pregnant during a three-week reproductive cycle during the breeding period of a lactation. Getting lactating cows pregnant has become one of the biggest challenges facing dairy farmers. Genetic evaluations for DPR were not officially published by the USDA until February 2003. It was often incorrectly argued that because the heritabilities of reproduction traits were only 1–5%, it would not be worthwhile to try to improve fertility genetically. Hopefully, with prudent use of these genetic evaluations for DPR now available, the negative trend for fertility can be reversed.

The USDA's Net Merit Index was modified in January 2010 to include traits known to be economically important and reflect more accurately the genetics that cows need for maximum lifetime net profit. Traits considered in the index, heritabilities, and genetic correlations are presented in Table 17–4. Interestingly, the current genetic correlation between milk and productive life is now only 0.08, contrasted with the 0.75 published from earlier work (Table 9–7). This means that in the past higher-producing cows stayed in the herd much longer than low-producing cows, but that strong relationship is no longer true today.

The relative index weights on the various traits in the Net Merit Index, the expected PTA gain/year and expected genetic trend per decade is reported in Table 17–5. All of the traits in the index are expected to change in a desirable direction. Even though no weight is put on PTA milk, milk is expected to increase 1,374 lbs over the next decade because of its positive genetic correlation with fat and protein. **Somatic cell** score should decrease. The −0.98 in body size composite correlates to a reduction in about 20 lbs in weight per cow over the ten year period. Smaller cows tend to require fewer lbs of feed per lb of milk produced. The downward trend in daughter pregnancy rate should be reversed and significant increases in calving ease should be noted.

Somatic cells Cells in the body other than gametes.

Table 17–4
HERITABILITIES AND GENETIC CORRELATIONS OF TRAITS CONSIDERED IN THE NET MERIT INDEX

	PTA Trait									
PTA Trait	**Milk**	**Fat**	**Protein**	**PL**	**SCS**	**Size**	**Udder**	**Feet/ Legs**	**DPR**	**CA$[1]**
Milk	**0.30***	0.45	0.81	0.08	0.20	−0.10	−0.20	−0.02	−0.32	0.15
Fat		**0.30**	0.60	0.08	0.15	−0.09	−0.20	0.02	−0.33	0.11
Protein			**0.30**	0.10	0.20	−0.10	−0.20	−0.02	−0.35	0.16
Productive life				**0.08**	−0.38	−0.16	0.30	0.19	0.51	0.40
Somatic cell score					**0.12**	−0.11	−0.33	−0.02	−0.30	−0.08
Size						**0.40**	0.26	0.22	−0.08	−0.24
Udder							**0.27**	0.10	0.03	0.06
Feet/legs composite								**0.15**	−0.04	−0.04
Daughter pregnancy rate									**0.04**	0.34
Calving ability dollars										**0.07**

[1]CA$ (Calving Ability Dollars) is a function of calving ease and stillbirth rate.
Source: aipl.arsusda.gov/reference/nmcalc-2010.htm

Table 17–5
RELATIVE NET MERIT INDEX WEIGHTS ON THE VARIOUS TRAITS AND EXPECTED GENETIC CHANGE FOR HOLSTEINS

PTA Trait	Relative Weight (%)	Expected PTA Gain/Year	Expected Genetic Trend/Decade
Milk (lb)	0	69	1,374
Fat (lb)	16	3.8	76
Protein (lb)	19	2.1	43
Productive life (mo)	22	0.50	10.0
Somatic cell score	−10	−0.022	−0.45
Size composite	−6	−0.05	−0.98
Udder composite	7	0.04	0.80
Feet/legs composite	4	0.04	0.80
Daughter pregnancy rate	11	0.17	3.5
Calving ability ($)	5	1.5	30

Breeds

Specialized dairy breeds were imported into the United States and breed associatio were established between 1868 and 1880. The six dairy breeds used in the Unit States and their average DHIA performance levels are reported in Table 17–6. T most popular breed by far is the Holstein, accounting for almost 95% of the cows DHIA test. Jersey is the second most popular breed with about 4% of the cows. The maining four breeds account for only a very small percentage of the cows in the Uni States.

In general, the number of registered dairy cattle has been declining (Table 17– However, the past few years have seen substantial increases in Holsteins, Jerseys, a

Table 17–6
Production Level of U.S. Dairy Breeds, 2010

Breed	No. of Cows	lbs Milk	% Fat	% Protein
Ayrshire	4,878	15,602	3.9	3.2
Brown Swiss	12,775	18,635	4.1	3.4
Guernsey	5,422	15,377	4.5	3.4
Holstein	3,776,761	23,187	3.6	3.1
Jersey	225,111	16,611	4.7	3.6
Milking Shorthorn	1,758	13,757	3.5	3.1

Source: DHI Report K3, USDA.

Table 17–7
Registration of Animals by Dairy Breed Associations

Year	Ayrshire	Brown Swiss	Guernsey	Holstein	Jersey	Milking Shorthorn	Total
1950	24,236	22,721	94,901	184,246	67,309	28,290	421,703
1970	15,069	16,416	43,783	281,574	37,097	5,410	399,349
1980	10,977	12,871	20,907	353,949	60,975	4,924	464,603
1990	7,752	11,756	13,930	395,906	53,547	2,596	485,487
2000	6,046	10,648	6,151	317,567	63,776	2,595	406,783
2005	4,860	10,076	5,093	301,852	72,885	3,154	397,920
2010	4,131	10,658	4,810	339,908	90,362	2,760	452,629

Brown Swiss. Total registration of dairy cattle peaked in 1984 at 590,298 registrations. Holsteins have had the highest numbers of registered cattle in the United States since very early in the 20th century. However, Jerseys are increasing registrations at a faster rate than Holsteins.

Traditionally, there has been very little **crossbreeding** in dairy cattle in the United States. The major reason was because Holsteins produced so much more milk than the other breeds that heterosis was not large enough to justify crossbreeding. However, in recent years, dairy producers have shown interest in crossbreeding. Reasons for the increase in crossbreeding include the decreased fertility in purebreds, a shift in payment away from milk volume and toward payment for lbs of fat and protein, and dairy producers wanting a more trouble-free and healthier cow.

Crossbreeding Mating animals from different breeds within a species.

It is difficult to determine what percentage of the cows in the United States are crossbreds, but the number is increasing. Many of the crossbred cows are in low input herds that are not on the DHIA test. The most popular crossbreds are Jersey-Holstein (Figure 17–11).

There is growing interest in four additional breeds from Europe for crossbreeding purposes: Swedish Red and Norwegian Red (collectively referred to as Scandinavian Red), Normande, and Montbeliarde. These breeds have had well-organized genetic improvement programs and have selected both for production and fitness traits (including fertility) for many years. Table 17–8 shows a comparison of these crosses with Holsteins in seven California dairies. On average, the pure Holsteins produced more milk in the first lactation. However, the crossbreds had fewer stillbirths, better fertility, and were less apt to be culled.

Figure 17–11
It is difficult to determine what percentage of the U.S. dairy cows are crossbred, but the number is increasing. (Photo courtesy Dr. Tony Seykora. Used with permission.)

Table 17–8
Average Production of First Lactation of Crossbreds and Holsteins in Seven California Dairies

	Holstein	Normande—Holstein	Montbeliarde—Holstein	Scandinavian Red—Holstein
Number of cows	380	245	494	328
Milk (lbs.)	21,510	18,805	20,196	20,461
Fat (lbs.)	763	703	736	750
Protein (lbs.)	672	611	646	655
% of Holsteins for combine fat plus protein		92%	96%	98%
% stillbirths at first calving	14%	10%	6%	5%
Average days open	150	123	131	129
% culled in first 305 days	14%	7%	8%	7%

Source: *Journal of Dairy Science* 89:2799, 2805, 4944.

Crossbreeding studies are currently being conducted by several univ ties. Results may determine the extent of future crossbreeding in the U.S. c industry.

REPRODUCTIVE MANAGEMENT IN DAIRY CATTL

Chapter 11 is devoted to reproductive physiology. Refer there for the fundame of male and female reproductive anatomy, physiology, and function. Chapter devoted to lactation. Likewise, see that chapter for a look at the specialized fun of lactation. Be aware that reproductive performance is closely tied to other fa especially nutrition and level of management.

Reproductive problems are especially troublesome in the dairy industry. ity and delayed breeding cost the dairy industry hundreds of millions of dollar year. A cow must have a calf to produce milk, and, because milk production de over time, it is desirable to have the cow calve with relative frequency to ini new cycle of milk production. Additionally, we need for the daughters of the herd to become the replacements for their dams. Their genetics should be better than that of their dams, and they are needed to replace cows that are culled. A realistic goal of breeding the dairy cow is to produce a calf at 13-month intervals. Because of the number of factors that influence the reproductive performance of a good dairy cow, this is a challenging goal. A cow must be pregnant within 115 days of calving or the 13-month calving interval cannot be maintained. The cow must recover from calving, start her heat cycle again, and conceive. She must do all of this while producing a sizable quantity of milk that is larger each year for the average cow. Good management is necessary for this to happen.

Nutrition is central to reproductive efficiency in dairy herds. A cow generally loses weight for the first few weeks after calving because it is impossible for her to eat enough to increase production during early lactation and maintain body weight. Thus, the body reacts by catabolizing stored tissue for energy and losing weight. This can create a problem because a dairy cow must maintain a certain body condition to begin preparing for heat cycles and impregnation. Thus, good nutrition is necessary for both maximal milk production and reproductive performance.

Because most dairy cattle in the United States are artificially inseminated, one of the challenges to a successful breeding program is heat detection. Use of **gomer bulls** or hormone-treated cull cows to help spot cows in estrus (heat) can help. Learning the physical and behavioral signs of a cow in heat is also essential. Remember that a cow only displays the signs of heat for 12 to 18 hours on a 19- to 21-day cycle, which presents a narrow window of opportunity for heat detection. Increasingly, dairy producers use hormone programs to help control and detect estrus by making it more predictable. Replacement heifers must be managed so they can be mated to calve at 2 years of age. To do this, they must be mated at 15 months of age and need to be at least 65% of their adult weight at the time of breeding. Dairy cows are freshened year-round. The gestation period varies slightly from breed to breed and ranges from 280 to 283 days.

Gomer bull Bull rendered incapable of mating naturally.

Diseases that affect reproductive efficiency directly include brucellosis (Bang's disease), campylobacteriosis, leptospirosis, IBR/BVD complex, and trichomoniasis. Control of these and other diseases can be accomplished easily by developing and following a complete health program for the herd. Use of AI, which eliminates the possibility of a bull spreading disease, makes disease management in a dairy much easier.

Good records are essential to managing reproductive issues in the dairy herd. A large number of programs exist to assist the producer in this regard. Both manual and computer programs are readily available. Most work as well as the person who is using them. Because management practices and standards vary with conditions across the country, cattle breeders are encouraged to contact their local extension service or their state extension specialists for help in setting up a recordkeeping program for their area. Many dairy producers use DHIA records in managing their breeding programs.

NUTRITION IN DAIRY CATTLE

Feed costs account for 45–65% of the costs of the dairy. Feeding is the single most important factor in the profitability of the dairy herd.

Dairy cattle are ruminants. They can use forages and roughages to produce a usable product for humans. The nutrition and feeding of dairy cattle is similar to that of beef cattle. Most of the production stages revolve around maximizing the use of forages as the feed base. However, higher-quality forages are required and dairy feeding has a greater dependence on concentrate feeds to supplement the forage. Chapters 5, 6, and 7 give detailed information relating to nutrition, feeds, and feeding. See those chapters for general nutrition information not provided in this section.

Managing the nutrition of dairy cattle is very dependent on the class of cattle to be fed. Different classes of dairy animals use different amounts of grain and other supplemental feeds to extend the use of forage by supplementing missing nutrients. The very young and the cow in production need the greatest amounts of supplementation of energy feeds. Mineral supplements critical in feeding the producing female include salt, calcium, and phosphorus. Additional individual mineral deficiencies occur in the various geographic regions of the country. Protein and energy feeds are often needed to keep heifers growing at an acceptable rate and to keep cows producing at optimal levels.

Baby calves destined to be producing cows are fed on a commercial calf mill replacer or on milk produced at the dairy. In some dairies, colostrum, milk bein discarded because of antibiotic use on a cow, or otherwise-contaminated milk is usec It is economically advantageous to switch calves to dry concentrate feeds and forag as soon as possible to decrease costs of feed, labor, and housing. Calves are usuall fed their liquid feed twice a day, although systems are available for free choice feec ing. Calves are offered dry feed (Table 17–9) when they are only a few days old an weaned when their consumption is adequate.

Heifer-growing programs depend increasingly on maximizing the u of forages as the heifer gets larger and more able to use the forages effectivel

Table 17–9
EXAMPLES OF SOME CALF STARTERS

	Grain Starters[1]		
	1	2	3
Ingredients (air-dry basis)			
Corn (cracked or coarse ground) %	50	30	
Ear corn (coarse ground) %			50
Oats (rolled or crushed)	22	18	
Barley (rolled or coarse ground) %		20	21
Wheat bran %		8	
Soybean meal %	20	16	21
Molasses %	5	5	5
Dicalcium phosphate %	.5	.5	.5
Limestone %	1.5	1.5	1.5
TM salt and vitamins %	1	1	1
Composition (dry-matter basis)			
Crude protein %	18.1	18.0	18.4
TDN %	80.0	78.8	78.0
ADF %	7.0	6.9	9.1
Calcium %	.80	.80	.82
Phosphorus %	.48	.56	.47
Vitamin A, IU/lb	1,000	1,000	1,000
Vitamin D, IU/lb	150	150	150
Vitamin E, IU/lb	11	11	11

[1] Hay may be offered free choice with grain starters.
Source: Linn et al., 1988.

Because replacement heifers should ideally enter the milking herd at 24 months of age, the plane of nutrition must be good to keep them growing at an appropriate rate. However, different programs must be developed for the animals at different ages, weights, and seasons. Energy and/or protein supplementation is usually necessary. Higher-quality forages are also needed to keep animals gaining rapidly enough to enter the milking string at age 2. After 1 year of age, it may be possible to feed heifers good-quality forage and mineral supplements until just before calving.

Dairies generally rely on one of two systems of feeding the producing cows. Cows can be allowed to graze on high-quality pastures and then fed their concentrate ration at a different time, often in the milking parlor. This has been the traditional method of dairying in the United States and is still used by many small dairies. Increasingly, however, dairy cows are handled in a dry-lot system. Cows are kept in confinement facilities, usually consisting of a barn or loafing shed and a small lot, often concrete, where they are fed and watered. The cows are often grouped by production level and fed a complete, mixed ration (total mixed ration, or TMR) from bunks. In this way, a cow uses fewer nutrients in procuring her feed and can divert more to producing milk. There is also less waste of feed in these systems. Forage is still the basis of the ration; however, it is mixed with the energy, protein, mineral, and vitamin concentrate portions of the ration prior to feeding. Thus, each bite a cow takes is balanced for her needs. Cows are not fed in the milking parlor in this system. Most dairy rations are formulated with the use of least-cost ration formulation programs. Table 17–10 shows examples of complete, mixed rations for producing cows (Figure 17–12).

The following list shows the advantages and disadvantages of the TMR system. Cows should be grouped by production level to best take advantage of the complete ration system.

Advantages:

1. There is no parlor grain feeding.
   a. Reduced cost of parlor construction and maintenance of feeding equipment.
   b. Less dust and mess in the parlor.
   c. No delay in milking time waiting for cows to eat grain.
   d. More cows milked per person-hour and cows are in the parlor less time.
   e. Cows stand more quietly and defecate less during milking.

Figure 17–12
Total mixed rations can be fed in dry-lot systems. These diets have the advantage of providing balanced nutrition in every bite. (Photo by Scott Bauer. Courtesy USDA Agricultural Research Service.)

Table 17–10
EXAMPLE RATIONS FOR VARIOUS MILK PRODUCTION PHASES[1]

Item	Phase 1	Phase 2	Phase 3
Milk (lbs/day)	90	80	50
DM intake (lbs/day)[2]	49	51	38
Ration 1 lbs/day (as fed)			
Alf hay (88% DM), 20% CP	28	34	27
Corn-oats[3]	21	24	16
SMB-44%	5.0		
Dical-18% P	0.5	0.45	0.30
Salt, vitamins, TM	0.30	0.25	0.25
Weight change	–1.5	—	+0.5
Ration 2 (corn silage limit fed)			
Alf hay, 20% CP	19	34	23
Corn silage (35% DM)	25	25	25
Corn-oats	18	12	10
SMB-44%	7.5	0.3	–
Dical-18% P	0.45	0.50	0.3
Salt, vitamins, TM	0.30	0.25	0.25
Weight change	–1.2	—	+0.5
Ration 3 (hay limit fed)[4]			
Alf-grass hay, 16% CP	10	10	10
Corn silage	41	70	57
Corn-oats	16	11	6
SMB-44%	11.5	8.2	4.5
Dical-18% P	0.40	0.30	0.25
Limestone	0.40	0.30	0.15
Salt, vitamins, TM	0.30	0.25	0.25
Weight change	–1.4	+0.7	+0.5
Ration 4			
Alf-grass hay, 16% CP	23	32	24
Corn-oats	22	22	19
SMB-44%	8.5	3.5	1.1
Dical-18% P	0.45	0.40	0.25
Limestone	0.20		
Salt, vitamins, TM	0.30	0.25	0.25
Weight change	–1.9	—	+0.5

[1] 1,350-lb cow, 3.8% fat test.
[2] Estimated average intake during the phase.
[3] 85% corn–15% oats mix.
[4] Feed amounts may have to be limited during phases 2 and 3 to avoid over conditioning.
Source: Linn et al., 1988.

2. The dairy producer has more control over the total feeding program.
   a. Concentrates can be liberally fed to high producers without overfeeding low producers. TMRs are often mixed and fed with greater accuracy than c ventional feeding.
   b. Silage tends to mask the taste and dustiness of feed ingredients, which all for the use of more economical but less palatable feeds in the diet.
   c. Cows eat many times a day. Feed intake is greater and nutrients are ι better, especially urea. Overall feed efficiency often improves.
   d. Fewer cows have digestive upsets and go off-feed.
   e. Milk production per cow is often higher.

3. Labor is less for feeding the total herd.
   a. Equipment and rations for the lactating herd can be used for feeding dry cows, heifers, and calves from 2 months of age.
4. Cost of cow housing and feeding facilities is less.
   a. Feed bunks are simpler with no need for conveyers or augers.
   b. Less bunk space is needed, as little as 8 in. per cow.
   c. Free-stall numbers can be reduced.

Disadvantages:

5. Special equipment is needed.
   a. The equipment must have the capability to blend the ingredients thoroughly.
   b. The mixer, preferably mobile, must have the capability for accurate weighing.
   c. A crowd gate or training gate may be needed initially to get cows into the parlor.
6. Cows should be grouped by production levels.
   a. If not grouped, cows in late lactation tend to get too fat.
   b. Dry cows must be removed from the lactating herd.
   c. Grouping cows is more difficult in small herds.

Forages commonly used in dairy production include legumes such as alfalfa or lespedeza, small-grain forage such as oats or barley, corn or sorghum forage, and various grasses. These forages may be harvested by the cow (grazing), harvested mechanically and fed immediately (often called "green chop"), or harvested and stored as hay, silage, and haylage. Commonly used grains and by-products are corn, sorghum, small grains, soybean meal, and cottonseed meal. Many by-product feeds, such as brewer's grains, distiller's grains, beet pulp, and citrus feeds are used to feed dairy cows. These by-products tend to be used in the region of the country where they are produced.

HERD HEALTH

Maintaining herd health and preventing problems that commonly affect high-producing dairy cattle is essential for achieving efficient and profitable milk production. In order to produce large volumes of high-quality milk, dairy cattle must be systemically healthy, reproductively sound, and receive adequate nutritional support. Workable dairy **herd health programs** include a total approach to management, nutrition, medicine, and environmental control. The general principles of a comprehensive herd health program include (1) prevention rather than treatment; (2) planned health-related procedures and examinations; and (3) sound recordkeeping and record use in making herd management decisions.

Herd health program A comprehensive and herd-specific program of health management practices.

Even with diligent efforts to prevent health problems, some diseases will still occur. A few of the common disorders that threaten the health of dairy cattle are described below. A significant number of other diseases may affect dairy cattle, but discussion of them is beyond the scope of this book.

Mastitis

Mastitis (Figure 17–13) is an inflammation of the udder caused by a wide variety of bacteria or occasionally other types of infectious organisms that enter the udder from the outside environment. Mastitis decreases the quality as well as the quantity of milk produced, even when the disease is not severe enough to make the cow noticeably ill. Therefore, preventing mastitis and effectively treating affected cows (or culling untreatable animals) is essential in dairy herds. Poor milking practices, faulty milking machines, and unsanitary conditions (muddy pens, dirty bedding, etc.) increase the

Figure 17–13
The cut surface of an udder affected by mastitis. The glandular tissue is severely inflamed due to a bacterial infection. Notice the tan, cloudy fluid (pus) filling the gland sinus. (Photo by Dr. Rodger Panciera. Courtesy Oklahoma Center for Veterinary Health Services.)

Contagious Capable of being transmitted from animal to animal.

risk for mastitis. Some forms of mastitis are caused by bacteria that are **contagious** and are transmitted from cow to cow through unclean milking machines. For that reason, detection of infected animals, followed by their treatment or elimination is essential for preventing the spread of infection to additional animals. With diligent treatment and hygiene, these contagious types of mastitis can be controlled or even eradicated from the herd.

Milk fever (hypocalcemia)

Milk fever, also called parturient paresis, occurs most commonly in dairy cattl around the time of calving. These cows undergo a sudden loss of calcium when mill production begins, which interferes with normal nerve and muscle function. As a re sult, affected cows first go through a period of restlessness and muscle tremors befor becoming unable to stand. If treatment with intravenous calcium supplementatio is not given, the disease may progress to unconsciousness and death. Even thoug the response to appropriate treatment is usually immediate, prevention of milk feve through nutritional means, such as the adjustment of dietary cation-anion differenc and dietary calcium during late pregnancy is often successful and is much preferrec

Displaced abomasum

The abomasum is the true stomach of ruminants. Due to its relatively loose attacl ments to other abdominal organs, it may become displaced following excess gas accı mulation or other processes that affect its function or motility. Displacement of tl abomasum happens most commonly in dairy cows within the first few weeks aft calving. Symptoms can range from decreased food intake and mild abdominal pa to severe cases in which animals rapidly become weak, depressed, bloated, and deh drated. These cows may die without rapid surgical correction. To decrease the risk this potentially serious disease, high-grain rations should be introduced slowly aı adequate roughage included in the diet to maintain normal function of the forestoı achs and abomasum. Early detection of decreased appetite or other signs in affect cattle is important because early treatment is more likely to be successful and preve progression to severe, life-threatening disease.

Johne's disease

Johne's disease is a contagious intestinal infection that can cause a significant crease in milk yield and eventually lead to diarrhea, severe weight loss, and de

Figure 17–14
Johne's disease. A cow infected with M. avium *subspecies* paratuberculosis *that is in the late stages of disease. She has typical clinical signs such as weight loss, watery diarrhea, and general poor health.* (Photo by Peggy Greb. Courtesy USDA-Agricultural Research Service.)

in adult cattle (Figure 17–14). This disease is unique in that cattle usually become infected when they are young (<6 months) but do not develop signs of illness until they are older (2–6 years). Large numbers of the disease-causing bacteria are shed in the feces of infected animals. Exposed calves become infected and later begin shedding bacteria and will likely develop disease as adults. Many cattle with this infection have subclinical disease, meaning that signs of illness are not readily observable, especially in the early stages. Cattle with subclinical disease can easily go undetected and contaminate the environment with bacteria, which transmit infection to susceptible animals. For this reason, testing to aid in detection and culling of infected animals, as well as careful attention to sanitation, are essential for eliminating Johne's disease from dairy herds. Replacement animals should be purchased from farms free of the infection and should be tested before introduction to the herd. Since youngsters are most susceptible to infection, in herds positive for Johne's disease, calves should be removed from cows immediately after birth, fed pasteurized colostrum, and remain segregated from adult cattle until after 1 year of age. Offspring born to cows with signs of Johne's disease should be culled, since they may be infected before birth and then serve as a source of infection for the rest of the herd. No effective treatment is available for Johne's disease, so husbandry practices that allow early detection of the disease and limit the spread of infection are the primary means of control.

BOVINE SOMATOTROPIN (BST)

This section is included as a stand-alone section in this chapter because of the uniqueness of the topic to the dairy industry. However, the implications are broader and have both biological and social implications that deal with all of agriculture, medicine, and, indeed, anything biological that occurs on this planet.

Bovine somatotropin (BST) is a hormone produced naturally by cattle in the pituitary gland, which is an endocrine gland located at the base of the brain. The effects of BST have been known since the 1930s. Each species produces its own unique version of this hormone. BST accomplishes several things in the body, including regulation of growth in the young. Injections of BST increase milk production in dairy cows. In and of itself, that is not earth-shaking news. What makes BST unique is that developments in recombinant DNA technology make it possible to produce BST on a large-scale basis. This product is referred to as rBST.

Bovine somatotropin (BST) A hormone produced by the pituitary gland of the cow. Injections of BST increase milk production in most cows.

With any product that would be used on an animal, rBST required government approval. Herein lies the importance of rBST, which was the first such product to be approved for use in animals in the United States. As such, the process was long and painful. A tremendous amount of controversy surrounded the approval of BST, and its approval was a landmark accomplishment for the fledgling biotechnology industry. Most of the concern was raised by consumer watchdog organizations. It is important to understand that several consumer and medical groups had approved and endorsed the use of rBST. It had been in use in Europe and Mexico for some years before it was approved in the United States. Commercial use of rBST received approval in 1993 for use in 1994. Actual herd records indicate that producers using rBST are realizing from 5 to 15 lbs of increased milk production per day per cow. Individual cows generally improve milk production by 10–15%.

Milk from rBST-treated cows is safe for humans to consume and has no ill effects on human health. A small amount of naturally occurring BST has always been found in milk. There are three major reasons why rBST use in cows is safe. First, BST is a species-specific protein that is active only in cattle. Second, over 90% of the BST found in milk is destroyed during the pasteurization process. Third, any BST found in milk is digested in the human digestive system as is any other protein. Slightly elevated levels of insulin-like growth factor (IGF-1) can be found in milk from cows treated with rBST. This is not a cause for concern for these reasons: First, these levels are not above normal ranges for cows. Second, human milk has higher levels of IGF-1 and it has not caused any problems. Third, IGF-1 is not biologically active when ingested by humans and is digested by the human digestive system just as BST is. Fourth, the amount of IGF-1 in a serving of milk is insignificant compared to the amount produced in the human body daily. A multitude of studies have demonstrated that BST, whether natural or synthetic, has no effect on humans.

Posilac Commercially available BST.

Posilac (sterile sometribove zinc suspension) is the registered trade name of commercially available rBST. The generic name of this product is recombinant DNA-derived methionyl bovine somatotropin. Posilac is administered as an injection every 14 days, beginning in the 9th week after calving. rBST has to be injected because it is a protein that would be digested by the cow if fed to her. Hormones like estrogen and progesterone (birth control pills) are smaller and can be absorbed intact from the gut.

For over a decade rBST use appeared to be a nonissue with most consumers However, consumers' general concerns over health and wellness as well as interes in organic and natural foods led some producers to begin producing certified rBST free milk. The availability of the rBST-free products seems to have kindled concer among consumers and has led several retailers and milk cooperatives to announc they were no longer willing to sell milk produced with the help of rBST. This effec tively eliminated the use of rBST in many herds. The controversy continues.

NUTRITIONAL BENEFITS OF MILK TO HUMANS

A 1-cup serving of 2% milk fat milk contains 125 calories and provides the followir proportions of the recommended daily dietary allowance for a 19- to 30-year-old ma

Protein	14%
Phosphorus	32%
Calcium	37%
Zinc	11%
Riboflavin	35%
Thiamin	8%
B_{12}	54%

Milk is a very nutritious food. Recent trends in eating patterns have shown consumers decreasing their consumption of whole milk in favor of lower fat versions. The only thing that consumption of lower fat milk changes substantially is that the calories go down incrementally with decreasing fat content of the product, and this improves the nutrient density. Calcium is especially important in the average diet, and milk does an excellent job of providing it.

TRENDS AND FACTORS INFLUENCING THE DAIRY INDUSTRY

The dairy industry is a dynamic industry. Several factors are shaping the changes and direction of the industry. The following discussion is not all inclusive but does discuss some of the major issues and factors to watch.

Restructuring

Trends Dairy production is shifting to larger operations and fewer dairy producers (total dairies shrank by over one-third in the 2000s), with a greater percentage of the cows in larger herds (see Figures 17–6, 17–7, and 17–15). Large dairies have significant cost advantages over small ones. The cost of adopting new technologies into a dairy will continue to cause the minimum economically feasible size of a dairy operation to increase. Bigger operations can make better use of machinery, equipment, and management because they can more easily achieve economy of size. Technological innovations and continued increases in the quantity of milk produced per cow will hasten this trend. Production will continue to shift, with the West benefitting the most from the shift. However, some traditional dairy states—such as Wisconsin, Michigan, Ohio, and New York—have increased their milk production in recent years. Much of this is due to increased milk production per cow. Dairy farms will increasingly become more specialized as they increase in size and reduce in number and more mega dairies with more than 10,000 cows will emerge in both new and traditional dairy states. Fewer farmers will raise their own feeds; they will buy all or part of it. More dairy farmers will rely on specialized heifer-rearing operations to rear their replacements. Confinement dry-lot housing and automation with concomitant reduction in labor requirements will continue.

Managers and Labor Dairying will need increasingly knowledgeable managers and high-quality labor, especially as the average size of a dairy increases and as the technological innovations become more and more sophisticated. Family-owned dairies will increasingly hire non-family members to manage or at least to assume major responsibilities in their dairies.

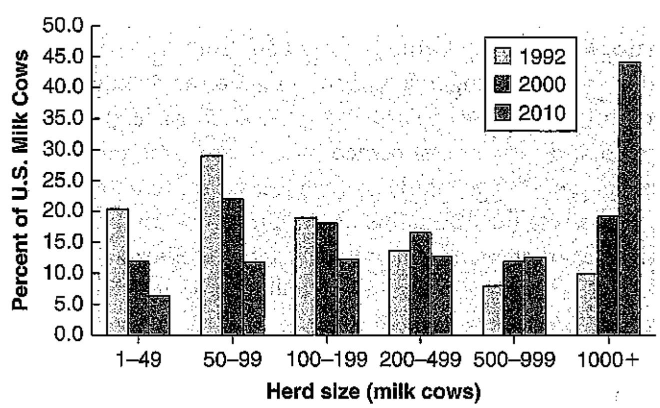

Figure 17–15
Milk production shifts to larger dairies. Source: USDA-NASS 2011.

Family Farms Most dairy farms are family enterprises. This will quite probably continue to be the case. However, more family operations will become legal partnerships or will incorporate. Large, corporate commercial dairies will continue to increase.

Policy The dairy industry has traditionally been the focus of a great deal of federal public policy and is heavily regulated. Increasingly, the argument is being made that U.S. dairy policy is too complex and a hindrance to market development, innovation in dairy product development, and development of export markets. Voices throughout the dairy industry have been calling for a dairy policy overhaul. Not all agree on what the new policies should look like, but most indicate reform is needed. As one of the author's colleagues stated, "Will we have supply-side management, or a continued messy and complicated government pricing program that is good for consumers but very bad for producers?"

Technology Historically, dairy producers have been progressive users of available technology. Cost competitiveness will give the edge to those producers who adopt and appropriately use the ever-increasing array of products and technological innovations. Expected aids include improved vaccines, better diagnostic aids, lower-cost sexed semen, designer embryos produced by recombinant DNA technology, an expanded arsenal of drugs, better heat detection mechanisms, ways of controlling reproduction, and lactation curve extenders.

Genomics The study of how the genome (DNA) of any species is organized and expressed as traits.

Genetic markers Biochemical labels used to identify specific alleles on a chromosome.

Genomics has the potential to increase genetic progress in the dairy industry by 50% or more. The sequencing of the cattle genome in 2004 allowed the development of the Illumina BovineSNP50 BeadChip in 2007. A single-nucleotide polymorphism (SNP, pronounced *snip*) is a DNA sequence variation occurring when a single nucleotide—A, T, C, or G—differs between individuals or paired chromosomes in an individual. For example, two sequenced DNA fragments from different individuals, AAGC**C**TA to AAGC**T**TA, contain a difference in a single nucleotide. The Illumina BovineSNP50 BeadChip allowed for the testing of over 38,000 polymorphisms spread evenly across the 30 chromosomes. This proved a huge advantage over marker-assisted selection where only a limited number of **genetic markers** could be tested for at one time. Genomics and SNP technology became synonymous. This technology was quickly adopted by the industry with thousands of dairy cattle genotyped and official genomic evaluations released by USDA for Holstein, Jerseys, and Brown Swiss by 2009. By May 2011, over 90,000 Holsteins had been genotyped in the United States. Genomics allows more accurate predictions of the genetics of bulls, heifers, and cows by more accurately estimating the relationships between animals and estimating the SNP effects on production, health, and conformation traits. Genetic progress is enhanced by using elite AI bulls at a younger age with more confidence and more accurately identifying elite females to be super ovulated for replacement bulls and heifers. Genomics also helps to detect and eliminate undesirable recessive alleles from the population.

Embryo transfer Collecting the embryos from a female and transferring them to a surrogate for gestation.

The use of **embryo transfer** will continue to help make genetic progress in the dairy herds of the United States and around the world. Because elite females can be identified at younger ages through genomic testing, increasingly younger animals are serving as donors of elite embryos. Both male and female offspring are then genotyped and generations turned over quickly. Because embryo transfer is still relatively expensive, it is generally only practiced on females of the genetic caliber in demand by AI studs for bull dams or on elite show ring cows to produce offspring for tha niche market. Increasingly, other technologies will be coupled with embryo transfe such as embryo sexing, embryo splitting, in vitro fertilization, and cloning.

There is increasing interest in the U.S. dairy industry in robotic milking systems Although several factors seem to motivate producers to consider robotic milking labor availability and costs head the list. Finding, keeping, and paying for qualit

Table 17–11
U.S. FLUID MILK SALES BY PRODUCT (MILLIONS OF POUNDS)

Year	Whole Milk	Lower Fat Milk	Skim Milk	Flavored Whole Milk	Other Flavored Milk	Butter-Milk	Total Beverage Milk[1]	Total Cream Products[2]	Eggnog	Yogurt	Total All Products[1]
1970	41,363	6,082	2,368	1,144	611	1,130	52,698	778	61	169	54,928
1980	31,253	15,918	2,636	1,075	1,197	927	53,006	1,173	95	570	54,844
1990	21,333	24,509	5,702	691	1,657	879	54,771	1,776	123	1,055	57,725
2000	18,448	23,649	8,435	892	2,444	622	54,490	2,665	93	1,837	59,085
2005	16,760	23,882	7,984	753	3,549	512	53,865	3,661	130	3,058	60,714
2006	16,443	24,271	8,123	719	3,733	504	54,687	3,715	132	3,301	61,835
2007	15,736	24,698	8,203	661	3,707	508	54,606	3,842	122	3,476	62,047
2008	15,309	25,924	8,246	579	3,729	547	54,554	3,734	124	3,599	62,011
2009	15,021	26,380	8,231	570	3,628	580	55,067	3,727	128	3,832	62,753

[1]Includes miscellaneous fluid milk products, beginning 2003.
[2]Light and heavy cream, half and half, sour cream, sour cream dips in CA, and sour cream used in dips elsewhere.
Source: USDA-ERS, Livestock, Dairy and Poultry Outlook, June, 2011.

labor is a growing problem in the dairy industry. Robotic milking has potential as a solution. Robotic systems are also reported to reduce stress on dairy cows. Only available in the United States since 2000, they have been commercially available internationally since the early 1990s. One of the major benefits to producers who use certain types of robotic systems is that cows decide when they want to be milked, eliminating the need for the dairy farmer to structure the day around milking times.

Consumption

Trends Milk is consumed as a variety of products including fluid milk, cheese, ice cream, yogurt, cream, and many more. National consumption of several fluid milk products is shown in Table 17–11. Per capita fluid milk consumption has declined in the United States since the middle of the 20th century (Figure 17–16). This trend is probably destined to continue. Milk competes with other beverages for the consumer's dollar. Milk's market share is less than that of soft drinks and similar to that for coffee and beer. Even bottled water has cut into milk's market share. Industry groups identify several problems that contribute to the low market share, ranging from health concerns to taste preferences and packaging. Lower-fat milk products are more popular with consumers than whole milk (Figure 17–16).

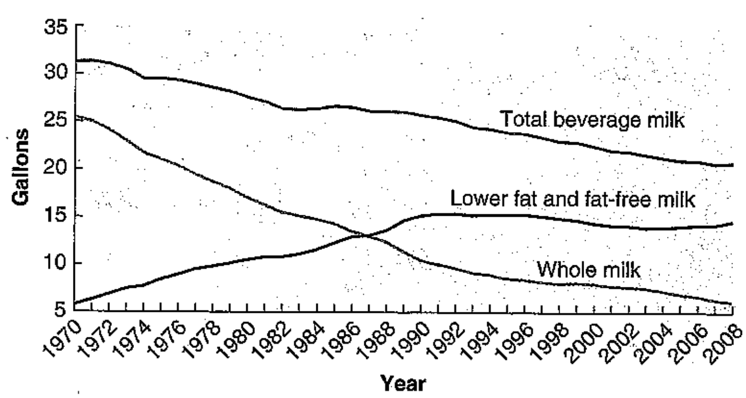

Figure 17–16
Whole, lower-fat, and total beverage milk per capita consumption, gallons, 1970–2008. Source: USDA-ERS. Food Availability (Per Capita) Data System (Release 23). http://www.ers.usda.gov/data/foodconsumption/.

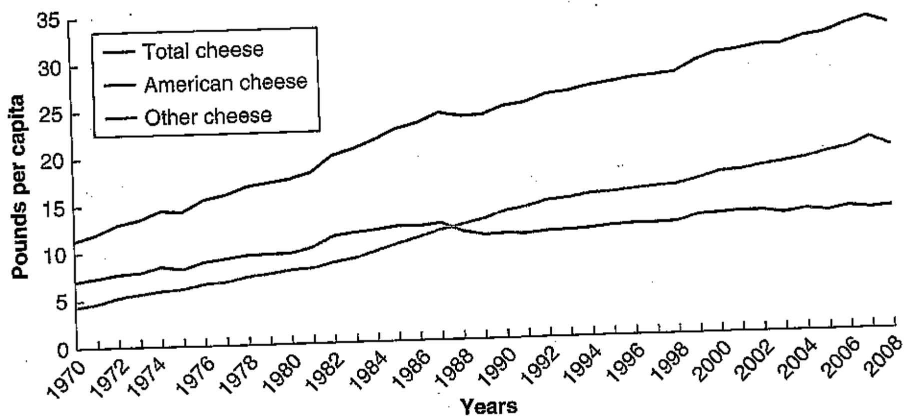

Figure 17–17
Per capita cheese consumption. (Source: USDA-ERS, 2011b.)

Cheese consumption (Figure 17–17) has increased dramatically. The amount of milk used to make cheese has been greater than fluid milk and cream use since the late 1980s and now accounts for over half of the end-product use of raw milk. Increased cheese consumption has provided for most of the growth in dairy product demand for decades. Factors contributing to increased cheese consumption include new cheese-containing products, wider availability of different kinds of cheese, demand for convenience foods, increased consumption of cheese-containing ethnic foods (especially Mexican and Italian foods), and cheese's ability to add rich flavor to a variety of foods. The increase in eating out and ordering in have also contributed to increased cheese consumption because it is a major ingredient in food manufacturing. Pizza and cheeseburgers both contribute significantly to overall cheese consumption (Figure 17–18).

Other products, such as yogurt, have enjoyed increasing popularity. In addition to traditional yogurt products, yogurt is now in cereals, fast-food desserts, toothpaste, makeup, and pet food. Better-for-you yogurts (Dannon's Activia, Yoplait's Yo-Plus and many others) have become common in the U.S. marketplace.

Other changes are at work in U.S. dairy product consumption. Individual milk components such as individual proteins, skim solids, milk fat, and lactose are being marketed. As both at-home and away-from-home eating patterns change, the demand for dairy products is shifting from retail sales to restaurant and food processor use, which now account for the majority of dairy product use. These uses are especially important for cheese, butter, and cream. The growing diversity of the U.S

Figure 17–18
Pizza has contributed significantly to increased cheese consumption. Other contributing factors include new cheese-containing products, availability of different kinds of cheese, increased consumption of cheese-containing ethnic foods (especially Mexican and Italian foods), demand for convenience foods, and cheese's many rich flavors. (Photo by Scott Bauer. Courtesy USDA-Agricultural Research Service.)

consuming population is also a factor. Because of increased use of dairy products, per capita milk equivalent use is increasing modestly.

Nutrition and Health Consciousness Milk consumption has been affected by its nutrient content and will continue to be so affected. As previously discussed, there has been a decline in whole-milk sales and an increase in reduced-fat milk sales. However, many consumers don't consider lower-fat milk products to be as palatable as whole milk. On the positive side, recent research studies have confirmed the positive role of calcium consumption in bone health, and milk is an excellent source of dietary calcium. Cheese already contributes over a quarter of the calcium in the U.S. diet. Other studies have suggested a positive role of milk consumption in a weight-loss diet and a positive role of milk consumption after exercise in muscle building. If these studies are confirmed, and the information becomes common knowledge, then milk consumption could get a boost with those relevant interest groups. Milk-based sports drinks, milk-based energy drinks, and cholesterol-cutting milk entered the marketplace in 2007. Several companies have subsequently introduced health-promoting products targeting specific user groups. More such products are under development. Milk and other dairy products are included in the dietary recommendations of all of the major health organizations. Based on the 2005 *Dietary Guidelines* and loss-adjusted food availability data from the USDA-ERS, Americans consume, on average, about 60% of the recommended daily amounts of milk and milk products (Wells and Buzby, 2008).

Organic Milk Production Dairy has been one of the fastest growing segments of the organic foods industry. Reasons consumers give for preferring organic milk include environmental and animal rights concerns and health benefits. However, research has demonstrated no health benefits for organic milk over conventionally produced milk. In addition, organic milk is more expensive, selling for double the price of other milk in some parts of the country.

At this writing, the overall share that organic milk and milk products have of the market is approximately 3% and growing. The economic downturn of the late 2000s slowed the growth of organic dairy products. However, for the near future, growth of the organic milk segment is expected.

Food Safety

Consumer Concerns Dairy products have an enviable record of safety. Certainly, dairy products are not immune from safety concerns, but the way milk must be handled and processed to keep it from perishing has also kept it from being a common source of food safety concerns. Bovine spongiform encephalopathy (BSE) should never become an issue in the U.S. dairy industry because milk is not a form of transmission of the disease.

Environmental Concerns Waste disposal is an increasing concern to dairies. Concentrated animal feeding operations (CAFOs) are considered a significant source of ground- and surface-water pollution because of the high levels of nitrates and phosphorus, harmful bacteria, and salt found in manure. Many modern dairies fit this category of operation.

Most analysts predict the enactment of increasingly tougher waste disposal laws that will add costs to production. Individual states have enacted environmental regulations that go beyond federal requirements, and more are expected to do so. New, low-cost, effective means of animal waste disposal should help blunt the added costs that environmental stewardship will bring. Quality of the air, soil, and water supply is an important issue with consumers. Dairy producers will increasingly be concerned with nutrient management plans, carbon footprint, and other environmental issues in order to remain in business (Figure 17–19).

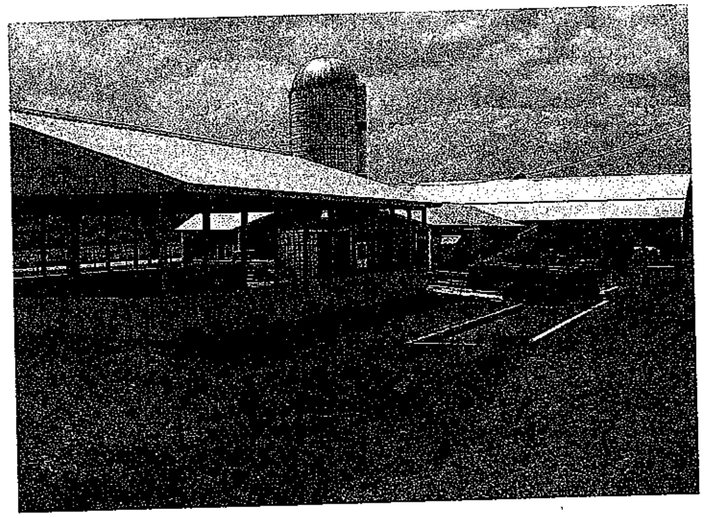

Figure 17–19
Many modern confinement dairies must consider ways to effectively and efficiently manage animal waste and control pollution. Shown here is a roofed, concrete-walled solid manure stacking facility basin and filter strip at a Michigan dairy.
(Photo by Lynn Betts, USDA-Natural Resources Conservation Service.)

Trade

Dairy product exports have been rising as world demand for food increases and new markets open. According to the U.S. Dairy Export Council, export volume amounted to nearly 13% of U.S. production in 2010—a sharp rise from previous years. However, increased dairy exports are expected to continue as dairy products and fast-food pizza and cheeseburgers become part of the diet in China, India, and various Southeast Asian nations. Access the latest export data from the U.S. Dairy Export Council at http://www.usdec.org/home.cfm?navItemNumber=82205.

INDUSTRY ORGANIZATIONS

American Dairy Science Association

http://www.adsa.org/

Dairy Management Inc.

10255 West Higgins Rd., Suite 900

http://www.dairyinfo.com/

Dairy Management, Inc., (DMI) is the domestic and international planning and management organization that works to increase demand for U.S.-produced dairy products abroad. DMI manages the **American Dairy Association**, the **National Dairy Council**, and the **U.S. Dairy Export Council**.

National Dairy FARM Program

http://www.nationaldairyfarm.com/

The National Dairy FARM Program: Farmers Assuring Responsible Manage mentTM provides nationwide verification of dairy cow well-being. The organiza tion's goal is to provide consistent and uniform animal practices and verify thes practices on farm to reassure customers and consumers.

National DHIA

http://www.dhia.org/

National Milk Producers Federation

http://www.nmpf.org/

The National Milk Producers Federation (NMPF) is a farm commodity orga nization representing dairy marketing cooperatives in the United States. Th NMPF provides a forum through which dairy farmers and their cooperativ formulate policy on national issues that affect milk production and marketing

SUMMARY AND CONCLUSION

Dairy products provide approximately 11% of all yearly cash receipts from agriculture in the United States, amounting to approximately $26 billion. The purpose of the U.S. dairy industry is to provide high-quality food from resources that the human population cannot use, such as forage and by-products.

The dairy industry is dispersed across the country because it is generally more cost effective to produce milk near the human population that will consume it. Dairy cattle fill a niche in resource utilization, similar to other ruminants except that they require better feed, intensive management, and considerably more attention per animal. Milk is such a valued product that it makes the higher inputs worthwhile.

The dairy industry is restructuring. The West is becoming more important, operations are becoming larger, and technology is increasingly important in driving the industry. Because of the dairy industry's importance to U.S. agriculture and to human nutrition, an extensive network of resources and information is available to the dairy producer. Organizations like the DHIA help in providing information for making management decisions. Good information is available to dairy producers, but increasingly good managers are needed to make best use of the information.

Herd health is an especially important management tool for the dairy producer. Dairy cows produce a high-volume product. They must stay healthy to continue producing in an economical fashion. A program of total herd health can help. Trends and matters of importance to the dairy industry include continued restructuring, technological innovation, changing consumer preferences and demands, the fortunes of organic milk, and green concerns, such as environmental impacts and animal welfare.

Facts about Dairy Cattle	
Birth weight:	Varies with breed and sex; 50–110 lbs
Mature weight:	Varies with breed, sex, and condition; female 900–1,600 lbs; male 1,400–3,000 lbs
Weaning age:	Commonly removed from cow at 1–2 days of age and fed milk or milk replacer for 4–8 weeks
Breeding age:	14–19 months (female)
Normal season of birth:	Year-round
Gestation:	280–283 days
Estrous cycle:	19–21 days
Duration of estrus:	12–18 hours
Calving interval (months):	11–15 (12 is preferable, but 13 is more realistic)
Normal calf crop:	70–80%
Names of various sex classes:	Calf, heifer, cow, bull, steer
Type of digestive system:	Ruminant

STUDY QUESTIONS

1. Dairy amounts to how much of the total cash receipts of animal agriculture? Describe the magnitude of this industry in other ways. In addition to milk and its products, what other major product does the dairy industry provide?
2. What is the primary purpose of the dairy industry in the United States? What are the resources it uses? What is the dairy's role in using homegrown feeds?
3. Study the section on the history of the dairy industry. Select five elements that you feel are the most important and justify your list.
4. How geographically concentrated is the dairy industry compared to the other animal industries? Why is this?
5. What are the major dairy areas in the United States? Include the states in each area. Where are the dairy areas in a state most likely to be found? Name the

10 leading dairy states. What has been the historical role of the dairy in a farming enterprise?

6. How many dairy cattle are there in the United States? What is happening to the overall numbers? What is happening to dairy cow production per cow?
7. Describe the function and value of NCDHIP.
8. Name the major dairy breeds in the United States. Rank them on milk production and on popularity.
9. Why are reproductive problems such an issue in the dairy industry? What role does nutrition play in reproduction? How can DHIA records be used to help reproductive efficiency?
10. Why is feeding the most important variable that needs to be controlled if a dairy is to be profitable? Why is good forage so important to dairy feeding and profitability?
11. Describe complete mixed ration feeding in dairy cattle. What are its advantages?
12. What are some common diseases that all dairy producers must understand and be able to prevent and respond to?
13. Describe the use of BST in dairy cattle. Does it work? Is it safe? Why or why not?
14. Describe the nutritional benefits of milk to the human diet. What nutrient is milk most famous for providing? After looking at the nutritional information, do you feel milk is being overlooked as an important source of other nutrients?
15. Describe the trends that are shaping the dairy industry in one sentence each.

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Beginning with the second edition, Dr. Tony Seykora, professor of animal science, University of Minnesota, has reviewed this chapter. In addition, Dr. Seykora contributed new material to the chapter. For the 5th edition, Melanie A. Breshears, DVM, PhD, Diplomate ACVP, assistant professor of veterinary pathobiology, Center for Veterinary Health Sciences, Oklahoma State University, contributed material to this chapter. The author gratefully acknowledges these contributions.

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