DAIRY CATTLE FEEDING AND MANAGEMENT

Frontispiece.

The Dairy Barn at The Pennsylvania State College.

DAIRY CATTLE FEEDING AND MANAGEMENT

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PREFACE

The First Edition of "Dairy Cattle Feeding and Management," published in 1917, has met with general favor both among practical dairymen and among teachers of dairy husbandry in our agricultural colleges and secondary schools. During the eleven years intervening since the First Edition was published, the science of dairying has advanced rapidly. This is especially true in the fields of nutrition, pathology, and genetics. For this reason the book has been entirely rewritten and enlarged, although the general plan of the former edition has been retained. Six entirely new lectures have been included and others have been expanded and brought up to date.

In the writing of the new edition the best literature on the various subdivisions of the subject has been used, and in each case where the author of any statement is known, credit is given in the bibliography at the end of the lecture. In addition, a list of references for further study is given after each lecture so that students who have the opportunity can pursue their studies on the various subjects by following the references cited. The instructor can also use these references for outside assignments.

The object of the authors of this book has been to bring together in a compact and teachable way the more important findings of investigators in the field of dairy husbandry. It has not been their purpose to tabulate every experiment that has been published, in order to ascertain whether there is complete agreement, but rather to present the best information available at the present time, and to present it in the most teachable manner. The book is divided into lectures, with the idea that one period may be spent on each lecture. When two lectures are given per week, the complete course could be covered in eighteen weeks; or, by giving three lectures per week, the course could be completed in twelve weeks. Suggested laboratory exercises are given in the Appendix. In case less than two laboratory exercises per week are devoted to this course, certain of these exercises may be omitted.

Although this book has been written primarily for the student in dairy cattle feeding and management, it is believed by the authors that the lectures may be used as a reference and a helpful guide by practical diarymen, herdsmen, teachers, and any others interested in the feeding, care, and management of dairy cattle. The authors wish to express their obligation to Professor E. L. Anthony for many helpful suggestions, and to Professor G. Malcolm Trout for reading the manuscript.

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DAIRY CATTLE FEEDING AND MANAGEMENT

LECTURE I

THE RELATION OF DAIRYING TO AGRICULTURE

More than 80 per cent of all the farmers in the United States are interested in the feeding, care, and management of dairy cattle. There are 21,824,000 dairy cows, two years old or over, in this country.[1] Because of the nature of dairy products, and especially of milk, the producer and the consumer are equally interested in maintaining an adequate and wholesome supply of these products. There is a daily demand for milk or some of its products by every family, throughout the year. There are no substitutes for milk. Children must have it for growth; adults require it for health; and invalids as well as old people must turn to it as a means of prolonging their lives.

Dairy husbandry, as it exists to-day, is of comparatively recent origin. Milk, however, has been used as food for man from the very earliest times. As far back as history records, milk and its products, especially butter and cheese, were used as articles of food. The Book of Genesis contains records of their use, and excavations reveal the presence of the bones of dairy animals among very ancient remains of human life. Through all the ages dairying has held an important part in the agriculture of the various nations, but it did not begin to reach its present status until about 1850.

Nature intended the cow to produce enough milk to feed her calf, but man has developed this instinct to such a point that to-day a single cow frequently produces sufficient milk to feed many calves. As land was taken up and the herder was not permitted to move his cattle from field to field as he found new pasture necessary, he was obliged to adopt a system of feeding that required a greater production.

The dairy cow, to be profitable, must be the producer of a large amount of milk. In order to do this she must be able to consume large quantities of feed. The average cow in the United States produces only about 5200 pounds of milk. There was one cow, however, that produced over seven times this amount, showing that the possibilities for improvement are great.

By far the greatest proportion of milk produced in this country is from the small dairy herd. It is possible to produce milk as a side line and to sell it cheaper than it could be produced in the specialized dairy, where all labor must be hired and where good marketable crops must be fed. In a dairy of few cows, much of the roughage, such as stover, straw, and hay, that may be discolored by rain or otherwise

FIG. 1.—A large specialized dairy.

made unmarketable, can be used to a better advantage than by putting it on the market. Moreover, a few cows may often be milked and cared for without extra cost for labor.

Because of the competition brought about by the small dairy herds on general farms, the large specialized herds have been developed under certain definite conditions. However, with the increased demand for milk produced under exceptionally clean conditions from healthy cows, the specialized dairy will gradually take the place of the system of milk production as a side line, especially in those sections where milk is produced for direct consumption. Special equipment and methods are needed for producing clean, sanitary milk. Such milk will be produced at a somewhat higher cost but the consumer will eventually pay for the improvement in quality.

A few other animals besides the cow have been used for the production of milk. The most common of these are the goat and the ewe, though the mare and the ass have been used to some extent in other countries. In the United States the goat is the only animal besides the cow that is used to produce milk commercially. Goats' milk is produced for infant feeding, although it is used to a limited extent for other purposes.

Extent of the Dairy Industry.—While the dairy industry in the United States developed slowly at first it has increased very rapidly within the past seventy-five years. Table I shows the amount of milk produced and its utilization,[1] as given by the United States Department of Agriculture, for 1926.

TABLE I

MILK PRODUCTION AND UTILIZATION, 1926

Purpose for Which Used	Whole Milk Used, Lbs.	Amount of Product Produced, Lbs.	Per cent of Total Milk
Creamery butter	30,487,086,000	1,451,766,000	25.245
Farm butter	12,915,000,000	615,000,000	10.694
Cheese (all kinds)	4,274,160,000	427,416,000	3.539
Condensed and evaporated milk	4,333,760,000	1,733,504,000	3.589
Powdered milk	86,144,000	10,768,000	0.071
Powdered cream	6,289,000	331,000	0.005
Malted milk	45,481,000	20,673,000	0.038
Sterilized milk	1,286,000	1,286,000	0.001
Milk chocolate	171,543,000	....	0.142
Ice cream	4,464,144,000	324,665,000	3.698
Total	56,784,893,000	....	47.020
Milk:			
Household purposes	56,417,000,000	....	46.716
Fed to calves	3,941,600,000	....	3.264
Wasted (estimated)	3,622,487,000	....	3.000
Grand total	120,765,980,000	....	100.000

The number of cows and heifers two years old and over kept for milk was 21,824,000, as estimated January 1, 1927. The estimated number of such cows in various states and their value are given in Table II, arranged according to the number of dairy cattle within the state.

TABLE II

MILK COWS AND HEIFERS TWO YEARS OLD AND OVER,[1] JANUARY 1, 1927

Rank	State	Number of Cows and Heifers	Total Value
1	Wisconsin	2,014,000	$149,036,000
2	Minnesota	1,560,000	93,269,000
3	New York	1,318,000	118,620,000
4	Iowa	1,314,000	86,724,000
5	Illinois	988,000	68,172,000
6	Texas	973,000	43,785,000
7	Ohio	926,000	64,820,000
8	Pennsylvania	845,000	67,600,000
9	Michigan	841,000	61,393,000
10	Missouri	827,000	41,350,000
11	Kansas	715,000	39,325,000
12	Indiana	645,000	41,280,000
13	Nebraska	613,000	36,780,000
14	California	596,000	46,488,000
15	Oklahoma	581,000	27,307,000
16	South Dakota	534,000	29,370,000
17	North Dakota	498,000	24,900,000
18	Kentucky	464,000	21,808,000
19	Tennessee	425,000	17,426,000
20	Mississippi	379,000	12,128,000
21	Arkansas	374,000	12,342,000
22	Alabama	350,000	11,200,000
23	Georgia	343,000	12,348,000
24	Virginia	326,000	14,670,000
25	North Carolina	303,000	14,241,000
26	Vermont	285,000	22,515,000
27	Washington	264,000	19,536,000
28	Colorado	224,000	12,544,000
29	Oregon	214,000	13,910,000
30	Louisiana	210,000	7,560,000
31	West Virginia	207,000	9,729,000
32	Montana	188,000	10,152,000
33	Maryland	178,000	12,460,000
34	Idaho	170,000	11,050,000
35	South Carolina	158,000	6,320,000
36	Maine	148,000	9,916,000
37	Massachusetts	138,000	13,110,000
38	New Jersey	119,000	13,090,000
39	Connecticut	110,000	11,000,000
40	Utah	89,000	6,408,000
41	Florida	78,000	3,120,000
42	New Hampshire	78,000	6,630,000
43	Wyoming	70,000	4,340,000
44	New Mexico	64,000	3,072,000
45	Arizona	35,000	2,800,000
46	Delaware	35,000	2,625,000
47	Rhode Island	21,000	2,100,000
48	Nevada	20,000	1,600,000
	Total	21,824,000	$1,361,968,000

While the United States has more dairy cattle than any other country in the world, the number is not so large in proportion to the area as is the case in some European countries, nor is the production of the cows as high. For these reasons the United States is not classed with the great dairy countries of Europe.

The dairy industry in the United States is to-day, however, the biggest and most profitable branch of the farm business. About one-quarter of the total value of farm production comes directly or indirectly from the dairy cow. The growth of the dairy industry during the past decade has been very great. This has been due largely to the fact that the consumption of dairy products has increased about 50 per cent during that time. This increase in consumption has been brought about to a very large extent by a better understanding of the high dietary value of milk.

The increased efficiency in the production of milk has also been remarkable. The average milk production of the cows in the United States has increased in the past ten years over 1000 pounds per cow. Thus the increase in total production during that period has been brought about with the use of fewer cows, both as to total number and as to number of cows per 1000 population. This is shown by Table III,[2] which also gives the production of the cows in the United States since 1840.

This increase in production has been brought about by the use of more efficient methods. Dairymen understand the problem of feeding better than they did formerly. They are also culling more closely—raising the heifer calves from their best cows and disposing of the others, and selling off all cows that do not show a fair production.

Reasons for and against Dairy Farming

There are several reasons why dairy farming has reached its present place in the agriculture of our country. In the first place, milk is an excellent food and cannot be replaced in the diet without considerable difficulty; in the second place, dairy cows produce food more economically than any other kind of livestock; and in the third place with dairy farming the fertility of the soil can be maintained more readily than with any other type of agriculture. Furthermore, dairying is a stable form of agriculture and gives quick and regular returns.

In pointing out the disadvantages of dairying it may be said that good labor is hard to obtain, that a large amount of capital is needed to start a specialized dairy business, and that much risk is involved.

TABLE III

PRODUCTION STATISTICS, 1840–1926

Year	Milk Cows on Farm, Jan. 1	Average Milk per Cow, Lbs.	Total Milk Produced, Lbs.	Farm Cows per 1000 People
1840	4,837,000	....	....	287
1850	6,385,000	....	....	278
1860	8,586,000	....	....	276
1870	8,935,000	....	....	234
1880	12,443,000	....	....	251
1890	16,512,000	....	....	264
1900	17,136,000	....	....	237
1910	20,625,000	2902	64,211,000,000	225
1914	20,737,000	....	75,000,000,000	213
1917	22,894,000	3716	84,612,000,000	226
1918	23,810,000	3937	87,906,000,000	231
1919	23,455,000	3412	90,058,000,000	225
1920	21,427,000	3964	89,657,000,000	203
1921	21,408,000	4336	98,862,000,000	200
1922	21,788,000	4435	102,562,000,000	201
1923	22,063,000	4698	109,736,000,000	201
1924	22,255,000	4865	114,666,000,000	198
1925	22,481,000	4954	116,505,000,000	195
1926	22,148,000	5208	120,766,000,000	189

Milk as a Food.—That milk is an excellent food, especially for growing children and invalids, has long been recognized, but the reason for this was not fully appreciated until recently. It has been known for a long time that the solids of milk are present in just the right proportion to produce the best results and that milk is digestible and palatable. Recently, however, it has been found that there is more to be considered in the diet than these essentials. We know now that not all the proteins are of equal value, as some of them do not contain all of the important amino acids which the body requires. The proteins of milk, however, are very complete and when milk is fed with the cereals it supplements their proteins in such a way that good results are obtained.

The diet must contain, besides these, two other things, namely, sufficient mineral matter and the vitamins. Milk contains all the important minerals needed in the body, with the possible exception of iron and iodine. It is particularly rich in calcium, which is the element most likely to be deficient in the ordinary diet. A deficiency of minerals causes poor teeth and other bodily ailments.

Milk also contains the four important vitamins which are necessary for the growth of the young and the well-being of the adult. No other food, except green leaves, contain all of the vitamins, and man must therefore depend largely upon milk for his supply of these important elements.

For these reasons, milk is one of the most important food substances and must be supplied in liberal amounts. It has been said that no nation that was not a great consumer of milk has ever become a great world power, and also that our country cannot maintain its present position as a world power without the continued use of milk.

Dairy Cows as Efficient Producers of Human Food.—Of the common domestic animals, the cow is the most economical producer of human food. A comparison of the dairy cow with other animals, as to efficiency in the production of human food, is given in Table IV, which is taken from Jordan.[3]

TABLE IV

HUMAN FOOD PRODUCED BY ANIMALS FROM 100 POUNDS OF DIGESTIBLE MATTER CONSUMED

Animal	Marketable Product, Lbs.	Edible Solids, Lbs.
Cow (milk)	139.0	18.0
Pig (dressed)	25.0	15.6
Cow (cheese)	14.8	9.4
Calf (dressed)	36.5	8.1
Cow (butter)	6.4	5.4
Poultry (eggs)	19.6	5.1
Poultry (dressed)	15.6	4.2
Lamb (dressed)	9.6	3.2
Steer (dressed)	8.3	2.8
Sheep (dressed)	7.0	2.6

From 100 pounds of digestible matter consumed, the cow will yield 139 pounds of milk, 18 pounds of which is edible solids, practically all digestible. On the same basis the pig returns 25 pounds of marketable product of which 15.6 pounds is edible. The pig and the hen are the greatest competitors that the dairy cow has in the production of human food. They both, however, require a different kind of food from the dairy cow, which will consume vast quantities of roughages, such as hay, straw, stover, and other rough feed that would often go to waste otherwise. The pig and the hen must have an abundant supply of grain and are not adapted to the use of large quantities of roughages.

The sheep and the steer, on the other hand, are both adapted to the use of roughage; but the dairy cow returns about six times as much edible solids in her milk, for each 100 pounds of digestible nutrients in the feed consumed, as the sheep or the steer yield in their carcasses, and the cow still remains to continue production for from two to six years longer. This fact accounts, no doubt, for the prominent place held by the dairy cow in intensive farming, and by the steer in extensive farming. It also accounts for the decrease in the number of beef cattle in the country as the population increases and the size of the farm decreases, and for the accompanying increase in the number of dairy cattle. The dairy cow fits into an intensive system, and is the chief producer from the very high-priced land of Holland and Denmark.

Relation of Dairying to Soil Fertility.—Dairy farming, perhaps more than any other system of farming, makes it possible to conserve the fertility of the land and even to build up the soil. This is especially true in intensive dairying, when some of the grains are purchased, and even more so when butter is sold off the farm. Such feeds as wheat bran, linseed meal, and cottonseed meal, which are the ones commonly purchased for dairy cows, are rich not only in nitrogen, but also in phosphoric acid and potash. The amounts of the fertilizing constituents contained in a few of the common feed stuffs, together with their value per ton, based on the normal prices of the fertilizer constituents, are given in Table V.[4]

Table V shows that whenever a ton of hay or straw is sold off the farm it takes with it a certain amount of soil fertility which must be replaced in some manner if the farm is to maintain its fertility. Where dairy farming is practiced, usually all the hay, straw, and grain are fed on the farm, and very often large amounts of high-protein feeds, such as cottonseed meal and linseed meal, are purchased for supplementary feeds. These add very materially to the fertility of the soil. When these and the home-grown feeds are fed to the dairy cow, about 70 per cent of fertilizer value can be restored to the farm in the form of manure. The selling of milk, and more especially of butter or cream, does not take very much fertility from the soil.

TABLE V

FERTILIZING CONSTITUENTS OF 1000 POUNDS OF MATERIAL AND ITS VALUE PER TON

Feeding Stuff	Feeding Constituents in 1000 Lbs.			
	Nitrogen, Lbs.	Phosphoric Acid, Lbs.	Potash, Lbs.	* Value per Ton
Alfalfa hay	23.8	5.4	22.3	$12.28
Clover hay	20.5	3.9	16.3	10.22
Timothy hay	9.9	3.1	13.6	5.58
Corn silage	3.4	1 6	4.4	1.96
Corn meal	14.9	6.1	3.7	6.94
Gluten feed	40.6	6.2	2.3	17.08
Wheat bran	25.1	29.3	16.1	14.58
Wheat middlings	27 7	21.1	11.8	14.36
Cottonseed meal	63.7	26.6	18.0	29.94
Brewers' grains (dried)	42.4	9.9	0.9	18.04
Oats	19.8	8.1	5.6	9.28
Linseed meal	54.2	17.0	12.7	24.64

*Nitrogen figured at 20¢ per pound and phosphoric acid and potash at 5¢ per pound.

In general, farms on which no livestock is kept are not maintaining their soil fertility. It is not necessary to keep livestock in order to maintain fertility, but livestock farms are almost universally in a higher state of production than other farms. This is accounted for by the fact that manure is a by-product that cannot usually be marketed, while the maintenance of fertility by commercial fertilizers requires a direct cash outlay.

Sure and Regular Returns.—Of all the farm occupations, that of dairying gives the surest and most regular returns. In the raising of beef or of grain, the return comes but a few times during the year, while with dairying the returns are steady throughout the year. There is always a market for dairy products. It is true that the returns at times may not be as great as they are with other forms of livestock, but on the whole they vary less than with any other agricultural product.

With the development of good roads and with increased transportation facilities, dairying is spreading to all parts of the country. Formerly, most of the butter was made in the Eastern States; but with improved shipping facilities and because the cost of production in the Middle West is low enough to make up for the greater cost of transportation from the Middle West to the East, there has been a great decrease in the amount of butter made in the East. The same thing is true of milk, except that in this case it applies only to somewhat shorter distances. The dairymen within a few miles of a city are now obliged to compete with dairies four or five hundred miles away and even farther. This is due largely to the use of improved refrigerator and tank cars. Centralizers are buying cream from territory many

FIG. 2.—The home of the famous Guernsey bull, "King of the May."

miles from the place of manufacture. To-day, as a result of these developments, there is a market for all the milk produced.

The Labor Situation.—The problem of labor on the dairy farm is a perplexing one. In some sections it is not difficult to secure men who are competent to do such work. There are other sections, however, where labor is scarce and therefore hard to obtain. The long hours required and the low wages paid by dairy farmers, as compared with the prices paid in other industries in the community, result in discontent.

The labor problem is further complicated by the fact that more intelligent men are required in dairying than in many other lines of work. This limitation restricts the number of men available for the dairy and also requires that they be selected from a class who are paid more than ordinary laborers. Many states have passed workmen's compensation acts, but few of them have extended their scope to include men employed on dairy farms. This fact also may have a slight tendency to cause men to seek employment elsewhere.

While these disadvantages are well known, there are other factors which tend to make the labor on a dairy farm more stable. While in most other forms of agriculture, and even in the industries, employment is very uncertain, on the dairy farm it is certain and continues throughout the entire year. Even though the wages are not so high as in some other occupations, nevertheless they are paid regularly and at the end of the year may amount to more than in many other forms of work. It is true that the hours are usually long, but many dairymen are now regulating their work so that their help have as much time off as other farm hands. This is necessary if the men are to be kept contented. Much of the monotony of dairying has been taken away by labor-saving devices, such as the milking machine. If attention is paid to the matter of labor, many of the disadvantages will disappear.

Capitalization and Risk.—A farmer cannot establish a specialized dairy unless he has a large amount of capital. From the standpoint of capital, good dairy cows and good dairy equipment are expensive. They also require a large outlay of money for feed and labor. This should be compensated for by an increase in the price of the special product. However, it is not often wise for a beginner to go into the dairy business without previous experience. It is usually better to grow into it, as one can do gradually and with a minimum amount of outlay.

A man with a herd is also confronted with risks, because of disease and sickness which may develop among the animals. These things must be considered when going into the dairy business.

Unprofitable Dairies.—Many of the dairy herds in this country are unprofitable. This difficulty will be largely remedied by more efficient methods of production. Careful records of cost show that many dairies are running at a loss. Any one of the following reasons may be given to explain why dairymen who operate at a loss continue in the business:

1. On account of changed conditions some dairymen are producing milk either at no profit or at a loss. An improved method of shipping milk may be a factor in such a case. A dairyman who lives near a city is able to sell his straw, stover, and other feeds at a higher price, and perhaps his labor is also high-priced. With improved facilities of transportation he is obliged to compete with a farmer who occupies cheaper land and who places a low value on his coarse feeds.

2. Certain dairymen are satisfied to produce milk at actual cost in order to get some return for labor that they could not use without the dairy. To illustrate, let us assume that one of two farmers, each with 160 acres of equally good land, has 10 cows, and that the other has none; that the farmer with 10 cows sells his milk at exactly the price that careful and accurate records show it to cost. Figuring roughly that labor is charged at $30 per cow yearly, the farmer with 10 cows will have $300 more than his neighbor at the end of the year, for he will spend no more for his labor. In the summer his children are at home to do the milking, and during the winter it can be done by the farmer himself. He is, therefore, at the end of the year, $300 better off than his neighbor. Some consider that this $300 is not saved, that it is merely pay for the work done; others, that it has nothing to do with the actual cost of milk. It is, nevertheless, one reason why some dairy farmers are apparently more prosperous than farmers on similar farms without cows.

3. Some dairymen have land that cannot be used for anything except pasture, or have stover or inferior hay and other feeds that can be utilized for milk production but cannot be marketed.

4. There are those who found the milk business profitable when feed, labor, and other requirements were cheaper. Although the price for their product may not have advanced in the same proportion as its cost, they continue in the industry in the hope of eventually getting a higher price for the milk.

5. With some farmers a few cows fit in well with the general farm scheme. To this class belong those who have a little pasture, those who want a certain quantity of manure for a particular crop, and those who want a certain small cash income throughout the year. It is the farmers with small herds, more than any others, who produce the bulk of the milk of this country and keep the price low.

6. There are a certain number of wealthy men who do not care whether they make any money or not. They keep cows for a hobby

or to furnish milk to some establishment where good milk is desired regardless of cost.

The above reasons are not given to justify low prices of milk, but rather to explain why some are producing milk although, when all actual costs are counted, the business does not show a profit.

Pure-bred Dairy Cattle.—For those who have sufficient capital and know the methods of breeding, the raising of pure-bred dairy cattle offers a special opportunity. Most of the dairy cattle in this country are grade animals. As dairymen are constantly seeking to improve the production of this class of cattle, higher-producing pure-bred animals are needed in order to furnish the necessary bulls. Perhaps the greatest development of the industry, as far as the animals themselves are concerned, will be brought about by the use, in the grade herds, of bulls that will increase the production of those herds. The value of a good bull can hardly be overestimated, and the producers of milk and dairy cattle are rapidly learning this. They are willing to pay high prices for good breeding stock. There has always been a demand for good pure-bred animals and this demand will probably always continue. Therefore, the dairyman who can produce not only good milk but also high-class livestock, and who can properly feed, show, and market the latter, can establish an especially desirable business. The raising of pure-bred cattle is a separate business, distinct from that of producing milk.

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LECTURE II

THE COMPONENTS OF PLANTS AND ANIMALS

Elements of Animals and Feeds.—Of the many chemical elements now known, only eighteen are important insofar as plant and animal life is concerned. These are hydrogen, oxygen, sulphur, nitrogen, phosphorus, carbon, chlorine, sodium, calcium, magnesium, iron, potassium, arsenic, silicon, iodine, fluorine, manganese, and copper. Some of these are found only in very small amounts and are essential only to a small group of plants and animals.

Compounds.—The elements named above combine to form a great many different compounds. These compounds can be divided into five great classes, as follows: water; ash; crude protein; carbohydrates; and fat, which is also called ether extract. Frequently the carbohydrates are further divided by the chemist into nitrogen-free extract and crude fiber. The following diagram will show how these compounds of the plant are divided during analyses. The water and ash are incombustible while the remaining compounds are combustible.

All feeding stuffs consist of

Water	Dry matter	
Ash	Organic matter	
Protein	Carbohydrates	Fat or ether extract
	Nitrogen-free extract	Fiber

It is necessary to study these compounds before we can understand how they can be used by the animal body.

WATER

Water is a very necessary compound of plants and animals. The bodies of animals consist of from 70 to 90 per cent water. Water has several very important functions in the plant or animal. It gives elasticity and rigidity to the supportive tissue of the plant or animal, helps to dissolve the food, acts as a carrier of food and waste, and helps to maintain the osmotic pressure of the body. It serves also as electrodes, which are very closely related to the chemistry of life. Any interference with the normal amount of water, in either plants or animals, produces disastrous results. Water, therefore, should always be supplied to livestock in large amounts.

DRY MATTER

If a substance is heated to a temperature at or above that of boiling water until it ceases to lose weight, the remaining residue is known as dry matter. The loss of weight represents the moisture or water. A small amount of moisture, however, is still held in the dry matter. Dry matter is divided into organic matter and ash or inorganic matter.

Ash or Mineral Matter

When dry matter is burnt the organic matter can be burnt out, leaving what is known as ash or mineral matter. There is considerable ash in all of the common feeding stuffs. In the animal the dry matter of the bones consists largely of ash, while the dry matter of the rest of the body contains, on the average, about 7.1 per cent of ash.[1] The analysis, however, does not tell how the inorganic matter is distributed in the body. The important minerals in the animal body are calcium, sodium, potassium, iron, phosphorus, chlorine, fluorine, iodine, and sulphur.

The functions of the minerals in the animal body are numerous. They furnish material for the formation of new tissues, especially that of the skeleton. This is more important in young, growing animals than in mature ones.

The minerals help to maintain the osmotic pressure. The cells of the various body tissues draw their nourishment from the lymph, from which they are separated by cell walls. These walls partake of the nature of a semi-permeable membrane. In order to maintain normal conditions in the protoplasm of the cells, the osmotic pressure of the lymph, and therefore that of the blood from which it is derived, must be maintained approximately constant. This constant osmotic pressure is due largely to ash ingredients contained in solution.

The minerals help to maintain the proper ionic concentration in the body. Certain important reactions in the body will not take place unless the proper ionic concentration is maintained. Ptyalin, for example, is very sensitive to acid, while pepsin is most active when the reaction is slightly acid. The different minerals dissociate and yield the desired ionic concentration.

The minerals help to maintain the neutrality of the body. The body katabolism is continually producing acids, especially carbonic, phosphoric, and sulphuric, which tend to increase the acidity of the blood. These are in part neutralized by the ammonia produced in the katabolism of the protein, and in part by the salts in the blood serum, especially the sodium phosphate and bicarbonate, which play an important part in maintaining its neutrality.

The minerals aid in respiration. Iron is an essential part of the hæmoglobin by means of which the oxygen is distributed through the body. Iodine also is an essential ingredient of the thyroid gland, without which serious disturbances result.

The minerals are also necessary in putting certain materials into solution. Certain proteins, for example, are soluble only in dilute salt solutions. Certain minerals also aid in digestion, especially of the fats and protein, and certain others are useful in protein and carbohydrate metabolism.

Organic Matter

The chemist obtains the organic matter by taking the difference between the dry matter and the ash. Organic matter is divided into three groups, namely: protein, fat and carbohydrates.

Protein.—The crude protein of feeding stuffs is not obtained directly by the chemist. The usual method of analysis is to determine the amount of nitrogen and then to multiply this amount by the factor necessary for the particular feed. The factor most commonly used is 6.25.

Classification of Proteins.—The proteins have been classified, not according to their nutritive properties, but according to certain characteristic chemical properties, particularly that of solubility. The classification is as follows:

A. Simple Proteins.—These are naturally occurring proteins, which, on being treated with enzymes or acids, break up only into amino acids or their derivatives.

1. *Albumins.*—These are soluble in pure water and coagulable by heat. Egg albumin, lactalbumin, and serum albumin are the most important ones, but others are found in small amounts in some of the common grains and legume seeds.
2. *Globulins.*—These are insoluble in pure water, but soluble in neutral salt solutions. Globulins are found in blood, in milk, and in many of the seeds.
3. *Glutelins.*—These are insoluble in pure water and neutral salt solutions, are soluble in dilute acids or alkalies. They are characteristic of the cereals. Combined with a prolamine, they form the gluten.
4. *Prolamins.*—These are soluble in 70 per cent alcohol. They are found especially in the seed of the cereals. Zein in corn, gliaden in wheat, and hordein in barley are examples.
5. *Albuminoids.*—These are insoluble in all neutral solvents but soluble in strong acids or alkalies, which decompose them. They are found in animals only. Collagen, found in connective tissue, and keratin, found in epidermal tissue, such as hair, horn, and hoof, are examples.
6. *Histones.*—These are soluble in water but insoluble in very dilute ammonia. They are found only in animals. The globin of hæmoglobin in the blood is a histone.
7. *Protamins.*—These are soluble in water, and not coagulable by heat. They are also found in animals. They have the smallest number of amino acids in their molecule of any class of proteins.

B. Conjugated Proteins.—These are compounds of simple proteins with some other non-protein groups. The non-protein group is usually acid in reaction.

1. *Nucleoproteins.*—These are proteins combined with nucleic acid and are especially characteristic of the nucleus of the vegetable or animal cell.
2. *Glycoproteins.*—These are proteins combined with substances containing a carbohydrate group other than nucleic acid. The mucins and mucoids are the most important.
3. *Phosphoproteins.*—These are proteins combined with some phosphorus-containing substance. Casein in milk and vitellin in egg yolk are important.
4. *Chromoproteins.*—These are conjugated proteins in which the additional groups are colored. The most common is hæmoglobin which is a combination of globin with hæmatin and gives the red color to blood.
5. *Lecithoproteins.*—These are protein combined with lecithin.

C. Derived Proteins.—This group is artificial, but includes all those decomposition products of the simple proteins which are produced by the action of enzymes or other agencies.

1. *Primary Protein Derivatives.*—These include proteans, metaproteins, and coagulated proteins. They are derivatives of proteins in which the proteins have been broken up slightly.

2. *Secondary Protein Derivatives.*—These include proteoses, peptones, and peptids, each simpler than the preceding one. They are obtained by the breaking up of the protein molecule.

Composition of Proteins.—All proteins contain carbon, hydrogen, oxygen, and nitrogen; many contain sulphur, and a few contain phosphorus. The protein molecule is very complex, and there are very few proteins of which the exact formula is known. That of hæmoglobin has been given as $C_{758}H_{1203}O_{218}N_{195}S_2Fe$.

Structure of Proteins.—When simple proteins are broken down they yield amino acids. This indicates that proteins are made up of amino acids linked together. About twenty-one different amino acids have been isolated. The number of amino acids contained in a protein molecule varies in different proteins. There are no two proteins alike in this regard. Some proteins contain none of the more important amino acids. This fact is very important in the study of nutrition, as it is thought that the animal cannot make these amino acids, and many of them are essential to proper nutrition.

Function of Proteins.—The function of the protein in the animal body is to supply the animal with the living tissue necessary for the replacement of all worn-out material, and to supply the protein content of the milk. Protein can also be used as a source of energy.

Non-protein Nitrogen-containing Substances.—Feeding stuffs contain a great variety of nitrogen-containing substances which are not proteins but have a very much less complex molecular structure. The most important of these compounds are amids and amino acids. Plants build up proteins through these compounds; therefore they are found in more abundance in young, growing plants. Animals use amino acids to build up proteins within their bodies; when animals eat young plants, therefore, they obtain these compounds in a more or less predigested state. Armsby[2] at first thought that these compounds could not be used by animals, so he originated the term "digestible true protein," by which he meant simply the digestible crude protein minus these non-protein nitrogen-containing substances. It is pretty well agreed now, however, that these can be used as food in the animal body.

Carbohydrates.—The carbohydrates of plants are one of the most important parts of the feeding stuffs. They are found only in small amounts in animals but are especially characteristic of plants. The carbohydrates of feeding stuffs are divided into fiber and nitrogen-free extract. The fiber is the woody portion of the feeding stuff and is determined by boiling a sample in weak acid and alkali and washing out the dissolved matter. It is less digestible than the other nutrients of feeding stuffs. The nitrogen-free extract is determined by the difference and not by direct analysis. The total dry matter minus the sum of the protein, ash, fat, and fiber gives the nitrogen-free extract. It has a high nutritive value.

Composition of Carbohydrates.—The term carbohydrate means simply a compound composed of carbon, and hydrogen and oxygen in the proportion in which they exist in water. The more important carbohydrates in nutrition are as follows:

1. *The monosaccharides, or simple sugars*, $C_6H_{12}O_6$.—In this group glucose, levulose, and galactose are the most important. Of these glucose is the most common. It is not commonly found in the feed, but is the sugar of the body. All carbohydrates, before they can be utilized by the body, are converted into glucose.
2. *The disaccharides, or compound sugars*, $C_{12}H_{22}O_{11}$.—In this group, sucrose, maltose, and lactose are the most important. They are compounds of two molecules of the simple sugars, with the elimination of one molecule of water, $C_6H_{12}O_6 + C_6H_{12}O_6 \longleftrightarrow C_{12}H_{22}O_{11} + H_2O$. Sucrose, also known as cane sugar, is the most common. It is the sugar of the beet and the cane, and is made from one molecule of glucose and one of levulose. Maltose, or malt sugar, is formed by the union of two molecules of glucose, while lactose, the sugar of milk, is formed by the union of one molecule of glucose with one of galactose.
3. *The polysaccharides* $(C_6H_{10}O_5)_x$.—While there are several compounds belonging to this group, the most important in nutrition are the starches, glycogen, and cellulose. They are compounds of many molecules of the simple sugars. The starches are the reserve carbohydrates of the plant and are very abundant; especially in seeds, fruits, and roots. Glycogen is the storage carbohydrate of the body and is not found in plant life. Cellulose is even more complex than the starches and goes to make up the woody parts of the plant. As plants mature, the cellulose combines with other substances, especially lignin, and forms compounds even more insoluble.
4. *Pentosans* $(C_5H_8O_4)_x$.—The pentosans are found in large amounts in animal feeds. They are the result of the union of a large number of molecules of pentose, $C_5H_{10}O_5$, in the same way as starch is formed from the union of many molecules of glucose. They are found in the largest amounts in the woody portion of plants. They are very abundant in many of the common feeds. The straws contain from 23 to 30 per cent, while corn contains 5.9 per cent, and cottonseed meal 7 per cent.

Properties of Carbohydrates.—Carbohydrates have three important properties in nutrition. They are unstable, easily oxidized, and easily reduced. All carbohydrates are very unstable in the presence of living protoplasm, and can be easily broken down or changed into other sugars. They are readily oxidized, heat being given off during the oxidation (exothermic). In this manner they can be used as fuel in the body. They are also easily reduced and form products which can be readily turned into fat. In this way they can store up heat (endothermic).

Function of Carbohydrates.—The carbohydrates are the energy givers of the body. They are not stored in the body in large amounts as carbohydrates, but can be changed into fat, the form in which energy is largely stored.

Fats.—Fats are not as important in nutrition as either carbohydrates or proteins, but they do play some part and are made and stored in large quantities by farm animals. The chemist obtains the fat of feeding stuff by treating a sample of feed with ether, which dissolves the fat and related substances. This is called ether extract by the chemist, but really contains other substances besides the fats.

Structure of Fats.—Fats are formed by a union of compounds, known as fatty acids and glycerin. They contain the same elements as do carbohydrates, but the proportion of oxygen is much less, and that of carbon and hydrogen much greater, than in the carbohydrates. The principal saturated acids contained in the animal fats are palmitic acid, $C_{15}H_{31}COOH$; stearic acid, $C_{17}H_{35}COOH$; and arachnic acid, $C_{19}H_{39}COOH$. Others occur in small amounts. In butterfat a large number of the fats in the lower series are present, such as butyric, C_3H_7COOH.

The unsaturated acids differ from the saturated acids in that they contain two or more carbon atoms united by two bonds. As a result, the unsaturated acids contain less hydrogen than the saturated ones. The most important one in animal fat is oleic acid, $C_{17}H_{33}COOH$. Linolenic acid, $C_{17}H_{29}COOH$, found in linseed oil, and linoleic acid, $C_{17}H_{31}COOH$, found in cottonseed oil, are also unsaturated.

Characteristic Properties.—Fats can be changed into fatty acids and glycerin and vice versa. The one is a process of hydrolysis while the other is a process of condensation. This is a very important reaction in nutrition. It is isothermic and so does not require energy:

$$\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + 3C_3H_7COOH \longleftrightarrow \begin{array}{l} CH_2OOCC_3H_7 \\ | \\ CHOOCC_3H_7 \\ | \\ CH_2OOCC_3H_7 \end{array} + H_2O.$$

Fats are soluble in ether, in oils, and in oily materials, and will dissolve in oleic acid. They will also emulsify very easily. These properties are of great importance in nutrition.

Functions of Fats.—The fats are used in the animal body as a source of fuel. They are a concentrated form of fuel containing much more energy per unit than any of the other nutrients. Since this is true, they are well adapted for the storage of reserve energy in the body, for which function they are used. They also have, to a limited degree, certain structural functions.

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LECTURE III

THE WORK OF DIGESTION

THE animal body secures all the nutrients for its growth from solutions of the food, much in the same way that plants secure all the nutrients for their growth from water solutions in the soil. The process of preparing the food ingredients for passage into the blood stream is known as digestion. It is a process in which the complex molecules are broken down into simple ones so that the soluble portions can be separated from the insoluble, and the latter eliminated from the body. In this process the carbohydrates are broken down into monosaccharides, the fats into fatty acids and glycerol, and the proteins into amino acids. In every case a larger, more complex molecule is broken down into a smaller, simpler one. This change is brought about largely by the digestive enzymes. Many other reactions in the body are dependent on enzyme action.

Enzymes.—Enzymes are organic compounds of unknown chemical structure which have the power to change or break down other organic compounds without themselves being changed or broken down. No enzyme has ever been isolated. Enzymes do not in themselves cause any chemical action but are merely agents which control the rate at which chemical reactions take place. The most important reaction which they control is hydrolysis; however, some enzymes control oxidation while others control reduction.

Enzymes are sensitive to heat and can be destroyed if heated above a certain temperature. Some work best in an acid medium while others act only in an alkaline medium. Each enzyme of digestion is capable of acting only upon one kind of material; in other words, there is a specific enzyme for proteins, a specific enzyme for carbohydrates, and a specific one for fats. There are four groups of digestive enzymes: namely, the amylases, which act on starch; the invertases, which act on the disaccharides; the proteases, which act on the proteins; and the lipases, which act on fats. These are secreted in fluids by numerous secreting glands which are essential parts of the organs of digestion.

The Alimentary Canal.—The alimentary canal of the ruminants, which include the dairy animals, is much more complex than that of other animals. It includes the mouth, the gullet, the four stomachs, the small intestine, and the large intestine. These together form a long, winding canal approximately 180 feet long in the average dairy animal. The dairy animal has four stomachs, which are as follows:

1. The rumen, or paunch;
2. The reticulum, or honeycomb;
3. The omasum, or manyplies;
4. The abomasum, or true stomach.

The first three of these may be considered as an enlargement of the gullet and should not be considered as true stomachs.

Digestion in the Mouth

The mouth is the organ of prehension, mastication, and insalivation. The animal, by means of its tongue, lips, and teeth, conveys its food to its mouth. With the teeth also, it chews and prepares the food for swallowing. The dairy cow, while eating, chews her food only enough to moisten it and to form it into a mass of suitable size to be swallowed. The food is then held in the paunch until her hunger is satisfied; she then returns it, in the form of a "cud" to her mouth where it is thoroughly masticated and mixed with the saliva before being reswallowed. The dairy animal can masticate on only one side of the mouth at a time. When this side becomes tired, the process is reversed and the opposite molars take on the work of mastication.

The process of mastication excites the three salivary glands, causing them to secrete a large amount of saliva which readily mixes with the food. The amount of saliva secreted in a day's time is enormous. Colin[1] estimates that a cow utilizes as much as 112 pounds of saliva a day. This amount is increased if the food is unusually dry. The saliva of some animals contains the enzyme ptyalin, which converts starch to sugar. In dairy animals, however, this enzyme is either entirely absent or is present in a very small amount. The use of the saliva in these animals, therefore, is to assist mastication and swallowing, to stimulate the nerves of taste, and to assist rumination. There is, then, no true digestion taking place in the mouth. The food is merely prepared there for the later action of the enzymes in the rest of the digestive tract.

Colin states that the bolus, or "cud," weighs from 3 to 4 ounces and requires about three seconds to ascend and one and one-half

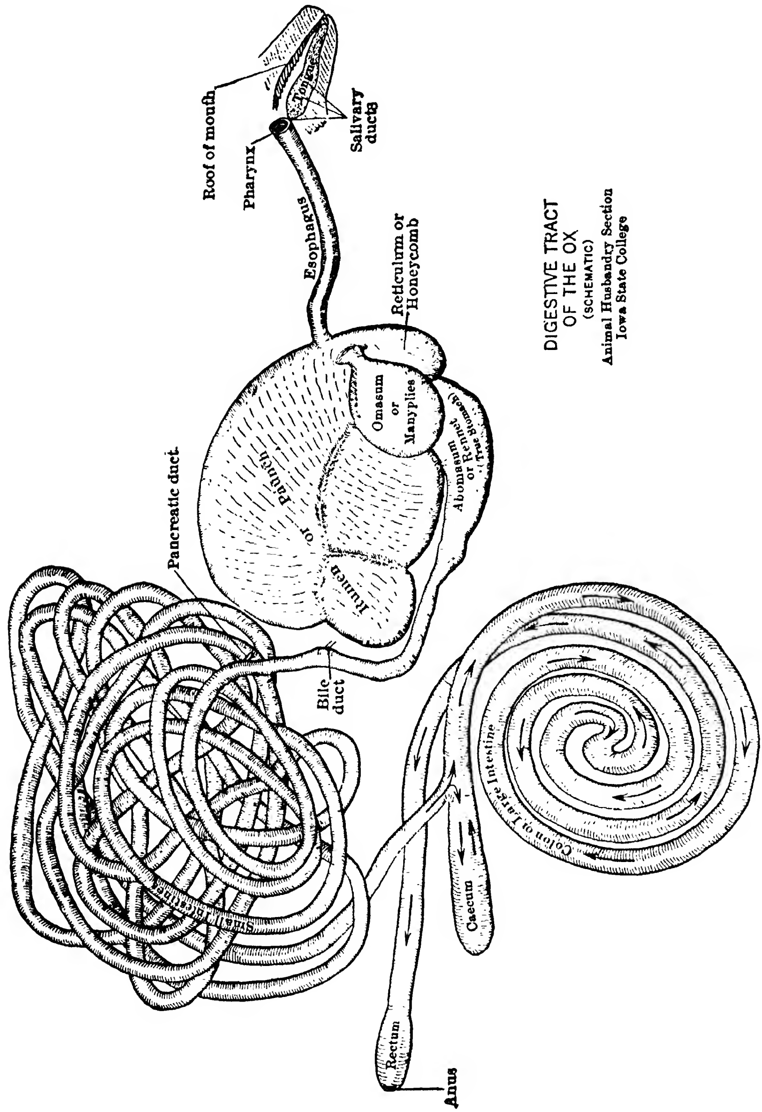

FIG. 3.—The digestive tract of the ox (schematic).

seconds to descend after complete mastication. The chewing of the "cud" occupies about fifty seconds. Rumination is, therefore, a slow process and occupies at least seven hours out of the twenty-four. If an animal is alarmed or disturbed she immediately ceases to ruminate. One of the very first signs of ill health is the suspension of rumination.

After the food has been thoroughly masticated and mixed with saliva, the act of deglutition, or swallowing, takes place. This is brought about by the action of the muscles of the throat and tongue, which force the food into the esophagus, or gullet, the tube-like passage extending to the stomach. The gullet of a cow is easily stretched, with the indirect result that animals are often choked. Food passing into the gullet without proper mastication, as when apples are swallowed in large pieces, is likely to cause choking.

Digestion in the Stomach

The Rumen.—As previously stated, mastication in the dairy cow is not completed at the time the food is taken into the body. The cow simply chews the material sufficiently to pass it through the esophagus into a reservoir called the paunch, or rumen.

The material is then held in the rumen until a convenient time for complete mastication. The rumen of the dairy cow has a very large capacity, having a breaking point of about 50 gallons.[2] The rumen is divided into four sacs, by constrictions in the wall produced by large muscular bands. The interior of the organ is lined with a well-developed mucous membrane, covered with pointed papillae.

The food is passed back and forth in the paunch with a churning motion, fermentation taking place at the same time. When fermentation proceeds at such a rate that the blood is unable to absorb the gases formed, a case of hoven, or bloat, occurs. The bolus, or "cud," is formed when the animal desires to ruminate, and is passed back to the mouth by the combined action of the rumen and reticulum. The passage between these is known as the esophageal groove. From this groove the cud is passed into the esophagus and returned to the mouth for complete mastication.

The rumen never empties itself. Even after long periods in which no food is eaten, the rumen will contain food. In young calves the first three stomachs are rudimentary and the food passes directly into the true stomach, or abomasum. The rumen has no digestive juices, and, since the saliva of the dairy cow does not contain much, if any, ptyalin, no true digestion takes place in this stomach. The contents of the rumen are generally alkaline. The fermentation in this organ enables the cow to digest large amounts of cellulose or crude fiber and pentosans which would otherwise go to waste. Certain bacteria, which form the flora of the rumen, seem to have the power of secreting enzymes which act on the cellulose and pentosans, thereby breaking them down with the production of heat and the formation of organic acids, particularly acetic and butyric, and such gases as methane, carbon dioxide and hydrogen. The bacteria may also attack starch and sugar and break them down.

The Reticulum, or Honeycomb.—The reticulum, or honeycomb, is much smaller than the rumen. In the dairy cow it has a breaking point of about 13 quarts. Its interior is lined like a honeycomb, hence the popular name. It is connected with the rumen and the esophagus by means of the esophageal groove. In this sack, stones, nails, and other foreign objects may frequently be found. Oftentimes nails or wires penetrate the heart from the reticulum.

The contents are fluid and alkaline. There is no secretion from the walls of this stomach, and as a result, it has no true digestive power. Its function has not been fully demonstrated, but it seems to assist in passing the bolus up the esophagus and to regulate the passage of the food from the rumen to the omasum, and from the rumen to the esophagus.

The Omasum, or Manyplies.—After the food has been thoroughly masticated it goes directly to the omasum. This is a peculiarly shaped organ with a breaking point of about 20 quarts. The omasum, like the reticulum and rumen, possesses no secretive powers but consists of powerful muscular leaves that squeeze the water out of the matter which it receives. Some of this water, of course, is absorbed by the organ, but most of it passes directly to the abomasum, or true stomach. The solid portion remains in the omasum to be further acted upon by the leaves. These leaves are covered with papillae which become shorter, thicker, and stiffer as they advance. The movement of the leaves is not simultaneous, but successive, in such a way that the rasping of the food is continuous, so that the food is ground finer and finer until it enters the abomasum. When illness occurs, rumination ceases, thus cutting off the chief supply of fluid to the omasum. The content then becomes dry and often cakes, resulting in a condition in which it is practically impossible to pass anything through the animal. From the omasum the food passes directly into the abomasum.

The Abomasum, or True Stomach.—This organ, which has a breaking-point capacity of about 20 quarts, is the true digestive stomach of the cow. The walls of this stomach secrete the gastric juices, which contain less than one-half of one per cent of hydrochloric acid, and the two enzymes, pepsin and rennin. Pepsin can act only in an acid medium, hence it is the function of the hydrochloric acid to change the alkaline condition, which the food has maintained up to this point, to an acid one. Pepsin acts on the proteins and breaks them down into simpler compounds, mainly peptones, and proteoses, but does not break them down into amino acids.

Rennin is an enzyme which curdles milk, and is therefore very important in the case of young calves that are fed milk. If it were not for the action of the rennin, the milk might pass through the digestive tract without being acted on by the digestive enzymes.

Digestion in the stomach is sometimes spoken of as a process of chymification, since the pulpy mass of semi-liquid food which is ready to pass from the true stomach to the intestines is spoken of as the chyme. The opening of the stomach into the intestines is controlled by a sphincter muscle which in turn is controlled by the reaction of the chyme. When the reaction of the chyme within the stomach becomes acid to a certain degree, this sphincter muscle relaxes and allows some of the chyme to pass through into the intestines. Mechanical stimulation may also have some effect in keeping this muscle rigid.

Digestion in the Intestines

The intestines are composed of two well-defined parts, the small intestine and the large intestine. The small intestine is a long, folded tube into which the stomach empties. Its length in the cow is about 135 feet and it has a capacity of about 40 quarts. The walls of the intestines are covered with very small, finger-like projections called villi. In the intestines, the food comes into contact with three digestive juices: the pancreatic juice, the bile, and the intestinal juice.

The Pancreatic Juice.—The pancreatic juice is a clear, watery fluid and has an alkaline reaction. It is secreted by the pancreas, or "sweetbread," which is a slender gland lying just below the stomach. Careful experiments have shown that the pancreatic juice flows only when chyme is coming from the stomach. This chyme is acid in reaction. The acid, acting on the lining of the intestines, produces a substance which is absorbed into the blood, and after being carried to the pancreas, causes it to secrete the pancreatic juice. This substance is called a hormone. In this way the organs of digestion are made to work in harmony. This pancreatic juice contains three enzymes: trypsin, amylase, and lipase. *Trypsin* is a protease and, like pepsin, acts on the proteins, converting them into proteoses and peptones and breaking them up to a certain extent into amino acids, in which form the protein can be taken up by the animal body. Trypsin will not work on the protein until it is made active by coming in contact with the enzyme enterokinase which is secreted by the intestinal walls. *Amylase* converts starches into maltose. In the case of a ruminant, such as the dairy cow, it is undoubtedly used more largely than in the case of a non-ruminant, where ptyalin has a greater effect. *Lipase* separates the fats into fatty acids and glycerin, thus enabling them to pass through the walls of the intestines. Some of the fatty acids unite with the alkalies in the bile and form soaps, a form in which they are soluble.

The Bile.—The bile is the thin, yellowish-brown, or greenish liquid secreted by the liver. It is alkaline in reaction and changes the reaction of the chyme as it comes from the stomach from an acid to an alkaline or neutral one. Bile is stored in the gall bladder and flows only when required. It is stimulated by a hormone in the same manner as is the pancreatic juice. Bile does not contain any digestive enzymes, but it does greatly aid digestion. It is useful in emulsifying the fats, breaking them up into very small globules, and thereby greatly increasing the surface area so that the lipase can work on them more easily. It furnishes salts which may combine with fatty acids, thus forming soaps, in which form fat can be taken up by the body. It also helps to dissolve the soaps and fatty acids. If bile is excluded, the digestion of fat is reduced, and this in turn retards the digestion of carbohydrates and proteins. One of the acids which bile contains, taurocholic, accelerates the peristaltic movement of the bowels. Colin states that the cow will secrete nearly 5.7 pounds of bile in a day.

The Intestinal Juice.—The mucous membrane of the intestines is lined with glands which secrete the intestinal juice, also known as the *succus entericus.* This fluid contains several enzymes, the most important of which are erepsin, a proteolytic enzyme, and the invertases, namely, sucrase, maltase, and lactase. It also contains enterokinase, the principle that activates trypsin.

Erepsin acts on the proteoses and the peptones, which have been broken down from the proteins by the pepsin and trypsin, and breaks them down to simple amino acids. It cannot act on protein that has not already been broken down to the proteoses and peptones.

Sucrase, maltase, and lactase convert the cane, malt, and milk sugar into the simple sugars. Sucrose is broken down into one molecule of glucose and one molecule of levulose; maltose, into two molecules of glucose; and lactose, into one molecule of glucose and one of galactose. These enzymes do not act upon the starch.

The food is carried forward in the intestines by a peristaltic movement. This is a wave of constriction followed by a wave of relaxation. The food moves very slowly, and the digestive juices have plenty of time to do their work. The upper part of the intestinal tract is specialized for secretion, and the lower part is specialized for absorption.

The Large Intestine.—When the content of the small intestine reaches the large intestine it still contains undigested food. The food remains in the large intestine a relatively long time, thus permitting the digestive processes started in the small intestine to continue, and also permitting complete absorption of all digested food. In the large intestine the food undergoes a great deal of bacterial action. Putrefaction takes place, causing the offensive odor of the feces and often setting free large quantities of poisonous products. No digestive fluid is secreted in the large intestine, but many katabolic products are there returned to the digestive tract. Often the food remains in the large intestine for some time and becomes more solid, much of the water being absorbed. It is finally passed out through the anus as feces. The feces consist of the undigested residue of the feed, the remains of the digestive secretions, waste material resulting from wear and tear on the digestive tract, certain excretory products, and the bacterial flora.

Chemistry of Digestion

Water requires no digestive process. It is simply absorbed by the capillaries of the villi of the entire digestive tract. The *mineral matter* also passes into the blood stream without being acted upon by digestive enzymes. Some of the minerals may be taken up in organic combinations, but it is thought that most of them are brought into solution, to a greater or lesser extent, by the hydrochloric acid of the gastric juice, or by other agencies.

The *proteins* are first acted upon by the pepsin of the gastric juice in the stomach. They are there broken down to proteoses and peptones. The trypsin of the pancreatic juice also breaks down proteins and converts them chiefly into proteoses and peptones, although it may convert some of them into amino acids. The erepsin of the succus entericus works on the proteoses and peptones and converts them into amino acids which are the final products of protein digestion.

Of the *carbohydrates*, the starch is broken down to maltose by the enzyme amylase. The compound sugars are then converted into the simple sugars by the invertase enzymes, maltase, lactase, and sucrase—maltose forming two molecules of glucose; sucrose, one molecule of glucose and one of levulose; and lactose, one molecule each of glucose and galactose. The cellulose and pentosans, however, are not attacked by the enzymes secreted by the walls of the digestive tract. The digestion of the cellulose and pentosans is a process of fermentation, probably brought about by enzymes secreted by bacteria which accompany the food. This occurs in the paunch. The products of fermentation are gases, such as methane and carbon dioxide, which cannot be used as food, and organic acids, such as butyric, acetic, and lactic which may be taken up and used as food.

The *fats* are not acted upon to any extent until they reach the small intestine. Here they are hydrolyzed into glycerin and fatty acids by the enzyme lipase, which is secreted in the pancreatic juice. The bile causes emulsification to take place. If there is some free alkali in the digestive tract it may unite with the fatty acids, converting them into soap, but not all of the fatty acids are converted into soap.

The process of digestion is complete when the proteins have been converted into amino acids, the starches into simple sugars, and the fats into glycerin and fatty acids.

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LECTURE IV

THE USE OF FOOD IN THE BODY

Absorption

The food within the intestines is spread out in thin layers over the intestinal surface. This surface is increased millions of times by the finger-like projections, called villi (singular, villus), which line the walls of the intestines. Each villus is supplied with an artery, a vein, a capillary, and a lacteal. The mucus of the villi is very thin. Just how the food is taken up by the body is not fully known. The laws of diffusion and osmosis explain to a large extent the theory of absorption, yet it is believed that living protoplasm is essential to this process.

The food can enter the blood stream in either of two ways: by the portal vein and the liver; or by the lacteals into the lymphatic circulation which empties into the blood by means of the thoracic duct.

The amino acids resulting from the breaking down of the proteins pass through the cell wall unchanged and enter the blood stream by the portal vein. The glucose is not changed, but the levulose and galactose seem to be changed into glucose. The glucose also enters the blood stream by the portal vein. The fatty acids and glycerin are changed back to glycerides as soon as they enter the body. These glycerides then go into the lymph system in a very fine state of emulsion and later enter the blood stream by means of the thoracic duct. After a meal rich in fat, the chyle in the lymph system, flowing away from the digestive system, is white in color. While a large part of the absorption takes place in the small intestine, some of the nutrients also enter from the large intestine.

Circulation

The Blood.—In the process of digestion the food is converted into simple compounds which must be carried to the parts of the body where they are needed. This is done by means of the blood circulation. The central organ of the circulation is the heart, which is divided into four quarters. The blood coming to the heart enters the right auricle and from there is forced into the right ventricle. This contracts and forces the blood out through the lungs, where it is relieved of its carbon dioxide and takes on a supply of oxygen. The blood then returns to the left auricle, whence it is forced into the left ventricle, which, by contracting powerfully, drives the blood through the aorta and the subdividing arteries to all parts of the body. The arteries divide repeatedly into smaller branches, and finally carry the blood to the capillaries. It is through the capillaries that the cells receive their supply of oxygen and food and unload their waste products. From this point the blood returns to the heart through the veins.

The blood has many important functions, among which are the carrying of digested food from the digestive tract to the tissues, the carrying of oxygen from the lungs to the tissues, and the carrying away of all waste products of the cells to the proper place of disposal. The blood serves to keep the heat of the body evenly distributed, and it transfers water from one part of the system to another. All internal secretions are carried by the blood.

The blood is a red, opaque, rather viscous fluid. It is alkaline in reaction. The shade of red depends upon whether the source of the blood is an artery or a vein. According to Sussdorf,[1] blood forms about 7.7 per cent of the weight of a living cow's body. It is composed of serum, red corpuscles, white corpuscles, blood platelets, and fibrin. The number of red corpuscles in the blood is enormous, being estimated at 4 to 6 million per cubic millimeter. They contain as a characteristic ingredient the conjugated protein, hæmoglobin. The hæmoglobin carries the oxygen from the lungs to the tissues, while the blood serum carries the food.

The Lymph.—The body cells are not closely packed together but are surrounded by a colorless, transparent fluid known as lymph. From it, by osmosis or in other ways, the cells receive their food, and into it they deposit their waste. The lymph in turn is separated from the blood only by the thin walls of the capillaries, through which the body is supplied with its food and eliminates its waste. The lymph spaces unite to form the lymphatic system which empties into the jugular vein in the lower left side of the neck.

Metabolism

The cell, as defined by Armsby,[2] is the biological unit of life. The cells are the laboratories of the body, within which extensive chemical reactions take place. In them the food is either built up into body tissue or broken down to serve as a source of energy, as the case may be. The sum total of the chemical changes which the food undergoes in the body is known as *metabolism.* Those processes by which simple materials are built up into more complex ones are spoken of as *anabolism*, while those by which living matter is broken down into simpler substances are spoken of as *katabolism.* While digestion is characterized by hydrolyses, metabolism in general is characterized by oxidation although other forms of reaction are common. These reactions are thought to be brought about by intercellular enzymes, which are present in every cell and are able to alter the velocity of chemical reactions and thus to keep the mechanism of the body running smoothly. The final end and aim of metabolism is to supply energy for the vital activities of the body. The demand for energy is the controlling factor in the activities of the cells.

Ash Metabolism.—Very little is known concerning the metabolism of ash. As previously pointed out, many of the ash ingredients are essential to the vital processes of the animal body. Sulphur is taken into the body largely in organic combinations and is built up in the body as such. Inorganic sulphur cannot be used for this purpose. Phosphorus is probably taken into the body as phosphoric acid. Phosphorus, along with calcium, constitutes a large part of the bones, but it is also found in many other parts of the body in organic combination. The cells seem to be able to use inorganic phosphorus for building up organic compounds. At least two other ash ingredients enter into organic combinations within the animal body. They are the iron of the hæmoglobin, and the iodine of the thyroid gland. Little is known concerning the metabolism of any of the other ash ingredients.

Protein Metabolism.—As previously noted, the proteins are absorbed in the form of amino acids. These are carried in the blood to the parts of the body where they are needed, and there they are built up into new proteins peculiar to the tissues in which they are formed and different from the proteins from which they were derived. Each individual cell seems to have the power of building up these compounds. This is a condensation process.

In the katabolism of proteins, two general stages are recognized. The first stage is one of hydrolysis by which the proteins are broken down into amino acids, while in the second stage the nitrogen is split off from these acids as ammonia. This process is known as deaminization. The ammonia resulting from it is rapidly converted into urea or in the case of the herbivora, largely into hippuric acid, in which form it is excreted from the body by means of the urine. The residue of the amino acid, after the removal of the ammonia, is closely related chemically to both the carbohydrates and the fats, and may, like these, be used to supply energy, or, as has been shown with some of the amino acids, may be converted into glucose. It is probable that fat can be formed from protein, but the amount of fat thus formed under normal conditions is insignificant. All of these reactions are supposedly brought about by the intercellular enzymes.

The non-protein, nitrogen-containing material, consisting chiefly of amids and amino acids, probably enters the body in the form of amino acids and is used as such.

Carbohydrate Metabolism.—The glucose, into which the starches and sugars are converted, passes through the portal vein to the liver. Here, by a process of condensation, the glucose is changed into a polysaccharide, glycogen. The liver acts as the principal storehouse of glycogen, although some of it is stored in the muscles. As much as 10 to 15 per cent of the weight of the liver may be glycogen, and about one-half of this amount may be stored in the muscles. No glycogen is found in the blood. If more glucose is provided than the liver and muscles can take care of at once, it is eliminated through the urine. The amount of glucose in the blood is from 0.1 to 0.2 per cent, but remains remarkably constant and seems to be regulated by the supply stored in the liver and muscles. If the supply of glucose from the intestine is insufficient to maintain the normal supply in the blood, the glycogen is changed by hydrolysis into glucose and thus the supply of glucose in the blood is kept constant. It is believed that this reaction is brought about by intercellular enzymes or by the influence of the internal secretion of the pancreas. The removal of the latter organ results in the loss of glucose through the kidneys, as in diabetes. Much of the energy used by animals to warm their bodies, to do muscular work, and to produce milk comes from the oxidation of glucose and the simple sugars. In ordinary feeding stuffs, one-half to two-thirds or even more of the oxidizable material consists of carbohydrates, which when digested are taken up as glucose. Also, about 60 per cent of the protein and 10 per cent of the fats are believed to be converted into glucose in the course of metabolism.

According to Shaffer,[3] glucose may be burnt during metabolism into carbon dioxide and water, with or without an intermediate conversion into glycogen; or it may be converted into fat by reduction. The path of glucose metabolism is through a series of reactive compounds; and it is these substances resulting from molecular rearrangements which are finally oxidized, liberating energy, or are synthesized into fat and other substances. According to the generally accepted view, lactic acid represents the main intermediate in glucose metabolism, and it is with this substance that oxidation actually begins. Jordon and Jenter[4] have demonstrated that with dairy cows much of the milk-fat is produced from carbohydrates.

The organic acids resulting from the fermentation of the celluloses and pentosans enter the body without change. The lactic and acetic acids can be used directly for energy, and the others are probably changed into forms in which they can be used.

Fat Metabolism.—The fatty acids and glycerin, upon entering the lymphatic circulation, are changed back to glycerides and in this state are carried as a fine emulsion through the thoracic duct, which empties into the blood stream in the neck. Just how the blood carries the fat is not fully known. Bloor[5] states that the red blood corpuscles take up the fat from the plasma and transform it into lecithin and that lecithin is an intermediate step in the metabolism of fats. Gage and Fish[6] were able to follow the very minute particles of fat emulsion, which they call chyle microns, in the blood through the entire body, by the aid of a high-power, dark-field microscope. They found that these particles appeared in the blood one-half to one and one-half hours after eating and that after six to eight hours they had disappeared from the blood. They also found, by means of dyes, that the source of the fat in the milk of dairy cows was not the fat in the food, although with the goat and other animals this seemed to be the case.

The fat is stored in the adipose tissues and can be used as a source of energy when needed. It has been shown that when the food supply is inadequate, the stored fat is drawn upon for the support of the internal activities of the body and as a source of energy. The exact chemical changes which take place are not known, but it is probable that different lipase enzymes which are widely distributed in the body break up the fat into glycerin and fatty acids, which are then oxidized. The final products of this oxidation are carbon dioxide and water. Whether fat can be converted into glucose is not fully known. It is thought, however, that at least the glycerin part can be so converted.

Milk Secretion

The food that enters the body of the dairy cow is used not only in building up tissue and performing work, but also in the production of milk, for which a large amount of food is necessary. Milk is composed of water, protein, fat, carbohydrates, and ash, as are the feeds from which it is made. However, the individual compounds present in the milk vary greatly from those found in the feed or in the cow's body. The principal protein in milk is casein, which is found nowhere else in nature. The other proteins contained in milk are lactalbumin and a small percentage of globulin, which is very similar to the globulin found in the blood. Lactose, the sugar of milk, like casein, is found nowhere else in nature. The fats of milk are also different from those of the body or of the feed, as they contain many of the fatty acids of a low molecular weight. The ash ingredients are not found in the milk in the same proportion as in the blood.

These facts indicate that milk formation is a true secretion process and not merely a filtration of material from the blood. Many of the ingredients of milk are found nowhere else in the body and so must be manufactured in the mammary gland itself. Gowan[7] states that the cells secrete the materials of the milk solids without themselves breaking down. This means that the mammary gland constructs its constituents in its cells, just as does the salivary gland, and is thus quite distinct from an excretory gland. Recent experiments denote that a large percentage of the milk is already in the udder at the beginning of the milking period.

Paths of Excretion

The vital activities of the body lead to the formation of products which must be removed. The most common of these are carbon dioxide, water, urea, and some mineral ingredients. An accumulation of such products tends to stop the vital activities of the cells.

Carbon dioxide is mainly given off through the lungs, but a small amount is excreted through the skin. It is carried to the lungs by the blood. Water is removed by evaporation from the lungs and from the surface of the body. According to Armsby,[2] a 1000-pound steer, at an ordinary temperature and on light feed, may easily excrete through the lungs and skin 8 to 10 pounds of water in twenty-four hours. The feces also contain a large amount of water. Water is likewise excreted in the urine, serving as a solvent for the nitrogenous product of cell activity.

The urea and other nitrogenous materials which result from protein katabolism are excreted mainly through the urine. Most of the mineral ingredients, especially sulphur, chlorine, and the alkalies, are also excreted through the urine; but the intestines are the usual path of excretion of calcium, phosphorus, iron, and to some extent magnesium.

Digestibility of Food Stuffs

The word " digestion " is used to include all the processes necessary for the conversion of food into the soluble forms in which it is assimilable. However, not all of the food can be converted into soluble forms so that it can be absorbed. To determine what portions of a food may be absorbed, digestive trials are run. For this purpose it is necessary to analyze the foods consumed and the feces excreted; the difference between what is fed and what is excreted is said to be the digestible food. *The coefficient of digestibility* is the percentage of food that is digested. The sheep and the steer have been used more often in digestion trials for the determination of the coefficient of digestibility than any other animals. The dairy cow has not been used so often because it is difficult to harness her in such a way that the liquid portion of the excreta is kept separate from the solid portion. When dairy cows are used it is essential that they be watched constantly in order to make such separation. For the proper conduct of a digestion trial, samples are taken from six to ten days after a preliminary period of two weeks. It is necessary that several days' collection of excreta be taken in order that a satisfactory average may be secured. Aliquot portions of the daily excreta are saved and composted for the final sample.

Table VI[8] gives the chemical analysis of the dry matter of the hay fed to a steer and of the feces of the steer in a digestion trial at the Pennsylvania Experiment Station:

TABLE VI

Analyses of Dry Matter of Hay Fed to Steer and Feces of the Steer at the Pennsylvania Experiment Station

	Ash	Protein	Non-Protein	Crude Fiber	Nitrogen-Free Extract	Ether Extract
Timothy hay...	5.82	7.11	0.50	34.06	50.73	1.78
Feces.........	6.60	10.71	0.00	34.61	46.02	2.06

The animal was fed 3000 grams of timothy hay per day; but after the residue was subtracted, the amount eaten daily was 2647.2 grams. The average daily weight of the feces collected was 1199.1 grams. From these figures it can be calculated that the amount digested was as given in Table VII:

TABLE VII

Amount of Feed Digested and Coefficient of Digestibility of Dry Matter of Timothy Hay Fed to Steer at Pennsylvania Experiment Station

	Ash	Protein	Non-Protein	Crude Fiber	Nitrogen-Free Extract	Ether Extract
Timothy hay...	154.1	188.2	13.2	901.6	1342.9	47.1
Feces.........	79.1	128.4	00.0	415.0	551.8	24.7
Digested......	75.0	59.8	13.2	486.6	791.1	22.46
Coefficient of digestibility..	48.67	31.77	100.0	53.97	58.91	47.56

It is assumed that the feces contained only undigested food. This, of course, is not strictly true, since many metabolic substances are added from the blood and from the excretions which enter the digestive tract, and there is no method of determining these metabolic products; hence, that which is really apparent digestibility is called digestibility. Since some of the minerals, especially calcium, phosphorus, iron, and part of the magnesium, are excreted mainly through the intestines, this method cannot be used to determine their digestibility.

Factors Influencing Digestibility.—Several factors influence digestibility. Animals of different species vary widely in the percentage of food digested, but animals of the same species are nearly the same in this respect. There is very little difference between the various breeds of dairy cows. The main differences are individual ones and are due to faulty teeth, diseased digestive organs, intestinal worms, etc.; but these differences rarely exceed 3 or 4 per cent. In the young calf the first three stomachs are not well developed, and until the calf is old enough to eat roughage it cannot ruminate and properly develop these stomachs. After the stomachs are fully developed, the age of the animal seems to have far less influence on the percentage of food digested. Heavy feeding seems to decrease the digestibility of the food, probably because of the greater bulk, the relatively rapid passage through the digestive tract, and the consequent lessened extent of bacterial fermentation. Roughages as a rule are less digestible than concentrates because the large amounts of crude fiber in such feeds tend to protect them from the action of the digestive juices. Palatability may have some effect on digestibility since it has been shown that palatability influences the secretion of the digestive juices. Feeders practice cooking, soaking, grinding, and the use of condiments, with the idea of increasing digestibility. Grinding does increase digestibility, especially in the case of hard seeds, which otherwise would go through the digestive tract unbroken. Grain should, therefore, be ground when fed to dairy cows. The cutting of roughage or the soaking of feeds apparently does not increase digestibility.

Total Digestible Nutrients.—The total digestible nutrients of any feeding stuff are determined by taking the sum of the digestible crude protein, the digestible carbohydrates, and two and one-quarter times the digestible fat. The total digestible nutrients are simply the nutrients of the feeding stuff converted into carbohydrate equivalents. On the average, fat contains about two and one-quarter times as much energy as do carbohydrates, and protein contains about the same amount as do carbohydrates.

Determination of the Use of Food in the Body.—The coefficient of digestibility tells the percentage of the food that is assimilated by the body, but it does not tell what use the animals make of the nutrients, after they are once within the body. This has to be determined by a complete balance of nutrition, in which the entire intake is balanced against the entire outgo. The intake includes air, food, and water, while the outgo includes the feces, urine, gases, and heat. By measuring each of these, it is possible to determine exactly how much of the gross energy of the feed the animal has been able to use for growth, fattening, work, or milk production.

The Respiration Calorimeter.—Several forms of respiration apparatus, permitting a very exact determination of the gaseous exhange, have been constructed; but only when a respiration calorimeter was built at the Pennsylvania Experiment Station, in 1898, was it possible to combine with a determination of the respiratory products a direct measurement of the heat given off by a domestic animal, such as the dairy cow.

The respiration calorimeter at the Pennsylvania Experiment Station [9] consists of a stall, constructed of sheet copper, and large enough to hold a cow or steer comfortably. It is completely air-tight. Under the rear portion of the stall there are receptacles, enclosed in a small, air-tight chamber, for collecting the feces and urine which are conducted to them by means of rubber tubes. This chamber is close with an air-tight door. The feed and water are put into the stall through an air-tight door in the front. All the doors are kept tightly closed except when the animals are being fed and watered, or the excreta removed. This requires only a few minutes each day. Samples of the feed and excreta are taken and analyzed. Exact records of their weight are also kept.

The air is measured, sampled, and analyzed for water, carbon dioxide and methane, both, as it enters and as it leaves the stall. The heat given off is also measured. It is thus possible to determine accurately the expenditures of an animal.

Table VIII shows how it is possible to compare the income and outgo of energy and get the balance of energy by means of the respiration calorimeter.

TABLE VIII

DAILY ENERGY BALANCE OF A STEER [2]

	Income, Calories	Outgo, Calories
6,988 grams timothy hay	27,777	
400 grams linseed meal	1,811	
16,619 grams feces	....	14,243
4,357 grams urine	....	1,210
37 grams bushings	....	88
142 grams methane	....	1,896
Heat	....	11,493
Gain in body	....	608
	29,538	29,538

Metabolizable Energy.—The animal body may be compared to a gasoline engine, requiring, first, repair material to keep it in good running order, and second, fuel with which to do its work. The working part of the body is furnished by the water, protein, and ash, while the fuel is supplied by the carbohydrates and fats, although the protein also furnishes energy during its katabolism. The total energy furnished in the feed is the gross energy. However, not all of this is available to the body, as some is lost in the feces, some in the urine, and some in the gases which escape from the body. The metabolizable energy is that part of the gross energy which is not carried off in the urine, feces, or gases. In other words, it is the energy that is capable of transformation in the body.

Net Energy.—It has been found by means of the respiration calorimeter that some energy is spent in the work of digestion. This is especially true of the herbivora. The metabolizable energy minus the energy required for the work of digestion is known as the net energy. Armsby defines the net energy value of a feeding stuff as the energy remaining after the losses of chemical energy in the various excreta and also the energy expended in the processes incident to the consumption of the material have been deducted from its gross energy.

An example of the method of determining the net energy value of a feeding substance is given in Table IX.[2] In the balance experiments with a steer, two different amounts of timothy hay, both insufficient for maintenance, were fed during successive periods.

TABLE IX

DETERMINATION OF NET ENERGY VALUE OF TIMOTHY HAY

	Dry Matter of Hay Eaten, Lbs.	Metabolizable Energy, Calories	Heat Produced, Calories	Gain of Energy, Calories
Period 4	10.21	9544	9812	− 268
Period 3	6.17	5768	8064	−2296
Difference	4.04	3776	1748	2028
Difference per pound dry matter of hay	....	935	433	502

In this case the net energy of one pound of dry matter was 502 calories.

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LECTURE V

SELECTION OF FEEDS

In order to feed dairy cattle most efficiently it is necessary to know the characteristics and properties of some of the more important dairy feeds. The selection of feeds is important both from the standpoint of economy of production and from that of the health of the animals.

It is always best to use as many home-grown feeds as possible and to buy only what is necessary to balance them properly. By this method the crops can be disposed of directly to the cow, and thus the expenses and losses due to marketing are avoided and profits which would otherwise be absorbed by purchasing feeds are saved.

Feeds can be divided into two great classes:

1. Roughages;
2. Concentrates.

The roughages consist of silage, hay, and all the other coarse, bulky portions of the ration. The concentrates include the cereal grains and a great number of by-products of the milling and other industries.

Legume Roughages

Alfalfa.—Alfalfa hay is one of the very best roughages for diary cattle. It is very palatable and has a good effect upon the digestive system, as it is slightly laxative in character. It is high in protein and is the highest of all common feeds in calcium.

Clovers.—Clover hay has the same advantages as alfalfa hay, except that it is a little lower in protein and is slightly less palatable. There are at least four kinds of clover grown in the United States, viz., alsike, crimson, red, and sweet. These all have about the same feeding value, but alsike is finer in the stem, which makes it especially well adapted for feeding young calves. Sweet clover is hard to cure properly and should be cut when the first blossoms appear, as the stems rapidly grow woody after this stage is reached. Although it has about the same feeding value as the other clovers, a much larger proportion is usually refused by dairy cattle.

Cow Peas.—Cow-pea hay, when it can be properly cured, provides a roughage that is even better than alfalfa or clover, as far as its food constituents are concerned. It is grown principally in the southern part of the United States.

Soy Beans.—Soy-bean hay, when properly cured, makes a very good roughage for dairy cattle. It is slightly higher in protein and total digestible nutrients than is alfalfa, but it is usually coarser and for this reason more is refused. It is very palatable, but, when allowed

Fig. 4.—A field of soy beans ready to be harvested for hay.

to get too ripe, has coarse, woody stems which the cows will refuse. It is slightly constipating in its effect but is high in calcium. Its chief disadvantages are, first, that it is hard to cure properly; and second, that the cost of growing is usually higher than that of alfalfa, as it must be seeded each year. However, it can be grown in some places where alfalfa cannot.

Non-Legume Roughages

Corn Fodder.—Corn fodder, which includes both the grain and the stalk, is not very satisfactory as a feed for dairy cattle, especially if they are to be fed in the barn, as it is difficult to feed in the mangers. Because of its bulkiness, it is usually fed out of doors. It is unpalatable, low in protein, and, aside from the grain, is about equal to timothy hay in its nutritive value.

Corn Stover.—Corn stover is corn fodder from which the ears have been removed. The same general statements can be made relative to corn stover as have been made concerning corn fodder. It is even less palatable than corn fodder and is very low in protein. Its feeding value is about the same as that of timothy hay. Sometimes it is shredded; although this does not increase its feeding value, it makes it much easier to store and handle, and the refuse can be used as bedding.

Millets.—Millet ranks about the same as timothy in feeding value. It is less palatable, however, especially if allowed to become too ripe. It should be cut when in bloom, but at best is not a desirable feed for dairy cattle.

Oat Hay.—Oat hay, when cut at the proper time and not allowed to become too ripe, makes a palatable roughage. It is slightly lower in energy than timothy hay and other hays of its class, but it is superior in its protein content.

Straws.—The feeding value of straws depends largely upon the method of growing and handling them. When grain is allowed to become entirely ripe, its straw is of little value for dairy cows in milk. When cows are fed on straws which are low in energy and digestibility, and are unpalatable besides, the best results cannot be expected. Straw, especially oat straw, may be given in limited quantities to young stock and breeding animals. *Oat straw* is to be preferred to all other straws, but it is low in protein, constipating, and very unpalatable, and is used only for bedding in the best dairies. *Wheat straw* and *rye straw* have no place in the feeding of dairy cattle but make excellent bedding. *Barley straw* is sometimes used for feeding. When barley straw of the bearded variety is fed, it is necessary to watch the cow's mouth to detect the accumulation of beards which may penetrate the sides of the mouth, thereby causing infection.

Timothy.—Timothy hay, although one of the most common of roughages fed to dairy cattle, is very low in protein and is not palatable except when harvested early. It is constipating in effect and very low in mineral content. Cows do much better when fed on one of the legume roughages than when fed on timothy, unless large quantities of expensive purchased protein feeds are used. Many dairymen continue to use timothy because of the ease with which it can be grown over a large section of the country.

Succulents

Silage is one of the cheapest and most convenient forms of succulent feed for dairy cows. It costs less to grow, and can be given with less labor cost than other green feeds. At one time there was an objection to the use of silage because it was thought to have an injurious effect upon milk, but it is now generally admitted by physicians that the feeding of silage does not impair the quality of the milk, even for infant feeding.

Corn Silage.—Of all the crops used for the making of silage, corn is the most common. It can be harvested and put into the silo more

Fig. 5.—Harvesting hay in Holland.

easily and is more certain of keeping than silage made from most of the other crops. Corn is superior in total nutrients to any other crop used for silage, but is low in protein. The moisture content of silage is very high; it averages 74 per cent leaving only 26 per cent of dry matter. Corn silage is very palatable and is laxative in effect. It should not be fed as the sole roughage but should be combined with some legume hay which will make up its deficiency in protein and minerals. Twenty-five to 50 pounds daily is the average feed, but the quantity, of course, depends on the size of the cow.

Carrots.—Carrots are sometimes used, as a feed for dairy cows, but their yield is low and so their use is not general. They are palatable, however, and have a tendency to color the fat in the milk.

Legume Silage.—Clover, alfalfa, soy beans, and cow peas are all used to some extent for silage, although in general they are not as satisfactory as corn. They are higher in digestible protein but not quite as high in total nutrients as is corn silage. As a rule they do not keep well since it is hard to pack them tightly. When they are cut for silage, care should be taken that they do not contain too much moisture. It is usually better to harvest them in the form of hay.

FIG. 6.—Mangels make excellent feed for dairy cows.

Mangels.—Of all the root crops, mangels are the highest yielders and for this reason are the most commonly used. They are used extensively in Europe. Even though their yield is very high, they have a very low dry-matter content, averaging only about 10 pounds of dry matter in 100 pounds of mangels. In this country they are used especially for cows that are being forced for heavy milk production and they are unexcelled in adding succulence to a ration. They are fed at the rate of 40 to 80 pounds per day, depending upon the size of the animal. They should be fed more generally, especially where there are too few animals to justify the use of a silo, or where the tillable acreage is limited.

Potatoes.—Potatoes have much the same general characteristics as do the roots. They are slightly higher in nutritive value than the roots, being almost equal in that respect to corn silage. There is danger of bloat and indigestion if potatoes are fed in too large quantities.

Pumpkins (field).—The same general statement may be made of pumpkins as of the roots. Pumpkins rank about the same as the roots in food value, but there is considerable labor in their preparation for feeding. The idea that the seeds must be removed before feeding is erroneous, as they contain nothing injurious.

Rutabagas.—Rutabagas have a little higher dry-matter content than do mangels, and keep a little better. They do not yield quite as well, however, and for this reason are not as widely grown. Unless care is taken they are likely to taint the flavor of the milk.

Sugar Beets.—Sugar beets are slightly higher in total nutrients than the other roots, but the yield is much lower than that of either mangels or rutabagas and for this reason they are not generally used. Beet tops are sometimes put in the silos, where they make very satisfactory silage.

Sunflower Silage.—Sunflower silage has been gaining in importance during the past few years, especially in regions where, because of dryness or low temperature, it is impossible to grow corn to advantage. The yield is usually large but the percentage of total nutrients is not quite so high as in the corn silage. Sunflower silage is not as palatable as corn silage although cows soon learn to eat it.

Turnips.—The yield of turnips is lower than that of mangels or rutabagas and hence their cost of production is higher. They are about equal in feeding value. With turnips, however, care must be exercised in feeding, or their flavor will appear in the milk.

CONCENTRATES

It is possible to produce milk without feeding grain. Some dairymen make it a practice to produce the greater part of their milk supply during the summer and to feed only roughage during the winter. It is also possible to produce fairly large yields of milk by feeding only roughage consisting of silage and alfalfa hay, or even alfalfa hay alone. To get a fairly large production, however, and to keep up the flow of milk over a long period of time, it is necessary to feed some concentrates. The grain part of the roughage, together with the by-products, is known as the concentrates. If some of the grains can be grown on the farm as is usually the case, they will be found cheaper than purchased feeds.

Grains

Barley.—Barley is an excellent substitute for corn. It can be substituted for corn, pound for pound, with equally good results. It contains a little more protein than corn but is a little lower in total digestible nutrients. It is used quite extensively in countries and localities where corn is not available.

Buckwheat.—The whole grain of buckwheat is not so desirable as are the middlings or bran from this cereal, because of the large amount of crude fiber or hulls that it contains. These, however, give bulk to a ration and may be used when other grains in the ration are heavy. Buckwheat is not a very palatable feed, nor is it equal to corn as a dairy feed. Dairymen believe that buckwheat produces a hard, white butter-fat.

Corn.—Corn is grown on almost every dairy farm and should usually be included in the dairy ration. Not only is it very palatable, but it economically supplies a large amount of total nutrients. It is low in protein and also in minerals; therefore, some high-protein feed must be used in order to supply these deficiencies. It is best to feed corn ground as a meal. Some of the commercial corn meal is made from that part of the kernel which remains after the manufacture of cracked corn or table meal. It is then correctly called *corn feed meal.* It has about the same value as corn meal.

Sometimes whole ears are ground, making *corn and cob meal.* This is used in some dairy rations in place of corn meal and may be useful in adding bulk when other bulky feeds are not found. The cob is high in pentosans and therefore can be utilized, to a certain extent, by the digestive system of the dairy cow. It has been found that when fed to steers about 2.5 pounds of cob was equal to 1 pound of corn meal.

Oats.—Oats are an excellent feed for dairy cattle, and when not too high in price should be used in the dairy ration. They are considerably higher in food value than wheat bran. They are bulky, palatable, and fairly high in protein and mineral matter; and if they are home-grown the straw comes in handy for bedding.

Rye.—Rye may be used in place of corn in a dairy ration. It is just about equal to corn in its food value, but it is not very palatable. There may be danger in feeding it when it is infected with ergot. When fed in large quantities it tends to produce butter-fat with a hard body.

Wheat.—When the price will permit, wheat may be substituted for corn in a dairy ration. It is a little higher than corn in feeding value and is quite palatable. Because of the small size and hardness of the kernels the wheat should be ground before being fed. Wheat when fed alone often forms a paste in the cow's mouth. In a great many sections the cost prohibits its use in the dairy ration.

Leguminous Seeds

Soy beans and *cow peas* are used to a limited extent in the ration of the dairy cow. They are rich in protein and in energy but are not very palatable and on account of their cost are not widely used.

By-products

Blood Meal.—Blood meal is a by-product of the slaughter house and is very high in protein. It is not often used in the feeding of cows but is sometimes used in calf feeding.

Brewers' Grains.—Brewers' grains is a residue from the brewing of barley in the making of beer and certain "soft" drinks. After the sugar is extracted the grains are dried and sold as dried brewers' grains. They are fairly bulky and, being medium-high in protein, are often used to an advantage. They are high in crude fiber and not very palatable. When the brewery is nearby, many diarymen secure them wet. In this form they make a very satisfactory feed, but unless care is taken to have the feed boxes tight the liquid will run through and sour, creating an undesirable odor in the stable. When the grains are properly taken care of and the feed boxes kept clean, the wet grains can be fed without difficulty to dairy cows.

Buckwheat Middlings.—Buckwheat middlings is a by-product of the buckwheat-flour industry. It is fairly high in protein and, when it can be purchased at a reasonable price, makes a very good dairy feed. It should not be mixed with the hulls as they are worthless as a dairy feed.

Cocoanut Meal.—Cocoanut meal is the residue from the manufacture of oil from the cocoanut, and is made by the two processes which will be described in connection with linseed meal. The old process is slightly lower in protein than the new one, but is higher in total nutrients. Cocoanut meal is higher in feeding value than is wheat bran but not as high as many of the other oil meals. It has a tendency to turn rancid in warm weather.

Cottonseed Meal.—Cottonseed meal is the residue from the extraction of oil from the cotton seed, and is sometimes sold in cake form. There are a number of different grades of this product on the market. The highest grade is usually the cheapest and best to purchase. This feed is one of the most commonly used high-protein feeds. In general, it furnishes protein in the cheapest form of any of the concentrates. However, it is somewhat constipating, is not very palatable, and should not as a rule form more than one-third of the ration. It contains a poison which is known as "gossypol" and which is thought to be injurious when fed in very large amounts.

Sometimes the hulls are ground and mixed with the feed and sold as *cottonseed feed.* This is not nearly as good as the meal since the hulls are worthless as dairy feed.

Distillers' Grains.—Distillers' grains are by-products of the manufacture of alcohol from corn and rye. Very few of them are available in this country, although formerly their use was very common. The distillers' grain from corn is much superior to that from rye. It is slightly more palatable than brewers' grains. Corn distillers' grain is about equal to brewers' grain in feeding value. Distillers' grains are sometimes fed wet, and practically all that has been said of the wet brewers' grains may be applied to the wet distillers' grains.

Dried Beet Pulp.—Beet pulp is the residue left after the sugar has been extracted from the sugar beet. It is very high in carbohydrates but low in protein. When silage or other succulent feeds are not available, dried beet pulp makes an excellent substitute when soaked with about three times its weight in water for about twelve hours before feeding. It is very palatable and has a very good physiological effect upon the cow. Dried beet pulp is especially valuable in feeding cows for heavy production.

Gluten Meal and Gluten Feed.—Gluten meal and gluten feed are by-products in the manufacture of starch and glucose. The gluten of corn is separated from the starch, and is dried and sold as *gluten meal;* but when mixed with the corn bran it is known as *gluten feed.* The meal is therefore richer in feeding value than the feed. Both are good and usually can be purchased at a price that makes them satisfactory feeds to include in the ration. The meal is heavy and should always be mixed with some more bulky feed. Neither is as palatable as some of the other feeds. As their protein content varies considerably they should always be purchased on guaranteed analysis.

Hominy Feed.—In the manufacture of hominy grits from corn, a by-product known as hominy feed is obtained. It has practically the same protein and energy as corn, and may be used as a substitute for corn. Practically the same things can be said of it as of corn for the feeding of dairy cows, although it is a little more bulky. When it can be purchased as cheaply as corn meal it may well be used in the ration.

Linseed Meal.—This high-protein feed is the residue left after the linseed oil has been extracted from the flax seed. In its manufacture two processes are used, one known as the old process and the other as the new. The old process consists in crushing the seeds, heating them to a high temperature, and removing the oil under high pressure. In the new process the seeds are treated in the same way except that the oil is extracted by being dissolved in naphtha instead of by pressure. The old process is the more commonly used in this country, although the new-process feed is sometimes found on the market. The difference in the methods of extracting the oil results in a slight difference in the composition of the residue from which the linseed meal is made. The new-process meal is slightly richer in protein but lower in energy value. These feeds are sometimes called "oil meal." They are more palatable than cottonseed meal, are laxative in effect, and seem to brighten the coats of the animals to which they are fed. They are used advantageously in small quantities, up to 4 pounds, in the rations of dairy cows.

Molasses.—Molasses is a by-product of the manufacture of sugar from both beets and cane. A crude syrup is produced that is used in feeding dairy cows. The molasses from cane is known as *black strap.* These by-products are essentially energy feeds; they contain practically no protein. Molasses is quite laxative, and should not be fed in a quantity to exceed 2 or 3 pounds daily for each animal. The customary way of feeding it is to dilute the molasses with water and sprinkle it over the feed.

Peanut Meal.—Peanut meal, a by-product of the manufacture of peanut oil, is becoming more important as a dairy feed. It varies considerably in composition, but first-grade peanut meal is very high in protein, is palatable, and has a slightly laxative effect upon the cow.

Soy-bean Oil Meal.—Soy-bean oil meal is the residue left after the oil has been extracted from soy beans. It is very rich in protein, carrying more digestible protein than does choice cottonseed meal. It is being used to some extent in the dairy ration and has been giving excellent satisfaction.

Wheat Bran.—Wheat bran is one of the best of the milling products for feeding dairy cattle. It is bulky and acts as a mild laxative. It also has a cooling effect which makes it very useful as a feed for cows after calving. It is the highest of the common feeds in its phosphorus content. It is desirable in any ration for dairy cows when the price is not too high.

Wheat Middlings.—In the manufacture of flour the finer particles of bran and some of the flour are collected and sold as middlings, or *shorts*. This is a very satisfactory feed for dairy cows, but is more like ground corn in composition than bran. If middlings can be purchased cheaper than corn, it may be used as a substitute for corn in a ration.

Ready-mixed Feeds

There are now on the market a large number of ready-mixed feeds sold under special trade names. They have the advantage of supplying the necessary variety to the ration, and, being ready-mixed, they save the labor of mixing. In the past these ready-mixed feeds were not looked upon with favor because many of them were sold simply as a means of disposing of some inferior products. More recently laws have been passed requiring the labeling of each sack with a guaranteed analysis. At the present time many excellent ready-mixed feeds may be purchased. Recently the *open-formula* feed has been put on the market. These open-formula feeds have the advantage that they show on the sacks the ingredients used in the ration and the amount of each. They have been gaining in popularity very rapidly.

Ready-mixed feeds are of especial value to the dairyman who uses only a small amount of feed or who is so located that it is impossible for him to secure readily a variety of feeds for home mixing. The buyer should always pay close attention to the guaranteed analysis, so that he may get his protein and total nutrients as cheaply as possible. His decision as to the use of ready-mixed feeds should depend largely upon the relative price. If the dairymen, however, has on his farm corn, barley, or oats, and needs a high-protein feed to balance these, he can usually purchase his protein cheaper in the form of cottonseed meal, or gluten feed. It is always best to figure the cost of a pound of protein of each feed before purchasing, and in that way to be sure of purchasing the most economical ration.

Tonic Feeds

There have been put on the market a large number of tonic or stock feeds. They are usually harmless but not worth much more than ordinary feed, although as a rule they cost many times more. They usually consist of some of the common feeds, such as linseed meal or wheat middlings, besides such ingredients as charcoal, salt, gentian, bicarbonate, ginger, sulphur, etc. The dairyman cannot afford to buy such feeds. If his animals are in good condition they do not need tonics; if they are sick he should give them specific treatment. If an animal needs salt, charcoal, sulphur and ash, the dairyman should mix them with the feed himself. The following home-made tonic feeds have been recommended by the Vermont Experiment Station.[1]

Formula I.—Ground gentian, 1 pound; ground ginger, ¼ pound; powdered saltpeter, ¼ pound; powdered iron sulphate, ¼ pound. Mix and give 1 tablespoonful in feed once daily for ten days, omit for three days; and feed as above for ten days more.

Formula II.—Fenugreek, ½ pound; ginger, ½ pound; powdered gentian, ½ pound; powdered sulphur, ½ pound; potassium nitrate, ½ pound; resin, ½ pound; cayenne pepper, ¼ pound; ground flaxseed meal, 3 pounds; powdered charcoal, 1½ pounds; common salt 1½ pounds; wheat bran, 6 pounds.

The Iowa State Experiment Station[2] recommends the following:

Formula I.—Powdered gentian, 1 pound; powdered ginger, 1 pound; fenugreek, 5 pounds; common salt, 10 pounds; bran, 50 pounds; oil meal, 50 pounds.

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LECTURE VI

DESIRABLE CHARACTERISTICS OF A RATION

In order that the feeds may be combined in such a way that the best results are obtained, one must not only be familiar with the characteristics of the individual feeds, but must also know what factors enter into the make-up of a desirable ration.

What Becomes of the Cow's Feed?—Milk, as has already been pointed out, contains the same compounds as the cow's feed, but in a different form. Figure 7 shows how the elements unite into compounds to form the feed out of which animals manufacture milk and satisfy their bodily needs. This figure shows that the dairy cow produces her milk entirely from the feed and water which she consumes, and that unless she receives sufficient of the right kinds of feed she cannot be expected to produce milk.

Summer Conditions Throughout the Year.—In the making of a dairy ration, it should be the aim to imitate as nearly as possible the feed conditions of early summer. Every dairyman knows that the period of highest and most economical milk production is during the early summer months. The reason for this is not hard to explain. Early summer pasture provides for the dairy cow an *abundance* of *palatable* feed which is *succulent* in nature. It also has plenty of *bulk* and *variety* and it has a good *physiological effect upon the cow.* Pasture also contains *plenty* of *minerals* and *is cheap.* These and certain other requirements of a dairy ration will be considered in this lecture.

Right Amount of Feed

An abundance of feed is the first essential in feeding cows for profit. The primitive cow had only to care for herself and to feed her calf for a few months. After freshening in the spring of the year, she could develop the calf and dry off in the fall, and her labors were practically done. In these days the cow is looked upon, especially in the best dairy sections, simply as a factory, and, as in any other factory, the

FROM ELEMENTS TO MILK

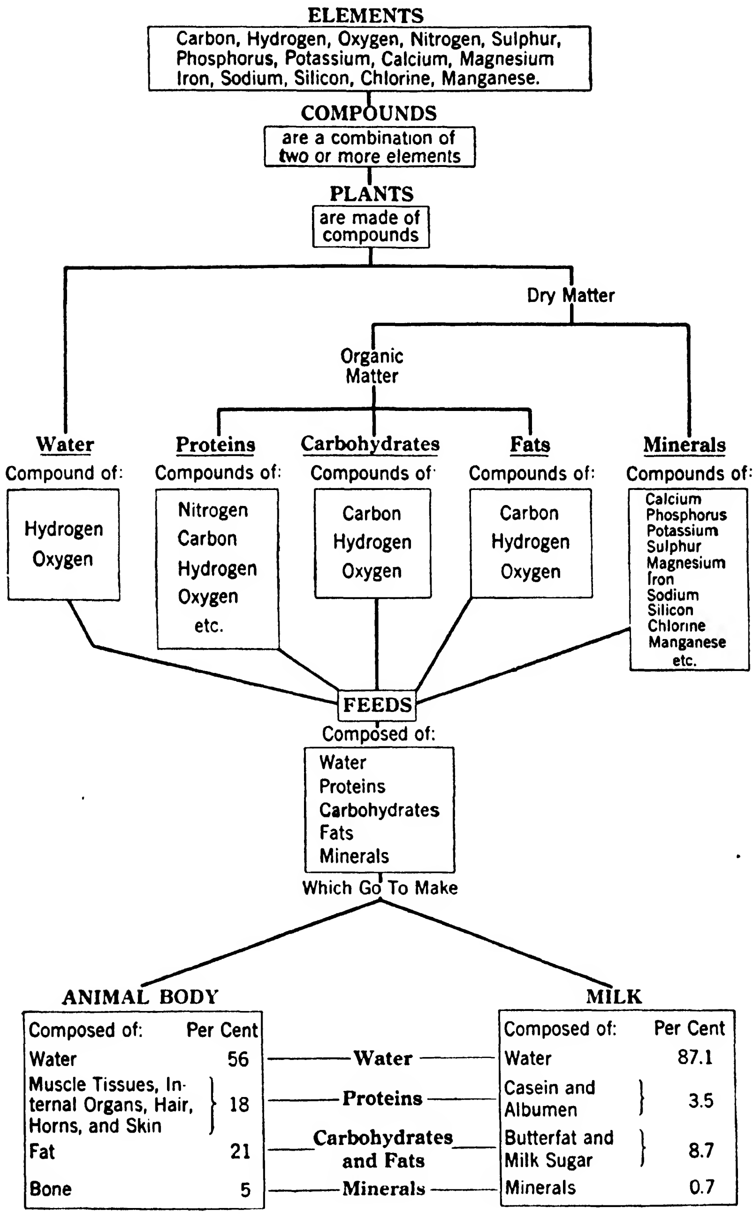

FIG. 7.—Chart showing interrelation of plant and animal life and the common component elements with their occurrence in various substances which go to make up feed and finally milk.

cheapest production is possible only when the plant is being run nearly to its full capacity.

A cow needs her food mainly for two purposes, namely, for the maintenance of her body and for the production of milk, although at times she may need it to grow a fetus or to put on weight. Young animals also need it for growth. The feed requirement for the maintenance of the body is the amount necessary to keep the body in running order, that is, to perform such functions as pumping blood, breathing, chewing and digesting food, and making body repairs. It has been shown that certain rather definite amounts of protein and energy are required for body maintenance, the amount depending upon the size of the cow. Figure 8 illustrates how the feed consumed by a dairy cow is utilized when she is given different amounts.

What Becomes of a Cow's Feed

When Fed too Much

Maintenance	Milk Production	Gain in Weight
1000-pound cow	20 pounds of 4 per cent milk	Stored up

When Fed Just Enough

Maintenance	Milk Production
1000-pound cow	20 pounds of 4 per cent milk

When Fed too Little

Maintenance	Milk Production
1000-pound cow	10 pounds of 4 per cent milk

Fig. 8.—Chart showing how the dairy cow utilizes her feed.

Figure 8 refers to a cow whose body weight is 1000 pounds and whose maximum production is 20 pounds of 4 per cent milk. It will be noted that the maintenance requirement remains constant regardless of the production. The feed requirement for maintenance is determined entirely by the size of the cow, irrespective of breed, age, or any other factor. It is true that a good diary cow will draw on the reserve of her body to produce milk for a limited length of time. Nevertheless, the factor for maintenance remains constant and this reserve must eventually be replaced from the feed, otherwise the cow will become emaciated and her production will be diminished.

Figure 8 also shows that it is poor economy to feed sparingly. The feed required for maintenance remains the same, and unless the cow is fed enough for liberal milk production in addition to the requirement for maintenance, the proportion of food which goes to make the milk is less than it should be. A cow should be fed practically to the limit of her milk-producing capacity. Aside from her feed and care, the limiting factor is the cow's inherent capacity for milk production. In the case of the 1000-pound cow producing 20 pounds of 4 per cent milk, approximately 50 per cent of the feed is used for maintenance and 50 per cent for production. When, however, this cow produced only 10 pounds of 4 per cent milk, largely because of lack of feed, approximately 66 per cent of the feed was required for maintenance, leaving only 33 per cent for milk production.

Overfeeding.—While most dairymen do not feed enough, there are some who, being good feeders, and having cows in their herd which do not have the inherent ability to produce heavily, overfeed them. There is no economy in feeding a dairy cow more than she will return in the milk she produces. This is illustrated in Figure 8 where the cow still produces 20 pounds of milk and uses the remainder for gain in weight. Unless the cow is in poor condition, the gain in weight is of no value as far as milk production is concerned, unless it is used as a reserve which may be drawn upon at some future time.

Palatability

In order to be palatable a feed must be pleasing in flavor so that the cow will like it. A cow will do her best when she relishes her feed. A ration may contain everything necessary for maximum production; yet, if it is not palatable, the cow may not consume enough of it to supply nutrients for her maximum production. One of the objects of feeding is to tempt the cow's appetite, thereby inducing her to eat up to the limit of her ability to produce milk.

Cows, like people, show individuality by different tastes and appetites. Certain feeds not eaten at all by some cows are relished by others. Cows can become accustomed to eating some feeds that do not at first appeal to them. It is known that palatability has little effect, if any, on digestibility. The advantage of the palatable feeds over the unpalatable ones is simply that the cow will consume a larger amount, and, as has been pointed out, the economy of production depends largely upon the amount of food the cow will eat above what is necessary for her maintenance. If unpalatable feeds are to be used, they should be mixed with palatable ones. Molasses is sometimes mixed with unpalatable feeds to give them the desired palatability.

Succulence

A succulent feed is one that contains the natural juices of green forage, similar to the natural juices of pasture grass. It is well known to practical feeders, and has been demonstrated by experiments, that cows will consume more feed and keep in better physical condition when the ration is made succulent by including some form of green feeds or others high in moisture. Some of the most common succulent feeds are green grasses, silage, roots, and wet beet pulp. Some form of succulence is very necessary for economical milk production.

Bulk

A grain mixture is said to have bulk when a definite weight of it occupies a relatively large space. To illustrate: 100 pounds of wheat bran occupies much more space than 100 pounds of corn meal, hence it is said to be more bulky or lighter. Bulkiness enables the digestive juices to penetrate the food more completely and thereby facilitates digestion. A dairy cow, during heavy milk production, must have her digestive tract well distended. When heavy grain feeding is practiced, this distention should be partly effected by bulk in the grain mixture. Unless the grain mixture is fed on the silage or other roughages, it is well that it have bulk in itself. Wheat bran, ground oats, corn and cob meal, dried brewers' grain, and beet pulp are the more common bulky feeds.

Variety

In compounding a grain ration so that it will have palatability and bulk, three or four grains are generally used for the sake of variety. It is a common belief that if a cow is kept on the same ration for a long period of time she will lose her appetite. This, however, is not necessarily true. If the ration contains variety and succulence and is palatable, the cows will do better without many changes.

For winter feeding two kinds of roughages are desirable: one a silage or some other succulent; and the other preferably a legume hay. The grain ration for moderate-producing cows should contain at least three grains, or three by-products, preferably from different plant sources. For heavy-producing cows, five or more different feeds should be supplied, from at least four different plant sources. Many feeders for advanced registry use as many as seven or more different feeds.

As was mentioned previously, proteins are made up of a large number of amino acids, some of which are essential for life and for maximum milk production. The proteins from one plant are often deficient in some of these. For example, zein, which makes up more than one-half of the protein of the corn grain, is completely lacking in three amino acids and has a relatively small amount of three others. Corn-grain protein alone will not support life, but when supplemented with a small percentage of protein from the corn fodder it serves for the growth of calves. Furthermore, some feeds are deficient in certain minerals. The oat plant, for example, does not contain enough calcium for proper growth and reproduction. For these reasons it is necessary to have a ration which represents several different plants. For example, a ration consisting of corn stover, corn silage, corn and cob meal, gluten feed, and wheat bran would represent only two plants; while a ration consisting of alfalfa hay, corn silage, corn meal, ground oats, and linseed meal would represent four plants and for this reason should give better results. Variety is not so important for moderate-producing animals, but with heavy producers it should be given consideration.

Effect on Health

Each feed has its own peculiar effect upon the animal body. The specific effects of all feeds are not known as yet, but certain effects of some of the feeds are well known. Cottonseed meal, for instance, is known to cause constipation, while linseed meal has a laxative effect. For these reasons neither of these feeds should be fed in large amounts. Three or 4 pounds per day is about the maximum amount that should be fed. Cottonseed meal also contains the poison "gossypol" which is said to make it dangerous when fed in very large amounts. Some of the roughages, such as silage, clover hay, and alfalfa hay, are laxative; some, such as timothy hay, oat straw, and corn stover, are constipating. When the roughages are constipating in effect, a grain mixture of a laxative nature must be fed if the dairy cow is to do her best. The bowels of a dairy cow should be in a slightly laxative condition if she is to make her best production.

Cheapness

The careful feeder will try to select cheap feeds, but in this he will not make the cost per ton the essential consideration. The important thing to be considered is the cost of one pound of protein and one pound of total nutrients. It is well, from the point of view of economy, to make use of as many home-grown feeds as possible, and to purchase only what is necessary to balance them properly. If home-grown feeds are used the cost and labor of marketing is eliminated.

Minerals

It has been demonstrated that animals fed on rations practically freed from minerals will die even sooner than animals deprived of all feeds. The necessity of supplying minerals has already been demonstrated. The minerals that are most likely to be lacking in a ration are calcium, phosphorus, sodium, chlorine, and sometimes iodine. These are all contained in varying amounts in the common feeds, but sometimes it may be of advantage to supply additional quantities.

Common Salt.—The sodium and chlorine are contained in common salt (NaCl) which should be supplied at all times. All herbivorous animals require a large amount of salt, but carnivorous animals do not require any more salt than they obtain in their feed. Bunge[1] states that chlorine is the essential element supplied by salt. He says that it is used to unite with the potassium which is found in large amounts in feeding stuffs, and thus helps expel it from the body.

One of the common ways of supplying the needed salt is to keep it so that the animals will have free access to it and will take what they require. It may also be mixed with the grain ration in the proportion of 1 to $1\frac{1}{4}$ pounds of salt for each 100 pounds of grain mixture. When this is done the cows should also be given free access to salt so that they may secure more if necessary. Salting at intervals of several days or weeks is not to be recommended. The actual amount needed depends on the size of the animal and the amount of milk she is producing. Babcock[2] concluded that dairy cows should be given about $\frac{3}{4}$ ounce per day for each 1000 pounds of live weight and about $\frac{3}{8}$ ounce in addition for each 20 pounds of milk produced.

Calcium and Phosphorus.—The importance of supplying calcium and phosphorus in the ration, in addition to the amounts found in ordinary feeds has perhaps been overestimated. Under ordinary conditions, if the dairy cows are given plenty of legume hay in winter and pasture in summer and are fed a good grain ration, there is little to be feared from a lack of these elements. Legume hay is especially rich in calcium; and the concentrates, such as wheat bran and cottonseed meal, are rich in phosphorus. However, if cows show abnormal appetites, such as a craving for wood, bones, dirt, and so forth, this is a strong indication that the ration is lacking in one or both of these elements. Such a condition is more likely to occur with the heavy-producing cows or when the roughage is timothy or other non-legumes.

There are two times when minerals may be lacking in the ration of the dairy animal, during heavy lactation and during growth. It should be understood, however, that a cow may produce milk for some time, even for several months, without having sufficient minerals in her feed. This is possible because she can draw on her reserve supply—the calcium and phosphorus in her bones. She should be given a chance at some time to replace this reserve. Restoring minerals in the body is done only when the cow is dry or nearly so, and best when she is on grass. This shows the necessity of a dry period. Forbes[3] found that the calcium metabolism of the milch cow, regardless of how she is fed, is characterized by a rapid loss from the body during the early part of the lactation period, changing to retention late in the lactation; by continued retention during the dry period; and by the most rapid storage at the end of the period of gestation. He attributes the loss during the first part of the lactation to the impulse to secrete milk, as accentuated by selective breeding, and to a limited ability to assimilate calcium. Meigs[4] found that the feeding of additional phosphorus to cows during the dry period seemed to have a beneficial effect upon their production during the lactation period.

Recent experiments have shown that a vitamin is associated with calcium assimilation. It has been shown also that the ultra-violet rays from the sun or other sources help with the calcium assimilation. The vitamin just referred to is found most abundantly in green grasses and in well-cured legume hay. Hart[5] found that feeding either alfalfa hay cured under caps or green alfalfa led to the storing of lime and phosphorus, even by liberally milking cows. He also showed that losses in minerals in milking goats could be changed to storage by exposure to the ultra-violet light.

Form in which to Feed Calcium and Phosphorus.—When it is found advisable to supply calcium or phosphorus in addition to that supplied by the feed used, it is best to feed some bone meal of the kind especially prepared for livestock feeding. This contains both calcium and phosphorus in the proportion used in the body. It is sold under the name of "raw bone meal for feeding purposes." "Spent bone black" serves the same purpose as bone meal and sometimes can be purchased at a lower price. Finely ground limestone or wood ashes may also be used, but they supply only the calcium. Only limestone that is low in magnesium should be used. Many commercial mineral compounds are on the market, but no better results can be expected from them than from bone meal or a mixture of bone meal and limestone. The price of commercial preparations is usually much higher than that of bone meal.

The bone meal, ground limestone, or wood ashes can be fed like salt by allowing free access to it, or it may be added to the grain ration at the rate of about 2 pounds to each 100 pounds of the ration.

The best way to supply minerals is through the feed. Some feeds are low in calcium, and others in phosphorus. In general, the roughages are low in phosphorus, and the concentrates low in calcium. The following table shows the feeds that are rich, medium, and poor in these elements:[6]

Calcium Poor	*Calcium Medium*	*Calcium Rich*
Cereal grains	Dried beet pulp	Legume hays
Corn	Corn silage	Alfalfa
Wheat	Corn stover	Red clover
Oats	Linseed meal	Soy bean
Rye	Cottonseed meal	Tankage
Cereal grain by-products	Corn gluten	Dried milk products
Legume seeds		
Roots		
Timothy hay		
Straws		

Phosphorus Poor	*Phosphorus Medium*	*Phosphorus Rich*
Beet pulp	Cereal grains	Wheat bran
Polished rice	Corn	Wheat germ
Red-clover hay	Wheat	Wheat middlings
Timothy hay	Oats	Cottonseed meal
Millet	Rye	Legume seeds
Straws	Alfalfa hay	Linseed meal
	Corn stover	Tankage
	Corn silage	Dried milk products
	Sweet clover	

Iodine.—In certain sections of the country, cattle suffer from goiter, or "big neck." This is caused by a lack of iodine in the ration. It appears in calves as a swelling of the neck at birth. Sometimes it may be so severe that death occurs, but usually the calf recovers although the swelling may remain until she matures.

When this trouble is experienced it is well to take the proper precautions and treat all pregnant animals in the herd. The iodine[7] may be administered by pouring one teaspoonful of tincture of iodine on the back of each pregnant cow once every two weeks, being careful to choose a different spot for each succeeding application. A better method, however, is to give potassium iodide or sodium iodide (a cheaper source) in the feed. When this method is used a solution is made by dissolving one ounce of either substance in one gallon of water. One tablespoonful of this solution on the grain ration constitutes the daily dose.

Vitamins

During the past few years it has been discovered that protein, carbohydrates, fat, and mineral matter are not the only things necessary for complete nutrition. Other organic substances, known as vitamins, are also necessary. Up to the present time five vitamins have been discovered; these are known as vitamins A, B, C, D, and E. It seems, however, that neither vitamin B[8] nor vitamin C[9] is necessary in the nutrition of dairy animals. Probably the dairy animal is able to manufacture its own supply of these vitamins, as the milk from animals fed on rations lacking in these vitamins contains them in liberal amounts. Recent experiments[10] have demonstrated that vitamin B at least can be manufactured in the paunch of the dairy cow.

It has been found[11] that the young dairy animal when fed a ration deficient in vitamin A takes on the characteristic symptoms of vitamin A deficiency, such as failure to grow, xerophthalmia, respiration troubles, diarrhoea, and finally death. This vitamin is found in cod-liver oil, butter-fat, yellow corn, and the green parts of plants. Well-cured hay, especially legume hay, supplies this vitamin in liberal amounts. If dairy animals are fed liberally on these, there should be no lack of this factor. White corn, beet pulp, and oxidized skim-milk powder are lacking in vitamin A, while most of the cereals and skim milk are very low in it. The ordinary ration, however, will contain a sufficient amount of vitamin A for normal growth and reproduction.

The second vitamin likely to be deficient in a dairy ration is vitamin D, the antirachitic vitamin. Its chief function, as has been shown, is to help in the assimilation of minerals, especially calcium and phosphorus. This vitamin is necessary for proper mineral assimilation. vitamin D prevents rickets in young, growing animals, and osteoporoses in mature animals that use large quantities of calcium, as do heavy-producing dairy cows. This vitamin is found in green pasture and well-cured hay, and especially in cod-liver oil and other fish oils. Good results can also be secured by exposure to the ultra-violet rays from either artificial sources or from the sun.

Vitamin E, or vitamin X, as it is commonly called, has to do with the reproduction of the young. Sprouted oats, yellow corn, wheat embryo, and the green leaves of certain plants seem to supply this vitamin. Too little is known about vitamin E to warrant further statements, but it is doubtful if cows fed a good balanced ration will lack this factor. However, the lack of this vitamin may be the cause of many of our breeding failures.

Preparation of Feeds

Grinding.—The grinding of grains increases their digestibility only in case of hard seeds which otherwise might pass through the digestive tract unbroken. This may amount to a fairly large proportion, perhaps as much as 10 to 20 per cent in the case of dairy cows, although in the case of heifers and calves it is much less because young animals seem to masticate their food better than older ones. This seems to indicate, except in the case where hogs run after cattle, that there would be considerable loss if the grain were not ground. Sometimes when corn is mature when put in the silo the grains will pass through the animal undigested. It is always advisable to grind the grain for the dairy herd.

As a rule it is not profitable, as far as digestibility is concerned, to cut up the roughages. When cut, however, they are easier to feed and the cows will usually eat more of the coarser parts. This is especially true of corn stover which, when cut into small pieces, is much easier to handle in the barn, as the cows will consume a large proportion and the refuse can be conveniently utilized for bedding. Alfalfa is sometimes ground and sold as alfalfa meal, but this does not increase its feeding value.

Soaking.—As a general rule, the soaking of grain is not necessary as it does not add anything to its digestibility or palatability. However wheat bran is often mixed with warm water, in which condition it is known as bran mash. It is a good conditioner for cows just before and after freshening or at other times when they are out of condition. Beet pulp, when soaked for several hours before feeding, takes on the nature of a succulent, which is an advantage.

Cooking.—The cooking of feeds for dairy cattle has no advantage and is very seldom practiced, except in the case of potatoes where it seems to be of some benefit.

Amount of Feed

Feeders should know the amount of grain and roughage to give their animals. The digestive system of the dairy cow is especially adapted to consume large amounts of roughages and she should be given plenty of bulky feeds. The proportion of grain to roughage will depend largely upon the amount of milk the cow is giving. Heavy milkers will consume much more grain in proportion to roughage than will those that are not producing so heavily. Usually, the poor to medium producers receive only about 25 to 30 per cent from their concentrates, while a good producer will receive from 40 to 50 per cent from her concentrates. Very high producers may be fed as high as 70 to 80 per cent of their feed in their grain.

The following general rules are given as a guide for the beginner in feeding, to help him to use proper proportions of grain and roughages in his ration:

Feed all the roughage that the cows will eat up clean. This will usually be about ½ to 1 pound of hay and 2½ to 3 pounds of silage to 100 pounds of live weight. In case no silage is fed, as much as 1½ to 2 pounds of hay may be fed. When beet pulp is used, feed about

4 to 8 pounds of dry pulp soaked in three times its weight in water. Beets can be fed up to 60 or 80 pounds.

Feed the grain mixture in proportion to the milk yield. With a good roughage, feed high-testing cows 1 pound of grain to each 2½ to 3 pounds of milk, and low-testing cows 1 pound of grain to each 3 to 3½ pounds of milk. With poor roughage, the grain allowance should be increased.

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LECTURE VII

THE DEVELOPMENT OF FEEDING STANDARDS

Feeding Standards.—The science of feeding is based upon certain requirements for maintenance and milk production. These requirements are known as feeding standards. They have developed with the progress of other sciences. The first standard was based upon simple feeding trials in which one feed was substituted for another and the results compared. A standard obtained in this way is said to be of the comparative type.

With the beginning of food analyses, a new standard was made, based upon food constituents. It was soon found that the food constituents were not all equally digestible. This led to digestion trials, and the standard then proposed was based upon digestible constituents. Such standards are said to be of the digestible-nutrient type. The German respiration apparatus and Armsby's respiration calorimeter have given us what is known as the energy standard or the production-value type.

A feeding standard, then, is simply the food requirement for maintenance and milk production. Of the many standards proposed and used, only three are in wide use in the United States at the present time. These are the Armsby, the Haecker, and the Morrison systems.

Comparative Type

Thaer's Work.—The German scientist Thaer[1] in the year 1810 suggested a method of comparing the different feeds. He used meadow hay as a unit and based the value of the rest of the feeding stuffs on its value. He found, for instance, that only 91 pounds of alfalfa hay were necessary to equal 100 pounds of meadow hay in feeding value, and that 200 pounds of potatoes were required to replace 100 pounds of meadow hay. He never formulated a definite standard but simply gave a comparison of the feeding stuffs. However, a system very similar to this is now used very extensively in the Scandinavian countries.

Scandinavian Feeding System.—The Scandinavian Feeding standard is more valuable than that of Thaer in that it is the result of observations on thousands of cows, extending over a great number of years. The quantity of milk was also taken into consideration. For some years[2] a number of dairy farms in Denmark, Sweden, and parts of Norway were under the direct observation of the respective governments. Complete records were kept of the food consumed and of the quantity of milk produced, and in 1884 Professor Fjord formulated the Scandinavian Feeding Standard. Because of its simplicity this standard met with considerable favor in this country for some time. In the Scandinavian standard there was but one factor, namely, the feed units, to be taken into account, while in the Wolff-Lehmann and older Haecker standards there were protein, carbohydrates, and fat to be considered. However, since most of the standards now commonly used have only two factors to be considered, and since the type of feed raised in this country is quite different from that grown in northern Europe, so that it has been found necessary to use digestible crude protein besides the feed unit, the use of this standard has gradually decreased until at present it is employed very little in the United States.

The term feed unit is used as the basis for the standard. One pound of the common grains, such as corn, barley, wheat, etc., is given a value of one unit and the value of all the other feeds is based upon this. This is similar to the method of Thaer, who based his standard on 100 pounds of meadow hay. According to the Scandinavian standard, one feed unit is required for each 150 pounds of body weight, and one additional unit for every 3 pounds of milk produced. In addition to the feed units, the ration should also contain 0.065 pound of digestible protein for each 100 pounds of live weight and 0.05 pound of digestible protein for each pound of milk produced.

The general composition of the Danish feeds is somewhat different from that of the feeds of this country as a number of those used in this country are not used in Denmark. Corn silage, for example, is scarcely used at all in Denmark. Rabild, of the United States Department of Agriculture, therefore worked out the following table showing the feed units in a number of our most common dairy feeds.

The feed units in this table are based upon average analyses of feeds and are subject to revision. A somewhat similar table presented by Woll is given as Table B in the appendix.

TABLE X

SCANDINAVIAN FEEDING STANDARD

American Feed Unit

	Lbs. Required for One American Unit	Range of Variations
Rye, ground	0.95	0.95– 1.05
Oats, ground	1.00	1.00– 1.20
Wheat middlings	1.09	
Wheat bran	1.28	1.18– 1.38
Barley ground	0.95	0.95– 1.05
Dent corn	0.97	0.87– 1.07
Corn and cob meal	1.20	
Gluten feed	0.88	0.73– 1.13
Cottonseed meal	0.76	0.76– 0.86
Linseed meal	0.85	0.75– 0.95
Dried beet pulp	1.17	
Malt sprouts	1.03	1.03– 1.33
Dried brewers' grains	1.11	
Potatoes	6.00	5.00– 7.00
Sugar beets	8.15	7.15– 9.15
Rutabagas	9.70	8.00–10.00
Mangel wurzels	12.10	11.10–13.10
Alfalfa hay	1.92	1.72– 2.22
Alfalfa, green	6.47	4.47– 8.47
Alfalfa meal	1.64	1.64– 2.64
Red clover hay	2.32	2.12– 2.62
Oat straw	4.35	3.85– 4.85
Fodder corn, green	8.06	6.00–10.00
Corn stover	2.73	2.70– 4.70
Corn silage	6.62	5.62– 7.62

It will be noted that one pound of various grains, such as barley, oats, corn, etc., is given almost equal value. These feed units are not, therefore, entirely accurate, because they are based on comparison and do not give the true energy value. Feeds rich in protein are given a higher value than those low in protein but containing an equal amount of net energy. For example, gluten feed has a feed-unit value of 0.88; this is lower than that of corn, which is 0.97, but according to Armsby's table corn contains more net energy than does the gluten feed. The greatest merit of the Danish system is its simplicity. The feed-units value of the common feeds can be remembered, and after a little practice a practical ration can be figured without referring to tables.

Digestible-nutrient System

Grouven's Feeding Standard.—In 1859,[3] about fifty years after Thaer published his standard, Grouven, another German experimenter, proposed a feeding standard based upon the crude protein, carbohydrates, and fats contained in the feeds. His standard required that a cow weighing 1000 pounds be fed 28.7 pounds of dry matter containing 2.76 pounds of crude protein, 0.86 pound of crude fat, and 14.55 pounds of crude carbohydrates.

Very soon after this standard was proposed, Henneberg and Stohmann carried on digestion trials and found that the total nutrients contained in a feed did not form an accurate guide to its value. The proportions of the digestible parts varied with the different feeds, hence digestible nutrients would be more valuable.

Wolff's Feeding Standard.—Dr. Emil von Wolff made similar studies and proposed, in the year 1864, a standard based upon the digestible protein, digestible carbohydrates, and digestible fat. His standard for dairy cows weighing 1000 pounds is as follows: Dry matter, 24.5 pounds, containing 2.5 pounds of digestible protein, 12.5 pounds of digestible carbohydrates, and 0.4 pound of digestible fat. This has a nutritive ratio of 1 to 5.4. The nutritive ratio is the proportion of protein to carbohydrates plus $2\frac{1}{4}$ times the fat. This standard, although a great improvement over the others, was deficient in that it did not take into consideration the quantity and quality of the milk produced.

Wolff-Lehmann Feeding Standard.—The Wolff Standard was used until 1896 when it was modified by Dr. C. Lehmann of Berlin, after which it was called the Wolff-Lehmann Standard. Lehmann took into account the quantity of milk. This was an improvement over the Wolff Standard, although Lehmann failed to take into account the quality of the milk. The Wolff-Lehmann Standard is given in Table XI.

This standard was used for a great many years, and at the present time various modifications of it are employed very extensively in the United States. The modifications most commonly used are the Haecker, the Morrison, and the Savage feeding standards.

TABLE XI

WOLFF-LEHMANN STANDARD FOR DAIRY COWS

Daily Yield of Milk	Dry Matter, Lbs.	Digestible Nutrients for 1000-Pound Cow				
		Lbs. Crude Protein	Lbs. Carbo-hydrates	Lb. Fat	Sum of Nutri-ents	Nutri-tive Ratio
11.0	25	1.6	10	0.3	11.9	1 to 6.7
16.6	27	2.0	11	0.4	13.4	1 to 6.0
22.0	29	2.5	13	0.5	16.0	1 to 5.7
27.5	32	3.3	13	0.8	17.1	1 to 4.5
For maintenance	18	0.7	8	0.1	8.8	1 to 11.8

Haecker's Feeding Standard.—The improvement of the feeding standard was a gradual one. Up to the end of the nineteenth century, one important consideration, namely, that of the quality of the milk, had not been considered. It was Professor T. L. Haecker[4] of Minnesota who proposed a standard which not only included the quantity of the milk but also the quality. He was also the first to separate the requirements for maintenance from the requirements for production. While the German investigators worked with a few animals and controlled their experiments very carefully, Haecker worked with a large number over a long period of time under normal conditions. He put out three sets of figures, each a little higher than the one before.

With this system the needs of a cow of any size, producing any quantity or quality of milk, can be easily computed. Haecker expressed the value of the feeds under three heads—digestible crude protein, carbohydrates, and fat. Recently, however, they have been grouped under two heads,[5] namely, digestible crude protein and total digestible nutrients. Tables XII and XIII show the amount of nutrients required for maintenance and milk production, expressed in single terms and also as total nutrients.

Savage Feeding Standard.—Savage, of the Cornell Experiment Station,[3] after many trials, came to the conclusion that the Haecker standard was too low, especially in protein. He maintained that the nutritive ratio should not be wider than one to six. His standard, therefore, increased the protein requirement above that of the Haecker standard by about 20 per cent. He also combined digestible protein, digestible crude fiber, digestible nitrogen-free extract, and digestible fat multiplied by 2¼ into what is called total digestible nutrients. This was done to simplify the computation of a ration. Other standards, including the Haecker standard, have later been expressed in this manner. Table XIV is the standard as suggested by Savage.

TABLE XII

DAILY MAINTENANCE REQUIREMENTS FOR DAIRY COWS BY HAECKER STANDARD

Weight	Digestible Crude Protein, Lbs.	Carbohydrates, Lbs.	Fat, Lb.	Total Digestible Nutrients, Lbs.
800	0.560	5.60	0.08	6.340
850	0.595	5.95	0.08	6.725
900	0.630	6.30	0.09	7.132
950	0.665	6.65	0.09	7.517
1000	0.700	7.00	0.10	7.925
1050	0.735	7.35	0.10	8.310
1100	0.770	7.70	0.11	8.717
1150	0.805	8.05	0.11	9.102
1200	0.840	8.40	0.12	9.500
1250	0.875	8.75	0.12	9.895
1300	0.910	9.10	0.13	10.302
1350	0.945	9.45	0.13	10.689
1400	0.980	9.80	0.14	11.095
1450	1.015	10.15	0.14	11.480
1500	1.050	10.50	0.15	11.887

TABLE XIII

REQUIREMENTS FOR MILK PRODUCTION BY HAECKER STANDARD

For Each Lb. of Milk Testing, Per Cent	Digestible Crude Protein, Lb.	Carbohydrates, Lb.	Fat, Lb.	Total Digestible Nutrients, Lb.
3.0	0.047	0.20	0.017	0.285
3.5	0.049	0.22	0.019	0.312
4.0	0.054	0.24	0.021	0.341
4.5	0.057	0.26	0.023	0.369
5.0	0.060	0.28	0.024	0.394
5.5	0.064	0.30	0.026	0.422
6.0	0.067	0.32	0.028	0.450
6.5	0.072	0.34	0.029	0.477

TABLE XIV

SAVAGE'S FEEDING STANDARD FOR DAIRY COWS

	Digestible Protein, Lb.	Total Nutrients, Lbs.
Milking cows *		
For maintenance of 1000-pound cow........	0.700	7.925
For product in addition to maintenance:		
For 1 pound of milk testing 3.0 per cent....	0.0567	0.2870
For 1 pound of milk testing 3.5 per cent....	0.0608	0.3185
For 1 pound of milk testing 4.0 per cent....	0.0648	0.3497
For 1 pound of milk testing 4.5 per cent....	0.0689	0.3787
For 1 pound of milk testing 5.0 per cent....	0.0729	0.4048
For 1 pound of milk testing 5.5 per cent....	0.0770	0.4311
For 1 pound of milk testing 6.0 per cent....	0.0810	0.4572
For 1 pound of milk testing 6.5 per cent....	0.0851	0.4835

* In rations for milking cows there should be not less than 24 pounds of dry matter. The nutritive ratio should not be wider than one to six or narrower than one to four and one-half. About two-thirds of the dry matter in the ration should come from the roughage and one-third from the grain, except in the case of the heaviest producers, when relatively more may come from the grain.

Morrison's Feeding Standard.—Morrison, of the Wisconsin Experiment Station,[2] has modified the Wolff-Lehmann standard by adopting certain parts of Armsby's, Haecker's, Kellner's, Savage's, and other standards. By the use of these different standards Morrison has made an approximation, slightly different from other rations, which he believes to be more accurate than any other standard published up to this time. The standard is simplified in a way similar to that used by Savage, so that only digestible crude protein and total digestible nutrients form the basis of it. This standard is largely used in the United States. Table XV gives the requirement for maintenance and the production of dairy cows by this standard.

PRODUCTION-VALUE TYPE

Kellner Feeding Standard.—Dr. O. Kellner, a German investigator, published in 1907 a feeding standard[6] based upon starch as the unit of measure. He also took into account not only the digestibility of the feeds, as calculated from the amount lost in the feces, but the entire loss from the body and the energy expended in digesting and passing the food through the body. The amount remaining is what the animal has left to use in a productive way. Kellner's standard is thus more complete than the previous ones. The standard for maintenance of a 1000-pound animal is 0.6 pound of digestible protein and 6.35 pounds of starch equivalent. Table XVI gives the standard as formulated by Kellner.

TABLE XV

MORRISON'S FEEDING STANDARD FOR DAIRY COWS

	Digestible Crude Protein, Lb.	Total Digestible Nutrients, Lbs.
Dairy cows:		
For maintenance of 1000-pound cow........	0.700	7.925
After allowing for maintenance add:		
For each pound of 2.5 per cent milk........	0.045–0.053	0·230–0.256
For each pound of 3.0 per cent milk........	0.047–0.057	0·257–0.286
For each pound of 3.5 per cent milk........	0.049–0.061	0·284–0.316
For each pound of 4.0 per cent milk........	0.054–0.065	0·311–0.346
For each pound of 4.5 per cent milk........	0.057–0.069	0·338–0.376
For each pound of 5.0 per cent milk........	0.060–0.073	0·362–0.402
For each pound of 5.5 per cent milk........	0.064–0.077	0·385–0.428
For each pound of 6.0 per cent milk........	0.067–0.081	0·409–0.454
For each pound of 6.5 per cent milk........	0.072–0.085	0·434–0.482
For each pound of 7.0 per cent milk........	0.074–0.089	0·454–0.505

TABLE XVI

KELLNER'S FEEDING STANDARD FOR DAIRY COWS

Daily Yield of Milk, Lbs.	Dry Matter in Total Ration, Lbs.	Digestible Substances				
		Protein, Lbs.	Starch Equivalent, Lbs.	Crude Protein, Lbs.	Fat, Lb.	Nitrogen-free Extract and Crude Fiber, Lbs.
10	22–27	1.0–1.3	7.8– 8.3	1.2–1.6	0.3	9.8–10.2
20	25–29	1.6–1.9	9.8–11.2	1.9–2.3	0.5	11.5–12.8
30	27–33	2.2–2.5	11.8–13.9	2.6–3.0	0.6	12.9–14.7
40	27–34	2.8–3.2	13.9–16.6	3.3–3.8	0.8	13.9–15.3

Any of the feeds, the composition of which is known, may be converted readily into the starch equivalent by using the following factors: Digestible protein × 0.94, + digestible fat × 2.41, + nitrogen-free extract, + crude fiber = total starch equivalent. The starch equivalent in turn can be converted into net energy by a method worked out by Armsby and Kellner.[7]

Armsby Feeding Standard.—By the use of the respiration apparatus, Kellner and Zuntz were able to determine how much of the energy of the feed was required for mastication, digestion, and assimilation, while Armsby went a step further by using the respiration calorimeter. He determined not only the energy required for mastication, digestion, and assimilation of the food, but also the amounts of heat and gases given off by the body. By the use of his apparatus he was able to calculate the true net energy available in the various feeding stuffs. Table XVII[8] shows what becomes of the digestible nutrients of corn meal, timothy hay, and wheat straw when fed to dairy cattle.

TABLE XVII

NET ENERGY FROM 100 POUNDS OF CORN MEAL, TIMOTHY HAY, AND WHEAT STRAW

	Gross Energy, Therms	Energy Lost in			Available Energy Remaining, Therms	Energy Lost in Work of Digestion, Therms	Net Energy Remaining, Therms
		Feces, Therms	Methane, Therms	Urine, Therms			
100 pounds corn meal...	180.3	21.2	15.9	8.1	135.1	52.2	82.9
100 pounds timothy hay.	181.2	86.2	13.6	7.1	74.3	31.3	43.0
100 pounds wheat straw.	184.6	107.5	15.3	4.4	57.4	47.3	10.1
			Expressed in Per Cent				
Corn meal............	100	12	9	4	75	29	46
Timothy hay..........	100	48	7	4	41	17	24
Wheat straw..........	100	59	8	2	31	26	5

As seen from this table, the amount of energy lost in the gases and in the labor of mastication, digestion, and assimilation in some cases exceeds the amount lost in the feces and urine, the two latter being the only losses considered in the other standards. It is not the amount of digestible parts alone, but the net value for use in maintenance and production that is essential. The Armsby standard is based, then, upon the actual work that the feed will perform.

Armsby based his ration on the digestible true protein and therms of net energy. The digestible true protein differs from the crude digestible protein in that true protein does not include the amino acids and amids. The net energy is based upon the calory as the unit, but in order to simplify the method Armsby suggested the name "therm," to apply to 1000 large calories.

A definite amount of digestible true protein and net energy is required for the maintenance of animals of different sizes, while an additional definite amount is required for milk of different quantities and qualities. The amount of these substances required for maintenance is not based upon the weight of the animal, as in the other standards, but upon its body surface.

The immense amount of work necessary to determine the net energy value of any one feed made it impossible to secure data on a great many feeds. For this reason the actual net energy values of but very few have as yet been determined. Most of them have been computed from Kellner's data on the starch values. It has also been found that even those that have actually been run should be considered merely as averages. This is true because different samples of feeds will vary considerably. Their results, also, were secured with steers only, while other classes of livestock may vary from this average. It has been shown by Eckles [9] that Armsby's figures are a little low for the best results with dairy cattle.

Table XVIII gives the maintenance requirements for animals of different sizes according to the Armsby standard,[10] and Table XIX shows the amount of digestible true protein and net energy which should be added to the maintenance requirements in order to produce one pound of milk of different qualities.

Limitations of Feeding Standards.—A standard should be looked upon as a guide and cannot be used at all times. It must be departed from sometimes to suit the individuality of different animals, and at other times to meet conditions when the prices of certain types of feeds are too high. The most economical results may not always be secured by feeding according to a standard.

TABLE XVIII

MAINTENANCE REQUIREMENTS FOR COWS BY ARMSBY STANDARD

Weight, Lbs.	Digestible True Protein, Lb.	Therms Net Energy	Weight, Lbs.	Digestible True Protein, Lb.	Therms Net Energy
750	0.413	4.95	1200	0.565	6.78
800	0.431	5.17	1250	0.580	6.96
850	0.449	5.38	1300	0.596	7.15
900	0.466	5.59	1350	0.611	7.33
950	0.483	5.80	1400	0.626	7.51
1000	0.500	6.00	1450	0.641	7.69
1050	0.517	6.20	1500	0.655	7.86
1100	0.533	6.39	1550	0.670	8.03
1150	0.548	6.58	1600	0.684	8.21

TABLE XIX

REQUIREMENTS FOR MILK PRODUCTION IN ADDITION TO MAINTENANCE BY ARMSBY STANDARD

For 1 Pound of Milk Testing, Per Cent	Digestible True Protein, Lb.	Net Energy, Therms
2.5	0.041	0.19
3.0	0 043	0.21
3.5	0.045	0.24
4.0	0.049	0.27
4.5	0.052	0.29
5.0	0.055	0.32
5.5	0.058	0.34
6.0	0.061	0.36
6.5	0.064	0.39
7.0	0.068	0.41

There are also many other factors, as brought out in the previous lecture, which are not taken into account in balancing rations. These factors include the more recent knowledge concerning the complete and incomplete proteins, the mineral requirements, the palatability, the succulence, the bulk, the vitamins, and other requirements which go to make up a good ration. In other words, a ration may meet the requirements of a standard as far as food nutrients are concerned, but may be very undesirable from a physiological or economical standpoint.

Another difficulty with feeding standards is that they are too difficult for general use. Farmers do not take the time necessary to study them out. However, herdsmen and others interested in dairying should become acquainted with their use.

Feeding standards, as a rule, are quite accurate, and can be used very advantageously in showing the deficiencies of a ration which is being fed. It should be understood, however, that feeding standards, as well as the tables of nutrients, are but averages and will not apply to all feeds or to all conditions.

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LECTURE VIII

BALANCING RATIONS FOR INDIVIDUAL COWS

Balanced Rations.—A balanced ration is the feed or combination of feeds which will supply the daily food requirements of an animal. To tell what these daily requirements are, the various feeding standards have been formulated. The next problem, then, is to adjust the feeds in such a way that they will meet the requirements. This is called balancing rations. It is very necessary that the student in dairying and any others interested in the feeding of dairy animals understand how rations are balanced.

In this lecture we shall take up the methods of balancing a ration for an individual cow by the Scandinavian, the Haecker, the Morrison, and the Armsby standards. The Wolff-Lehmann standard is used very little in this country at present while the method used in the Savage system is similar to that of the Morrison system and for that reason will not be taken up. For convenience and for comparison, the same conditions will be considered in every case. It will be necessary, in order to have a balanced ration by the use of each standard, to vary the amounts of the different feed stuffs. The amount of roughage, however, will be kept the same throughout this problem.

Problem.—Calculate a balanced ration for a cow weighing 1000 pounds and giving 25 pounds of 4 per cent milk. The following feeds are available:

Roughages	*Concentrates*
Red-clover hay	Wheat bran
Corn stover	Gluten feed
Corn silage	Cottonseed meal
	Cornmeal

Scandinavian System

In Lecture VII it was learned that for maintenance a cow requires one feed unit for every 150 pounds of weight and that she requires one additional unit for each 3 pounds of milk produced. In addition, it is necessary that the ration contain, for maintenance, not less than 0.065 pound of digestible protein for each 100 pounds of live weight and 0.05 pound of digestible protein for each pound of milk produced.

The requirements, then, for the particular cow in the problem would be as follows:

	Digestible Crude Protein, Lbs.	Feed Units
Maintenance of 1000-lb. cow	0.65	6.66⅔
25 lbs. of 4 per cent milk	1.25	8.33⅓
Total	1.90	15.00

The problem now is to apportion the feeds so that they will supply these requirements and, at the same time, to keep in mind the characteristics of the different feeds. The amount of digestible protein can be secured from Table C in the Appendix, and the feed units from Table X in Lecture VII.

For a trial ration we shall use the feeds in the following proportions:

	Digestible Crude Protein, Lbs.	Feed Units
Roughages:		
30 lbs. corn silage	0.363	4.53
5 lbs. clover hay	0.369	2.15
4 lbs. corn stover	0.079	1.46
Concentrates:		
4 lbs. corn meal	0.250	4.12
1 lb. gluten feed	0.213	1.14
1½ lbs. wheat bran	0.180	1.17
1½ lbs. cottonseed meal	0.555	1.97
Total	2.009	16.54
Requirements	1.900	15.00
Difference	+0.109	+1.54

It will be noticed that the protein is but little in excess of the requirements while there are 1.54 feed units in excess. It will be necessary, therefore, to take away a little of the low-protein feed, which in this case is corn meal. For a new trial we shall take away 1½ pounds of corn meal.

	Digestible Crude Protein, Lbs.	Feed Units
First trial ration	2.009	16.54
Deduct 1½ lbs. corn meal	0.094	1.54
Total	1.915	15.00
Requirements	1.900	15.00
Difference	+0.015	0.00

The ration would then be very close to the requirements.

The ration balanced by this system would be as follows:

Roughages	*Concentrates*
30 lbs. corn silage	2½ lbs. corn meal
5 lbs. clover hay	1 lb. gluten feed
4 lbs. corn stover	1½ lbs. wheat bran
	1½ lbs. cottonseed meal

It would require, then, 6½ pounds of concentrates to fulfill the needs of the standard. This is about 1 pound of concentrates to each 3.8 pounds of milk.

Haecker Standard

The Haecker standard was originally expressed in three terms, digestible crude protein, digestible carbohydrates, and digestible fat, although it has since been changed over to the protein and total-nutrients basis. In calculating the ration by this standard we shall use the old method, since the new method is similar to the one that will be used in the Morrison standard.

By referring to Tables XII and XIII in Lecture VII, it is seen that the maintenance requirement for a cow weighing 1000 pounds is 0.7 pound of digestible protein, 7.0 pounds of digestible carbohydrates, and 0.1 pound of digestible fat; and that for each pound of 4 per cent milk which the cow is giving she requires in addition 0.054 pound of digestible protein, 0.24 pound of digestible carbohydrates, and 0.021 pound of digestible fat. The requirements, then, for the cow in the problem would be as follows:

	Digestible		
	Protein, Lbs.	Carbohy-drates, Lbs.	Fat, Lb.
Maintenance of 1000-pound cow......	0.70	7.0	0.10
For production of 25 lbs. of 4 per cent milk..........................	1.35	6.0	0.53
Total requirements........... .	2.05	13.0	0.63

Table C is the Appendix contains the analyses of different feeds. For a trial ration, the same ration as was used in the Scandinavian system will be used. It is as follows:

First Trial Ration

	Digestible		
	Protein, Lbs.	Carbohy-drates, Lbs.	Fat, Lb.
Roughages:			
30 lbs. of corn silage.............	0.363	4.36	0.264
5 lbs. of red-clover hay..........	0.369	1.91	0.091
4 lbs. of corn stover.............	0.079	1.32	0.023
Concentrates:			
2½ lbs. of corn meal..............	0.157	1.63	0.087
1 lb. of gluten feed.............	0.213	0.53	0.029
1½ lbs. of wheat bran............	0.180	0.62	0.043
1½ lbs. of cottonseed meal........	0.555	0.25	0.189
Total.........................	1.916	10.62	0.726
Requirements..................	2.050	13.00	0.630
Differences...................	−0.134	−2.38	+0.096

The trial ration is deficient in both protein and carbohydrates but supplies more fat than is required. The carbohydrates are especially low, while the fat is considerably above the requirements. By looking at the feeds we see that gluten feed and corn meal are the highest in carbohydrates and at the same time are quite low in fat. For the second trial, therefore, we shall add 2 pounds of gluten and 2½ pounds of corn meal:

Second Trial Ration

	Digestible		
	Protein, Lbs.	Carbohydrates, Lbs.	Fat, Lb.
First trial ration	1.916	10.62	0.726
2 lbs. gluten feed	0.426	1.06	0.058
2½ lbs. corn meal	0.157	1.63	0.087
Total	2.499	13.31	0.871
Requirements	2.050	13.00	0.630
Difference	+0.449	+0.31	+0.241

In this trial there is an excess of all the nutrients. The protein and fat are especially high. The nutrient which will bring these down without bringing down the carbohydrates so much is the cottonseed meal. For a third trial, therefore, a pound of cottonseed meal is removed.

Third Trial Ration

	Digestible		
	Protein, Lbs.	Carbohydrates, Lbs.	Fat, Lb.
Second trial ration	2.499	13.31	0.871
Deduct 1 lb. cottonseed meal	0.370	0.17	0.126
Total	2.129	13.14	0.745
Requirements	2.050	13.00	0.630
Difference	+0.079	+0.14	+0.115

The ration is now not far from the requirements of the Haecker standard. It is as follows:

30 lbs. corn silage	5 lbs. corn meal
5 lbs. clover hay	3 lbs. gluten feed
4 lbs. corn stover	1½ lbs. wheat bran
	½ lb. cottonseed meal

It would require, then, 10 pounds of concentrates to supply the requirements of this standard under the given conditions. This is about 1 pound of concentrates to each 2.5 pounds of milk.

Morrison Standard

Morrison uses only two terms, digestible crude protein and total digestible nutrients. The total digestible nutrients are the sum of the digestible crude protein, the digestible carbohydrates, and the digestible fat multiplied by 2.25. The 2.25 is the factor used to convert the fa tinto its equivalent carbohydrate value. For milk production, Morrison allows a range, and it is therefore necessary to take the average when calculating a ration.

By referring to Table XV in Lecture VII, it may be seen that the maintenance requirement for a cow weighing 1000 pounds is 0.7 pound of digestible protein and 7.925 pounds of total digestible nutrients. It will be seen also that for each pound of 4 per cent milk the cow requires 0.0539 pound of digestible protein and 0.3285 pound of total digestible nutrients in addition. The total requirements, then, for the particular cow in the problem would be as follows:

	Digestible Protein, Lbs.	Total Digestible Nutrients, Lbs.
Maintenance of a 1000-lb. cow	0.700	7.925
For production of 25 lbs. of 4 per cent milk	1.487	8.212
Total requirements	2.187	16.137

In Table C in the Appendix the analyses of the different feeds can be ascertained. For a trial, the same ration as was used in the Scandinavian system may be used. It is as follows:

FIRST TRIAL RATION

	Digestible Protein, Lbs.	Total Digestible Nutrients, Lbs.
Roughage:		
30 lbs. of corn silage	0.363	5.325
5 lbs. of red-clover hay	0.369	2.480
4 lbs. of corn stover	0.079	1.457
Concentrates:		
2½ lbs. of corn meal	0.157	1.985
1 lb. of gluten feed	0.213	0.806
1½ lbs. of wheat bran	0.180	0.896
1½ lbs. of cottonseed meal	0.555	1.227
Total	1.916	14.176
Requirements	2.187	16.137
Difference	−0.271	−1.961

The first trial ration is deficient in both digestible protein and total digestible nutrients, but is not greatly out of proportion. In the second trial, therefore, we shall add 1 pound of gluten feed and 1½ pounds of corn meal:

SECOND TRIAL RATION

	Digestible Protein, Lbs.	Total Digestible Nutrients, Lbs.
First trial ration	1.916	14.176
1½ lbs. corn meal	0.094	1.191
1 lb. gluten feed	0.213	0.806
Total	2.223	16.173
Requirement	2.187	16.137
Difference	+0.036	+0.036

This ration is now not very far from the requirements of this standard, and is as follows:

Roughage	*Concentrate*
30 lbs. of corn silage	4 lbs. corn meal
5 lbs. of clover hay	2 lbs. of gluten feed
4 lbs. of corn stover	1½ lbs. of wheat bran
	1½ lbs. of cottonseed meal

It would require 9 pounds of this mixture to supply the requirements of this standard. This would be about 1 pound of concentrate to each 2.8 pounds of milk produced.

Armsby Standard

The Armsby standard is expressed in pounds of digestible true protein and therms of net energy. By referring to Tables XVIII and XIX in Lecture VII it can be seen that the maintenance requirement for a cow weighing 1000 pounds is 0.5 pound of digestible true protein and 6 therms of net energy, and that for each pound of 4 per cent milk she requires 0.049 pound of digestible true protein and 0.27 therm of net energy. From this it can be seen that the requirements are as follows:

	Digestible True Protein, Lbs.	Net Energy, Therms
Maintenance of 1000-lb. cow	0.500	6.00
For production of 25 lbs. of 4 per cent milk.	1.225	6.75
Total requirements	1.725	12.75

In Table A in the Appendix the true protein and net energy of the various feeding stuffs can be found. The same ration which was found to meet the requirements of the Scandinavian standard will be used in the first trial:

First Trial Ration

	Digestible True Protein, Lbs.	Net Energy, Therms
Roughages:		
30 lbs. of corn silage	0.180	4.770
5 lbs. of red-clover hay	0.245	1.934
4 lbs. of corn stover	0.064	1.265
Concentrates:		
2½ lbs. of corn meal	0.160	2.130
1 lb. of gluten feed	0.201	0.807
1½ lbs. of wheat bran	0.162	0.795
1½ lbs. of cottonseed meal	0.531	1.402
Total	1.543	13.103
Requirements	1.725	12.750
Difference	−0.182	+0.353

The first trial ration is slightly deficient in pounds of digestible true protein but supplies 0.353 therm of net energy more than is required. It will be necessary, then, to take away some of the low-protein feed and replace it with a high-protein feed. Accordingly, we shall remove 1½ pounds of corn meal and add ½ pound each of gluten feed and cottonseed meal for the second trial ration. This ration will be as follows:

SECOND TRIAL RATION

	Digestible True Protein, Lbs.	Net Energy, Therms
First trial ration	1.543	13.103
Deduct 1½ lbs. of corn meal	0.096	1.278
Total	1.447	11.825
Add ½ lb. of gluten feed	0.100	0.404
½ lb. of cottonseed meal	0.177	0.467
Total	1.724	12 696
Requirements	1.725	12.750
Difference	−0.001	−0.054

This ration now just about meets the requirements of the Armsby standard. It is as follows:

Roughages	*Concentrates*
30 lbs. of corn silage	1 lb. of corn meal
5 lbs. of red-clover hay	1½ lbs. of gluten feed
4 lbs. of corn stover	1½ lbs. of wheat bran
	2 lbs. of cottonseed meal.

This standard would require 6 pounds of concentrates to fill its needs. This is about 1 pound of grain to each 4 pounds of milk given by the cow.

The foregoing problems show how rations can be balanced. With a little practice one becomes able to adjust a ration by adding, for instance, a little of one feed and taking away a little of another, thus obtaining the right proportion to meet the requirements. A method has been suggested for the exact calculation of balanced rations, but its use is usually unnecessary as one can come near enough by the above methods for all practical purposes.

Comparison of Feeding Standards

It is not possible to make a direct comparison of all the feeding standards as they are not all expressed in the same terms. In Table XX, however, the requirements for maintenance and for the production of 1 pound of 4 per cent milk are brought together so that a comparison can be made. The Wolff-Lehmann and the Haecker systems have been converted to the total-digestible-nutrient basis, although the production of 1 pound of milk with the Wolff-Lehmann system has been omitted since this system includes the maintenance requirement with the production requirement:

TABLE XX

Comparison of Feeding Standards

Name of Standard	Maintenance of 1000-Lb. Cow					Production of 1 Lb. of 4% Milk				
	Digestible					Digestible				
	Crude Protein, Lb.	True Protein, Lb.	Total Nutrients, Lbs.	Feed Units	Energy, Therms	Crude Protein, Lb.	True Protein, Lb.	Total Nutrients, Lb.	Feed Units	Energy, Therms
Wolff-Lehmann	0.70	.....	8.925							
Haecker	0.70	.....	7.925	.....	....	0.0540	.....	0.3410		
Savage	0.70	.....	7.925	.....	......	0.0648	.....	0.3497		
Morrison	0.70	.....	7.925	.....	....	0.0595	.....	0.3460		
Scandinavian	0.65	.....	......	$6\frac{2}{3}$	....	0.0500	.....	......	1/3	
Armsby	......	0.50	......	.....	6	......	0.049	......	.....	0.2700

This table shows that there is very little difference in the maintenance requirements as far as comparisons can be made. The requirements of the Savage standard for milk production, however, are higher than the others. The requirements of the Morrison standard are between those of the Haecker and the Savage standards. A direct comparison cannot be made between the Armsby and Scandinavian standards and the other standards. With the rations balanced in the problem of the first part of this lecture, the amount of concentrates required by these standards was considerably less than was required with the Haecker or Morrison standards. It has been found that for maximum production more feed is required than is provided for by the Armsby standard. At times, however, it may be economical to feed less than would be fed for maximum flow. The requirements of the Scandinavian standard do not seem to be far from those of the Armsby system.

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LECTURE IX

BALANCING RATIONS FOR THE HERD

The method of balancing rations as given in the last lecture is adapted for individual cows. When it is a question of feeding a herd, it is not practical to figure an individual ration for each animal. One way that the standard can be used, however, is to figure a ration for an average cow in the herd, using the average weight of the cows and their average production. If the herd is all of one breed, the average test may also be used. Then, by following the method used in the last lecture, a ration can be calculated which, when fed according to the rules that have been laid down, should give good results.

Other methods, however, have been devised so that a person can quickly calculate an approximate balanced ration which, when fed according to certain rules, should give good results. One method which is commonly used with the net-energy system is published in a bulletin of the Pennsylvania State College and will be given in this lecture.

Roughages Used.—As stated before, feeds are divided into two general groups, roughages and concentrates. Roughages are, as a rule, the cheaper and cows should therefore be fed all that they will clean up. However, they ordinarily cannot eat enough roughage to supply the required food nutrients for both maintenance and milk production. They must, therefore, be fed grain in addition to the roughage. The concentrates are used to balance the roughage fed, hence the kind of concentrate or grain mixture needed will depend upon the class of roughage fed. It is easy to divide roughage into three general groups:

Group I includes timothy hay, corn stover, and corn silage. With any one of these, or any combination of them, a great deal of protein will be required in the grain mixture.

Group II includes mixed clover and timothy hay, or any combination half leguminous and half non-leguminous. This group will require a grain mixture with a medium amount of protein.

Group III includes the legumes as the entire roughage. This group needs the smallest amount of protein in the grain mixture.

Nutritive-ratio Method

Helps in Compounding Grain Mixtures.—Many dairymen do not know the exact yield and composition of their milk. In such cases, the exact amount of roughage fed is usually not known; yet it is possible, by using the accompanying table, to make a grain mixture that will practically balance the roughage.

By dividing the therms of net energy by the pounds of digestible true protein, we can secure the ratio of these two in the grain mixture. This is known as the ratio of digestible true protein to net energy and is shown as follows: 1 to 4, meaning that for every pound of digestible true protein in a grain mixture there are 4 therms of net energy.

To make Table XXI useful, it is necessary:

1. To determine to which group the available roughage belongs.
2. To determine the average yield of milk of each cow in the herd, or of the average cow in the herd.
3. To determine the average test of the milk.

For example, if we were going to figure a ration for a herd of cows giving 30 pounds of 4.5 per cent milk, and the only roughage available was timothy hay and corn silage, then, by looking at Table XXI we should see that the roughage would fall into Group 1 and that the nutritive ratio of the grain ration should be around 1 to 4. This can then be used as the basis for figuring the grain ration.

When the test of butter-fat is not known the following table will be of help in making an estimate:

	Per cent
Herd of all Jerseys or Guernseys or high grade	5.0
Mixed herd with some Guernsey or Jersey animals	4.5
Common mixed herd and Ayrshires	4.0
Herd of all Holsteins	3.5

Amount of Grain to Feed.—Grain should be fed in proportion to milk yield. The following table will give the approximate amount of grain to feed in proportion to the milk obtained. The proportion will vary according to the fat content of the milk.

3 per cent to 4 per cent fat in milk, feed 1 lb. of grain for 3.5 to 4.0 lbs. of milk.
4 per cent to 5 per cent fat in milk, feed 1 lb. of grain for 3.5 lbs. of milk.
5 per cent to 6 per cent fat in milk, feed 1 lb. of grain for 3 lbs. of milk.

TABLE XXI

THE RATIO OF DIGESTIBLE TRUE PROTEIN TO NET ENERGY FOR THE GRAIN MIXTURE TO BE USED WITH DIFFERENT ROUGHAGES, QUALITIES AND QUANTITIES OF MILK

Roughage	Daily Milk Production per Cow, 15–25 Lbs.			Daily Milk Production per Cow, 25–35 Lbs.		
	3 to 4% Fat	4 to 5% Fat	5 to 6% Fat	3 to 4% Fat	4 to 5% Fat	5 to 6% Fat
	Ratio of Digestible True Protein to Net Energy 1 to			Ratio of Digestible True Protein to Net Energy 1 to		
Group I Timothy hay, corn stover, timothy hay and corn stover, timothy hay and corn silage, mixed hay and corn stover, mixed hay and corn silage, corn stover and corn silage, or any other non-leguminous roughage.	3	3.5	4	3.5	4	4.5
Group II Mixed clover and timothy hay, clover hay and corn stover, clover hay and corn silage, alfalfa and corn silage, or any combination half leguminous and half non-leguminous.	4	4.5	5	4.5	5	5.5
Group III Clover hay, alfalfa hay or when all the roughage is leguminous.	7	7.5	8	6	6.5	7

Balancing Ration for the Herd.—Let us assume that we have a herd of cows averaging 1000 pounds in weight and giving an average of 20 pounds of 4.5 per cent milk. The roughage available is in Group I and consists of timothy hay. From Table XXI it will be seen that a cow being fed a roughage in Group I giving 20 pounds of 4.5 per cent milk would need a ratio of digestible protein to net energy of 1 to 3.5. The problem, then, is to compute a grain mixture with this ratio.

For a trial ration we shall use the following:

FIRST TRIAL RATION

	Digestible True Protein, Lbs.	Net Energy, Therms
100 lbs. of wheat bran..................	10.8	53.00
50 lbs. ground oats.....................	4.3	33.78
50 lbs. cottonseed meal (prime)..........	16.0	45.00
100 lbs. linseed meal (O P)...............	28.5	88.91
300 lbs. mixture contains.................	59.6	220.69
1 lb. mixture contains..................	0.199	0.735

The ratio of digestible true protein to net energy is 220.69 divided by 59.6, which equals 3.7, or 1 to 3.7.

In order to narrow the ratio, as it is necessary to do, some food of very narrow energy ratio should be added, for example, 50 pounds of cottonseed meal. By the addition of 50 pounds of cottonseed meal for a second trial, the following is obtained:

SECOND TRIAL RATION

	Digestible True Protein, Lbs	Net Energy, Therms
300 lbs. of first trial ration...............	59.6	220.69
50 lbs. of cottonseed meal..............	16.0	45.00
350 lbs. mixture contains................	75.6	265.69
1 lb. mixture contains................	0.207	0.76

The ratio of digestible true protein to net energy is 265.69 divided by 75.6, which equals 3.5, or 1 to 3.5. Since 1 to 3.5 is the required ratio, the completed grain mixture would be as follows:

100 lbs. of wheat bran
50 lbs. of ground oats
100 lbs. of cottonseed meal (prime)
100 lbs. of linseed meal (OP)

In this particular case, according to our rules of feeding, when the milk tests 4.5 per cent, grain should be fed at the rate of 1 pound to each 3.5 pounds of milk which the different cows in the herd are giving.

The following will illustrate how the foregoing grain mixture would work successfully in practice. From Tables XVIII and XIX in Lecture VII it will be seen that the requirements of a 1000-pound cow giving 20 pounds of 4.5 per cent milk would be as follows:

	Digestible True Protein, Lbs.	Net Energy, Therms
Maintenance of 1000-lb. cow	0.50	6.0
20 lbs. of 4.5 per cent milk	1.04	5.8
Total requirements	1.54	11.8

It is recommended that a cow giving milk testing 4.5 per cent fat be fed 1 pound of grain for every 3.5 pounds of milk. For 20 pounds of milk, approximately 5.5 pounds of grain would be needed. Five and one-half pounds of the above grain mixture would contain 1.14 pounds of protein and 4.18 therms of net energy. The rule for feeding roughage when no silage is fed is to allow from 1.5 to 2 pounds of hay per hundred pounds live weight. The food supplied, therefore, would be as follows:

	Digestible True Protein, Lbs.	Net Energy, Therms
18 lbs. of timothy hay	0.40	7.74
5.5 lbs. of grain mixture	1.14	4.18
Total supplied	1.54	11.92
Requirements	1.54	11.80
Difference	0.00	−0.12

It will be seen that the total food supplied in this case is practically equal to the requirements.

Determining the Cost of the Ration.—The cost of the ration should be figured on every farm. This is especially true of the grain ration, a large proportion of which is often purchased. The following table will show the cost, at various prices, of 100 pounds of digestible true protein and 100 therms of net energy in the foregoing grain mixture:

	Digestible True Protein and Net Energy	Price per Ton	Price per 100 Lbs.	Cost of 100 Lbs. of Digestible True Protein	Cost of 100 Therms of Net Energy
Wheat bran..........	P. 10.8 E. 53.0	$36.00	$1.80	$16.66	$3.39
Ground oats.........	P. 8.7 E. 67.56	40.00	2.00	22.99	2.96
Cottonseed meal (pr)..	P. 32.0 E. 90.0	40.00	2.00	6.25	2.22
Linseed meal (OP)....	P. 28.5 E. 88.9	58.00	2.90	10.18	3.26

The following explanation illustrates how the cost of digestible true protein and net energy is determined. Dividing the cost of 100 pounds of wheat bran ($1.80) by 10.8 pounds of digestible true protein, which it contains, gives 16.66 cents, the cost of 1 pound of digestible true protein; multiplying this result by 100 gives $16.66, the cost of 100 pounds of digestible true protein. In a like manner, dividing $1.80 by 53 therms of net energy, the content of 100 pounds of wheat bran, gives $3.39, the cost of one therm of net energy; multiplying this result by 100 gives $3.39, the cost of 100 therms of net energy. By this method the cost of the digestible true protein and net energy in each feed can be determined.

It can be seen that, at the prices assumed, the relative cost of net energy does not vary as does that of digestible true protein. In the purchase of feeds the cost of these items should be considered rather than the cost of 100 pounds of the feed. The cheapest ration will usually contain the grain that furnishes the digestible true protein at the cheapest rate as well as that which furnishes net energy relatively cheap.

The actual cost of the ration would be as follows:

Actual Cost of the Grain Ration

100 lbs. of wheat bran costs	$1.80
50 lbs. of ground oat costs	1.00
100 lbs. of cottonseed meal costs	2.00
100 lbs. of linseed meal costs	2.90
350 lbs. of mixture costs	7.20
100 lbs. of mixture costs	2.20
100 lbs. of digestible true protein costs	10.62
100 therms of net energy costs	2.90

In a similar manner the cost of any ration can be figured, as well as the cost of 100 pounds of digestible true protein and 100 therms of net energy.

Balancing by the Protein Method[2]

For general farm use, a simple method of balancing a ration for a herd is required, and even the one just described may sometimes prove too elaborate to be practical. Since there is seldom a deficiency in carbohydrates and fats when the animals have all the roughage that they can eat, a roughly balanced ration may be obtained by balancing the protein of the grain mixture to go with the kind of roughage used, and disregarding the carbohydrates and fats.

The roughages can be divided into the three groups given above as follows:

I. Low-protein Group: Timothy hay, corn stover, straw, corn silage, or any other non-legume. Percentage of digestible protein required in grain ration, **18** to **22.**

II. Medium-protein Group: Mixed hay, clover and silage, or other roughage, with at least half of the roughage legume. Percentage of digestible protein required in grain mixture, **15** to **18.**

3. High-protein Group: Clover hay, alfalfa hay, soy-bean hay, or any of the legume roughages. Percentage of digestible protein required in grain mixture, **12** to **15.**

Making Up a Grain Mixture for the Herd.—As an example of this method of making up a ration for a dairy herd, let us assume that we have on hand alfalfa hay and corn silage for roughage, which are in the medium-protein group, and that we have available corn meal, ground oats, wheat bran, and cottonseed meal. By referring to Table C in the Appendix we get the following figures for protein:

100 lbs. of corn meal contains 6.26 lbs. of digestible protein;
100 lbs. of wheat bran contains 12.01 lbs. of digestible protein;
100 lbs. of ground oats contains 9.25 lbs. of digestible protein;
100 lbs. of cottonseed meal contains 37.01 lbs. of digestible protein;
then, 400 lbs. of the mixture contains 64.53 lbs. of digestible protein.
64.53 divided by 400 equals 0.161, or 16.1 per cent of digestible protein.

By referring to the groups of roughages, it will be noted that when the roughage is in the medium-protein group, the percentage of protein in the grain mixture should be from 15 to 18 per cent. This ration, then, should fulfill the requirements, provided, of course, it meets the needs of the animals as to bulk, variety, palatability, physiological effect, mineral content, and so forth.

Now let us assume that instead of alfalfa and silage for roughage we have only timothy hay and corn stover, which are in the low-protein group, and that we have the same concentrates as before. It would be necessary to add more of the high-protein feeds as follows:

400 lbs. of the mixture contains 64.53 lbs. of digestible protein;
100 lbs. of cottonseed meal contains 37.01 lbs. of digestible protein;

500 lbs. of the new mixture contains 101.54 lbs. of digestible protein.
101.54 divided by 500 equals 0.203, or 20.3 per cent of digestible protein.

By referring to the groups of roughages, it will be noted that when the roughage is in the low-protein group the digestible protein in the grain mixture should be from 18 to 22 per cent. This ration fulfills these requirements and therefore should be a good one under the given conditions.

Now suppose that the roughages consist of alfalfa hay alone, which is in the high-protein roughage group, and that the same concentrates are available. It would be necessary to add a low-protein concentrate, such as corn meal, to the first ration, as follows:

400 lbs. of the mixture contains 64.53 lbs. of digestible protein;
100 lbs. of corn meal contains 6.26 lbs. of digestible protein;

500 lbs. of the new mixture contains 70.79 lbs. of digestible protein.
70.79 divided by 500 equals 0.141, or 14.1 per cent of digestible protein.

We note that the grain mixture in the high-protein group should be between 12 and 15 per cent, and hence the foregoing ration would fulfill the requirements; yet, if desirable for any reason, the protein content of the ration could be still lower.

It is comparatively easy to balance a grain mixture in this way for any kind of roughage. If the roughage is low-grade, use a higher protein percentage in the grain mixture, and *vice versa*. It is important, however, to keep in mind the characteristics of the feeds when making up the grain ration, and always to feed the ration according to the production of the individual cows in the herd.

It is also well to consider the cost of the protein and total digestible nutrients in the feeds used to make up the ration, and always to take the cheapest, everything else being equal.

Mixing the Ration.—When mixing a ration, the grain ingredients should be spread out in thin layers on a clean floor, one on top of another. The salt and mineral matter may also be added at this time. The whole should then be shoveled over several times to insure complete mixing. After mixing, the feed can be stored in a bin or in sacks and used when needed. If a larger amount is desired than is called for in the mix, the amount of each ingredient may be doubled or even trebled without affecting the results in any way.

FIG. 9.—Students mixing a grain ration.

General Rules for Feeding.—The following rules can be used as a guide in the feeding of dairy cows:

1. Feed all the roughage that the cows will eat up clean. Legume roughage is the best.
2. Be sure the ration is properly balanced. Then feed the grain mixture in proportion to the milk yield: for a Holstein or Ayrshire, about 1 pound of grain for each 3½ to 4 pounds of milk; for a Jersey or Guernsey, about 1 pound of grain for each 3 to 3½ pounds of milk. A variety of grains in the mixture is desirable.
3. Give some succulent feed, such as silage or roots.

4. During the dry season of the year, supplement the pastures by feeding silage or some green crop together with a little grain.
5. If the cows show a tendency to become fat, reduce the amount of grain or roughage or both.
6. Give the cows an abundance of pure water.
7. Feed regularly and give access to salt daily.

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LECTURE X

FEEDING FOR MILK PRODUCTION

Causes of Milk Secretion.—Milk secretion is stimulated by two factors. The first is the action of hormones, or stimulating substances, secreted by some ductless gland upon the udder, while the second is a nervous reaction brought about by the treatment which the animal receives.[1] The hormone stimulus seems to be the predominating one for a period of time after parturition and is more or less independent of the feed supply. As lactation advances, however, the nervous stimulus gradually replaces the hormone stimulus, the latter gradually dying out. The nervous stimulus is entirely dependent upon the food supply and the treatment received by the cow. The hormone stimulation, however, is due to the heredity of the cow and will continue for some time even after all food has been removed. It is nature's provision to feed the young even though the mother herself may suffer.

Eckles and Palmer[2] fed several cows which had just freshened on rations sufficient only for maintenance, and in certain cases the milk flow continued the same for twenty-two to thirty days. The animals were able to maintain this flow by drawing upon their surplus fat and flesh. One cow which was thin at the start was so weak at the end of thirty days on this ration that she had difficulty in getting up, and staggered considerably in her walk, but her milk production actually increased. This is a striking example of the strength of the hormone stimulus which the cow receives at parturition.

Resting the Cow.—Heavy milk production is a severe drain upon a dairy cow, and for this reason it is very important that the cow be given a rest of from four to eight weeks between each lactation period. The length of time necessary will depend upon the condition of the cow and the amount of milk which she is producing. For a heavy producer or for a cow in poor flesh, six weeks or two months should be given so that she will have ample time to rest and store up any materials which she may need in greater quantities than she can consume during the stress of heavy production.

It has been found that a cow that has been given a good rest will usually milk heavier than one that has been given little or no rest. One reason for a long period of rest is to allow the cow time to recuperate in her lime supply. It has been found, as stated before, that a cow on heavy milk flow is always in a negative balance as far as calcium is concerned. She is in a positive calcium balance, however, when not producing milk. This, then, is one reason for giving heavy producers a good rest. A cow should also be in moderately good flesh at the time of parturition since very few heavy milkers are able to consume enough feed to supply the nutrients in the milk which they produce for the first few weeks. Owing to the hormone stimulation, a cow will often draw on the reserve of her body in the early months of lactation in order to supply the nutrients in the milk. If she has no reserve she must start on a much lower level than she would otherwise, and as a result will produce much less milk during the lactation period.

Drying the Cow.—In many cases it is easy to dry the cow, as too many of them go dry by themselves after milking for a short time. Sometimes, however, the hormone stimulation remains quite strong and the cow will continue to give a good flow of milk up to the time of freshening. This is often given as a reason for not drying a cow off. A cow, however, should always be given a rest. If she is producing as little as 8 or 10 pounds a day she can easily be dried off by increasing the time between milkings for a few days and then ceasing altogether to milk her. At this period the stimulus is practically all of the nervous type and the cow can be dried off very easily. When the cow is milking heavier than 10 pounds per day it is usually necessary to keep all food away from her for several days and at the same time increase the time between milkings until she is reduced to 10 pounds or less of milk per day, when she can be let go. If a cow is not dried off until a week or ten days before she is due to freshen, it is almost impossible to get her completely dry since she is usually increasing in her milk flow at that time.

Feeding the Dry Cow before Parturition.—If the cow is dry during the summer or early fall and is on good pasture she will need very little extra feed or care before parturition. A pasture separate from the general herd is desirable as there is then less danger of injury. Under these conditions the cow will usually need very little grain. If she is in poor condition, however, she should be fed a light ration containing such feeds as ground oats, wheat bran, and corn meal. Corn should not be fed in large quantities at this period as it is a heating feed. The cow should be in good condition at the time of freshening as her production depends upon her getting a good start.

When the dry period occurs in the winter the ration should consist of 20 to 30 pounds of corn silage with a liberal amount of legume hay and a grain mixture containing such feeds as linseed meal, wheat bran, ground oats, and, in case the cow is in poor condition, corn meal. The regular herd ration is often fed with good results, but a ration a little lower in protein is more desirable.

A few days before freshening, the grain ration should be considerably reduced and at that time the cow should be fed a ration which will keep the bowels in a laxative condition. A mixture of two parts of wheat bran and one of linseed meal is often fed at this time. It is often necessary to give the cow a dose of Epsom salts or a quart of raw linseed oil a few days before parturition. Freedom from milk fever and other post-parturient troubles are in a large measure due to the care with which a cow is handled during the few weeks previous to parturition.

Feeding a Cow just after Parturition.—The grain ration for the first few days after parturition should be light in character and should be fed in small amounts. A bran mash made by moistening the bran with warm water is the only grain which should be fed at first. It has a cooling effect on the cow and is slightly laxative. She can also be given some legume hay and a limited amount of corn silage. If the weather is cold her water should be warmed slightly. A mixture of oats, bran, and linseed meal can be used to replace the bran mash after the first day or two.

Getting the Cow on Full Feed.—After the first three or four days, if the cow is in good condition, she can be given the regular herd ration just as fast as her physical condition will permit. If the udder is swollen the amount of grain must be kept down until the congestion disappears. Great care should always be exercised in increasing the cow's ration to full feed. Oftentimes, with heavy producing cows, full feed will not be reached for a full month after parturition. The heavy-milking cows usually lose weight during the first month as they are drawing on their reserve for milk production.

Under ordinary conditions, one can begin on the fourth or fifth day after freshening to feed 4 or 5 pounds of the regular grain ration, and this can be increased at the rate of 1 pound per day on every two or three days until the cow reaches her maximum production. It is often hard to judge when the maximum has been reached. The cow should be given enough feed to supply the amount needed in the milk and to keep her from dropping off in her weight. If she is giving 30 pounds of milk per day and is receiving 9 pounds of grain, and if one is not sure she has reached her maximum production, the feed should be increased slowly to possibly 12 pounds and the effect upon the cow watched carefully. If she responds with more milk, then a further increase should be attempted. If, however, she does not give any increase in milk production within two or three days, the amount of grain should be gradually diminished until she is receiving just the amount to which she will respond.

Feeding the Milking Herd.—In feeding the milking herd for production, it is well to keep in mind the requirements for a good dairy ration, which have been brought out in a previous lecture. A cow should receive an abundance of feed, containing plenty of nutrients in the correct proportions and made up of feeding stuffs that are palatable and low in price. The other requirements of a good ration should also be given consideration.

Weight a Good Index.—The condition of the cow is a good index as to whether she is being properly fed. A cow will usually lose weight during the first four to six weeks of her lactation, the amount lost depending upon her condition at the time of freshening and her ability as a producer. For the next five to six months the weight of the cow should remain fairly constant; the exact length of time depending upon the time of her next calving.

From two to four months before parturition the cow usually increases in weight, partly on account of the growth of the fetus, but more largely on account of the storage of body fat which may later be used for milk production. The cow should be so fed that she will not lose weight during the greater part of her lactation period.

Feeding Cows as Individuals.—The dairy cow should be fed as an individual. Each cow has her peculiar likes and dislikes, and these must be catered to if the best results are to be obtained. It is never advisable to feed all cows in the herd the same amount, as they each have different requirements. Some are larger than others, some give more milk than others, and some give milk of higher quality than do others. These factors should be considered in feeding individual cows. Heifers during their first and second lactation periods should be fed a little more liberally than mature cows, because they are still growing. Cows that possess a highly nervous temperament are often fed a ration with a wider nutritive ratio than those that tend to take on fat.

Avoid Overfeeding.—Although liberal feeding is advisable, overfeeding must be guarded against. If a cow is being fed more than she requires for the milk which she is producing, she is probably storing up fat which, although not entirely wasted, is not giving any immediate return. It would be much better if the cow were fed just as much as she requires for the milk she is producing. Anything over that amount is largely wasted. Sometimes overfeeding results in the cow's going off feed. In this case, the grain ration should be immediately cut down, and the cow should be fed only light, laxative feeds for a few days. After this she may be slowly put back on her full ration.

The Amount of Nutrients Required for the Growth of the Fetus.—It has always been known that, with the onset of pregnancy, the dairy cow must provide the nutrients not only for the production of milk but also for the building up and the maintaining of the developing fetus. Eckles[3] found from experimental results that the amount of nutrients necessary to develop the bovine fetus is so small that it cannot be measured by ordinary means of experimentation. He analyzed four Jersey calves at birth and found that they contained an average of 73.09 per cent of water. The amniotic fluid weighed about 30 pounds, 95 per cent of which was water. The placenta weighed 18 pounds, approximately 85 per cent of which was water. A Jersey cow, on this basis, produces a total of only 15 to 20 pounds, and the Holstein 20 to 25 pounds, of dry matter in the fetus and accompanying fluid and membrane. On a dry-matter basis, Eckles found that a Jersey calf at birth is equivalent to from 110 to 170 pounds of Jersey milk, and that the Holstein calf is equivalent to from 200 to 275 pounds of Holstein milk. Other investigators have found that the carrying of the calf was a slight but significant drain upon the mother's milk production. All experimental work points to the fact that the amount of feed required to grow the fetus is not such that it must be seriously considered during the feeding period.

Order of Feeding.—The cow is a creature of habit and expects her feed at regular intervals. Regularity is much more important than is any order of feeding, although in order to give the feed regularly some system of feeding must be followed. There is, perhaps, no best order of feeding, but certain factors should be considered. Hays, which are likely to cause dust in the barn, and feeds such as silage and roots, which tend to impart taints to the milk, should be fed after the milking rather than before. The grain is often fed before milking. Frequently it is desirable to feed the grain on the silage. It does not seem necessary in that case to have so much bulk in the grain mixture.

A good system would be to feed the grain before milking and the silage just as soon as the milking was done. The hay could then be fed just as soon as the cows had finished their silage. This would give

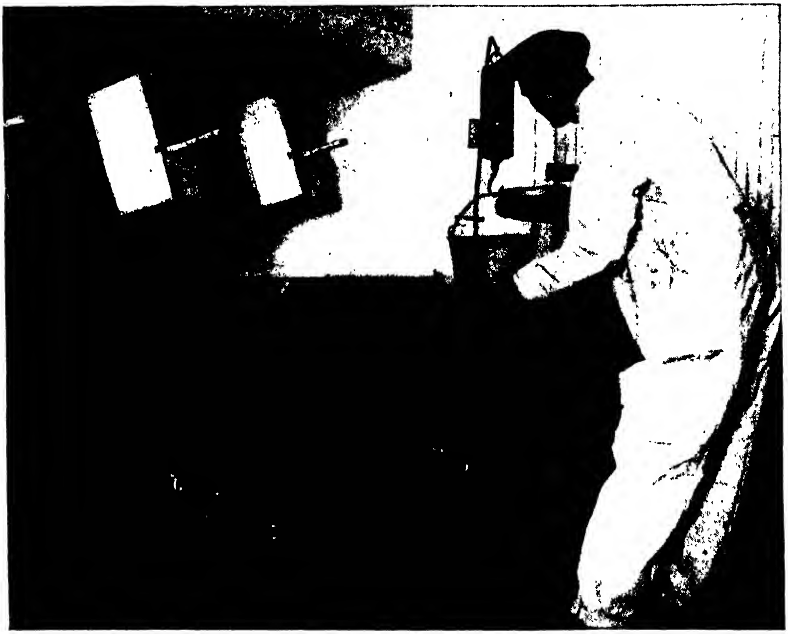

FIG. 10.—Weighing feed is an important step in successful feeding.

time to turn the cows out, in nice weather. If corn stover were to be fed it could be fed out in the lot at this time. The same order could be followed in the evening. This would leave the mangers filled with hay the last thing at night so that the cows would have as much time as necessary to clean it up. When cows are milked oftener than twice a day, the number of feedings is usually increased.

Feeding Equipment.—The farm should be so arranged and the equipment should be such that the feeding can be done with a minimum amount of labor. The grain should be kept, if possible, in bins on the second floor, from which it can be run directly into a feeding truck. If this is not possible it can be kept in sacks or in bins in a room on the first floor, where it can be poured or shoveled into the feeding truck. The truck may be run on a track in front of the cows, or it may be on wheels and be pushed in front of them. Often, in the smaller dairies, the grain is kept in a large feed box in the barn and the feeder simply feeds out of this box. Whatever the system of feeding, it is very necessary that the feed be kept well covered or out of reach of the cows, as they are very liable to be foundered if they do get to it. The choice of a system should depend upon the size of the herd. It is usually advisable to weigh the feed to each cow. Some dairymen, however, prefer to measure it. This can be done if the feeder is careful to weigh a measure or two and so become accustomed to the amount which the measure will hold. It should always be borne in mind, when feeding by measure, that feeds vary considerably in weight. In any method there should be a simple feed sheet to show the amount that each cow is to be fed.

For convenience in the feeding of silage, the silo should be reasonably near the cow barn. The silage in the smaller dairies is often pitched out of the silo upon the barn floor, whence it is carried in baskets to the cows. In larger dairies it is usually thrown into a silage truck which runs either on wheels or on a track and which may be pushed around in front of the cows as is done in feeding the grain. Beets can be fed in the same way. They are usually stored in a root cellar, which should be easily accessible.

The hay chute from the mow should be located in a convenient place where the hay can be thrown down into the barn and from there fed to the cows in the quantities desired. The hay may be loaded into a small hayrack, the weight of which is known, and pulled on to scales. In this way the actual weight of the hay for the entire herd may be determined. It can then be distributed according to the feeder's judgment. When baled hay is fed it is much easier to handle, but unless care is taken there is a tendency to feed more than when the hay is fed loose.

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LECTURE XI

FEEDING AND MANAGEMENT OF COWS ON OFFICIAL TEST

THE first essential for a large record is a good cow. Unless the cow is capable of large production, no amount of good feeding and handling will make it possible for her to produce a large amount of milk or butter-fat. If the cow is capable of making a large record, then it is up to her feeder and caretaker to get the production out of her. No two men will use exactly the same methods in doing this. Each will work out a system which is best suited to his individual conditions. It has been said that " the secret of large records is so simple that many men do not successfully follow it. The mysterious method is but a liberal application of good common sense with untiring faithfulness to the cow."[1] The directions given in the following paragraphs are merely guides and are not given as set rules from which one cannot vary.

Feeding Cows Previous to the Testing Period.—One of the most important considerations in the feeding of a cow for a large record is to have her in a good healthy condition at the beginning of the test. To do this it is necessary to give the animal that is to be put on test the best of care from birth, and by liberal and judicious feeding have the heifer large, vigorous, and in good flesh at the time of freshening. In case the animal to be put on test is mature, she should be dry for from six to ten weeks so that she will have ample time to rest and to build up her reserve for the time of heavy milk production. In feeding for large records it should be the aim to get the cow in a good thrifty condition and in fairly good flesh while dry. This is known as " fitting." It requires a liberal feeding of grain, the amount depending upon the condition of the cow and upon her ability to handle feed. The grain ration should be light, palatable, and not too high in protein. The following rations have been fed successfully during fitting periods:

RATION NO. 1	RATION NO. 2
100 lbs. ground oats	100 lbs. hominy feed
200 lbs. wheat bran	100 lbs. wheat bran
100 lbs. corn meal or hominy	100 lbs. ground oats
100 lbs. linseed meal	100 lbs. linseed meal
50 lbs. cottonseed meal	

The cow should be fed practically all the grain that she will eat at this time. She may be fed three or even four times daily. This is especially true of a Holstein cow that is to be put on a short-time test. As much as 25 pounds of grain per day has been fed successfully, but the amount depends largely upon the ability of the cow to handle feed.

If good pasture is available the cow may be allowed to secure her roughage from it. When good pasture is not available, corn silage and alfalfa hay usually form the foundation of the ration. Other legume hay may be used in place of the alfalfa, and beets are equally as good as silage. Beet pulp moistened with water is also successfully used as a succulent, either by itself or in conjunction with corn silage.

Care of Cow at Freshening Time.—A few days before freshening, the cow should be changed to a cooling ration. The following ration has been recommended for this period:

Ration No. 3

100 lbs. wheat bran
100 lbs. ground oats
50 lbs. linseed meal

This ration should be fed at the rate of 8 to 15 pounds a day along with some beets or beet pulp. The cow should then be put in a well-bedded box stall and watched carefully. It is particularly necessary to see that she has plenty of water and that her bowels are kept loose. If care is exercised in this matter, there is little fear that the cow will come down with milk fever after she freshens.

After the first signs of calving, if no abnormal conditions develop, it is best to leave the cow entirely alone until immediately after calving, when the fetal membrane that covers the calf's nose should be removed so that the calf will not suffocate. The cow should then be given some warm water and a bran mash. It is sometimes recommended that a little Epsom salts be added with the bran mash. About 4 pounds of bran and enough warm water to make a soft mash may be given. The cow should not be fed again for about twelve hours, when she may be given some good, clean legume hay and a little grain ration of a laxative nature.

Getting the Cow on Feed.—For the first three or four days after freshening a cow should get a very small amount of grain which should consist mostly of bran, ground oats, and linseed meal. In fact, she should not be fed much until she has gained strength and her udder and digestive organs are in normal condition. Usually on the fourth or fifth day she can be put on the regular test mixture, but it should be some time before she is given very much. The grain ration can be gradually raised until the cow is getting as much as she can handle.

Feeding for Short-time Records.—In making short-time records it is customary to start the cow on test just as soon as possible after calving, because the percentage of fat in the milk is highest at this time. Since cows are creatures of habit it is best to start handling them at the beginning just as they are to be handled during the test. During most short-time tests, cows are milked four times daily; this practice, therefore, should begin as soon after calving as possible. Cows on short-time tests are fed all that they will eat. It is customary to feed them as much grain as possible without throwing them off feed. It is quite common to feed as much as 30 pounds of grain per day, and from 40 to 50 pounds is sometimes reached. One should be very careful when feeding more than 20 pounds, and if the cow does not respond to an increase in grain it should not be given to her. There is perhaps no best ration for feeding at this time. Usually, however, a test ration will embody all the requirements of a good ration, as already described. It will be palatable and bulky, will have variety, and will be fairly laxative. The following have been used with good results:

Ration No 4	Ration No. 5
300 lbs. corn meal or hominy	200 lbs. distillers' dried grains
300 lbs. ground oats	200 lbs. wheat bran
200 lbs. wheat bran	100 lbs. gluten feed
100 lbs. oil meal	100 lbs. ground oats
100 lbs. gluten feed	200 lbs. hominy
100 lbs. cottonseed meal	100 lbs. linseed meal
100 lbs. dried beet pulp	12 lbs. salt
	12 lbs. charcoal

For roughage, nothing seems to give better results than mangels or beets. They should be fed in large quantities; as much as 60 to 100 pounds is sometimes fed. They seem to be able to keep the cow in good physical condition and to help her in the consumption of large amounts of grain. Silage is usually fed sparingly; not more than 20 to 25 pounds is usually given. Beet pulp also makes a good feed at this time. It is usually fed wet and molasses is often mixed with it. Besides these, the cow should be given all the good, clean legume hay that she will eat.

Feeding for Long-time Records.—In feeding for long-time records it should be remembered that there is a long time to make the record and the cow that milks heavily during the entire lactation is the one that is going to make the largest record. The same method is used with these cows as with those on the short-time test except that a longer time is taken to bring them to full feed. They should not reach full ration until about a month after freshening. The aim should be to get them on their maximum production after about a month and to hold them there throughout the year. The grain ration should be

FIG. 11.—A well arranged test-cow stable.

increased gradually as long as the cow maintains a good appetite and responds with an increase in milk flow. When the cow ceases to increase in milk production, which usually occurs about four to six weeks after calving, her grain ration should be cut down a couple of pounds a day and she should be fed at this rate for some time. Some feeders lower the protein in the ration, during the last six months of the test period, to 16 or 17 per cent or less. The amount of grain fed to cows on long-time tests seldom reaches the amount fed on the short-time test. Usually not more than 20 pounds of grain per day is fed at any time. The following grain rations have been used successfully:

Ration No. 6	Ration No. 7
200 lbs. corn meal or hominy	100 lbs. dried distillers' grains
200 lbs. ground barley	100 lbs. wheat bran
200 lbs. ground oats	100 lbs. hominy
200 lbs. linseed meal	50 lbs. gluten feed
200 lbs. wheat bran	50 lbs. ground oats
150 lbs. cottonseed meal	100 lbs. cottonseed meal
100 lbs. gluten feed	10 lbs. charcoal
100 lbs. dried beet pulp	6 lbs. salt.

The roughage of a cow on yearly test is important. She should have all the good clean legume hay that she will eat. Silage is used successfully but not in large amounts. Usually about 20 to 35 pounds of silage is fed, depending upon the size of the animal. Beets are used extensively, but often they are not available. Very often beet pulp is fed. It should be fed at the rate of 6 to 10 pounds of dry pulp per day. This is usually soaked with water and fed wet. Green crops may be fed in the summer in place of silage. Pasture can be used if it is handy to the barn and abundant. Care should also be taken that the cows are given plenty of minerals throughout the year.

Management of Cow on Test.—Cows on test do better when they are treated regularly. It is well for one man to handle the cows throughout the test. Most cows respond much better to a feeder to whom they are accustomed. The feeder should study his cows. Some have unusual appetites and will respond to certain feeds which others do not relish. It is necessary for the feeder to watch for these individual peculiarities and to handle and feed the cows accordingly. When a ration is found to appeal to an individual cow it should be fed to her even though the other cows do not care for it.

At the first sign of a disposition on the part of any cow to refuse her feed, the ration should be cut in half for a couple of feeds and then gradually brought back to the normal amount.

Effect of Feeding on the Fat Percentage.—It is a general belief among feeders that the ration greatly influences the fat percentage. Experimental data have not shown this to be the case, although some feeds may have a stimulating effect for a short time. The use of feeds very high in fat has only a temporary effect. Ground flax seed perhaps has as great an influence as any feed, and even its effect is not pronounced and some cows do not respond to it.[2]

Influence of Galactogogues on the Fat Percentage.—Many people believe that it is possible to increase the percentage of fat in the milk of a cow by feeding certain galactogogues. There is undoubtedly a somewhat general belief that some successful feeders have gained a part of their success by the use of methods not generally known to the public. As a matter of fact, the different breed associations have made certain qualifications and in some cases have even required the feeder to take an oath and to sign an affidavit that he has not practiced unusual methods in feeding.

Several experiments have been conducted to determine the effect of certain galactogogues upon the yield of milk and the percentage of fat. Table XXII has been taken from the results of some work done at the Pennsylvania State College.[3]

TABLE XXII

EFFECT OF VARIOUS GALACTOGOGUES ON MILK YIELD AND PERCENTAGE OF FAT

The Kind of Galactogogue	Number of Trials	Number Increased In Milk Yield	Number Decreased In Milk Yield	Number Increased In Fat Percentage	Number Decreased In Fat Percentage
Sodium Bicarbonate...	10	10	0	5	5
Gentian..............	10	5	5	5	5
Ginger...............	10	3	7	10	0
Nux Vomica..........	9	4	5	3	6
Pilocarpine Hydrochlor.	6	2	4	3	3
Malt Extract.........	10	7	3	5	5
Alcohol..............	6	2	4	3	3

These were given under the direction of the college veterinarian. The alcohol was applied externally to the udder. The pilocarpine hydrochlor. was injected under the skin of the animal.

The ten cows to which sodium bicarbonate was fed all showed a slight increase in milk production. The increase was slight and the tests were not repeated a sufficient number of times to determine that the increases were not due to natural causes. In the case of ginger, which was fed in ounce doses twice a day, there was in all cases a slight increase in the percentage of fat, but in most cases there was a slight decrease in the milk yield, so that the total fat was not increased. The other drugs did not seem to have very much effect on either the milk yield or the percentage of fat in the milk.

At the Iowa Experiment Station[4] it was found that alcohol, castor oil, Epsom salts, pituitrin, pilocarpine, and aloes had no effect in increasing the milk yield. Hayes and Thomas[5] found that air-slaked lime had a beneficial effect upon the milk flow. None of the drugs which they used seemed to have any effect in increasing the percentage of butter-fat.

Protein and Energy in a Ration.—It is the general practice of feeders of cows on advanced-registry tests to supply an excess of protein and energy above that required by feeding standards. In fact, they usually feed the cows all that they will consume. No amount of forced feeding will produce high records unless the cow has inherited high milk-producing qualities. On the other hand, it is only by heavy feeding that high records have been produced.

A study of twenty tests was made at the Pennsylvania State College,[3] in which the exact amount of feeds given to the animals was known. The four main breeds of cattle were included in the test: there were ten Guernseys, six Ayrshires, three Jerseys, and one Holstein.

The amount of true protein and net energy of the ration fed was calculated. This was compared with the requirements of the different cows for net energy and true protein, as denoted by the Armsby Feeding Standard the average weight of the cows, their production, and the percentage of butter-fat in their milk being taken into consideration. It was found that with few exceptions the cows were extravagantly fed if the feeding standard could be considered as a true measure. The twenty cows were fed 27.23 per cent more true protein and 16.94 per cent more energy for the production of one pound of milk under forced feeding than was required by the Armsby Feeding Standard. They were fed 25.88 per cent more true protein and 16.46 per cent more energy, to produce a pound of butter-fat, than would have been required if they had been fed exactly according to the Armsby Feeding Standard. It should be realized, however, that these figures represent what the cows were fed; there are no data to show that they might not have done practically as well if they had been fed according to the standard. Nevertheless, since most feeders practice this method there is apparently good foundation for believing that this high nutritive plane is desirable for sustained production. Of late years there seems to be a tendency to feed cows on test on a lower plane, especially in regard to the protein. There seems to be some reason to believe that if the cows are fed too high a protein ration there will be more breeding troubles; and since the most desirable type of record is one that includes the production of a calf, this should be encouraged.

Influence of Stage of Lactation on Milk Yield.—The effect of stage of lactation upon milk production is quite well known. Data taken from 428 lactation periods at the Iowa Experiment Station[6] show that, in the case of the Jerseys and Guernseys, the highest milk yield is obtained during the first month of lactation and from that time on there is a very gradual decline until the eighth or ninth month, after which there is a very rapid decline until the end. In the case of Holsteins and Ayrshires the second month is the highest in milk production, and from then on the decline is very similar to that of other breeds.

Influence of Stage of Lactation on the Percentage of Butter-fat.—The most extensive study that has been reported concerning the effect of stage of lactation upon the percentage of fat is that of Ragsdale and Turner.[7] They used a total of 4045 cows, consisting of 3763 advanced-registry cows of the Guernsey breed, 299 register-of-merit cows of the Jersey breed, and 95 Holsteins from the University of Missouri herd. Their results show that with the Jersey and Guernsey breeds the percentage of fat dropped off from the first month to the second and there was then a very gradual increase from month to month until about the ninth or tenth month, after which there was a somewhat greater increase. The Holstein breed followed the same general curve, with the exception that they did not reach the low point until the third month. The following table gives the results:

TABLE XXIII

INFLUENCE OF STAGE OF LACTATION UPON THE PERCENTAGE OF BUTTER-FAT

Month of Lactation	Guernseys (3863) Per Cent	Jerseys (299) Per Cent	Holsteins (95) Per Cent
1	4.63	4.89	3.24
2	4.59	4.82	3.01
3	4.71	4.88	2.99
4	4.85	5.10	3.02
5	4.97	5.13	3.01
6	5.08	5.26	3.08
7	5.16	5.40	3.11
8	5.22	5.43	3.16
9	5.29	5.50	3.19
10	5.39	5.58	3.27
11	5.49	5.60	3.32
12	5.60	5.73	3.49

Advanced-registry Conditions Compared with Ordinary Ones.—The question is often asked: How much more do cows kept under test conditions produce than cows kept under average herd conditions? An investigation at the Beltsville Station[8] showed that cows kept under test conditions produced approximately 50 per cent more milk and butter-fat than those kept under average herd conditions. This is a very important point to remember in buying cows on the basis of records. A record of 600 pounds of butter-fat under test conditions would be equivalent to approximately 400 pounds under average herd conditions.

Feed Consumed by Large Producers.—The following data are presented to show just what some of the large-producing cows have been fed while on test:

The Jersey cow, *Lad's Iota,*[9] produced 18,632 pounds of milk and 1048.07 pounds of butter-fat in a year. She started her record in April, 1921. This cow is described as a great feeder. She was fed as much as 27 pounds of grain, consisting of 9 pounds of rolled oats, 8 pounds of corn, 6 pounds of bran, and 3 to 4 pounds of oil meal. She was on clover pasture from the first of May to the first of October but she was also fed clover hay and 4 pounds of beet pulp in addition. When she was taken off pasture she was fed silage and kale and was soon eating about 35 pounds daily of each. In November her grain ration was changed to 4 pounds of each of the following feeds: oats, bran, mill-run, corn, and oil meal, a total of 20 pounds of grain per day. This was later changed to the proportion of 2 pounds of oats and 2 pounds of bran to 1 of oil meal, but the total amount remained the same until the end.

The Holstein cow, *Belle Pontiac* 46321 *C. H. B.*[10] produced 27,017 pounds of milk and 1573 pounds of butter in a year. She freshened June 19, 1920, after having been dry about six weeks. She started out very easily on a light feed of wheat bran and oil meal with green alfalfa for roughage. About the first of July, green mangels, fresh from the field, with the tops on, were given her to the extent of about a bushel and a half a day. As soon as she settled down to work she was put on a ration consisting of 2 pounds of bran, 6 pounds of oil cake, 1 pound of gluten, and 2 pounds of crushed oats, with a maximum of 12 pounds of cottonseed meal. She ate 30 and 33 pounds of this ration per day. She was also fed from 60 to 70 pounds of roots, 25 pounds of corn silage, and all the alfalfa hay that she wanted.

About April 5th the ration was changed radically because the supply of silage was exhausted. The roots were increased to 150 pounds per day, the silage and cottonseed were cut out entirely, and the oil cake reduced to half, so that the ration stood for the rest of the year as follows: Two pounds of bran, 2 pounds of crushed oats, 1 pound of oil cake, 1 pound of cream of wheat. To each feed was added ¼ pound of salt and a handful of charcoal. Eight pounds of this grain ration was fed at a time, making a total of 32 pounds a day.

Another famous Holstein cow, *Segis Pietertje Prospect* 221856[11] produced 37,384.1 pounds of milk and 1445.9 pounds of butter in one year. She started on official test, December 1, 1919. This cow was dry for a little over two months preparatory to her test. During this time she was fitted on a ration consisting of equal parts of ground oats, bran, hominy, and oil meal, with some salt and charcoal. She received a small amount of beet pulp and a few beets.

After freshening she was at first fed very conservatively, receiving 17 pounds of grain daily. Her feed was gradually increased until March. It was then noticed that this pace was a little too heavy; accordingly, her feed was reduced. Table XXIV shows very clearly her feeding schedule.

TABLE XXIV

DAILY RATION OF SEGIS PIETERTJE PROSPECT

Month	Grain, Lbs.	Beet Pulp, Lbs.	Hay, Lbs.	Beets, Lbs.	Italian Rye Grass, Lbs.	Molasses, Lbs.	Oats, Lbs.	Sweet Corn, Lbs.
December	16	3	20	36	......	2		
January	22	5	25	56	......	2		
February	23	6	25	56	......	2		
March	25	6	30	36	10	3		
April	23	6	25	60	15	3		
May	23	6	20	60	25	3		
June	23	6	20	50	30	3		
July	21	5	20	40	......	3	40	
August	22	5	22	35	......	3	35	
September	22	6	23	48	......	3	10	20
October	22	6	25	56	......	3	......	25
November	21	6	28	60	......	3		
December	21	6	30	60	......	3		

The Grain Mixture was as follows:

6 parts ground oats	4 parts bran	3 parts corn meal
3 parts hominy	1 part cottonseed meal	2 parts soy beans
3 parts oil meal	1 part ground flax seed	1 part gluten

1 pound of charcoal to 100 pounds of grain—salt at all times.

Molasses was fed with the beet pulp. She received approximately 1 pound of grain to 4.6 pounds of milk produced.

Countess Prue, a seven-year-old Guernsey cow,[12] produced 18,629.9 pounds of milk and 1103.28 pounds of butter-fat in one year ending November 29, 1920. During the year she was fed 19 to 22 pounds of a grain mixture made up of a large variety of concentrates which were modified considerably at different periods. In winter she received in addition 15 to 20 pounds of soaked beet pulp, 21 to 31 pounds of silage, and 15 to 21 pounds of mixed hay. In summer soiling crops were fed instead of silage, and in autumn roots were added to the ration.

Of the Ayrshire breed, *Garclaugh May Mischief*[13] has produced 25,329.0 pounds of milk and 894.91 pounds of fat. During her record she consumed 4946 pounds of concentrates, 668 pounds of dried beet pulp, 11,200 pounds of corn silage, 22,300 pounds of beets, 2780 pounds of hay, and a small amount of soiling crops.

It can easily be seen by these records that large-producing cows consume large quantities of feed and are able to take care of it efficiently. Variety and palatability play a very important part in the feeding of these cows. The management of the test cow is a very important thing, and the records made rest almost entirely upon this one thing. It requires the utmost skill on the feeder's part to be able to tell when the cow is eating all she can, taking care not to give her too much feed, thereby causing her to lose her appetite and consequently fall down in her production. In three of the accounts given above there were certain days when the cows were reported slightly off feed, but by the utmost skill on the part of the feeders they were brought back without serious results. Special emphasis is laid on the way the cows were handled and fed. Much of the honor of high records should go to the feeder and caretaker, but no amount of care or feed will cause a cow to produce more than her inheritance.

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LECTURE XII

EFFECT OF UNBALANCED, INCOMPLETE OR ABNORMAL RATIONS

Unbalanced Rations.—A ration is said to be balanced when it contains the different nutrients in the proper proportion to meet all the requirements for maintenance and production. When any of the necessary constituents are not given in sufficient quantities the animal cannot produce milk up to the limit of her ability. A cow cannot change materially and permanently the composition of her milk, and its production is controlled by the constituents of her feed. An excess of protein, for instance, may be used to some extent for the production of energy, although it is not usually economical to produce energy in this way. An excess of energy-producing material, however, cannot take the place of protein. Experiments were conducted at the Illinois Experiment Station,[1] where twenty cows were separated into two lots of ten cows each, the two herds being as nearly equal as selection could make them. The two lots were fed as follows:

Lot 1	Pounds	Lot 2	Pounds
Corn silage	30	Corn silage	30
Clover hay	8	Timothy hay	5
Gluten feed	4⅔	Clover hay	3
Ground corn	3⅓	Ground corn	8

The ration of the first lot contained 1 pound of digestible protein to 6 pounds of digestible carbohydrates and fats, which is a balanced ration for cows giving 40 pounds of milk daily. The ration of the second lot contained 1 pound of digestible protein to 11 pounds of digestible carbohydrates and fats, which is a ration too low in protein for cows giving 40 pounds of milk.

Lot 1, which received the balanced ration, produced 1.7 pounds more milk during the preliminary week of the trial; during the second week, or the first week of the trial, the increase was 5.8 pounds for each cow daily; and in the seventh week the gain was 13.2 pounds. The average for the nineteen weeks of the test was 10.65 pounds of milk for each cow daily, in favor of the cows fed the balanced ration.

The cows that received the balanced ration were in better physical condition and had good flesh at the end of the trial, while those receiving the unbalanced ration lost greatly in flesh and their subsequent production was also reduced. The carbohydrates and fats could not take the place of the protein.

Many Cows are Better than their Feeders.—The rational feeding of dairy cows is of greater importance than is often realized. Many cows that are now causing a loss to their owners, if fed properly, would give a good return. The tests given below show that the milch cows of the United States are probably much better than their records indicate. The feeding of the balanced ration would no doubt greatly increase the average production of the cows in this country.

An experiment conducted at the Maryland Experiment Station[2] shows the effect of good feeding. A herd of eight cows was kept under observation by the Station on a farm for one year. The following year the same animals were kept at the Station, where a good feeding system was followed. The following table shows the effect of proper feeding on ordinary cows:

TABLE XXV

COMPARISON OF FEEDING METHODS

(Maryland Experiment Station)

Number of Cows	First Year, on Farm, Lbs. of Milk	Second Year, at Station, Lbs. of Milk	Average Lbs. Milk per Day, Best Week, First Year	Average Lbs. Milk per Day, Best Week, Second Year
1	4.004	6.092	27	40
2	4.122	5.051	21	33
3	5.192	6.163	27	40
4	4.537	6.134	27	48
5	6.097	6.995	31	35
6	4.035	7.995	27	57
7	6.357	6.828	38	33
8	4.653	5.465	24	37

A similar experiment, though somewhat more extensive, was undertaken by the New York Experiment Station.[3] A herd representative of the cows in the farming community near Cornell University was selected. During one year, these cows were fed and handled by their owner, but records of the feed used and the milk produced were kept by the Experiment Station. The following year the animals were kept in the college barns and fed balanced rations. The following table shows the average weekly production during the two years and the percentage increase:

TABLE XXVI

COMPARISON OF FEEDING METHODS
(Cornell Experiment Station)

Cow Number	Average Weekly Production		Percentage Increase
	1900, Lbs. Milk	1901, Lbs. Milk	
1	89	112	25
2	83.9	121.6	44.9
3	83	119	44
4	88	122	37
5	106	162	52
6	84	120	41
7	124	175	41
8	113	149	31
9	85	136	60
10	103	187	80

Not only was there a greater production, but the increase made the enterprise more profitable. The following table presents a comparison of the costs of producing milk and fat during the year on the farm and the year at the station:

TABLE XXVII

COMPARISONS OF FEED COST AT FARM AND AT EXPERIMENT STATION
(Cornell Experiment Station)

Feed Cost per 100 Lbs. of Milk		Feed Cost per 1 Lb. of Fat	
1900	1901	1900	1901
0.66	0.46	0.14	0.09
0.50	0.41	0.12	0.09
0.62	0.48	0.11	0.09
0.41	0.36	0.11	0.10
0.49	0.41	0.13	0.10
0.55	0.46	0.11	0.13
0.51	0.43	0.14	0.11

Another example of the increase in production resulting from better feeding appears in the following table, taken from the records of a herd of twenty cows in the Lake Pepin Cow-testing Association, Wabasha Co., Minnesota:[4]

TABLE XXVIII

INFLUENCE OF A BALANCED RATION

(Lake Pepin Cow Testing Association)

	Before Using Balanced Ration, Nov., 1921	After Using Balanced Ration, Dec., 1921
Total milk (20 cows)	11,920 lbs.	14,060 lbs.
Increase in milk	....	2,140 lbs.
Increase in fat	....	833 lbs.
Value of increase	....	$38.39
Cost of feed	$29.52	$42.17
Net gain for month	....	$25.74

This shows that, simply by feeding a good balanced ration, a large increase in the net profit of the herd can be realized.

Heavy or Light Feeding.—The intensity of feeding is an important factor in the economy of production. Experiments have been conducted at a number of the experiment stations to determine the economy of heavy and light feeding for dairy cattle. In an experiment at the Wisconsin Experiment Station[5] sixteen cows were fed what are called, respectively, heavy and normal rations. The heavy rations consisted of an average of 110 pounds of dry matter for each 100 pounds of milk and an average of 23.8 pounds of dry matter for each pound of fat. The normal rations averaged 81.8 pounds of dry matter for each 100 pounds of milk and an average of 21.7 of dry matter for each pound of fat.

All of the cows in the lot fed the heavy grain rations consumed more dry matter to a pound of milk and butter-fat than did those fed the normal ration. The cows fed the heavy ration did not maintain the full flow of milk during the following two months of the experiment any better than did the normally fed cows. There was actually a small difference in favor of the normally fed animals, perhaps due to digestive disorders or to overfeeding. The conclusion drawn from the experiment was that it was unprofitable to feed the cows more than a medium amount of grain (about 8 pounds per head daily) unless they were animals with marked dairy tendencies.

A somewhat similar experiment was conducted by the Vermont Experiment Station.[6] The following table shows the relative value of the low, medium, and heavy rations:

TABLE XXIX

RELATIVE VALUE OF A LOW, MEDIUM, AND HEAVY RATION

(Vermont Experiment Station)

	Medium Better than a Low Ration	High Better than a Medium Ration
Days of feeding on each ration	342	378
Cost of added grain feed	$13.85	$11.96
Net gain from butter sales at 20 cents	$7.86	$1.12
Net loss, i.e., cost of additional gain less value of butter	$5.99	$10.84
Value of skim milk and of two-thirds of the manurial ingredients	$6.25	$4.70
Net gain (or loss) from butter, skim milk, and manure	0.26 gain	6.14 loss
Net gain (or loss) from one day's feeding of one cow	0.08 gain	1.62 loss

The author concluded that if the returns for the butter-fat alone are considered the loss is even greater than is shown in the table. He also pointed out the danger of injury to the health and usefulness of the animals as a result of high feeding. He further concluded that from 6 to 8 pounds of grain daily seemed to be the most advisable amount for mature cows; 6 pounds when grains are very high-priced and 8 pounds when they are low priced. A number of experimenters[7] have found that dairy cows will digest a medium-to-low ration better than a heavy one.

The Economy of High Production.—It is profitable, however, to give to cows that have the ability to produce large amounts of milk all that is necessary in order to reach their normal limit of production. The amount of feed required for maintenance by cows of the same weight is practically the same, and the differences in production are due to the amount of feed consumed over that required for maintenance. This being the case, it is more profitable to produce milk from a cow that will produce 20 pounds than from one that will produce only 10 pounds. The higher producer is more economical because she produces more milk with the same amount of food for maintenance as the low producer. Two of the low-producing cows must be maintained to produce the amount of milk that is obtained from one of the higher producers. Although it is true that high production is the most economical, it does not follow that cows should be forced to the limit of their production. The last few pounds may cost more than they are worth. There is a point in the feeding of dairy cows where it is not profitable to use more feed in order to get a higher production. The law of diminishing returns is brought into operation because the proportion of concentrates required is greatly increased with the result that a very high percentage of the feed comes from the high-priced concentrates. In advanced-registry feeding it may pay to get the last few pounds of milk from the cow because of the value of the record. The extra milk, however, may be produced at an actual loss.

Feeding without Roughage.—The cow's stomach is especially adapted for the handling of a large amount of roughage, and it is believed by practical dairymen that a ration must contain some of the coarse feeds, such as hay or silage. However, experiments conducted a number of years ago by Miller[8] showed that dry dairy cows could be maintained for eight weeks on corn meal alone. He reported that the cows seemed contented after the first few days, but ceased to ruminate. At the Utah Experiment Station,[9] sheep and two-year-old steers were successfully fed on grain alone. The sheep were fed for almost six months while the steers were fed for almost eight months.

Experiments made at several of the experiment stations[10, 11] show that calves will not live on grain alone. They will die in three to eight months when fed milk and grain or either one alone. The calves show symptoms of intoxication. They go into convulsions, falling over and frothing at the mouth, with their legs rigid and their muscles hard and tense. Young calves will usually get over the first attack but will later come down with another and will eventually die. In many cases they develop a condition resembling rickets; their legs become crooked and their joints swell. Calcium carbonate will relieve these conditions for some time, but eventually the trouble will reappear. At the Michigan Station[12] it was found that roughage itself is not the vital factor, as a calf fed a ration of whole milk and straw failed to develop normally and eventually died. Well-cured legume hay, however, will quickly bring the calves back to normal.

While these studies are of experimental interest the question as to whether or not the animal could subsist upon grain alone is not so important as is the economy of the practice. The results of Van Norman and Borland[12] seem to indicate that at ordinary prices of concentrates and hays it is economical to feed roughages freely, at least to the medium-producing cows.

FIG. 12.—Calf four months of age which has been deprived of roughage.

Feeding Roughages Alone.—Dry cows can be maintained successfully on roughage alone, but when cows are producing milk such a ration is not high enough in net energy to give continued high production.

In a trial at the New Jersey Experiment Station[14] a ration consisting of 35 pounds of corn silage and 17½ pounds of alfalfa hay was compared with one consisting of about 9 pounds of concentrates fed with corn silage and corn stover. The latter ration produced 20 per cent more milk than did the one without any concentrates.

In the irrigated alfalfa districts of the West, alfalfa is often the sole feed of dairy cattle. While a large production cannot be expected with a ration such as this, yet sometimes the increase in production due to the feeding of concentrates may not be sufficient to pay for the extra feed. Under such circumstances it may not pay to feed any grain. As a general rule, however, it is more profitable to feed an animal more liberally, as the overhead is the same in a low-producing cow as in a high-producing one.

Feeding from Restricted Sources.—In extensive studies at the Wisconsin Experiment Station,[14, 15] the physiological value of rations from restricted sources for dairy cows was investigated. One lot of heifers was fed a ration consisting of feeds entirely from the corn

FIG. 13.—Results of mineral deficiency. This cow was so stiff she could scarcely walk, her joints made a noise as she moved, and she showed the typical abnormal appetite. (*Becker*).

plant, another from the oat plant, a third from the wheat plant. These rations were comparably balanced in regard to the supply of digestible organic nutrients. The heifers all grew fairly well, but those fed the oat and wheat rations failed to give birth to normal young. Most of them aborted, and the calves were born dead or very weak. The calves from the corn ration, however, were strong and vigorous. Further investigations[16] showed that the wheat and oat rations were lacking in a complete mineral mixture. When calcium was added to the ration the calves of the cows fed on the oats ration were normal, although in the case of the wheat plant this was not entirely successful. When alfalfa hay was added to the wheat ration in place of the wheat straw, the results were good for a while. Growth was normal and reproduction also was normal in the first gestation period, but weakness appeared in the second. The alfalfa introduced a better salt mixture, a little different protein mixture, and probably a more plentiful supply of growth-promoting substances. The failure was probably due to the toxicity of the wheat.

Feeding with Lack of Minerals.—Although feeding standards do not include mineral matter, it is necessary to have certain amounts of various minerals in the ration, both for growth and for production. The standard does not include the minerals because, in most practical

FIG. 14.—Results of feeding bone meal to cow shown in Fig. 13. Note the difference in apparent stiffness of hind legs, and appearance of thrift of the animal. (*Becker.*)

feeding methods, enough mineral matter is contained in the feed mixture. However, a cow may actually be suffering from a lack of minerals without showing it. In an experiment at the Wisconsin Experiment Station[17] lime was withheld from the feed of a Holstein cow in milk. The cow weighed 1150 pounds and was fed for a period of 110 days. The outgo of lime was approximately 50 grams daily and the intake only 25 grams, so that during the feeding period there was a loss of 2500 grams or 5½ pounds of lime. There was, therefore, a loss of about 25 per cent of the entire lime content of the cow's body without any decrease in the milk flow or the calcium content of the milk. Experiments have not been conducted to ascertain how long this could be continued.

Where the soil is very deficient in calcium or phosphorus the herbage growing on it is usually so low in these elements that trouble is experienced in the feeding of cattle. Such conditions have been reported in various parts of the world.[18, 19] The first symptom is usually a depraved appetite—an unconquerable craving to eat abnormal substances, such as wood, bones, clothes, earth, manure, etc. The cattle often become stiff in the joints. The symptoms usually follow a year of small rainfall. Cows in milk show the most severe symptoms, followed by young growing animals. The addition of phosphorus or calcium, whichever is deficient, to the ration of these animals results in complete recovery.

As noted before, Hart and his associates found that a ration derived from the oat or wheat plant required the addition of a calcium supplement in order to secure normal reproduction. They state that 0.45 per cent CaO is the least amount that can be fed in a ration to insure normal reproduction. Others have found that a deficiency of phosphorus also causes breeding troubles.

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LECTURE XIII

SILAGE AND SILOS

For a great many years the advantage of preserving green crops for winter feeding has been recognized. As early as 1786,[1] history records that the Italians preserved green crops for their animals by storing them in pits under the ground. The French and English are known to have stored green crops 150 years ago. We are not quite certain who should be given credit for the building of the first silo in the United States, but it is probably Fred L. Hatch, who built a silo on his farm in 1873.[2] For some time after this, however, farmers were slow to follow his example, and it is only in comparatively recent years that silos have been used extensively. Now they are to be found in all sections of the country, especially where dairying plays any large part in the farming industry. The use of the silo is no longer considered experimental. It is a necessary part of the equipment of a profitable dairy farm, more especially where corn can be grown.

Advantages of the Silo.—The first advantage of the silo is that it prevents waste. More than one-third of the total food material in the corn plant is found in the stover. When corn is husked in the field and the stover is fed, there is still considerable loss. The following table from the Pennsylvania Experiment Station[3] gives the relative amount of digestible matter found in the ears and in the stover of an acre of corn:

TABLE XXX

Comparison of Digestible Matter Found in the Ears and Stover of an Acre of Corn

Constituents	Ears, Lbs.	Stover, Lbs.	Total Crop, Lbs.
Protein	244	83	327
Carbohydrates	2301	1473	3774
Fat	125	22	147
Total	2670	1578	4248

Even when corn is husked and carefully shocked, much of the food value is lost. In tests made by the Colorado Experiment Station,[4] the losses due to curing corn in the field were considerable. The following table shows these losses under different ways of handling:

TABLE XXXI

LOSSES DURING CURING OF CORN UNDER DIFFERENT METHODS

	Large Shock		Small Shock		On the Ground	
	Total Weight, Lbs.	Dry Matter, Lbs.	Total Weight, Lbs.	Dry Matter, Lbs.	Total Weight, Lbs.	Dry Matter, Lbs.
When shocked	952	217	294	77	186	42
After curing	258	150	64	44	33	19
Loss in weight	694	67	230	33	153	23
Per cent loss	73	31	78	43	82	55

When the corn is put into the silo, all of the food material goes with it. The losses in the silo, due to fermentation, while considerable, are much lower than those that occur when the fodder is exposed in the field. At the Wisconsin Experiment Station[5] it was found that the losses in the silo averaged about 9.1 per cent.

The second advantage of the silo is that the crop can be harvested more cheaply and with less labor, because most of the work is done by machinery, more systematically, and on a larger scale. The corn is handled but once.

A third advantage is that the silage can be much more easily handled than can the stover. The stover, unless shredded, is a very difficult feed to handle.

One of the chief advantages, however, is that silage provides a succulent feed which is necessary for the most economical production of miik. Of the succulent feeds, corn silage is the cheapest in most sections of the country. It combines well with other feeds, forming a desirable ration for dairy cows, and is also good as a supplement to pasture.

Chemical Changes in Silage.—The first change which takes place in silage after it has been put in the silo is an increase in temperature, which may reach 125° F.[6] This high temperature, however, is reached only when air gets into the silage. Air gains entrance only near the surface when the silage is properly packed. When the air is excluded the temperature seldom rises over 85° F. The rise in temperature is due to fermentation caused by bacteria carried with the corn and by enzymes found in the live plant cells. In the fermentation process the sugar of the corn plant is changed into various organic acids, principally acetic and lactic. A small amount of alcohol is also formed. When the acid in the silage has increased to a certain degree it inhibits the further growth of the bacteria and enzymes and also checks the development of the putrefactive bacteria. This explains the difficulty in preserving such crops as clover, alfalfa, and other legumes. In such plants there is not enough sugar to form sufficient acid for the preservation of the silage. When these are mixed with corn or some other grain which contains sugar they can be preserved successfully.

Crops for Silage

A great many different crops are being used for silage, though corn is the most common and the most easily preserved. There is sometimes an advantage in putting other crops in the silo or in mixing some other crop with corn. This is especially true in the case of some of the protein feeds, such as legume hay. Some feeders make it a practice to add one of these crops to the corn, in order to increase the protein and thus to furnish a more nearly balanced ration. Sunflowers have been used rather extensively in some sections during the past few years. Kaffir corn is used in parts of the West. The sorghums are also successfully used.

Corn.—The variety of corn that should be grown for the silo will depend on several factors. In case a dairyman has plenty of land, so that he can grow an abundance of hay and other roughages and still have room for corn, he should select a variety of corn that will mature early in his locality; one that will give a good yield of grain, and at the same time produce fairly good stalks. If, however, he is short of tillable land, he probably should select a larger variety, one that will not mature so early but will give him a larger tonnage per acre. This may not be as palatable or as nutritious as the other but will furnish succulent feed for the entire winter, which the smaller variety may not do. Corn for silage may be planted a little thicker than corn for grain, although it should not be grown so thick that the grain will not yield well.

Time to Harvest.—It is difficult to decide on the proper time to harvest corn for silage, but there are a number of factors to remember. In the first place, it is not well to wait until there is danger of frost, though in general a frost would not be as great a risk as the ensiling of the corn when it is too green. Frosted corn may be preserved in a silo if it is properly packed and moistened. It is best to harvest corn for silage when it has begun to glaze and, if a dent variety, when the dent is well developed. The following table, taken from work done at the New York Experiment Station,[7] gives the composition of the corn plant in its different stages:

TABLE XXXII

CHEMICAL CHANGES DURING THE GROWTH OF THE CORN PLANT

Yield per Acre	Stage of Growth				
	Tasseled, July 30, Lbs.	Silked, Aug. 9, Lbs.	Milk, Aug. 21, Lbs.	Glazed, Sept. 7, Lbs.	Ripe, Sept. 23, Lbs.
Total yield	18,045.00	25,745.00	32,600.00	32,295.00	28,460.00
Water	16,426.00	22,666.00	27,957.00	25,093.00	20,542.00
Dry matter	1,619.00	3,078.00	4,643.00	7,202.00	7,918.00
Ash	138.91	201.30	232.15	302.48	364.23
Albuminoids	239.77	436.76	478.69	643.86	677.78
Crude fiber	514.19	872.93	1,261.97	1,755.85	1,734.04
Nitrogen-free extract	653.91	1,399.26	2,441.29	4,239.82	4,827.60
Fat	72.20	167.75	228.90	259.99	314.34

It is not well to let the corn become too well matured and dry. Even though it has been dry, if it is thoroughly wet it can be preserved satisfactorily. If it is put in the silo while too green an excessive amount of acid is formed.

Yield per Acre.—The amount of silage that can be grown on an acre of land varies with the soil, climate, care, and variety of corn. From 6 to 20 tons of silage can be grown to an acre, although the average is about the same as the yield of 50 bushels of shelled corn, which would be 8 to 12 tons of silage.

Sunflowers.—Sunflowers have been used successfully for silage in many of the states, especially in the arid regions. Their yield is a little higher than that of corn but they are not quite so high in nutritive value nor are they as palatable.

They can be planted in a row, the same as corn. The best distance to plant is about 10 inches apart in the row. They can be harvested in the same way as corn. The following table from the West Virginia Experiment Station[8] gives the analysis of sunflowers at different stages:

TABLE XXXIII

ANALYSIS OF SUNFLOWERS AT DIFFERENT STAGES OF MATURITY

Stage Analysed	Moisture, Per Cent	Ash, Per Cent	Protein, Per Cent	Fat, Per Cent	Fibre, Per Cent	Carbohydrates, Per Cent
Bud stage	80.75	1.53	1.41	0.55	5.48	15.76
Full blossom	86.69	1.59	1.21	0.50	3.90	10.01
Petals dropping	83.97	1.78	1.12	0.66	5.56	12.47
Dough stage	83.34	1.69	1.10	1.06	4.96	12.81
Mature	84.26	1.74	1.61	1.36	4.75	11.03

At the West Virginia Station,[9] the average yield for three years was 13.85 tons of green material per acre and 2.08 tons of air-dry material per acre, as compared with 11.79 tons green material and 2.91 tons of air-dry material per acre for a large variety of corn and 8.98 tons of green material and 2.57 tons of air-dry material per acre for a small variety of corn.

Sorghum and Kaffir Corn.—Both sorghum and kaffir corn make very good silage when put in the silo at the proper time. They are used in the Middle West, especially where the rainfall is so scant that the corn plant is not a safe crop.

Legumes.—Such crops as clover, alfalfa, and soy beans have been preserved in a silo with more or less success. As already pointed out, it is difficult to pack these crops well, since, on account of their lack of sugar, sufficient acid cannot be developed to keep down putrefying bacteria; but if the crops are allowed to dry a little before they are put in the silo they often develop into very good silage. In rainy seasons, when they cannot be cured for hay, they are often put into the silo and used as a summer feed or kept as a winter feed as desired.

These crops are often mixed with the corn at the time of ensiling. When this is done the proportion recommended is one-third of the leguminous crop to two-thirds of the corn.

Grasses.—Numerous attempts have been made to ensile some of the finer grasses, as well as oats, rye, and wheat, with varying degrees of success. In general, it is better to feed these crops either in the green or in the cured state. It is difficult to keep them in a silo, although some success has been had with some of them.

Corn Stover.—It occasionally happens that sufficient space is not available at silo-filling time for all the corn crop that it may be desirable to put in the silo. In such cases the corn stover may be put in later. Stover silage has the advantage that it is more palatable than corn stover; it prevents the loss of much of the stover; and it is much more convenient to feed. The stalks of the stover are put in the silo in the same way as the green corn, but in order to preserve it large quantities of water must be added. The amount of water added must be at least equal in weight to the stover. This can be done by turning a hose into the blower or by running water directly into the silo.

Filling the Silo

The corn or other crops, when put into the silo, should be cut into small pieces not over $\frac{1}{2}$ inch long. The silage may be put into the silo

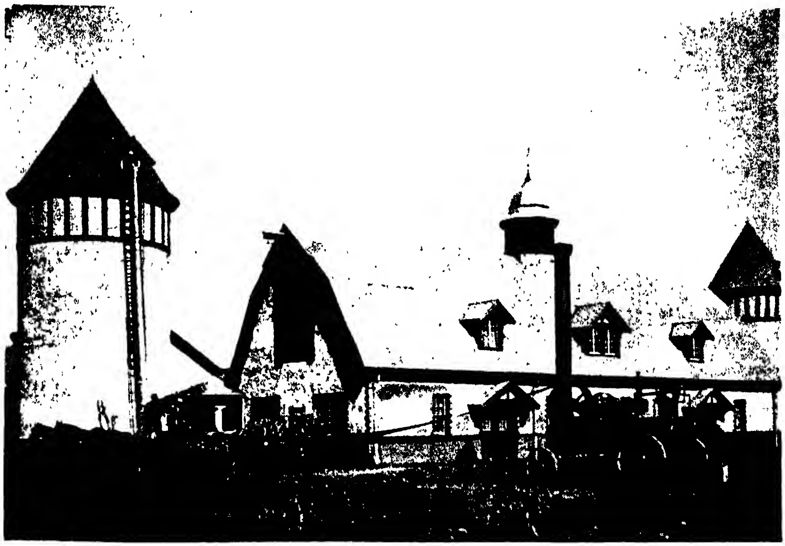

Fig. 15.—Filling a forty-foot silo.

either by the use of a blower or by a carrier, in such a way that the leaves, stalks, and grain will be evenly distributed throughout the entire surface. Even distribution is best obtained by the use of the jointed-pipe distributors. Besides being well distributed, the silage should be well tramped, especially along the walls. If the corn is dry it is sometimes necessary to add water. Sufficient water should be added to make the moisture condition similar to that of green corn. The water may be run directly on to the silage or it may be turned into the blower. The latter method distributes it somewhat better.

After the silo is filled the first foot or two will spoil. In order that the loss may be less it is well to pull off the ears from the corn that is to be put in the top, or to run some straw or other material on top. Sometimes oats are sowed on top of the silage, as with their roots they make a nearly air-tight surface.

Danger from Carbon Dioxide.—During the fermentation process, carbon dioxide, which is a poisonous gas, is given off. As this is a heavy gas it does not pass out if the doors are closed for some distance above the silage. Care should be taken, therefore, during the filling period when the machine has not been running for some time, not to enter the silo until the blower has driven off the dangerous gas.

Cost of Silage.—When the haul is not too long and good machinery is available, the following figures by the United States Department of Agriculture[10] furnish a guide to the amount of labor and teams required to fill a silo efficiently:

1 man and 3 horses to bind the corn
2 men to load the corn
3 men and 6 horses to haul
1 man to help unload
1 man to feed the cutter
1 or 2 men to work in the silo
1 man to tend the engine if steam is used
Total—10 to 11 men, 9 horses, and 3 wagons

In a study[11] at the farm of the Bureau of Dairying, situated at Beltsville, Maryland, it was found that the cost of growing a ton of silage was $3.30. This included labor, interest on land valued at $100 per acre, depreciation on machinery, seed, and commercial fertilizer. The yield of corn was 10.19 tons per acre. The cost of filling the silo was found to be $1.44 per ton, including the labor, supplies, depreciation, and interest on machinery and equipment. Adding to this the depreciation of the silo which, it is figured, amounts to 24 cents per ton, makes a total of $4.98 per ton for silage when stored in the silo. This price will vary with different farmers and in different localities and in some cases will probably run as high as $20 per ton.

Construction of Silos

Size of Silo.—One of the most common mistakes in the building of silos is to give them over-large diameters, which make it impossible to feed the silage fast enough to keep it from spoiling. Two to 3 inches from the surface of the whole silo should be removed each day in order to preserve the silage. A further advantage of a silo with a small diameter and a greater height is that the silage will be more compressed and less air will be admitted. If small quantities of silage are needed for supplementary feeding, as, for instance, for late summer feeding, it is well to provide a separate and smaller silo.

The diameter of the silo will depend upon the size of the herd. The following table gives the size of the silo relative to the length of the feeding period and the size of the herd:[12]

TABLE XXXIV

Size of Silo

Number of Cows in Herd	Feed for 180 Days			Feed for 240 Days		
	Estimated Tonnage of Silage Consumed, Tons	Size of Silo		Estimated Tonnage of Silage Consumed, Tons	Size of Silo	
		Diameter, Feet	Height, Feet		Diameter, Feet	Height, Feet
10	36	10	25	48	10	31
12	43	10	28	57	10	35
15	54	11	29	72	11	36
20	72	12	32	96	12	39
25	90	13	33	120	13	40
30	108	14	34	144	15	37
35	126	15	34	168	16	38
40	144	16	35	192	17	39
45	162	16	37	216	18	39
50	180	17	37	240	19	39

Walls.—In the building of a silo, the first essential is a tight wall that will exclude air and moisture and at the same time will not absorb moisture from the silage. When the moisture is taken up by the wall the absence of water from the outer layer of the silage makes the proper fermentation impossible, and molding takes place. Silos that are built of stone or porous cement should either be washed with a cement on the inside or given a treatment of tar or some sort of water-proofing material.

It is necessary also that the walls be smooth, with no ledges or projections. Wherever there is a ledge, settling does not take place uniformly, and air enters, causing the silage to spoil.

A further essential of the wall is that it be strong enough to withstand the pressure of the silage. It should also be durable enough to last for some years.

Foundation.—The foundation should be well constructed for there is a great weight in the silo. Usually concrete foundations are used. It is best also to have a floor in the silo, but this is not absolutely necessary. A floor of concrete keeps the rats from digging in and is easy to clean. It is often desirable to provide a drain in the bottom of the silo. This may be kept plugged except when the silo is to be cleaned or when water has gotten into it. Sometimes in very wet seasons, and when the corn must be cut green, the moisture is very great. In such cases a drain may be desirable.

Roof.—A roof is desirable but not absolutely necessary. It prevents snow and rain from entering the silo. These, especially the snow, often make the silage unpleasant to handle. A roof also reduces the freezing to some extent. The greatest advantage of the roof, however, is that it protects the silo itself so that it will last longer.

Doors.—The door of the silo should be air-tight and flush on the inside. Properly fitting doors are one of the essentials of a good silo. If the doors do not fit tightly air will get in and spoiling will result.

Shape.—With regard to shape, practically the only silos now in use are round. They are built in this form because in a square silo the corners would be difficult to fill. Besides, the round silo is stronger.

Types of Silos

There are many types of silo-building materials, most of which will prove satisfactory as far as keeping the silage is concerned. However, there is considerable difference in the cost and durability of the various kinds.

Stave Silo.—There is perhaps no other type of silo in use in the country that has met with such favor as the stave silo. It is cheaper than most other styles and can be easily constructed. It gives very satisfactory results when properly made and cared for. Only good material should be selected for a stave silo. The kind of wood to select may be judged by the following suggestions from the Iowa Experiment Station:[13]

" (*a*) *Redwood*, is one of the conifers which is generally accepted as having the best qualities of any wood used in silo construction. Redwood trees are very large and the lumber uniform. In buying redwood silos, a very good grade of practically clear and full-length staves may be secured. The shrinkage and swelling due to moisture are less than in any other woods. This is quite an advantage on account of the shrinkage which occurs when silos are empty. A stave silo built of this material eleven years ago was recently examined carefully. Every stave was gone over with a knife and not a soft spot was found anywhere.

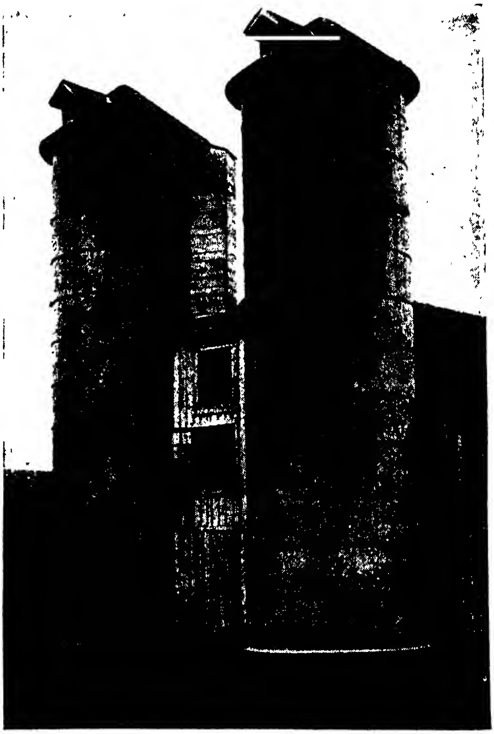

Fig. 16.—Twin stave silos.

" (*b*) *Cypress*, being quite similar to the quality and characteristics of white cedar, is well adapted to the building of silos. Only a clear or good sound-knotted stock should be used. More cypress than any other kind of wood is used for water tanks in the Middle West.

" (*c*) *Oregon Fir* is an excellent wood for stave silos, as it can be secured in full-length staves and is quite clear and uniform. With reasonable care and a foundation high enough to raise it above moisture, a silo with fir staves will last for a long term of years.

" (*d*) *Tamarack*, or larch, is very similar to the best hard pine, but where equal grades of each are obtainable it is best on account of its greater durability.

" (e) *White Pine*, if free from loose or large knots, makes a very good silo. The staves can not usually be obtained in full length for a desirable height of silo.

" (f) *Long-leaf yellow* or hard pine is the strongest and stiffest of all pines, and if a choice grade is secured, it makes a very good silo at a

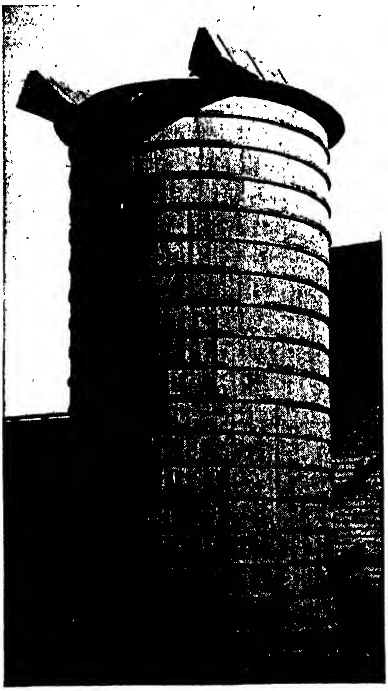

FIG. 17.—A wooden hoop silo.

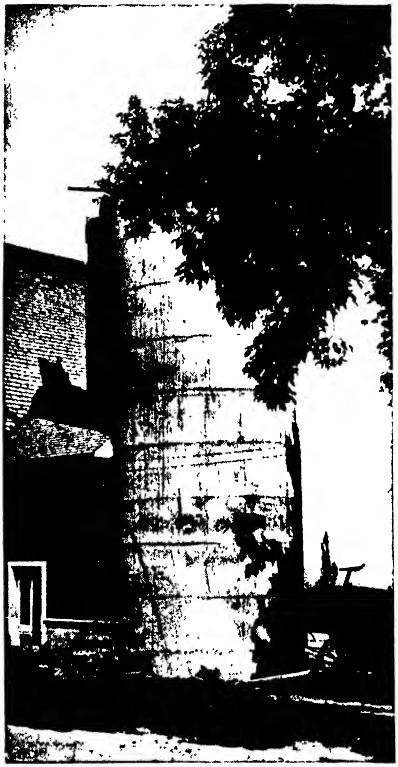

FIG. 18.—A monolithic concrete silo.

reasonable price. It shrinks a little more than the woods previously mentioned, but the hoops of any stave silo should be tightened when the silo is empty."

Monolithic Concrete Silo.—Concrete silos are now being used quite extensively in this country. They require special forms in their construction but these can easily be made by following directions put out by the United States Department of Agriculture.[14] In some of the earliest silos of this type, care was not taken to reinforce the walls sufficiently, and as a result some of the silos burst. With proper reinforcement it is not difficult to make them strong enough. A criticism made of them is that the acid attacks the cement, and that it will eventually destroy the wall. It is true that the acid may attack the cement to some extent, but the washing of the walls on the inside with cement plaster, or a thin application of tar, will maintain a tight surface. The cement silo has an important advantage over the wooden silo: it cannot be destroyed by fire or wind and if properly constructed will last indefinitely.

Hollow-wall Concrete Silo.—There are two types of hollow-wall concrete silos, known respectively as the hollow-cement-block silo and the hollow-wall silo. It is claimed that the contents are less susceptible to freezing in these silos than in the solid-wall silos. A further advantage of the cement-block silo is that it can be constructed more easily as no forms are necessary.

Hollow-tile Silo.—This type of silo has become very popular in many sections of the country. The advantages are that a strong, smooth wall can be obtained and no forms are necessary. It preserves the silage as well as other types and makes a very satisfactory silo.

Brick Silo.—In most sections brick are too expensive to be used for silos, but when they can be secured nearby at a low price they may be used if properly reinforced. The inside of the silo should be coated with cement plaster.

Metal or Steel Silo.—The metal or steel silo has been reported to give good satisfaction where it has been used. It can be made airtight, requires little attention, and preserves the silage satisfactorily.

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LECTURE XIV

PASTURES

PASTURE is the natural feed for dairy cattle and in many respects the best. Abundance of good pasture will give most of the requirements of a good dairy ration for economical milk production. The amount of land now in pasture in the United States is very great. The total land area of the United States is 1,903,265,000 acres, of which 878,789,000 acres are productive. Of these, it has been estimated that at least 350,000,000 acres are used annually for grazing purposes.[1] Except in very specialized dairies and a few small sections of the United States, pasture is of the greatest importance in the production of milk. It has been estimated that more than half of all the milk produced in this country is produced on pasture. In many sections the number of cows kept is determined by the number that can be pastured. There is an old Flemish proverb which says, " No grass, no cattle; no cattle, no manure; no manure, no crops." This is true to a certain extent in many sections of our country to-day. The pasture lands in most sections of the United States have been depleted and it is necessary that they be built up again if the greatest benefit is to be derived from them.

DESIRABLE CHARACTERISTICS OF A PASTURE

A pasture, to be of the greatest benefit to the dairyman, must possess certain characteristics which make it desirable. Some of the points to be considered in judging the value of a pasture are as follows:

1. **Density.**—A pasture, to be good, should have a dense sod as this determines the amount of forage available for the cattle. If the sod is not dense, more acreage will be necessary, with the result that the cattle will have to graze over a larger amount of land in order to obtain sufficient feed.

2. **Palatability and Digestibility of the Plant Cover.**—The palatability and digestibility of the plant cover determine the amount of feed that will be eaten by the cattle and its nutritive value. The pas-

ture grasses, of course, should be palatable and highly digestible. Certain grasses may change in their palatability and digestibility as the season advances. It is important that a pasture grass remain palatable and nutritious even after growth has ceased.

3. **Even Distribution of Forage.**—The time at which different pastures begin to grow in the spring varies considerably. This determines the time at which the forage is available for spring grazing. Different grasses also show different characteristics in regard to their growth during the summer and early fall months. A good pasture

FIG. 19.—A pasture scene in Holland (*Anthony*).

should have the ability to furnish sufficient palatable feed for the cattle throughout the normal grazing season.

4. **Convenience.**—Dairy animals require a pasture that is not too far distant from the stable, as they should not be compelled to travel any great distance in order to secure food. It is also very desirable that there be water in the pasture.

5. **A Good Fence.**—A pasture that is not well fenced is always a great annoyance to the owner of dairy cattle. One of the most desirable characteristics of a good pasture is that it have a good fence around it.

Kinds of Pasture

Pastures are classified (1) according to the nature of the plant which is used and the use made of the land, as temporary and permanent. The best to use will depend upon the local conditions.

Temporary Pastures.—A temporary pasture lasts for only one or two years and is designed to carry stock only for such a period. On account of the large amount of work necessary to prepare the ground and to sow the seed, this type of pasture has not been used extensively in the past in many parts of the United States. In some sections, however, temporary pastures are now being widely used. Their advantage is that the yield is very much greater than that of a permanent pasture.

Sweet Clover has been especially recommended for such pastures. It is a biennial and seldom blossoms the first year. It is usually sown

Fig. 20.—A luxuriant sweet clover pasture.

with a nurse crop in the spring and is often pastured to some extent the following fall. During the first season, however, one may expect to get very little return from a sweet-clover pasture, but during the second year the yield will usually be extremely good. It has a bitter taste and, until the cows become accustomed to it, some trouble is experienced in getting them to eat it.

The carrying capacity of a grass mixture containing sweet clover, as compared with other standard mixtures, was shown at the Belle Fourche Reclamation Project Experiment Station.[2] This was on irrigated land. Four different plots were used. Plot 1 was seeded with a mixture of Kentucky blue grass, brome grass, meadow fescue, orchard grass, tall oat grass, and white clover; Plot 2 was seeded with a mixture of Kentucky blue grass, meadow fescue, and white clover; Plot 3 was seeded with a mixture of brome grass, tall oat grass, and white clover; and Plot 4 was seeded with a mixture of brome grass, tall oat grass and sweet clover.

Five grade Holstein heifers from six to twelve months of age, weighing on the average 380 pounds, were turned on these plots. The following table shows the carrying capacity of the different pastures:

TABLE XXXV

CARRYING CAPACITY OF DIFFERENT PASTURES

Plot	Acre	Pasture Afforded (Days)		Gain per Acre, Lbs.
		Per Heifer	Per Acre	
1	0.50	89	178	340
2	0.50	103	206	500
3	0.50	88	176	400
4	0.25	127	508	500

The carrying capacity of Plot 4, which contained the sweet clover, was nearly three times that of the others, although the total gain per acre was not much greater.

Other annual crops used as temporary pasture by dairymen in different parts of the United States are Sudan grass, oats, field peas, and millet.

Permanent Pastures.—Permanent pastures consist of perennial plants and can be used under favorable conditions for many years in succession. They have the advantage that they do not have to be plowed every few years, and furthermore they are adapted to conditions under which plowing is not possible. A large part of the pasture land in the United States is permanent, and rightfully so, since there are many acres on hillsides and lowlands which should never be broken up, but which should return a very profitable income when in pasture and cared for properly.

Kentucky blue grass, Canadian blue grass, red top, and Hungarian brome grass are examples of desirable permanent-pasture grasses, while timothy, orchard grass, and red clover are also desirable but less enduring.

The cost of maintaining permanent pastures is not great. A survey of the farms in Eastern Pennsylvania[3] showed that good bluegrass pasture is about as profitable as any field in the farms. The cost of maintaining it was as follows:

One application of manure once in eight years at rate of 8 tons per acre...	$1.50
One application of lime once in ten years at rate of 20 bushels per acre...	0.55
Repairs and depreciation of fences, per acre	0.65
Taxes, per acre	0.75
Total, per acre	$3.45

FIG. 21.—Dairy herd on a good permanent pasture.

These pastures were all in good condition, and some would pasture as many as two cows per acre for the season.

Yields of Pastures

There is a prevailing opinion that lands put to pasture will not yield a return in comparison with the value of the land or with the returns secured from other crops. While this is undoubtedly true of much of the pasture land in the United States as it is now handled, it need not be so. The farmers in Holland måke extensive use of pasture on land which is valued at $500 to $1000 per acre and which annually rents for more than most of the land in this country would bring if sold.

This land, however, is not considered as waste land, nor is the pasture a neglected crop. Indeed, the pasture sod, some of which is more than one hundred years old, is more carefully handled than any other crop on the farm. Care is taken that the cattle are not placed on it too early, that it is not over-pastured so that the plants are destroyed, and that the sod is as carefully and as systematically manured and fertilized as any other crop.

In the United States, a permanent pasture that will furnish abundant feed for a 1000-pound cow for the season, on $2\frac{1}{2}$ acres, is considered a good one. A comparison of the feeding value of a Kentucky blue-grass pasture and of a dry ration off pasture was made at the Pennsylvania Experiment Station.[4] The feeding value and carrying capacity were estimated in terms of dairy cattle producing different quantities of milk. Eighty pounds of green grass per head each day was used as the basis of computation. The cows that are producing 20 pounds of milk daily do not usually require any supplementary feed, while the cows producing more than this should be given some feed in addition. The dry ration fed while the cows were not pastured was figured according to the Morrison Standard.

The following table shows the difference in favor of pasture as compared with dry feeding:

TABLE XXXVI

VALUE OF KENTUCKY BLUE-GRASS PASTURE FURNISHING 80 POUNDS OF GREEN GRASS PER DAY FOR A PERIOD OF 150 DAYS

(Cost of Feed for 150 Days)

	Pasture	Dry Ration off Pasture	Difference in Favor of Pasture
1200-pound cow:			
20 pounds 3.5 per cent milk daily...	......	$44.67	$44.67
35 pounds 3.5 per cent milk daily...	$19.20	56.74	37.54
50 pounds 3.5 per cent milk daily...	33.84	71.12	37.28
Average..........................	$17.68	$57.51	$39.83

This does not represent the acre value of pasture but simply the value of an area capable of producing 12,000 pounds of green grass during a period of 150 days. The investigators found that it required from less than 1 acre to more than 2.5 acres to support a cow for this length of time, depending upon the type of the soil and its treatment. Many of the ranges and unimproved pastures require as many as 10 to 20 acres for each animal. Most pastures of this kind may be easily improved.

Methods of Improving Pastures

There have been but few experiments conducted to show the best way of handling pastures in order to improve them, but information has been obtained on certain points.

Light vs. Heavy Grazing.—Overgrazing has been given as one of the chief causes of the depletion of pastures. While this is probably true of certain kinds of pastures, experiments at the Virginia Station[5] show that with well-established blue-grass pastures comparatively closely grazed plots resulted in a higher yield than did lightly grazed plots. It was also found that at the end of three years the sod on the closely grazed plots was in a much better condition, and that there were fewer weeds, than in the lightly grazed plots. Cattle should not, however, be turned on pasture until after it has made a good start in the spring. Neither should they be turned on the pasture during the winter or late fall especially when the pasture is wet and soggy.

Very little difference was found at the Virginia Station between alternate and continuous grazing with blue-grass pastures, but with bunch-grass pastures alternate pasturing is recommended.[1]

Fertilizer Treatment.—Pastures often respond remarkably well to fertilizers. They cannot be expected to maintain their yield year after year unless some fertilizer is added to replace the plant food which is removed by the growing crop. If the soil is acid, lime should be added. This must be done before other fertilizer treatments will do any good. The fertilizer-treatment requirement will depend upon the type of soil and its condition. One should always realize that a pasture should be treated as any other crop and not be expected to produce year after year without any treatment.

Cutting the Weeds.—Weeds in a pasture usually indicate depleted soil conditions. If the soil is built up so that pasture does its best, weeds are very seldom found. The weeds, however, should be kept out of pastures since they tend to crowd out the desirable plants and hinder their development. They should be cut at least once every year.

Certain weeds, such as the wild garlic, leek, etc., are a very serious trouble in a pasture. Wild garlic, when eaten by milking cows, taints the milk and makes it unfit for consumption. Garlic will go quickly through the animal's body and enter the milk. Experiments[6] have shown that it can be tasted in the milk within three minutes after it has been eaten and that it can still be detected twelve hours after being eaten. Such weeds should be eliminated from the pasture.

Care should be taken to eliminate plants of poisonous nature from the pasture. Some species of the oak, withered wild cherry, and several other weeds and leaves will kill cattle when eaten by them.

Feeding Cows on Pasture

The problem of feeding cows on pasture is one that is frequently overlooked by dairymen. The beginning of the pasture is awaited with impatience, and often this impatience overcomes good judgment and the cows are turned on pasture too early in the spring. When this is done it generally decreases the yield of grass throughout the summer. Since much of the food of the grass plant is manufactured in the leaves or blades, if the cows are allowed to graze while the grass is very short, its growth will be slow. The early grasses are mostly water, and heavy-milking cows cannot eat enough immature grass to supply them with the necessary nutrients. Hence, it is a good practice to continue feeding the cows some hay, silage, and grain for a time after they are first turned on pasture.

Experience has proven that even good pasture will not furnish enough food for high-producing cows. Grasses contain a large amount of water and are bulky. It is therefore impossible for heavy producers to consume enough to keep up production.

The best and most abundant pasture will furnish only enough nutrients for cows that are producing not more than 20 pounds of milk per day. A guide for feeding grain to cows on pasture is as follows:

For Jersey or Guernsey Cows Producing:

25 lbs. of milk daily feed 1 lb. of grain to each 6 lbs. of milk.
30 lbs. of milk daily feed 1 lb. of grain to each 5 lbs. of milk.
35 lbs. of milk daily feed 1 lb. of grain to each 4½ lbs. of milk.
40 lbs. of milk daily feed 1 lb. of grain to each 4 lbs. of milk.

For Holstein, Ayrshire, Brown Swiss, or Shorthorn Cows Producing

25 lbs. of milk daily, feed 1 lb. of grain to each 7 lbs. of milk.
30 lbs. of milk daily, feed 1 lb. of grain to each 6 lbs. of milk.
35 lbs. of milk daily, feed 1 lb. of grain to each 5½ lbs. of milk.
40 lbs. of milk daily, feed 1 lb. of grain to each 4 lbs. of milk.

In feeding grain to cows on abundant pasture, the grain mixture can be made up of relatively small amounts of the high-protein concentrates. As late summer approaches, the need for pasture supplement generally becomes more acute and the grain mixture at this time should be richer in protein. It is during this period that the pastures generally become short owing to dry weather. Summer silage or some other soiling crops should then be used if the production is to be maintained. A further consideration of these crops will be given in a later lecture.

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LECTURE XV

SOILING CROPS AND SUMMER SILAGE

THE practice of cutting crops green and feeding them in that condition to dairy cattle has long been followed. It is a common custom in Continental Europe, except in the high Alps. In the valleys of Switzerland all crops are harvested and brought to the cattle. There, only the highest-producing cows are kept in the barn and fed soilage, while the low producers are turned out to pasture on the heights. In our own country, however, the custom of feeding green crops has never become general. It is practiced to a limited extent in certain localities, especially around some of the larger cities. Partial soiling is practiced to a considerable extent, however.

The first comprehensive account of soiling crops written in this country was published in 1820 by Josiah Quincy.[1] It appeared in the *Massachusetts Agriculture Journal* and was later published in a booklet entitled, " Soiling of Cattle." Soiling is especially adapted for use in cases where intensive agriculture is necessary, as it requires a small amount of land but considerable labor.

ADVANTAGES OF SOILING

Soiling has several distinct advantages as compared with pasturing.

1. **A Large Amount of Feed Can be Obtained per Unit of Land.**— There is no question that a much larger yield to the acre can be obtained in the form of soiling crops than in the form of pasture. Detrick[2] was able to produce all the roughage necessary to feed thirty head of stock, seventeen of which were in milk, on 17 acres, by the use of soiling crops. Henry[3] found that it required 3.8 acres of excellent blue grass to pasture three cows for a period of 122 days, while he was able to keep three others for the same length of time with soiling crops on 1.5 acres of land. Frandsen, at the Nebraska Station[4] was able to keep four cows on 1.47 acres of soiling crops during the summer, adding

only some field corn and, in one year, alfalfa for thirteen days. These results show that it is possible, by this intensive method, to double or triple the production that could be obtained by pasturage.

2. **Less Waste is Experienced in Feeding.**—When cattle are fed in the barn it is easier to feed them so that there will be no waste, whereas under the pasture system cattle will tramp over much of the pasture and thereby waste it. Neither will they eat from places where dung or urine has recently been dropped. For these reasons there is a valuable saving of feed under the method of soiling crops.

3. **Less Fence is Required.**—Fences are not necessary where soiling is practiced. This relieves the dairyman of the initial cost of the fence

FIG. 22.—Scene in Denmark showing cattle staked out to gather soiling crops.

and the cost of its upkeep. Where fences are already on the farm very little is saved, but otherwise the saving is considerable.

4. **More Manure is Saved.**—The manure dropped on the pasture does not do the greatest amount of good unless it is spread. Since cattle do not, as a rule, graze around the droppings, the result is that groups of weeds grow up around them before they become sufficiently decayed for the grass to grow through them. Theoretically, the soiling system is a great conserver of manure. About 75 to 80 per cent of the fertilizing value of the crop will be gained under this system if the manure is handled properly.

5. **Animals Keep in Better Condition.**—If the pasture is good at all times, cows will keep in just as good a condition when on pasture as when fed a soiling crop. However, pasture usually fails in the late summer, resulting in a lower milk production and a poorer condition of the cows. With a soiling crop this shortage can be avoided and the food supply kept uniform throughout the year.

6. **Undesirable Flavors Can More Easily be Kept Out of the Milk.**—Even good, clean pastures often have weeds that affect the flavor of the milk. These can easily be kept out when soiling crops are fed.

Disadvantages of Soiling Crops

The soiling system also has several distinct disadvantages which prevent its wider use. Two of these disadvantages will be mentioned.

1. **A Large Amount of Labor is Required.**—This is probably the chief reason why soiling has not been more widely adopted in this country. The soiling crops must be cut and hauled regularly whether the weather is good or bad. Since about 100 pounds must be supplied for each cow per day, the labor of handling is considerable. Besides more labor is required to keep the barns and the cows clean when the animals are kept in the barn than when they are kept on pasture. When land values are high, as they are in Europe and near some of the larger cities in this country, it becomes necessary to use intensive farming systems in order to earn a fair rate of interest on the investment involved. In such cases soiling may be necessary.

2. **It is Difficult to Secure a Proper Rotation of Crops.**—Theoretically, it is easy to establish a rotation which will provide the soiling crops at the proper time. Practically, however, many difficulties occur. Often, because of dry weather, the crops will fail or the seeds will fail to germinate. At other times cold or wet weather will delay certain crops so that there will be periods between crops when hay or other feed must be supplied. There is often more or less waste, for the crop is good for only a short time and if not used at once for soiling must be used for other purposes.

Crops for Soiling

The following classification of soiling crops is abstracted from Bulletin 109 of the Pennsylvania Experiment Station:[5]

Soiling Crops

- Leguminous
  - Annual
    - Canada peas
    - Cow peas
    - Crimson clover
    - Soy beans
    - Vetch
      - Hairy
      - Spring
      - Winter
  - Perennial
    - Alfalfa
    - Alsike clover
    - Red clover
    - Flat pea
- Non-leguminous
  - Annual
    - Corn
      - Sweet
      - Dent
      - Flint
    - Millet
      - Common
      - Hungarian
      - German
    - Oats
    - Rape
    - Rye
    - Sorghum
      - Saccharine
        - Orange
        - Amber
      - Non-saccharine
        - Dhoura
        - Kaffir corn
        - Milo maize
  - Perennial
    - Brome grass
    - Orchard grass
    - Red top
    - Timothy

TABLE XXXVII

Yield per Acre of Various Soiling Crops

(Pennsylvania Experiment Station)

Crop	Green Forage, Lbs.	Air-dry Substance, Lbs.	Crude Protein, Lbs.
Canada peas and oats	17,293	2772	326
Cow peas	18,062	3273	503
Cow peas and sorghum	26,375	4512	400
Soy beans	13,019	2689	342
Alfalfa	10,722	2511	419
Dwarf Essex rape	19,370	2714	385
Rye	16,222	3775	353

Other crops besides the ones listed above are often grown. The best ones to grow will depend upon the local conditions, as weather and soil vary greatly over the country.

The average yields of a few of the crops are given in Table XXXVII. These results were secured at the Pennsylvania Station and are the averages for several years.

The Nebraska Station[4] secured the following average yields of green and air-dry material per acre:

TABLE XXXVIII

YIELD PER ACRE OF VARIOUS SOILING CROPS

(Nebraska Experiment Station)

Crop	Green Forage, Lbs.	Air-dry Substance, Lbs.
Rye	13,000	1800
Wheat	13,000	1700
Peas and oats	7,000	1800
Rape	12,600	2000
Corn	14,000–16,000	3000–3400
Cane	20,600	5800
Alfalfa:		
1st cutting	10,000	3000
2nd cutting	6,000	1800
3rd cutting	8,000	2400
Pasture	4,500	1000
Silage	16,000	4800

The yields will vary considerably even under the same soil conditions.

AMOUNT OF SOILAGE TO FEED

There is no reason why the cows should not be fed all they will eat of the soiling crops. The amount which a 1000-pound cow will consume varies from 30 to 100 pounds, depending upon the degree of maturity of the crop. With certain crops that are very laxative, such as alfalfa, great care must be taken not to feed the cows too heavily at first.

Succession of Crops

The proper succession of soiling crops is very necessary for their success. Most of the systems that have been worked out during recent

Fig. 23.—Soiling in Sweden.

years are centered around alfalfa. The following recommendation for ten cows has been made by the Pennsylvania Station:[6]

TABLE XXXIX

Succession of Soiling Crops in Pennsylvania

Crop	Area for Ten Cows	Time for Feeding
Rye	½ acre	May 15 to June 1
Alfalfa	2 acres	June 1 to June 12
Clover and timothy	¾ acre	June 12 to June 24
Peas and oats	1 acre	June 24 to July 15
Alfalfa (2nd cutting)	2 acres	July 15 to Aug. 11
Sorghum and cow peas (after rye)	½ acre	Aug. 11 to Aug. 28
Cow peas (after peas and oats)	1 acre	Aug. 28 to Aug. 30

The following table shows a plan for soiling crops sufficient for ten cows under Nebraska conditions.[4] The rotation may be worked out from the dates. It is centered around alfalfa and corn.

TABLE XL

SUCCESSION OF CROPS FOR SOILING CROPS IN NEBRASKA

Crop	Date Sown	Date Harvested	Number of Acres	Yield per Acre, Tons	Seed per Acre
Rye or wheat	9/15	5/1 – 5/20	1	5–6	8 pks.
Alfalfa	9/1	5/20– 6/10	½	3–6	18 lbs.
Canada peas and oats	4/1	6/10– 6/20	½	9	6 pks. each
	4/10	6/20– 6/30	½	9	6 pks. each
	4/20	6/30– 7/10	½	9	6 pks. each
Alfalfa (2nd cutting)	9/1	7/1 – 7/20	½	1–3	18 lbs.
Early corn	5/5	7/10– 7/30	½	10	⅕ bu.
	5/15	7/20– 8/10	½	10	⅕ bu.
Black cow peas	5/15	8/10– 8/20	½	9	4 pks.
Alfalfa (3rd cutting)	9/1	8/20– 9/1	½	2–4	18 lbs.
Late corn	5/25	9/1 – 9/20	½	10	⅕ bu.
Barley and peas	8/1	9/20–10/5	½	10	1½ bu.
	8/10	10/5 –10/20	½	10	1½ bu.

These successions are given simply as guides; others may be worked out, or these may be modified to suit local conditions. A suggested succession of crops should be obtained from the nearest experiment station.

PARTIAL SOILING

While complete soiling is practical only where intensive farming methods are necessary, partial soiling is quite largely practiced. During the hot, dry months of summer the pasture usually becomes poor and often scarce, and as a result the milk production will go down. If this happens it is usually very difficult to increase the production after the cows are put into the barn. For this reason the cows should be given some green feed during this time to supplement the pasture. This feed may consist either of some soiling crop or of summer silage.

COMPARISON OF SOILING CROP AND SUMMER SILAGE

If the number of animals to be fed is sufficient to require that at least 2 inches be taken off the silo per day during the summer, summer silage can be used advantageously. Often a special silo with a small diameter is built for this purpose. It has been found that the use of silage is a cheaper and better way of providing green material during the summer months than is soiling. At the Wisconsin Experiment Station,[7] for an average of three years, a group of cows fed silage produced practically the same amount of milk as did a group fed soilage, but the expense was considerably greater for the soiling crops. The investigators found that one advantage of silage is that years of poor rainfall and poor pasture are years of poor soiling crops, while the carrying over of corn in the silo from one year to the next tends to equalize this.

The following table, taken from the Nebraska Experiment Station,[4] gives a summary of two years' comparison of soiling and summer silage at that station:

TABLE XLI

Summary for Two Years—Soiling vs. Summer Silage

	Average Soiling	Average Silage
Number of days	141	141
Pounds of soilage consumed	61,186.5	
Pounds of silage consumed	....	16,231
Pounds of alfalfa consumed	....	3,933
Pounds of grain consumed	5,408	4,263.8
Pounds of milk produced	13,480.75	11,120.95
Average per cent fat	4.29	4.18
Pounds of butterfat	562.88	465.22
Hours of man and horse labor	247.57	189.32
Grain required per 100 pounds of milk	41.81	40.30
Pounds of soilage required per 100 pounds of milk	470.5	
Pounds of silage required per 100 pounds of milk	....	155.73
Pounds of hay required per 100 pounds of milk	....	36.74
Hours of labor required per 100 pounds of milk	1.813	1.245
Pounds of dry matter required per 100 pounds of milk	149.975	110.555
Pounds of crude protein required per 100 pounds of milk	14.567	10.742
Weight of cows at the beginning	901.2	1,050
Weight of cows at the end	990.5	1,016.5
Acres of ground required	2.445	1.665

The advantage of the summer silo were found to be as follows:

1. The feed was always at hand without any additional work.
2. The silage will keep for an indefinite length of time if properly prepared.

3. The silage was relished just as well as were the soiling crops.
4. The silage was independent of climatic conditions as the supply was from the previous summer.
5. The silage was always under cover; there was no harvesting during wet weather.
6. The silage was a cheaper succulent feed than was the soiling crop.

However, on farms where the number of cows is so small that the silage is not fed fast enough to keep it from spoiling, or where for any reason silage is not available, some soilage crops should be grown to feed during the hot, dry months of summer and early fall. A good practice is to keep the cows in a cool barn during the daytime and feed them some green feed, and then turn them out to the pasture during the night for grazing and exercise.

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LECTURE XVI

SOME DETAILS IN DAIRY CATTLE MANAGEMENT

IN the management of dairy animals, as in other lines of dairy industry, attention to details is important, but by details it should be understood that necessary details are meant. It is possible for a herdsman to attend to unessential details at the expense of larger and more important matters.

HANDLING THE HERD

Regularity of Care.—The dairy cow, as has been stated before, is a creature of habit. The same system of care should be used each day. It is desirable that the cow have approximately the same amount of exercise, and that she be fed and milked at the same hour daily. This is especially true of animals that are being forced for high production. A change of milkers or even a strange feeder or attendant in the barn has an effect upon some of the more sensitive animals. Most cows can, however, become accustomed to a certain amount of change.

Kindness in Handling.—To keep up the production of a cow one must always treat her with kindness. The beating of a cow should never be tolerated under any circumstances. It is not only cruel but it cuts down the production of milk. A man that cannot control his temper will never make a good dairyman. Dairy cows should never be raced in going to or from pasture or while in pasture. Very few dogs have a place on the dairy farm as most of them will race the cows. The presence of dogs around the farm at milking time, if the cows are not used to them, may disturb the herd to such an extent as to affect not only the quantity of the milk but also its composition.

Exercise.—It is not known just how much exercise is best for a dairy cow. Some herdsman believe that since the cow's work is to produce milk she can get along without any exercise, provided that she is kept in a sanitary, well-lighted and ventilated barn. Some herds that are producing well are kept in the barn throughout the year. In general, however, it seems desirable to give the animals at least some exercise as they seem to be a little more thrifty and maintain a better appetite when they are allowed to exercise. This is especially true when they are kept in stanchions, as they are able, when turned out, to rub certain parts of their bodies that they cannot rub when in the stanchion. A common method is to turn them out for an hour or two, even in winter, while the barn is being cleaned. This enables the dairyman to do the cleaning to better advantage and at the same time gives the animals a certain amount of exercise regularly every day. It is possible for a dairy cow to have so much exercise that she will lose energy unnecessarily. This is the case when she has to be driven too far to pasture or when the pasture is so poor that she has to cover too much ground in order to get enough food. Cows that are heavy milkers should not be given much exercise. In cold, wet weather the exercise should take place in a protected yard if possible.

Grooming Dairy Cows.—Dairy cows should be groomed every day, especially in the winter when they are in the stable all the time. In summer, when they are on pasture, this is not so necessary. Grooming is necessary not only from the standpoint of looks, but also from that of production of clean milk and the health of the animal. By grooming, the dirt and loose hair are removed and thereby prevented from getting into the milk. Grooming, properly done, also stimulates the skin, making it more pliable. In the case of heavy producers which are kept in the stable most of the time, it is said to have an effect upon the milk flow.

The method should be, first, to rub the cow vigorously with a brush and curry comb or card, and then to clean her off with either a cloth or a brush. The currying should be vigorous, but not so severe as to irritate the skin. The bone points should be rubbed more gently, especially with the comb.

Dehorning.—Cows in commercial herds that are not kept for show purposes should be dehorned. Cows with horns endanger their attendants as well as one another, and the horns are also an inconvenience in feeding and watering. Cows that are dehorned can be kept together in close quarters or yards without danger. Polled strains of the various breeds have been developed in order to bring about a hornless condition without the operation of dehorning.

There are two methods of dehorning which are commonly used.

1. *Removing with a Caustic.*—This method is to remove the button-

like rudiments of horns in the calf before it is ten days old. For this purpose a stick of caustic potash (potassium hydroxide) is used. The hair around these "buttons" should be clipped close and the caustic potash should be slightly moistened and then rubbed over the "button," or little horn, until the blood appears. This should be carefully done, as otherwise some of the horn cells may not be destroyed and a scur may develop. The caustic should be wrapped in a cloth or paper to protect the operator's hand. In about a week or ten days, the scab that is formed should drop off.

FIG. 24.—The hair is clipped close before the caustic is applied.

FIG. 25.—Applying the caustic to the "buttons" of the young calf.

2. *Removing with Forceps or Saw.*—This second method is to remove the horns, after they are partly or fully grown, with forceps or a saw. The operation should take place when the animal is two years of age or older. If it is done at an earlier age, scurs are likely to develop. The best time to dehorn is in the fall or in the spring. It should not be done during fly time. Whichever instrument is used, the practice should be to remove the horn just as near the head as possible. When the ring of hair at the base of the horn is removed in the operation it is seldom that even a small scur will grow. If there is considerable bleeding or if it is necessary to dehorn during fly time, it is advisable to cover the wound with pine tar, or cotton soaked in pine tar, and to bind it up.

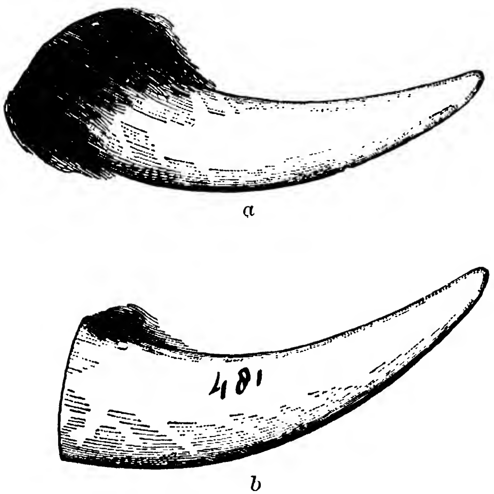

FIG. 26.—The horns should be cut close to the head as shown by "a."

Spaying. — A theory was prevalent a few years ago that by spaying (removing the ovaries of) dairy cows they could be maintained in milk over a number of years without the interruption incident to calving. This theory was found, however, not to work out. Cows would continue to milk for a longer time, but at a much diminished milk flow, even though they were spayed immediately after calving. The hormone secretion which circulates in the blood, and which is quite active after parturition, becomes less active after a reasonable number of months, and finally dies out. It must be renewed by the cow's dropping another calf. Moreover, the cow cannot assimilate enough minerals for continued high production. For these reasons, therefore, spaying was not successful in keeping up a continuous high milk flow.

Watering.—A large amount of water is contained in milk. Dairy cows, therefore, must consume large quantities of water for the production of milk. The amount that a cow will drink depends largely upon the outdoor temperature, the kind of food eaten, and the amount of milk the cow is producing. A large cow producing a heavy flow of milk will easily drink as much as 100 pounds of water per day. If the weather is warm more water is required than in moderate or cold weather. Also, if the feed is of a succulent nature, the cow will consume less water than if she were eating dry feed. In experiments at the Beltsville Station[1] average-producing cows were watered once a day, twice a day, and at will from watering cups. The cows watered once a day drank less and produced less than those watered twice a day, and the cows watered twice a day drank as much but produced less than those watered at will. The difference in production, however, was only about 5 per cent between those watered once a day and those watered at will. It was found that the higher the production the greater the benefit derived from frequent watering.

The temperature of the water should be uniform from day to day. In very cold weather the cows will drink more water if it is slightly warmed. However, except for very heavy producers, this will seldom pay. Ordinarily, if the water is given in the barn there will be no advantage in warming it.

Bedding.—Some sort of bedding is necessary to provide comfort for the animals, to keep them clean, and to absorb the liquid manure. The amount of bedding required will depend upon the kind of floor that is in the barn, and the method of keeping the cows fastened. With a cork-brick or wooden floor less bedding is needed than when other materials are used. Less bedding is also needed when the cows are fastened in stanchions with stalls of proper length than when they are fastened with chains or left loose in a box stall.

The common materials used for bedding are straws of various kinds, corn stover, shavings, and sawdust. The best kind to use will depend upon local conditions. On most farms sufficient straw is usually available, so that the problem of the proper kind of bedding is easily solved. In many cases corn stover can be shredded and used for bedding. They make very satisfactory bedding materials.

Where the bedding has to be purchased, the relative prices of the various bedding materials will usually be the deciding factor. Shavings have been used extensively in many dairies with good success. They have the advantage that they are clean and give the stable an appearance of cleanliness, which no other material can do. Shavings can be purchased in carload lots, in bales which are easily stored and handled. In regard to cost, the West Virginia Station found that they were the cheapest and most satisfactory bedding that could be obtained. Softwood shavings have a very much greater water-holding capacity than those containing some of the hard woods, and are greatly to be preferred.

The absorptive properties of different bedding materials are given by Doane[2] as follows:

TABLE XLII

ABSORPTIVE PROPERTIES OF BEDDING MATERIAL

Material	Water-absorbing Power of Bedding	Pounds of Bedding Required to Absorb for 24 Hours
Cut stover	2.5	4.0
Cut wheat straw	2.0	5.0
Uncut wheat straw	2.0	5.0
Sawdust	0.8	12.5
Shavings	2.0	4.4

The fertilization value of the straws and corn stover is much greater than that of either shavings or sawdust. About 4 to 8 pounds of bedding is required to keep the cow clean when fastened in stanchions [illegible] stalls of the proper length.

Manure Disposal.—All manure should be removed from the stable at least once per day, and [illegible]. This can be done by means of a wheelbarrow, or in the larger dairies by means of a litter carrier which runs on a track back of the cows. From this the manure can be dumped directly into a manure spreader and spread at once on the field, or it can be run into a manure pit situated some distance from the barn, where it will remain until it is convenient to spread it upon the land. The manure, especially during warm weather, should not be allowed to collect for any great length of time, for it is an excellent breeding place for flies. The practice of dumping the manure in a pile where the rain will wash out much of the fertilizing constituents should never be allowed. Properly preserved manure will return to the soil about 75 per cent of the fertilizing value of the feed, while manure that is exposed to the weather will lose a very large percentage of its value.

Marking.—It is necessary to have some way of designating the animals in the herd. Many dairymen name their cows. This is all right in grade herds when the herd is so small that one can keep in mind all of the animals. In large herds and in pure-bred herds it is never safe to trust to one's memory. Some method of marking must be used. Five ways of marking cattle are in common use:

1. *By a system of cuts in the ear.*—This system is used extensively in numbering pigs, but with dairy cows it is not recommended because of the unsightly appearance and because it would be difficult to read.

2. *By inserting special tags of various kinds in the ear.*—This is one of the best methods although it has the disadvantage that the tags are sometimes lost. The tags are of many designs. One is provided with

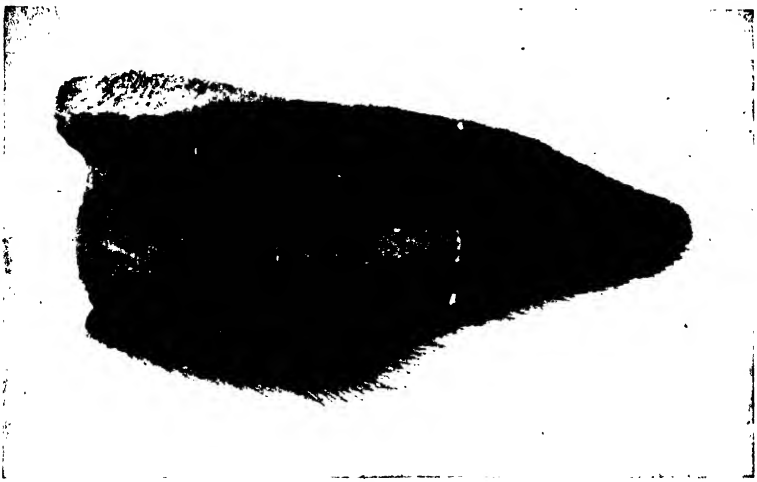

FIG. 30.—Ear tatooed with special marks.

a button on each side of the ear, the two being clamped or screwed together. Another consists of a round leather or composite tag which is attached to the ear by a ring similar to a common hog ring.

3. *By tattooing the ear or other part of the body.*—This method is used extensively. The method is to punch certain small holes in the form of numbers of letters through the ear and then to fill them with ink. This method is often used as a permanent mark along with some other mark easier to read.

4. *By stamping the number on the hoof or horn.*—While this is a safe way it is not commonly used. Dies are used to burn figures or numbers upon the hoof or horn. This method can also be used for a permanent number.

5. *By the use of tags attached to straps or chains placed around the horns or neck.*—The strap is often used on young calves until they are old enough for a permanent mark. In herds where animals are bought frequently and the same number is used over and over, this system of marking is common. By the use of a padlock it becomes more permanent.

Kicking Cows.—There are two classes of kicking cows. One develops the habit of kicking through improper treatment, and the other is characteristically vicious. Of the latter class there are fortunately very few. In almost every case, if the animals are carefully handled, especially during the first days of milking while they are heifers, and the teats and udder are carefully protected from soreness or other injury, kindness and patience will transform a kicking cow into a gentle one that can be milked without difficulty. With the vicious cow, however, or with one that has developed the habit of kicking to such a degree that it does not yield to kind treatment, some mechanical device must be used if the cow is worth it. One method is to tie her head high, thus making kicking more difficult. Another is to tie a rope or strap around the body of the cow just in front of the udder; with a good many cows, if this has been used several times, it seems necessary only to throw the strap over the back. Still another method is to loop a rope around the cow's leg above the hock, and to fasten it to some object in the rear so that it will be impossible for her to throw her leg forward. A device which has been used with some success is a wooden clamp with one claw in front and above the hock, and one behind and below the hock near the ankle; when the strap is tightened in the center the animal is unable to flex the hock. Perhaps the most common way is to make a simple loop with a strap or rope above the hocks, binding the legs together.

Sucking Cows.—Some cows develop the habit of milking themselves or other cows. There are many patent devices that are used successfully to overcome this habit, such as muzzles with sharp nails in them. Most of these require some attention. If they are used on cows that milk other cows there is danger of injury to the udder. A simple method that works satisfactorily is to insert through the nose of the sucking cow a ring with two or three other rings attached to it. This device needs no attention and does not interfere with the animal's eating, but it interferes with her attempts to suck.

Whitewash.—Whitewash is excellent to use in all dairy buildings

It is simple to make and easy to apply, is a mild antiseptic, and is perfectly safe. The following formula has been recommended by the United States Department of Agriculture:

"Take a half bushel of unslaked lime, slake it with boiling water, cover during the process to keep in steam. Strain the liquid through a fine sieve or strainer, and add to it a peck of salt previously dissolved in warm water, 3 pounds of ground rice boiled to a thin paste and stirred in while hot, ½ pound of Spanish whiting, and 1 pound of clean glue previously dissolved by soaking in cold water, and then hang over a slow fire in a small pot hung in a larger one filled with water. Add 5 gallons of hot water to the mixture; stir well; let it stand a few days covered from dirt. It should be applied hot, for which purpose it can be kept in a kettle or a portable furnace. Coloring matter may be added as desired. When a less durable whitewash will answer, the above may be modified by leaving out the whiting and glue and omitting the boiling. It need not be applied hot and may be applied with a spray pump."

Flies.—Flies are a great annoyance around the dairy barn. It seems almost impossible to get rid of them. By the use of screens they can be kept out of the dairy houses, but it is practically useless to screen the dairy stable as the flies come in on the cows and the screens often serve to keep them in rather than to keep them out.

Many different devices have been tried in order to get rid of flies. Some dairymen use poisonous solutions, mixed with syrup, which are put in different parts of the barn in shallow pans, while others use fly traps of various kinds. The most common method is to spray the cows with some material which will either kill the flies or else repel them. There are many commercial sprays on the market which give fairly good results.

Dairymen should, as far as possible, destroy the breeding places of flies. They should keep the manure well cleaned out and all other breeding places cleaned up, and then by the use of sprays and traps reduce the flies to the lowest possible number.

It has been found that flies do not have a great effect upon the milk flow of dairy cows. Formerly it was thought that one of the main reasons for the decreased milk flow in the later summer was the torment of the flies. Experiments[3] have shown, however, that flies have very little influence upon the milk yield of cows. Nevertheless, flies are unsanitary and likely to contaminate the milk and are at times very annoying to both the cow and the milker, and therefore every precaution should be taken to keep the number down to the minimum.

Milking the Herd

Next to feeding, perhaps there is no other operation in the dairy that requires so much skill as does milking. Considerable practice is required to become a good milker. A person with soft hands seems to be able to milk more efficiently than one whose hands are hardened with heavy work.

The operation of milking should be uniform, rapid, and continuous until practically all the milk has been drawn. One should not cease milking after one has begun, until the cow has been completely milked. In milking the hands should be dry; the practice of wetting them before beginning the operation is very unsanitary. If it seems necessary to have the hands moist, vaseline may be used without injury to the quality of the milk.

The method of milking should imitate that of the calf as closely as possible. The operation consists of an upward movement followed by a downward pull accompanied by pressure. The whole hand should be used, not merely one or two fingers. Unless the teats are small, the squeezing should be accomplished by closing the whole hand, first at the top of the teat as a check against the backflow of the milk, and then on the rest of the teat.

It is customary to milk diagonally placed teats simultaneously, for the reason that there is a blood connection between the teats on the same side, but not between those on opposite sides. It is believed that by milking alternate teats both sides of the udder are stimulated at the same time, and that changing to the other alternate pair permits secretion to proceed in the first two.

There is considerable difference in the length of time required to milk different cows, but on the average a good milker can milk six to ten cows per hour, the number depending somewhat upon the ease with which the cows can be milked. There is little difference, however, in the time required to milk cows that give large amounts of milk and those that give small amounts. When the milker is expected to weigh and sample the milk, a smaller number of cows can be milked per hour.

Description of the Hegelund Manipulation.—Professor Hegelund of Denmark has suggested a system of manipulation in milking which, he claims, increases the milk yield over that produced in the ordinary manner. A description of this manipulation follows:[4, 5]

"*First Manipulation.*—The right quarters of the udder are pressed against each other (if udder is very large, only one quarter at a time is taken) with the left hand on the hind quarter and the right hand in front of the fore quarter, the thumbs being placed on the outside of the udder and the forefingers in the division between the two halves of the udder. The hands are now pressed toward each other and at the same time lifted toward the body of the cow. This pressing and lifting is repeated three times, the milk collected in the milk cistern is then milked out, and the manipulation repeated until no more milk is obtained in this way, when the left quarters are treated in the same way.

"*Second Manipulation.*—The glands are pressed together from the side. The fore quarters are milked each by itself, by placing one with fingers spread on the outside of the quarter and the other hand on the division between the right and left fore quarters; the hands are pressed against each other and the teat then milked. When no more milk is obtained by this manipulation, the hind quarters are milked by placing a hand on the outside of each quarter, likewise with fingers spread and turned upward, but with the thumb just in front of the hind quarter. The hands are lifted, and grasp into the gland from behind and from the side, after which they are lowered to draw the milk. The manipulation is repeated until no more milk is obtained.

"*Third Manipulation.*—The fore teats are grasped with partly closed hands and lifted with a push toward the body of the cow, both at the same time, by which method the glands are pressed between the hands and the body; the milk is drawn after each three pushes. When the fore teats are emptied the hind teats are milked in the same manner."

Milking with a Milking Machine.—The milking machine is a success on many dairy farms. It has the advantage that it saves labor and time and is easier on the milker. The initial cost and the labor of keeping the machines in proper sanitary condition are disadvantages, especially when the herd is small.

As far as quantity of milk is concerned, the milking machine seems to give just as good results as does ordinary hand milking. It is the general practice for the hand milker to follow the machine in order to see that the milking has been done completely and to draw any milk that is left.

It has been claimed that the milking machine causes udder troubles. This was undoubtedly true with some of the older types of machines, especially when they were left on too long; but the newer machines are so constructed that there is now little danger of such trouble.

The trouble of keeping milking machines clean is the biggest drawback experienced with their use. Theoretically, milk drawn with a machine should be cleaner than that drawn by hand as it is better protected from the surroundings, but often milk produced in this way contains more bacteria than that drawn in the ordinary way. However, when the machines are given proper care, the bacteria count of the milk is kept quite low. Failure of the milking machine is usually due to lack of mechanical knowledge on the part of the operator, to his carelessness, or to his lack of attention to proper cleaning of the machine.

Frequency of Milking.—The frequency of milking should depend upon the ability of the cows to produce milk. In general, a cow that produces 50 or more pounds a day should be milked more than twice daily. With cows giving less than this amount it is probably not profitable, from the standpoint of actual amount of increase in milk flow, to milk more than twice. Experiments have shown that more milk and fat are produced by milking three times than by milking twice. At the United States Dairy Division farm at Beltsville it was estimated that the average increase in the yield of good cows for short periods (forty days) due to milking them three times instead of two was about 12 per cent, and for longer periods (a year) the increase was about 18 per cent. The cows milked three times a day were more persistent than those that were milked only twice. It was also estimated that the increase due to milking four times a day was 6 to 7 per cent over milking three times a day. Whether or not it will pay to milk more than twice depends upon individual conditions. In large herds where the system of labor can be handled, it may be advantageous to milk three times a day, even in a regular commercial herd. For very high-producing cows, or cows that are being forced for high records, it is customary to milk four times a day.

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LECTURE XVII

RAISING THE DAIRY CALF

THE total number of dairy cows in the United States in 1927 was 21,824,000. The average age at which the cow in the United States is removed from the herd has been found to be seven and three-fifths years. Assuming that a cow gives birth to her first calf at two and one-half years of age, and to one calf each year thereafter, this means that the average cow can give birth to five calves in her lifetime. Her period of usefulness in the herd, therefore, is just a little over five years. At this rate about 4,500,000 calves must be raised every year in order to maintain the present number of dairy cows. Furthermore, it is necessary to raise approximately 350,000 more calves to keep up with the increase in population. Many calves die while being fed milk, and a large number are disposed of later, so that most dairymen must retain at least three calves for each two cows that are to be replaced in the herd. Therefore, the number of calves actually being raised in the United States at any time is very large.

Importance of Raising Dairy Calves.—It is now a well-known fact that the dairy cow inherits her milk-producing ability, and that it is impossible by any kind of feeding to make an animal produce milk in excess of her inheritance. Since this is true, it is very essential that the dairy farmer raise only the heifer calves of cows possessing high milk-producing qualities. This is the way in which he can hope to maintain the production of his herd at its present level. By careful mating and feeding he may even develop a herd of cows with a higher average production than that with which he started.

Near the larger cities where the price of milk is high, many of the dairymen, instead of raising calves, depend upon purchasing cows with which to maintain their herds. While from the standpoint of immediate monetary return this method may be the best, nevertheless it has several disadvantages which make it very undesirable. In the first place only too often, the cows that can be purchased are culls which the owner himself does not want, and if the best cows in a herd are purchasd the price which is paid is usually very high. Furthermore, the buyer always runs the very great risk of bringing diseases, such as tuberculosis and abortion, into his herd. It is a well-established fact that little or no improvement results where this method of maintaining the herd is followed. Herd improvement can only come where discarded cows are replaced by well-raised heifers of good breeding and type. The only sure and practical way in which the dairyman can secure these is to raise his own heifer calves from the best cows in the herd and with the use of a good pure-bred bull. There are successful specialized dairies in which no young stock is raised, but

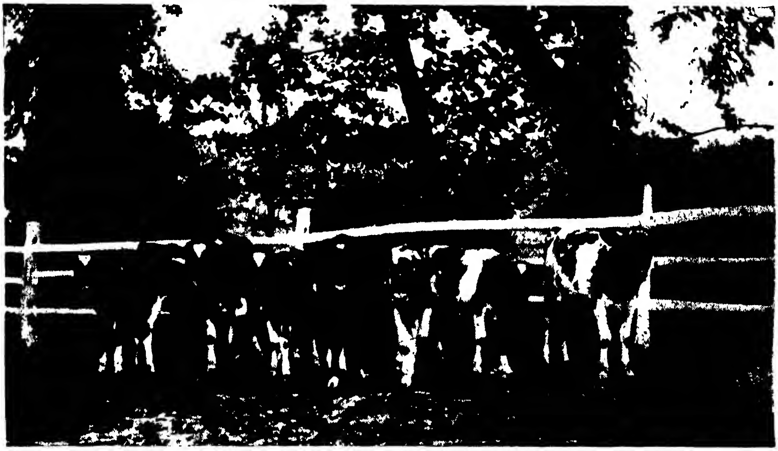

FIG. 31.—The future herd (*Bulkley.*)

such herds show no improvement from one year to the next, while the dairyman who raises his own replacements with careful breeding and attention to details may hope to improve his herd from year to year.

Care of the Cow and Calf at Calving Time.—If the cow is confined in the barn she should be put into a well-bedded box stall a few days previous to the time of calving. Although it is not always necessary for the attendant to be present while the cow is calving, he should be near by, where he can give assistance if necessary; but he should disturb her as little as possible. If the cow calves normally she will immediately begin to lick the new-born calf, and will thus start respiration, improve the circulation, and dry the young animal. It is important that the mother begin to lick the calf soon after it is dropped. Sometimes the fetal membrane covers the nostrils, and the young calf will suffocate unless this is promptly removed. Occasionally a young mother, even though she may have had several calves, will refuse to own her offspring. In such cases it is necessary to remove the calf to a safe distance and to dry it with burlap or other dry cloths. Generally, after a brief absence, the calf may be returned, and the mother induced to adopt it.

A vigorous calf will attempt to rise in about fifteen minutes and usually will be nursing in half an hour. The weaker the calf, the longer the time before it will be able to be up and nursing. Some calves are unable to nurse by their own efforts; in such cases it is necessary to assist the calf by holding it up to the cow's udder. If the calf is so weak that it is unable to drink, even when held up, it may be necessary to feed it from a bottle, either by drenching or by fitting the bottle with a nipple. It is always desirable to disinfect the navel with a strong solution of creolin or other disinfectant, after which it should be washed with tincture of iodine. This may prevent disease germs from entering by this means.

Care of the New-born Calf.—The first milk that a cow gives after dropping a calf is called " colostrum." It differs from normal milk in that it is thick and yellow and contains much more protein and ash. This abnormal milk is given for several days, gradually changing to normal milk. It is usually considered fit for human consumption after the eighth milking following the cow's freshening.

It is very important that the calf receive the colostrum. It seems to be the special purpose of this milk to cleanse away the metabolic products that have collected in the intestines of the young animal during the latter portion of its fetal days. Experiments[1] have shown that it is almost impossible to raise a calf that has not received any colostrum. If for any reason the young calf does not receive the colostrum, it should be given a teaspoonful of castor oil every two hours until the bowels have moved. Ordinarily, the colostrum should be fed for the first three or four days.

Birth Weight.—Table XLIII, compiled by Eckles,[2] shows the average birth weight of calves of different breeds.

Male calves are usually a little larger than female ones. Eckles found at the Missouri Station that the males weighed from an average of 1 pound, in the case of the Dairy Shorthorns, to an average of 8 pounds, in the case of the Ayrshire, heavier than the females. He also found that the first calf of a heifer was somewhat smaller than the average of the breed. On the average, the maximum weight of calves at birth will be between the third and sixth calvings. Old cows seem to have a tendency to drop smaller calves than they did when in their prime.

TABLE XLIII

BIRTH WEIGHT OF CALVES OF THE DIFFERENT BREEDS

Breeds	Number of Calves	Average Weight, Both Sexes, Lbs.	Average Weight of Dam, Lbs.	Weight of Calf in Proportion to Dam, Per Cent
Jersey	253	55	867	6.3
Holstein	229	89	1137	7.8
Guernsey	57	71	996	7.1
Ayrshire	80	72	983	7.3
Brown Swiss	5	100	1123	8.9
Dairy Shorthorn	30	73	1216	6.0

The nutrition of the cow during gestation does not greatly influence the size of the resulting calf. However, if extreme conditions are experienced and continued for a long period of time, they may prove detrimental, as, for example, when feed from a restricted plant source is given the cow. It is often observed that a cow in very poor flesh will drop a calf of normal size, while a cow in very good flesh will drop a calf that is small for the breed. This can be explained by the fact that the composition of the blood from which the fetus receives its nourishment tends to remain constant even when the food supply is limited. A shortage of any constituent in the blood is made up by drawing upon the reserve supply already in the body. For this reason, the food supply of the fetus remains practically constant even under adverse conditions.

Weaning the Calf.—There has been a great deal of variation in practice regarding the time at which the calf should be taken from the cow. Some successful raisers of calves let the calf nurse but once so that it may receive the colostrum, and then take the calf from the mother and feed it by hand. Others do not allow the calf to nurse even once. Most, however, seem to prefer to leave the calf with the mother for several days or until the milk is good. This seems to be a good practice if the cow is free from tuberculosis.

Sometimes, especially with young heifers, the mother's udder is very hard, and the butting which the young calf gives it while nursing seems to be a very helpful treatment for the reduction of the swelling. For this reason, a calf is frequently kept with the dam for some time, the herdsman himself doing part of the milking and allowing the calf to do the rest. The arguments for not allowing the calf to remain with the cow are that the amount of milk which the calf should receive can be better controlled, that there is less difficulty in teaching the calf to drink, and that there is less fretting on the part of both the cow and the calf. The best method, however, seems to be to allow the calf to be with the cow for at least a day or two.

Teaching the Calf to Drink Milk.—The longer the calf is nursed by the mother, the harder it is to teach it to drink. By instinct, the calf stretches upward to receive its nourishment. In learning to drink from a pail, however, it must be taught to reach downward. No better method of teaching the calf to drink is known than the simple one of putting one's fingers in its mouth, with one motion bringing head and fingers into a pail containing a small amount of whole milk, and then carefully withdrawing the fingers. It will probably be necessary to crowd the calf into a corner, and to stand astride of its neck, in order to teach it to feed in this way. Some calves will learn to drink after the first attempt; with others it is quite a long process. It is usually best to omit the first feeding period as the calf will then be more eager for its milk. It is desirable to use fresh whole milk for this purpose, especially if the calf is young. For the first ten days whole milk is best for the calf.

Amount of Whole Milk to Feed.—A calf that weighs 65 pounds or less should receive from 5 to 8 pounds of whole milk per day at first, while a calf weighing over 65 pounds should not receive more than 8 to 10 pounds. If possible, this amount of milk should be divided into three feeds for the first week. During the second week the amount can be increased slightly, if the calf remains healthy. After about ten days or two weeks, the food of the calf may be changed to skimmilk or some other milk substitute if the owner so desires.

Utensils.—Under any system of feeding, it is essential that all the utensils which are used in the feeding of the calf be kept clean. Pails should be of metal with well-soldered seams, so that milk will not lodge, thereby furnishing food upon which bacteria may thrive. The pails or mangers in which the grain and silage are fed must also be kept perfectly clean. The pails in which the milk is fed should be washed and, if possible, sterilized after each feeding. Many of the disorders of the digestive system of calves can be traced to dirty utensils. Wooden utensils are very difficult to keep clean. Too much care cannot be taken in order to have clean pails.

Methods of Raising Calves

Usually, whole milk is too expensive to feed to calves after they are ten days or two weeks old. In many sections of the country where cream or butter is sold, plenty of skimmilk is available for calf raising. Farmers thus situated are fortunate, and do not have a very serious problem in raising their calves. In other sections, where whole milk is sold from the farm and hence very little skimmilk is available, the raising of calves is somewhat of a problem. Several different methods of calf feeding have been devised for use on such farms. These consist of raising calves on some milk substitute, or of giving them a good start on whole milk or skimmilk and then raising them on grain and hay. Sometimes whey or buttermilk is available and is fed to calves.

Raising Calves on Farms Where Skimmilk, Buttermilk, or Whey is Available

The following table shows the average composition of whole milk, colostrum milk, skimmilk, buttermilk, and whey:

TABLE XLIV

Average Composition of Whole Milk, Colostrum Milk, Skimmilk, Buttermilk, and Whey [2]

	Water Per Cent	Ash Per Cent	Fat Per Cent	Protein Per Cent	Sugar or Carbohydrates Per Cent
Whole milk	87.0	0.7	4.0	3.3	5.0
Colostrum milk	74.5	1.6	3.6	17.6	2.7
Skimmilk	90.5	0.7	0.3	3.4	5.1
Buttermilk	91.0	0.8	0.5	3.5	4.2
Whey	93.4	0.7	0.3	0.8	4.8

As noted above, about the only difference between skimmilk and whole milk is that the fat has been removed from the former. Substitutions can easily be made for the fat, and just as good calves can be raised by the use of skimmilk as by the use of whole milk or by allowing the calf to run with the dam. The calves may not be as fat and thrifty looking, but they will grow into just as large and productive cows.

Calves that are to be raised on skimmilk should be fed on whole milk for the first ten days or two weeks, and, in case the calf is not thrifty, even longer. The change should not be made until the calf is growing vigorously. The transition period from whole to skimmilk should require about a week. For the first day or two, about a pound of skimmilk should be substituted for an equal amount of the whole milk, and later a gradually increasing amount up to 2 pounds. If whole milk is very valuable and the calves very thrifty, the change can be made in four or five days if attention is given to details.

After the change has been made, the amount of skimmilk should be gradually increased as the appetite of the calf indicates, until 16 to 18 pounds is being fed. With large thrifty calves, as much as 20 to 24 pounds of skimmilk may be fed, but unless skimmilk is very plentiful this is not necessary. Usually 16 to 20 pounds is the maximum amount which is fed. Probably more calves die from the effects of overfeeding than from any other single cause. This is due to the fact that most feeders, instead of weighing or measuring the amount to be fed, guess at it, and as a result there is a great variation in the amount which the calf receives from day to day. As a consequence, the calf is often overfed. It is a good rule always to keep the calf a little hungry.

Temperature and Quality of Milk.—The temperature of the milk is also a very important consideration, especially for young calves. The skimmilk should be heated to about the temperature of milk fresh from the cow, approximately 100° F. It is always well to use a thermometer to test the temperature. Judging by means of the finger is not sufficiently accurate to be relied upon. When the calf is two or three months old, it is not so necessary to heat the milk although even then calves can be raised with less trouble if the milk is heated. Giving the calf warm milk at one feeding and cold milk at the next is very likely to upset its digestion.

It is always best to feed the skimmilk when it is fresh. There is no easier way to upset the digestive system than to feed sweet milk at one feeding and sour milk at the next. Sour milk can be fed successfully to calves if care is taken to see that it is always uniform in quality.

If the skimmilk is obtained at the creamery, it is very necessary that it be pasteurized before being fed to calves. Otherwise the milk may carry disease germs which might infect the herd. Most states have laws requiring such milk to be pasteurized.

The skimmilk may well be fed for the first six months, and, if the supply warrants, it may be fed for an even longer period.

Grain and Roughage with Skimmilk.—Since the fat has been removed from the skimmilk, it is necessary that some grain, or grain and hay, be fed as soon as the change is made. Usually when a calf

FIG. 32.—A group of healthy Ayrshire calves on Auchenbrain farm in Ayr (*Anthony*).

is about ten days old it will begin to nibble hay and grain when these are offered to it. The amount first eaten is, of course, small, but should be increased as the calf grows older.

The hay should be bright and clean. Care should be taken at this time to prevent the calf from eating anything that is moldy or coarse. The hay may be either fine-grade timothy, clover, or alfalfa. Well-cured clover hay is to be preferred, since alfalfa is often slightly too laxative. The quality of the hay is an important consideration, especially during the first six months of the calf's life. The calf should be allowed to eat as much hay as it will. By the time it is six months old it should be eating 3 to 4 pounds daily. There seems to be no benefit from feeding silage to calves before they are two months of age. After that age they may be fed silage in limited amounts. A calf at six months of age will eat from 3 to 5 pounds of silage per day.

It has been calculated that it requires the following amount of feed to raise a calf to six months of age:

	Pounds
Whole milk	90 to 200
Skimmilk	2300 to 3000
Grain	150
Hay	500

Many grain mixtures have been proposed for dairy calves, although the kind of grain fed is not very important. It has been found that almost any combination of grains may be fed successfully. The principal thing necessary is to supply the nutrients which have been removed in the fat of the skimmilk. The ration need not contain a high-protein feed if a legume hay is fed, since the protein of the milk has not been removed.

In the sections where corn is plentiful, it may be used as the basis of the ration. It is desirable, however, when timothy hay is used for a roughage, to have some linseed meal in the ration. The following grain mixtures have been used with good results:

Mixture No. 1

3 parts corn meal
3 parts ground oats
1 part linseed meal
1 part wheat bran

Mixture No 2

2 parts wheat bran
2 parts ground oats
1 part oil meal

Mixture No. 3

3 parts corn meal
1 part wheat bran

While it is customary to grind the grain for calves, it is not absolutely necessary. They seem to prefer the whole grains. Until the calf is six months old, it need not be fed more than 3 pounds of grain daily.

The following feeding schedule has been arranged as a guide for the feeding of calves raised on skimmilk:

TABLE XLV

DAILY FEEDING SCHEDULE FOR SKIMMILK-FED CALVES

For Jerseys, Guernseys, or Ayrshires

Age of Calf	Whole Milk, Lbs.	Skim Milk, Lbs.	Grain, Lbs.	Hay Lbs.
1 to 3 days	with dam			
3 to 14 days	8 to 10			
2 to 3 weeks	10 to 1	1 to 10	1/8	all will eat
3 to 4 weeks	....	10	1/4	
4 to 5 weeks	....	11	1/2	
5 to 6 weeks	....	12	3/4	
6 to 8 weeks	....	13	1	
8 to 12 weeks	....	14	2	
12 to 24 weeks	....	16	3	

For Holstein, Brown Swiss, or Shorthorn

Age of Calf	Whole Milk, Lbs.	Skim Milk, Lbs.	Grain, Lbs.	Hay Lbs.
1 to 3 days	with dam			
3 to 14 days	10 to 12			
2 to 3 weeks	12 to 1	1 to 12	1/8	all will eat
3 to 4 weeks	....	12	1/4	
4 to 5 weeks	....	14	1/2	
5 to 6 weeks	....	15	3/4	
6 to 8 weeks	....	15	1	
8 to 12 weeks	....	16	2	
12 to 24 weeks	....	16 to 20	3	

Whey and Buttermilk for Calves.—The analysis of buttermilk, as shown in Table XLIV, is very similar to that of skimmilk, and so the same supplements that are used with skimmilk can be successfully used in raising buttermilk calves. On most farms, however, where buttermilk can be secured skimmilk is also available, and as a rule it will be found that sweet skimmilk grows a better and thriftier calf than does buttermilk. Some experiments, however, show that calves fed buttermilk are less subject to scours than are those fed skimmilk

Whey has a higher percentage of water and a much lower amount of protein, but about the same amount of fat and sugar as has skimmilk. If whey is to be fed the grain mixture must have a high protein content. Linseed meal is often mixed as a gruel in the whey. If whey must be fed, it should not be fed until the calf is five or six weeks old. After that age good calves can be raised on whey if it is properly supplemented and the calves are given good care.

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LECTURE XVIII

RAISING THE DAIRY CALF (*Continued*)

RAISING CALVES ON FARMS WHERE SKIMMILK IS NOT AVAILABLE

Feeding Milk Substitutes.—For many years, in England particularly, calves have been raised on milk substitutes, because there has been such a demand for the whole milk. Such a demand has also arisen around our cities where whole milk is sold. At first calves were not raised in these localities, but later a demand for a milk substitute brought upon the market several commercial calf meals, some of which have given fairly good results. Several home-made mixtures have also been recommended and have proven fairly satisfactory. Greater care must be used in feeding calves on these substitutes than in feeding them on skimmilk alone.

One of the first experiments in the use of milk substitutes for calf raising ever carried on in the United States was conducted by Hayward of the Pennsylvania Station.[1] He based his formulas upon one recommended by one of the agricultural colleges of England, which was as follows:

	Pounds
Flour	16⅔
Flaxseed meal	33⅓
Linseed meal	50

The mixture with which Hayward got the best results was as follows:

	Pounds
Wheat flour	30
Cocoanut meal	35
Nutrium	20
Linseed meal	10
Dried blood	2

The nutrium was similar to skimmilk powder. One pound of the foregoing mixture was added to 6 pounds of hot water, and after stir-ring for six minutes it was allowed to cool to 100° F., when it was fed either out of a pail or from a calf feeder. It was found that more care was required to produce calves on this mixture than on skimmilk, but the gains were satisfactory.

In an experiment at the Cornell Station[2] three commercial calf mixtures were fed to calves. While the calves raised on the commercial mixtures did not make as good gains for the first six months as those fed skimmilk, they later developed into just as large and thrifty cows as the ones fed on skimmilk. Linsey, of the Massachusetts Experiment Station,[3] has also published results with various commercial calf mixtures and with several home-made ones. He found that some proprietary meals gave satisfactory results as partial milk substitutes while others were not satisfactory. Two of his home-made mixtures gave very good results. They were composed as follows:

LINSEY'S CALF MEAL NO. V

22 lbs. ground oats flakes
10 lbs. flaxseed meal
5 lbs. flour middlings
11 lbs. fine corn meal
1½ lbs. prepared blood flour
½ lb. salt

LINSEY'S CALF MEAL NO. VI

35 lbs. ground oats flakes
12½ lbs. barley malt
1½ lbs. blood flour
½ lb. bicarbonate of potash
½ lb. salt

The trouble with most of the home-made mixtures is that so many of the ingredients are high in price and, moreover, cannot be readily obtained by all dairymen. However, the Purdue Experiment Station[4] recommends a ration which is both cheap and easy to obtain. It is as follows:

PURDUE CALF MIXTURE

Hominy feed
Linseed meal
Red Dog flour
Dried blood
} Equal parts by weight

This mixture was fed to ten calves, which were compared with ten calves fed on skimmilk and with ten others fed on Blatchford's calf meal. Two of the calves fed on the Blatchford's calf meal died during the experiment, one from chronic indigestion and malnutrition, and the other from malnutrition. The following table shows the averages of the calves in the three groups used in the experiment:

TABLE XLVI

RESULTS OF FEEDING CALF MEALS

	Birth Weight, Lbs.	Final Week, Lbs.	Total Gain, Lbs.	Daily Gain, Lbs.	Cost per Pound Gain
Skimmilk group	61.7	282.8	221.1	1.21	5.7
Home-mixed calf meal group	69.6	244.1	174.5	0.95	7.4
Blatchford's calf meal group	68.2	200.2	133.4	0.73	13.18

The Purdue calf meal has been used extensively and has given good satisfaction.

Preparing to Feed.—The Missouri Experiment Station[5] has given the following directions for preparing calf meal for feeding: As a general rule, one pound (dry weight) of a calf meal is a fair substitute for 4½ quarts or about 9 to 10 pounds of skimmilk. The meal should be made into a gruel or a thick paste by adding a very small quantity of cold water. All lumps should then be stirred out. After this is done boiling water should be added at the rate of 4½ quarts for every pound of meal used. It is a good plan to heat this mixture to 145° F. for thirty minutes and then cool to about 95° F. This gruel can be substituted for skimmilk, pound for pound.

Schedule for Feeding Calf Meals.—The feeding schedule, Table XLVII, may be used as a guide for the feeding of calves on calf meal.

Gruel feeding may be continued after the fourth month if desirable, but a calf can be grown very satisfactorily on grain and hay after reaching that age.

As a rule, the calves will not be as fat and thrifty looking when fed on calf meals as when fed on milk, nor will they be as growthy; but if they are fed carefully after being taken off the calf meal they will make just as large and thrifty cows. However, a calf meal to be successful must be made up of ingredients which are easily digested, which contain the necessary vitamins and minerals, and which are fairly cheap and easily obtainable.

TABLE XLVII

DAILY FEEDING SCHEDULE FOR CALVES FED CALF MEAL

Age	Pounds Milk, Daily	Pounds Gruel, Daily	Pounds Grain, Daily	Pounds Hay, Daily
1 to 3 days	with dam			
3 to 14 days	10			
2 to 3 weeks	9	1	$\frac{1}{8}$	all will eat
3 weeks to 1 month	9	3	$\frac{1}{4}$	
1 month to $1\frac{1}{2}$ months	6	6	$\frac{1}{2}$	
$1\frac{1}{2}$ months to 2 months	......	12	$\frac{3}{4}$	
2 to 3 months	......	14	1	
3 to 4 months	......	14	2	
4 to 5 months	......	......	4	
5 to 6 months	......	......	$4\frac{1}{2}$	

Feeding a Minimum Amount of Milk with Grain and Hay.—A method of raising calves which has been tried at several of the experiment stations with good results is to give them a good start on either whole milk alone or whole milk and skimmilk, and at the end of about two months have them changed to grain and hay. The object of this method is to use a minimum amount of milk and at the same time grow good healthy calves. This method also has the advantage that the grain ration need include only the common feeds which are available to all farmers and the ration can be prepared easily and fed dry. The secret of success with this method is to give the calves a good start before they are weaned from the milk.

Method of Feeding.—At the Missouri Station[5] it was planned to get the calves on a good ration of skimmilk, with some hay and grain, as soon as possible. They were fed whole milk for the first two weeks, and then, if skimmilk was available, it was substituted gradually. If skimmilk was not available the whole milk was continued. The calves were fed from 12 to 15 pounds of milk daily, depending upon their size and condition.

The calves should be taught as soon as possible to eat grain and hay, which should be fed liberally. At the Minnesota Station[6] the grain fed during the first few weeks was either cracked corn or crushed oats or a mixture of the two. Later, a mixture of 4 parts corn meal, 1 part wheat bran, and 1 part linseed meal was used. The hay should be a good clover or alfalfa.

At the Minnesota Station[7] five groups of calves were raised by feeding either whole milk alone or whole milk and skimmilk for periods ranging from fifty to seventy-two days and then feeding only hay and grain. The following table shows the average weight of the groups as compared with normal weight, at the end of the milk-feeding period and at the end of 180 days:

TABLE XLVIII

RECORD OF GROWTH OF CALVES FED MINIMUM AMOUNT OF MILK

Group	Number of Calves	How Fed	Length of Time Fed Milk, Days	Weight at End of Feeding, Per Cent Normal	Weight at End of 180 Days, Per Cent Normal
1	4	whole milk; grain and hay	72	100.2	94.5
2	3	grain and hay	50	98.7	91.3
3	2	grain and hay	72	89.0	85.0
4	6	whole milk; skim milk; grain and hay	70	107.0	92.3
5	3	grain and hay	60	102.0	90.3

Ordinarily, a calf can be raised by this method with as little as 200 pounds of whole milk and 600 pounds of skimmilk. The amount consumed at the Minnesota Station is given in the following table:

TABLE XLIX

AVERAGE FEED CONSUMED AT 180 DAYS OF AGE

Group	Breed	Age of Weaning, Days	Whole Milk, Lbs.	Skim Milk, Lbs.	Grain, Lbs.	Hay, Lbs.
1	Grade Holstein	72	864	....	555	263
2	Grade Holstein	50	442	....	528	279
3	Pure-bred Jersey	72	572	....	397	309
4	Grade Guernsey	70	449	88	412	295
5	Grade Holstein	60	166	378	476	385

This method offers to the dairyman with a small amount of available milk a cheap, efficient, and easy way to raise his dairy calves.

Dry Skimmilk, Dry aud Semi-solid Buttermilk.—Sometimes it is almost impossible, or at least very inconvenient, for the dairyman selling his milk to provide even a small amount of skimmilk for calf feeding. In such cases it has been found that skimmilk powder, buttermilk powder, or semi-solid buttermilk can be used satisfactorily in the place of skimmilk. Dried skimmilk is perhaps the most satisfactory. When being prepared for use, it should first be made into a thick paste with water and stirred until all the lumps are eliminated. It can then be mixed with warm water, in the proportion of 1 part of the powder to 9 parts of water, and fed in the same way and in the same amounts as ordinary skimmilk. In fact, it can be fed alternately with ordinary skimmilk without in any way affecting the digestive system of the calf. This is an advantage to the dairyman who may have a surplus of milk at one time and a shortage at other times, since he can keep some dried skimmilk for periods of shortage.

Powdered buttermilk can be used in the same way, but greater care must be used in starting the calves on it, on account of its acidity. Semi-solid buttermilk can also be used, but it is not as satisfactory as the dried, especially in the summer, since it will not keep as well. It should be mixed with about three times its weight of warm water.

These products are usually higher in price than skimmilk but not as high as whole milk.

Other Details in Calf Feeding

Feeders.—Hooper[8] found that calves fed through the nipple were more thrifty than those fed in the bucket, up to the age of seventy days. After this age there was very little difference. Hayward seems to favor the use of the calf feeder in feeding milk substitutes. In general however, it should be stated that calf feeders are difficult to keep clean and are often out of repair. There seems to be very little real use for them.

Salt and Water.—Most feeders add some salt to the grain ration. The demand for salt, however, is not great up to the time the calves reach the age of six months. Calves should be given water daily in addition to their milk. The best way to give the water is by means of watering cups, where the calves can supply themselves according to their desires. Many digestive disorders are said to be due to failure to provide water.

Stalls and Ties for Calves.—When the new-born calf is removed from the mother it should first be put in a small box stall by itself. This stall should not be more than 4 or 5 ft. square. Thus isolated, the calf can be taught to drink and kept from sucking other calves. Some dairymen prefer to keep their calves in such stalls permanently as a protection against disease. It is more usual, however, after the

Fig. 33.—Clean, well-bedded pens are essential in calf raising.

first week or ten days, to keep several calves together in a larger box stall. This stall should be provided with stanchions so that the calves can be tied while being fed, to insure each one's getting its proper amount of feed. Each calf should be fed individually, as some are fast feeders and others are slow. The feeding of all calves in a trough should never be practiced.

Keeping Pens Clean.—Calves should always have clean pens. A great deal of liquid is excreted by a calf, and hence care should be taken concerning the bedding. Any kind of clean bedding may be used if it is provided in sufficient amounts. Care should always be taken that the corners of the pens are thoroughly cleaned out.

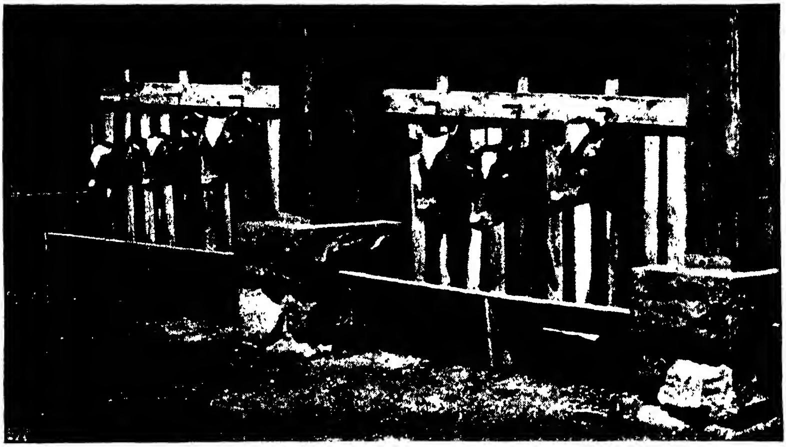

FIG. 34.—Calves should be fastened when being fed.

It is also advisable to give the pens a thorough cleaning and disinfecting every few weeks. Whitewash is one of the best disinfectants. It can be applied either with a spray pump or with a whitewash brush. Another disinfectant is a 5 per cent solution of crude carbolic acid.

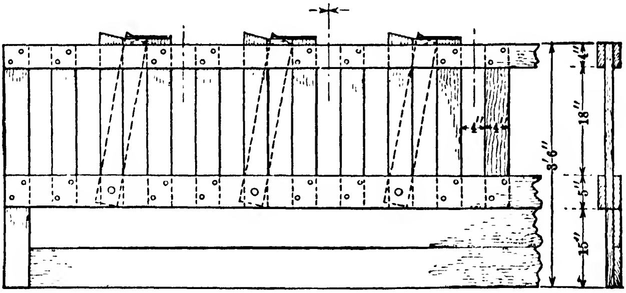

FIG. 35.—Plans for wooden stanchions for calves.

Creolin or lysol can be used in from 3 to 5 per cent solutions and are also satisfactory disinfectants.

Exercise.—Calf pens should be provided with exercise yards. Although the young calf does not require a large amount of exercise, still it should have a place of sufficient size for that purpose. The yard should be provided with shade in the summer time. A well-shaded pasture, near the buildings, in which the calves can graze and also exercise, is valuable. Stanchions can be erected in the pasture and the calves fed there.

Fall or Spring Calves.—The fall calf is fed milk, or whatever is used instead, until spring, and then is turned out to pasture. The spring calf is changed from milk to dry feed during the first winter of its life and does not make quite as good or as cheap gains as the fall calf. After the fall calf goes on dry feed it has only one winter feeding to go through before freshening, while the spring calf has two. As a general rule, it is cheaper to keep the calf on pasture as much as possible, and for this reason the expense of raising the spring calf is greater. Many dairy farmers, however, must have cows freshen the year around and so, of course, must raise spring calves as well as fall calves.

Veal Production.—The breeder of pure-bred stock is generally able to find a market for his surplus animals, but the man who keeps grades must dispose of his surplus calves. Many are sold at birth, but in some states it is against the law to kill calves for veal under a certain age. The meat from a calf killed for veal at a very early age is known as "bob veal." A calf that is over the age for good veal and has not received milk for some time is known as a "heretic."

If milk is not worth too much, calves may be raised for veal. In general, where whole-milk feeding is practiced in raising veal, 10 pounds of whole milk is required to produce 1 pound of veal. The market seems to demand veal from four to eight weeks old and from 150 to 175 pounds in weight. Whether it will pay to raise veal, then, depends not only upon the cost of milk and the price of veal but also upon the initial size of the calf. For example, a calf that weighed 100 pounds at birth would need to gain only 50 pounds to reach the desired 150 pounds. This would require around 500 pounds of milk. A calf weighing 60 pounds at birth would need to gain 90 pounds to reach the weight of 150 pounds, and the amount of milk required would be 900 pounds. Thus the latter calf would require almost twice the amount of milk as the first calf to reach the required size.

The following table shows the results of some veal experiments conducted at the Pennsylvania Experiment Station:[9]

TABLE L

Results of the Veal Production Experiment

Ration	Number of Calves	Average Number of Days Fed	Average Weight at Beginning	Average Weight at End	Average Gain Daily	Average Profit above Feed
Whole milk, dark stall	3	49	104	212	2.20	$4.10
Whole milk, nurse cow	3	59	75	179	1.69	0.26
Whole milk, ordinary stall	2	67	65	129	0.88	−4.10
Blatchford's calf meal	3	60	88	147	0.96	3.79
Schumaker's calf meal	3	58	86	151	1.24	1.16
Skimmilk and grain	2	65	63	137	0.96	2.91

The following table, prepared by Bechdel, shows the average returns at the different prices of milk and veal:

TABLE LI

Average Return at Various Prices of Milk and Veal

Milk per Cwt.	Price of Veal per 1 Pound Live Weight								
	$0.24	$0.20	$0.18	$0.16	$0.14	$0.12	$0.11	$0.09	$0.08
$1.40	....	....	$19.94	$16.34	$12.47	$9.13	$7.33	$3.27	$1.93
1.60	....	....	18.16	14.56	10.95	7.35	5.56	1.94	0.14
1.80	....	....	16.38	12.77	9.17	5.56	3.76	0.16	−1.65
2.00	....	....	14.59	10.99	7.34	3.33	1.98	−1.63	−3.43
2.20	....	$16.41	12.81	9.20	5.60	2.09	0.19	−3.41	−5.21
2.40	....	14.63	11.02	7.42	3.81	0.21	−1.59	−5.20	−6.99
2.60	$20.05	12.84	9.15	5.64	2.03	−1.51	−3.37	−6.99	−8.78
2.80	18.26	11.06	7.45	3.85	0.25	−3.36			
3.00	16.48	9.28	5.68	2.08	−1.53				
3.40	12.92	5.72	2.11	−1.49					

When the cost of milk is low and the price of veal is high, there may be considerable profit in raising calves for veal.

Requirements for Calves.—Armsby[10] has estimated the requirements of digestible true protein and energy, per day and head of calves, to be as follows:

TABLE LII

For Growing Cattle of Dairy Breeds

Age, Months	Live Weight, Pounds	Digestible True Proteins, Lbs.	Net Energy, Therms
3	165	0.65	3.6
6	275	0.85	4.1

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LECTURE XIX

CARE AND DEVELOPMENT OF THE DAIRY HEIFER

Growth.—Growth is one of the oldest of phenomena, yet we have hardly begun to understand the principles underlying it. Growth[1] has been defined as the increase in volume in a living material.

It is the result of three processes, namely, multiplication of cells, enlargement of cells, and deposition of intercellular substance, the first two being more potent than the third. Minot[2] states that the impulse to grow is imparted at the time of fertilization of the ovum and that the growth of the germ of the animal, from the time of fertilization to that of birth, represents an increase of over 5,000,000 per cent, the gain at first being 1000 per cent in a day. He calculated that 98 per cent of the growth impulse is used up at the time of birth.

Causes of Growth.—Just as there are two factors related to milk production, so there are two factors related to growth, one internal and the other external. It has been observed that animals will often continue to grow even under adverse conditions of nutrition. The impulse to grow, which is set free at the fertilization of the ovum, will continue until the full size has been reached unless adverse conditions are encountered. The cause of this growth stimulus is thought to be the hormones or secretions of the ductless glands. The ductless glands which are thought to be related to growth are the pituitary body, the thyroid gland, the thymus gland, the suprarenal body, the pineal body, and the ovaries and testes. The internal factors are not under the control of the feeder to any great extent and they will continue to act even under adverse conditions. They seem to influence the growth of the skeleton to a greater extent than they do that of the fleshy part of the body. The skeleton has a stronger tendency to grow than does the fleshy part. Waters[3] found that animals that were fed even less than a maintenance ration continued to make skeleton growth for six months while the fleshy part did not gain to any extent.

The external factors depend upon the nutrition and handling of the animal; that is, they are dependent upon conditions under the herdsman's control.

Limits of Growth.—It is thought[4] that the variation in the growth of different animals is largely inherited. In other words, an animal inherits the capacity to reach a certain size if given favorable conditions, and it will not grow any larger even under the most favorable conditions as to care and feed. However, if the conditions are adverse, the animal may never reach this maximum size. Animals are able to overcome adverse conditions, however, if not continued for too long a time and not too severe. It has been shown[5] that, after a period of retarded growth, calves will grow at a faster rate than normal when the conditions are again improved, and will continue to grow for a longer period of time. This will compensate for the loss due to retarded growth unless the retardation is continued for too long a time.

Measuring Growth.—Since the fleshy part of the animal does not gain at the same rate as does the skeleton, it can be seen that growth cannot be measured by the weight alone. Eckles[6] decided, after a study of several measurements, that the height at the withers would be the easiest and most satisfactory measure of the growth of the skeleton. There are thus two units commonly used for measuring growth, gain in live weight and gain in height at the withers.

Normal Growth.—In order to obtain information on the weight and height at withers of heifers fed according to good dairy practice, Eckles weighed and measured the calves and heifers in the herd at the Missouri Station, and, from the data collected, formulated a normal growth table for the Holstein, Jersey, Ayrshire, and Dairy Shorthorn breeds. This is given in Table LIII.

This table can be used by breeders to determine if their calves or heifers are growing normally. If scales are at hand the calves or heifers can be weighed at intervals, and their height at withers can easily be determined.

Table LIII also shows that there is a distinct difference between the different breeds as to the time that their skeleton growth is complete. The Jersey has practically its full skeleton growth at the age of four years, while the Holstein continues to grow in skeleton until it is almost five years of age. The other breeds mature at ages between these two extremes. The growth in the fleshy part, as denoted by weight, does not reach its maximum until about two years after the skeleton has ceased to grow.

TABLE LIII

NORMAL GROWTH IN WEIGHT AND HEIGHT OF DAIRY HEIFERS

Age, Month	Ayrshire		Holstein		Jersey		Dairy Shorthorn	
	Weight, Lbs.	Height at Withers, Inches	Weight, Lbs.	Height at Withers, Inches	Weight, Lbs.	Height at Withers, Inches	Weight, Lbs.	Height at Withers, Inches
Birth	69	....	90	....	55	....	73	
1	90	27.5	121	30.2	76	27.7	118	31.1
2	128	29.5	157	32.3	105	29.4	133	32.1
3	170	31.2	200	34.2	140	31.2	174	33.9
4	218	33.1	249	36.2	174	32.9	225	35.8
5	254	35.1	302	38.0	222	35.1	268	33.0
6	286	36.4	349	39.7	260	36.9	316	38.5
7	304	37.3	389	40.9	302	38.1	348	40.0
8	336	38.5	425	42.2	340	39.3	419	41.1
9	366	39.0	466	42.9	376	40.5	461	41.9
10	406	39.6	501	43.8	407	41.3	538	43.3
11	427	40.1	529	44.3	432	41.9	576	43.8
12	456	40.7	558	44.8	456	42.6	547	44.4
13	485	41.3	574	45.6	480	43.3	564	45.1
14	533	42.0	596	46.2	503	43.8	579	45.4
15	547	42.4	612	46.8	520	44.4	617	45.9
16	560	42.7	643	47.4	533	44.6	627	47.0
17	579	43.1	660	47.7	553	45.1	642	47.2
18	604	43.7	686	47.9	572	45.5	668	47.7
19	627	44.2	715	48.3	598	46.0	695	48.2
20	651	44.6	746	48.7	621	46.3	728	48.5
21	679	44.9	774	48.9	649	46.5	745	48.8
22	707	45.4	796	49.2	668	46.8	741	49.1
23	733	45.6	824	49.5	689	47.2	821	49.5
24	759	45.9	841	49.8	716	47.4	845	49.8
25	798	46.6	869	50.2	737	....	845	50.2
26	807	46.7	893	50.5	758	....	877	50.4
27	859	46.8	925	50.9	770	48.0	885	50.6
28	....	46.9	966	51.1	784	....	922	50.7
29	....	47.0	994	51.3	804	....	928	50.7
30	....	47.2	1021	51.5	....	48.3	998	51.3
33	....	47.7	....	52.0	....	48.5	....	51.7
36	....	47.9	....	52.3	....	48.8	....	52.0
42	....	48.3	....	52.6	....	49.0	....	53.0
48	....	48.5	....	53.1	....	49.4	....	53.5
54	....	49.0	....	53.3	....	49.3	....	53.7
60	....	49.0	....	53.6	....	....	....	54.0
72	....	....	....	54.0	....	....	....	....

Feeding the Dairy Heifer

There is not complete unity of opinion as to the best manner in which to feed dairy heifers. After the heifer is past the danger stage that is always present with young calves, and before she has reached a productive stage, the tendency has been to rough her through with as little care and feed as possible. Before taking up the method of feeding, it is necessary to understand the effects of nutrition during this period upon the growth of the dairy heifer; upon her dairy type, upon her sexual maturity, and upon the other factors that may affect her future usefulness.

Effect of Ration upon Growth and Size of Animal.—The most extensive study that has been made upon the development of heifers was carried on at the Missouri Experiment Station.[7] This study covered a period of eight years and entailed forty animals. The heifers were divided into two main groups. One group was fed skimmilk for the first six months, and all the grain and hay they would consume from birth until the time of first calving; while the other group was fed skimmilk for the first six months, and then only pasture or hay until the time of first calving. Weights and measurements were taken monthly. Half of each group were bred early, while the other half were bred late, so that data in regard to breeding could be obtained.

During the growing period the heavy ration caused a much more rapid growth, both in skeleton and in flesh, especially during the months of rapid development. Later, the heifers fed the heavy ration became much fatter. Those fed the light ration grew less rapidly but continued to grow for a longer period of time, never, however, reaching the size of the heavily fed group. The weights always showed a much greater difference than did the skeleton measurements.

Table LIV gives a comparison of the effect of rations upon skeleton growth and increase in weight in percentage of normal.

Effect of Rations Fed during the Winter on Summer Gains.—Heifers that have been fed heavily during the winter and are then turned out into a pasture in summer usually make much smaller gains during the summer than those that have been fed lightly. In experiments at the West Virginia Station[8] the tendency was for both the heavily and lightly fed groups to approach normal during the summer months. This would indicate that little is to be gained by too heavy feeding during the winter months if the heifers are to be pastured during the summer.

TABLE LIV

THE EFFECTS OF RATION UPON GROWTH AND WEIGHT OF HEIFERS IN PERCENTAGE OF NORMAL

	Jerseys		Holsteins	
	Light Fed	Heavy Fed	Light Fed	Heavy Fed
Months	Weight	Weight	Weight	Weight
6	95	99	85	120
12	80	104	73	118
18	83	128	84	130
24	84	109	88	119
	Height	Height	Height	Height
6	98	99	96	102
12	95	101	93	103
18	95	102	95	103
24	96	101	97	103

Effect of Ration on Dairy Type.—During the growing period, Eckles found that heavy rations tended toward the development of larger and somewhat coarser animals than lighter rations. When the heifers were placed on the same ration after freshening, however, the difference disappeared.

Effect of Ration on Dairy Qualities.—Eckles found some high-producing cows in each group, also some medium producers and some inferior producers. Heredity exerts a stronger influence upon the dairy cow's production than does the ration, but Eckles' data show that the heifers receiving the heavier ration were inferior as milkers to those receiving the light ration. He states, " It is not probable that within the limits ordinarily found under practical conditions this factor would exert sufficient influence to be worth consideration."

Effect of Ration upon Maturity.—Animals receiving a heavy ration mature sexually from two to three months earlier than those receiving a light ration. This may be an advantage in that they will come into milk somewhat earlier than the others.

Conclusions.—From the results noted above, we may conclude that heifers should be fed in such a way that they will make good gains, in order that they may obtain their full size. There seems to be no benefit, however, from feeding heifers too heavily. They should be so fed that they will reach their maximum growth as determined by their inheritance. The cows that have made the largest records for both milk and butter-fat have invariably been the large animals of the breed. It is true that the stimulation to produce milk may be inherited independently of size; nevertheless, an undersized cow is limited in her capacity to consume and digest feed and cannot compete with a larger cow even though she has inherited to an equal degree the stimulation to give milk. With these things in mind, the following feeding recommendations have been made.

Feeding the Heifer at Time of Weaning.—Too often dairymen make the mistake of weaning calves from milk and grain at the same

FIG. 36.—Calves on short pasture need grain and silage.

time and turning them out to pasture and allowing them to graze for themselves. A young heifer six months old will not graze enough on poor pasture to make the gains that she should make. For this reason it is recommended that calves be fed a little grain for the first month or two, or until they become accustomed to the change of feed. Spring calves should also be fed liberally at this time on both roughage and grain. After being weaned from milk, fall calves must be carried over two summers, one winter, and usually a part of the second winter, before they freshen. Pasture is by far the most economical means of feeding heifers, and when it is available it should be used to a large extent. After a heifer is eight or ten months of age she will make satisfactory gains on pasture alone, until a few months previous to the time she is due to freshen. The problem of feeding heifers is largely one of winter feeding.

Some Practical Winter Rations.—Eckles,[9] after a study ot a large number of heifers fed on different rations, made the following recommendations for winter rations:

1. " When silage and legume hay is on hand, or can be purchased economically, the ration suggested is as follows: corn silage and alfalfa, clover, cow-pea or soy-bean hay at will; and for animals less than ten months old 2 pounds of grain daily in addition. The grain fed may be corn, or a mixture of other grains, if the cost a pound is less. For heifers within three months of calving, 2 to 5 pounds of grain should be fed daily, depending upon conditions. The object is to have them in good flesh at calving time.

FIG. 37.—Heifers on good pasture make satisfactory growth.

2. " When corn silage is on hand but no legume hay, a satisfactory ration is silage at will for roughage, with some dry feed such as hay or fodder. Two or 3 pounds of concentrates should be fed daily, one-half of which should be a high-protein feed such as gluten feed, linseed meal, or cottonseed meal. The remaining half may be corn, oats, bran or any other mixture, if cheaper per pound than corn.

3. " When an abundance of legume hay but no silage is on hand a satisfactory ration is alfalfa, clover, cow-pea or soy-bean hay at will, and 2 pounds of corn daily. Other grains may be substituted with economy if the cost a pound is less than corn. On a ration of legume hay dairy heifers will do fairly well but will not make normal growth. It is believed to be economical, as a rule, to feed a limited amount of grain in addition.

4. "When corn fodder or kaffir fodder, or timothy hay is on hand but no silage or legume hay, it is generally best to purchase legume hay. The suggested ration is legume hay one-half, timothy hay one-half, and corn fodder at will. With this should be fed a grain mixture composed of 1 part of gluten feed, or cottonseed or linseed meal, and 2 parts corn. Other concentrates may be used in place of corn if the cost per pound is less.

"If legume hay cannot be purchased, more grain must be fed for even fair results. Under these conditions the ration suggested is: hay and fodder at will, with 5 pounds daily of a grain mixture composed of 1 part corn, 1 part bran, 1 part cottonseed meal, linseed meal, or gluten meal."

Eckles found in his experiments that neither alfalfa nor corn silage was satisfactory for growing heifers when fed alone, but that when they were fed together good results could be expected. The Virginia Experiment Station [10] found that corn silage could be used as the sole roughage, provided that suitable amounts of concentrates were added.

Heifers should be fed a good grain ration, beginning about three months before they are due to freshen, so that they will be in good condition at the time of freshening.

Age of Breeding

Effects of Early Breeding on Size of Animal.—The age at which heifers should be bred depends upon several factors. In his studies on the subject, Eckles[7] found that, while gestation in itself did not affect the rate of growth to any great extent, lactation had a decided influence upon it. Heifers during lactation did not grow nearly as fast as did unbred or pregnant heifers of the same age and breed. As a result, heifers that calved when twenty to twenty-four months of age did not average so large at maturity as those that calved at a later age. The most decided effect upon the size of the mature dairy cow is produced when the heifer is fed a light ration during the growing period and at the same time bred to calve early. This, no doubt, is one of the main reasons why numerous undersized cows are found in many herds.

Effect of Early Calving on Milk Production.—The following table shows the influence of age at first calving upon the milk production, as found at the University of Missouri:

TABLE LV

INFLUENCE OF AGE AT FIRST CALVING UPON MILK PRODUCTION

Jerseys

Age of Calving	Number of Heifers	First Lactation		Average Three Lactation Periods	
		Milk, Lbs.	Fat, Lbs.	Milk, Lbs.	Fat, Lbs.
Under 20 months......	5	2713	147	3,738	207
20 to 24 months......	13	4148	207	4,682	231
24 to 28 months......	20	4675	238	5,076	260
28 to 32 months......	13	5313	266	6,410	328
32 to 36 months......	12	4418	227	5,610	201
Over 36 months......	7	4780	251	5,247	273
Holsteins					
Under 24 months......	6	5506	187	6,873	225
24 to 30 months......	4	8619	266	10,084	307
30 to 36 months......	11	7478	238	8,456	266
Over 36 months......	4	8282	280	11,404	362

This table shows that Jerseys should not be bred to freshen before they reach the age of twenty-four months, and that twenty-six to

FIG. 38.—Large, thrifty heifers on pasture.

thirty months is perhaps the best age at which to have them freshen. After thirty to thirty-two months they seem to go down in production.

With Holsteins, the best production seems to have been obtained with the heifers that were well matured at the time of freshening.

Beam, in a study of the dairy herd at the Pennsylvania Station,[11] collected data on forty grade Guernsey cows that had milked over five lactation periods. From these data the following table was compiled to show the effect of age of calving upon later production:

TABLE LVI

EFFECT OF AGE OF CALVING ON FAT PRODUCTION

Age of Calving	Average Production of Fat, Lbs.
18 to 24 months	261
24 to 30 months	268
30 to 36 months	278
36 to 40 months	252

This study seems to indicate that later calving than is usually practiced gives higher production. In consideration of the extra cost and care, however, it may not be advantageous to keep the heifers to this age before breeding.

Effect of Early Calving on Type.—Eckles found that early calving tended toward a smaller and more refined type of cow than did late calving.

Conclusions.—From a consideration of the above, it would seem that the age of first calving should be given some consideration. Calving at too early an age is detrimental to the size and later production of an animal, while not much advantage is to be gained by having the heifers freshen at too late an age. Heifers that have been poorly fed or are small for any reason should not be bred as early as those that are well grown.

Heifers that are normal in size should be bred to freshen at the following ages:

	Months
Jerseys	24–27
Guernseys	26–29
Ayrshires	27–30
Holsteins	28–32

Housing the Heifer

Since the heifer is unproductive, she should be kept as cheaply as possible. The barn in which heifers are kept need not be expensive, but it should be dry and convenient. One of the best types of shelters for heifers is an open shed in which they can be protected from winds and rains. Many think that such quarters are healthier than closed barns. Such a shed can be cheaply and easily built.

It is often desirable to have stanchions or some means of tying the heifers while eating; otherwise the larger ones often consume more than their share, while some of the smaller ones go hungry and hence do not make normal growth.

Feeding Standards for Heifers.—The following table, taken from Armsby, gives the requirements of dairy heifers at various ages, for digestible true protein and net energy:

TABLE LVII

Feeding Standard for Heifers (Armsby)

Age, Months	Live Weight, Lbs.	Digestible True Protein, Lbs.	Net Energy Therms
9	325	0.90	4.4
12	400	1.00	5.1
18	550	1.10	6.4
24	700	1.20	7.6
30	800	1.20	8.2

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LECTURE XX

FEEDING AND CARE OF THE SIRE

LESS is known concerning the feeding and care of the herd sire than of the dairy cow or the calves and heifers. Probably the main reason for this is that usually there is only one bull on a farm, so that

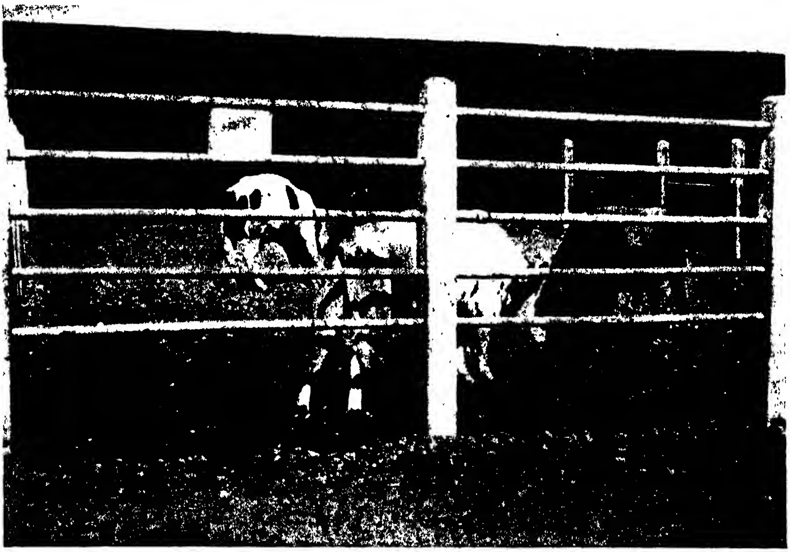

FIG. 39.—A cheap method of exercise for bulls.

there are very few of them to be cared for and fed as compared to cows and heifers. Furthermore, as they are not productive, there is not as good a means of knowing when they are being properly fed.

Feeding the Bull during the Growing Period.—Since the bull is going to be used at the head of a herd when he is mature, it is very necessary that he be given every possible chance to develop in size to the full extent of his inheritance. A stunted bull that never reaches its maximum size may be just as good a breeder as a well-grown one but there is no way to tell that the smallness is not due to inheritance, and the animal is looked upon with disfavor by those who do not know his history. For this reason the bull should be well fed from birth.

For the first six months of his life, the young bull should receive the same care and feed as a well-cared-for heifer. It is best to feed him on skimmilk, if this is at all possible, rather than to try to use substitutes. If skimmilk is not available, whole milk should be used for a longer time in order to give him a good start. Since he is to head the herd, the item of cost should not be considered as much as in the raising of a heifer. He should be fed in such a way that he will always be thrifty and growthy.

Skimmilk, when available, is often fed to the young bull for eight or ten months. This has been found to be a good practice, as skimmilk is one of the best feeds to provide ash for bone growth. Most bulls, however, are weaned from milk at six months of age. At this time they should be fed a good grain ration and practically all of the good legume hay that they desire. Almost any combination of grain will be satisfactory. A grain mixture which has been recommended for feeding at this time is as follows:[1]

5 parts wheat bran
4 parts ground oats
1 part linseed meal

Most feeders use the same grain mixture which is fed to the dairy heifers. The young bull should be fed from 4 to 8 pounds of grain daily, depending upon his size and the amount of service he is allowed. The amount of legume hay which a bull will consume depends upon his size; a mature bull will eat as much as 15 pounds daily.

There is a belief among feeders that silage fed to bulls reduces their potency. Although there are no experimental data to warrant this belief, many breeders feel that such impairment has occurred. Others, however, feed silage in large quantities and do not seem to get any undesirable results as far as breeding qualities are concerned. As high as 10 to 15 pounds of silage has been fed without any undesirable effects. Large amounts of silage or other bulky feeds may have a tendency to distend the paunch so that the bull may become too heavy on his feet. This belief does not seem to be held in regard to such other succulence as roots, green forage crops, and grass.

Feeding the Mature Bull.—A bull in service should not be fat but should be fed so that he is in good breeding condition. It is a common belief that a fat bull lacks stamina, and that he may even become impotent from too much fat. On the other hand, a bull should not be allowed to become too thin. If the conditions on a farm are such that breeding is limited to one season, the bull should be so fed that he is gaining in weight during this period. On most farms, however, it is necessary to have cows bred to freshen the year around, a fact which naturally causes the breeding to extend over a longer period of time. Bulls in such herds must be fed in much the same manner at all seasons of the year.

FIG. 40.—Bull exercising on wire cable.

Some dairymen feed the bull the same grain mixture that they feed the herd, on the assumption that to be in good breeding condition he should receive a reasonable amount of protein. A common grain ration for the mature bull after complete growth is as follows:

3 parts corn meal
3 parts ground oats
3 parts wheat bran
1 part linseed meal

This should be fed with legume hay. If non-legume hays are fed, it is necessary to have more protein in the grain mixture, especially during the heavy breeding season.

Teaching the Bull to Lead.—When the bull calf is five or six six months of age he should be separated from the heifer calves, because at that age he becomes sexually mature and may breed some of the young heifers if allowed to run with them. At that age, or even before, he should be taught to lead so that he may be more easily handled when older. It is best to lead him a little every day, but if this is not possible he should be led at least once a week.

Ringing the Bull.—When eight or ten months of age a bull should have a ring put in his nose. The ring at this time should be of light

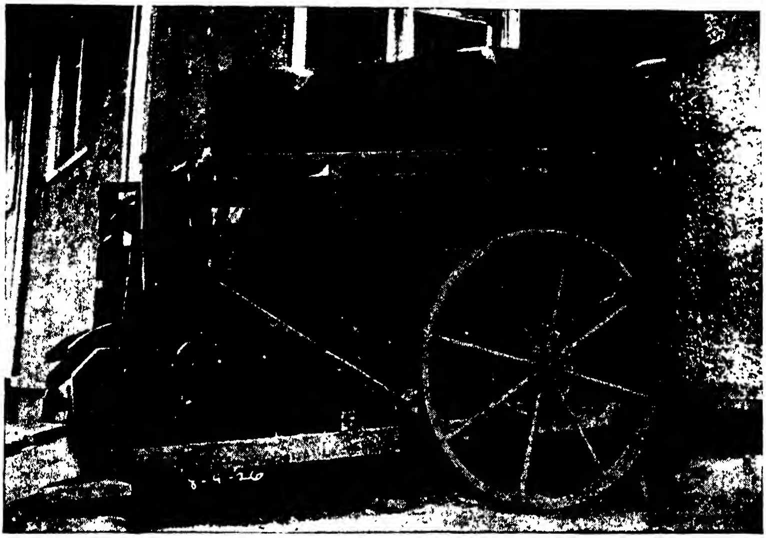

FIG. 41.—Bull being exercised in tread mill.

weight and about 1½ ins. in diameter. It should be of some non-rusting material, such as copper, brass, or cannon metal. When the bull is about eighteen months or two years old this ring should be replaced with a larger one, and when he is three or four years old this should be replaced with a 3-in. ring.

To ring the bull, it is advisable to have him well fastened in a stanchion or stocks. The opening through the cartilage may be made by the use of the trocar and cannula. The ring is then put in and fastened securely by means of a screw. Care should be taken to change the ring before it becomes too badly worn, because a weak ring often causes trouble.

Staffs.—After the bull has a ring in his nose he should be trained to lead with a staff. One should never take chances with a large bull because he may become vicious at any time. Many makes of staffs are on the market, some of which are fitted with special devices designed particularly to handle vicious bulls. The staff should always be used on all bulls, as it is usually the " gentle " bull that causes trouble. The owner of a vicious bull is generally prepared against him.

Dehorning.—If the bull is to be kept in a herd where showing at fairs is not practiced, it is advisable to prevent the growth of the horns by the use of caustic, as described previously. Many seem to prefer to allow the horns to grow until the bull is about two years of age, and then take them off. They think that the bull once having learned to use his horns, misses them and becomes much more tractable than he would be otherwise. Since bulls are always more or less dangerous, it is recommended that their horns be removed, except in herds of highly developed pure-breds. The dehorning of a mature bull is quite an undertaking unless one is equipped for it. The removing of the horns does not in any way affect the potency of the bull.

Service.—It is the general opinion among breeders that the young bull should not be allowed to serve an animal until he is at least ten months of age, and then only in case he is a vigorous, well-grown animal. The amount of service should be limited, until he is about eighteen months of age, to not more than two services a week As he grows older, however, he can be given more liberal service. Mature bulls may be used on as many as 200 cows per year, if they are evenly distributed throughout the year. However, on most farms the breeding cannot be evenly distributed; therefore, it is usual to keep one bull to each fifty or sixty cows. Young bulls should not be used too frequently as this may be responsible for a decline in their vigor and potency.

Bulls should not be allowed to run with the herd during the breeding season. One of the reasons for this is that a bull running in pasture is in contact with a cow in heat, causing dissipation on his part, a condition that brings on impotency much earlier than it would otherwise occur.

It is a custom in many sections of the country for a cow to receive two services from the bull. This is a needless waste of the energy of the bull. Nature is lavish in anticipation of reproduction, and one service properly conducted is sufficient to impregnate many animals.

Careful service will do much to preserve a bull's breeding qualities until old age. Usually a bull when he reaches the age of eight or ten years becomes slow when breeding and often becomes uncertain.

Exercise.—The importance of exercise for the dairy bull has not been fully realized in the past. Many dairymen who keep their bulls away from the herd retain them in a small paddock where they have little exercise from the time they are calves until they reach maturity. Such treatment will usually lead sooner or later to impotency of the bull. To avoid this, some form of exercise must be provided. Many dairymen keep their bulls in pens which open into a common paddock where they are turned for their exercise. The older bulls are first

FIG. 42.—An exercise, specially constructed for bulls.

dehorned, and the butting which they practice on one another gives them the needed exercise.

Others use the bulls in tread mills with which they separate their milk or pump their water and in this way give their bulls exercise. Still others arrange a long sweep to which the bulls are fastened. Usually one of the animals is driven and this forces the others around with him. Other systems have been used, but the main thing to keep in mind is that the bull should be given an ample amount of exercise. A bull kept in a paddock by himself, without being forced to take exercise, will not usually obtain sufficient to keep him in good shape.

Housing the Bull.—Too often the bull is kept in a dark, dirty stall and kept tied most of the time. Since the bull has so much influence on the success of the herd, he should be given comfortable quarters. Many dairymen keep the bull in a box stall in the same barn with the milking herd, but most of them seem to prefer to keep him in a separate barn away from all other dairy animals. The stall should be about 12 ft. square. It should open into a strongly fenced paddock into which the animals are turned daily. The stalls should be strongly built. Ordinary cow stalls will not be strong enough for most bulls. The pen should have a stanchion into which the bull can be tied during cleaning time.

The bull pens need not be tightly made. A good roof and a wall to keep the wind and rain off the animal is all that is necessary. A cer-

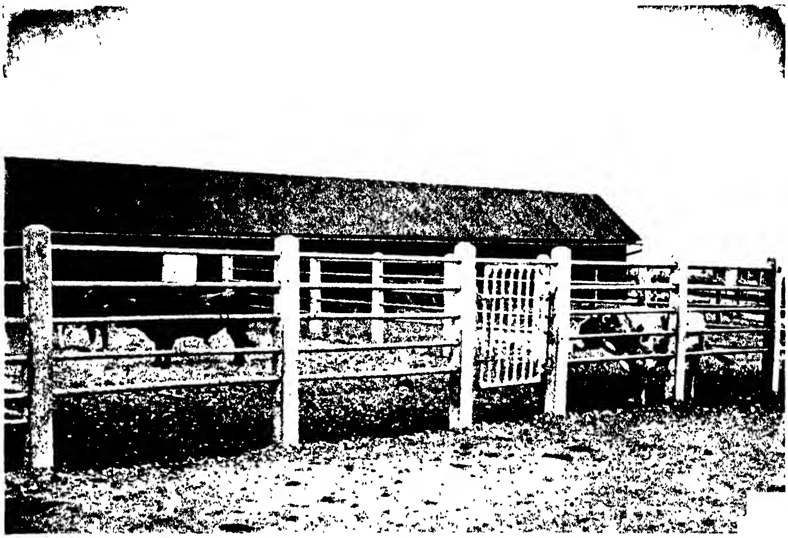

Fig. 43.—A safe and desirable bull fence.

tain amount of exposure will not harm the bull, provided he has a dry, well-bedded stall into which to go during cold, windy or rainy weather. Of course, if the bulls are to be kept looking their best at all times they should be kept in except on fine days.

Handling Vicious Bulls.—It often occurs that a valuable bull becomes vicious at the age of about five years, just about the time that his first daughters are in milk. Bulls should always be handled kindly and should never be teased. The attendant that handles the bull should never show any fear of the animal. He should handle the bull firmly and let him know that he is his master. A bull always seems to know when anyone is afraid of him and will make trouble for one who shows fear.

Great care should be taken to make the stalls and fences surrounding the paddock strong and reliable so that the bull will have no opportunity to realize his own power.

He should always be led with a staff, and in case he is very vicious two men should be used to lead him, one on each side. Each person may use a staff attached to a separate ring in the nose, or one may lead him with a strong staff while the other uses a rope or strap fastened into the second ring. Often vicious bulls are kept in such a way that they need be handled but very little. A breeding pen can be

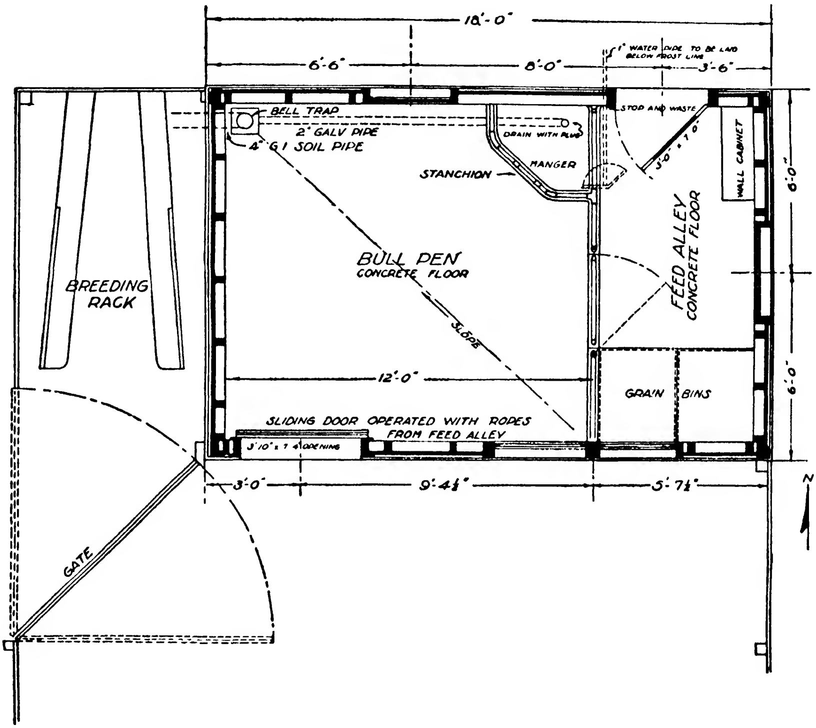

FIG. 44.—Plans showing the details of a safety bull pen.

built in connection with the bull's pen in such a way that, with a series of gates, the cows can be bred without its being necessary to handle the bull. This is a very satisfactory way to manage bulls.

Impotency.—Many bulls as they become older become less certain as breeders and often lose their potency entirely. This may be due to several factors. The most common are improper feeding, insufficient exercise, and excessive breeding. Very little is known concerning this problem. If more were known about the feeding of breeding bulls, this trouble would probably be greatly lessened. The exercising of the bull is also being recognized as a very important factor in helping to retain his potency. Bulls may be made impotent by improper feeding and then made potent again by proper feeding and exercise. Care should also be taken that the bulls are not given excessive service, especially when young.

Often very valuable bulls become useless at an early age just when their usefulness should be beginning. Greater attention to feeding and exercise would greatly lessen this trouble.

Disposal of the Sire.—When a sire has been used in a herd, he should not be disposed of by sale, slaughter, or otherwise, except perhaps to be loaned out to another breeder, until his daughters have come into milk. Many bulls are sold before their real value has been discovered. The first heifers do not come into milk until the bull is four or five years old. Usually the bull has been disposed of before that age is reached, and so, if his daughters prove to be exceptional milkers, it is then too late to get him back. In case such a bull has been retained he should not be sold as long as he keeps his breeding power. After he has passed his service days in one herd he should be transferred to another. Many instances are on record in which bulls have been transferred from one herd to another and in each herd have improved the records of the daughters over those of the dams. A bull properly handled should easily breed from nine to ten years, and many will breed much longer than this. Several methods have been used to retain the bulls until the worth of their daughters is known. Some large breeders put bulls out with other breeders, with an agreement that they may be secured again when needed. Others sell bulls with the option of buying them back again at a certain price if desired. Others retain them in the herd with limited use.

If the bull proves to be a poor breeder or if he becomes impotent for any reason, he should immediately be disposed of to the butcher.

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LECTURE XXI

THE PRINCIPLES OF DAIRY CATTLE BREEDING

WHILE dairy animals have been used since the dawn of history, the study of their breeding is of recent development. All breeding up to the time of Robert Bakewell of Deshley Hall, Liecestershire, England, in the middle of the eighteenth century, was without scientific foundation. The early herdsmen may have used selection to a very limited extent, but if so they had no knowledge of the reason for so doing. It was Bakewell who began to improve animals by a method founded upon the principle that " like produces like." By careful selection and by mating animals resembling each other closely in conformation, he was able to fix the type that he desired. By this method it has been possible to establish breeds of livestock which have done more to bring about better animals than any other one factor.

It is true that the ancestry of many of our dairy breeds may be traced back for several hundreds or even thousands of years. Caesar found in Friesland the ancestors of our present Holsteins, even then developed into a very good type of dairy animal. The Brown Swiss and the Simmenthaler have lived for hundreds of years in the mountains of Switzerland. However, up to the time of Bakewell, the introduction of new types into a country was brought about by conquest or by migration, and these were the chief factors in the development of distinct breeds.

To-day all cattle breeding can be classed under the two heads of breed improvement and herd improvement. The country as a whole, of course, is greatly interested in dairy-cattle breed improvement, which is a factor of great importance. Each individual dairy farmer, however, is chiefly interested in herd improvement. If he is able to improve his herd so that he gets a greater return for his labor, it means much to his own welfare. Whatever is for permanent herd improvement must in the end react for permanent breed improvement. In fact, all of the important breed improvements which we have had during the past years have come about largely through the great strides made by some of the master breeders in their own herd improvement.

While the early breeders did not fully understand the reason for selection and close breeding, the breeder of to-day has an explanation of the good results of these practices, and an understanding of the factors underlying breeding helps him in his breeding operations.

Carriers of Heredity.—The cell, as previously stated, is the unit of life. The body is made up of cells grouped together in a compact mass. There are two kinds of cells in the animal body—the body cells and the germ cells. The body cells, which constitute the bulk of the individual, last but one generation and then die. The germ cells, however, go on from generation to generation. They are specialized for reproduction and contain the hereditary material which determines the identity of each individual and which is known as germ plasm. This is the part of the living substance which passes down the line of descent from one generation to another.

Each cell contains within its walls a small body known as the nucleus, containing a number of microscopic bodies known as chromosomes. These are found in pairs and in a definite number for each species of plant or animal. The dairy cow for example, has 38 chromosomes, while the human has 48. The chromosomes are considered the bearers of the elements that determine the inheritance of any animal. These elements, or factors, as they are called, which determine the inheritance, appear to be strung along the chromosome in a linear arrangement. Each of the factors is distinct and is transmitted from one generation to another without undergoing any change or becoming contaminated by association with others. They do not mix like milk and water, but rather like black and white marbles. While these factors are distinct units in themselves, it often requires many of them to bring out a character. A character, then, is the result of the interaction of many factors plus environment. Milk production and butterfat percentage are probably dependent on the cumulative effect of a number of such factors.

The Cell in Reproduction.—The mature germ cell of the female is called the ovum, or egg, and that of the male is called the sperm. In the formation of mature germ cells the cell divides, and each sperm or egg contains only one-half the normal number of chromosomes.

" About the period of heat of the cow, one or more of the clear vesicles which can be seen in the ovary enlarges and ruptures. There is expelled a tiny colorless ovum or egg which can only be seen with difficulty by the naked eye. This ovum is received within the funnel-like membrane which normally surrounds the ovary, and then passes to the apex of this funnel and then into the narrow duct leading to the horn of the uterus. It is while in this duct that it comes in contact with a large number of male germ cells. A single sperm gains access to the ovum and fusion of the two results. This constitutes the act of fertilization, and the life of a new individual commences at once.

" The ovum carries the complete contribution of hereditary factors which are supplied by the mother while the sperm carries the complete paternal set. The fertilized ovum now commences to divide, and a process of rapid multiplication sets in."[1]

This leads to the development of a new individual with a new set of characteristics contributed equally by the male and the female.

Mendel's Law.—Inheritance is fixed at the time of the fertilization of the egg. It cannot be changed. An individual may fail because of environmental conditions to reach the full development of the inherited qualities with which he is endowed, but he can never exceed his inherited possibilities.

The laws of heredity were first discovered by Johann Gregor Mendel, an Austrian monk, who published the results of his work in 1866 after eight years of careful experimenting. His paper was not appreciated for several years, but in 1900 it was brought to light, and since that time it has been the general guide for students of genetics. Mendel experimented with peas and, by studying the inheritance of simple characters, such as size of pea or color of flower, was able to formulate the principles of inheritance, very much as they are understood at the present time. He found that when tall and dwarf varieties were crossed all the progeny of the first generation were tall; hence, tallness is said to be " dominant " over dwarfness, and in this case dwarfness is " recessive." However, when these hybrid peas of the first generation were planted they produced a mixed progeny, three-fourths of which were tall and one-fourth dwarf. By planting the dwarf peas it was found that in every case they bred true to dwarfness; but the tall variety did not behave in this manner. Careful study disclosed that one-third of the tall peas bred true to tallness, whereas two-thirds, while tall themselves, bred both tall and dwarf in the proportion of three to one, as did the first generation.

In the same way the factors in the animal body segregate at the time of mating. For example, if a red cow were bred to a black bull, the first-generation offspring would all be black; hence, black is said to be dominant over red. In the second generation, the offspring would split up in the proportion of three blacks to one red. The red would breed true to red when mated with red, and one-third of the blacks would breed true to black; but the others would give three blacks to one red, as did the first generation. This is illustrated in Fig. 45:

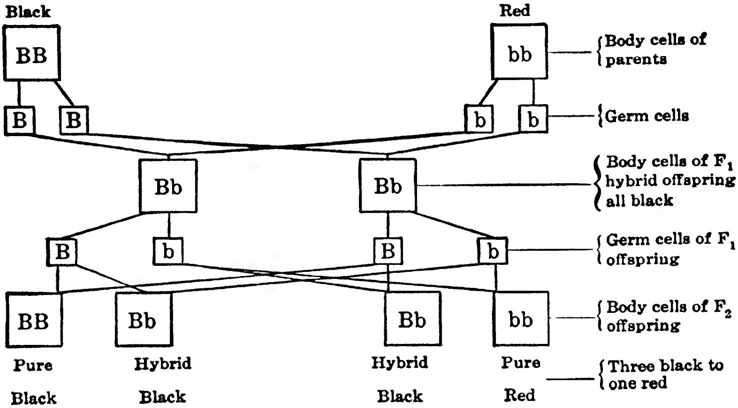

FIG. 45.—Illustration of Mendel's Law. When a pure black animal is mated with a pure red animal, the offspring will be black but will carry factors for red. If these are mated, the resulting offspring will be three blacks to one red.

Figure 45 also illustrates how an animal may be black in color but may carry factors for red and, when mated with another animal of the same factoral constitution, may give a red calf. Such cases, while not common in the United States, frequently occur in the Holstein breed. Such recessive factors may be carried forseveral generations without external manifestation, but when they recombine with other factors of the same kind the character will reappear. An animal that is pure for a pair of factors, as, for example, the animal containing *BB* in the preceding illustration, is described as being homozygous, while an animal that has both members of a pair of factors is described as being heterozygous, as, for example, the animal containing *Bb* in the foregoing illustration. The essential feature of Mendel's law, as stated briefly by Walter, is as follows: "Hereditary characters are usually independent units which segregate out upon crossing, regardless of temporary dominance."[2]

The foregoing example of Mendelian inheritance is for single unit characters. Such inheritance is comparatively simple; but when the two organisms that are crossed differ from each other with respect to two or more different unit characters, the problem becomes more complicated. Crosses of the latter type will not be considered in this lecture.

Inheritance of Milk Production and Butter-fat Percentage.—In the study of dairy cattle, milk production and butter-fat percentage are the characters that are the most important economically. The study of genetics, however, has not as yet helped greatly with the problem presented by these two characters. The evidence for the inheritance of milk production and fat percentage indicates that, like most other characters in animals, they are dependent on a number of factors for their development, and that the two characters are inherited independently of each other. The problem of breeding for high milk production and high percentage of fat is one of breeding animals, that are homozygous for the factors controlling these characters. If a dairyman has at the head of his herd a sire that is heterozygous for high production, and this sire is mated with cows which, although good producers themselves, carry factors for low milk production, some of the offspring will be poor producers, some may be good producers but may be carriers of factors for low production, while a few may be good producers and breed true. The problem, then, is to secure a sire that is homozygous for high milk production. Such a sire will produce high-producing cows even though the cows to which he is bred are low producers. The only sure test of such a sire is the breeding test, by which a sufficient number of his daughters are tested to see if they inherit the characters desired. If all the daughters inherit the desired character, the sire may be considered homozygous for high production. If, however, he has some good daughters and some poor ones, he may be considered heterozygous for high production. It can be seen from this that a cow may be a good milk producer herself but yet carry factors for low production. This shows how a person may be led astray by choosing animals out of cows with high official records. A high official record does not in itself insure that the offspring of the individual possessing it will be able to make a high record or that their offspring will produce well. The only animals that can consistently produce offspring with high milk production are those that carry all the factors for high milk production in a homozygous condition.

The same things can be said of butter-fat percentage as have been said of milk production. Wilson[3] found that milk and fat are inherited entirely independently. He believes that there is no reason why it should not be possible to breed cattle giving a large quantity of milk as well as a high quality. If has also been found that high milk production is dominant over low milk production, while low fat percentage is dominant over high fat percentage.

All breeding results can be explained by means of Mendel's law, although many believe in the inheritance of acquired characters.

Determination of Sex.—Many theories have been advanced concerning the method of controlling the sex of an individual before birth. Most of these have no scientific background and have not stood the test of experimentation. Wodsedalek,[4] however, has after careful research offered an explanation of the determination of sex in cattle, which has generally been accepted. He found that the male has 37 chromosomes. Of these, 1 is a sex chromosome and the other 36 are the ordinary chromosomes, called autosomes. The female, on the other hand, has 38 chromosomes, of which 36 are ordinary and the other 2 are sex chromosomes. During the reduction the male forms two types of sperms, one of which carries a sex chromosome while the other does not. The female forms only one type of egg. At fertilization, when the sperm unites with the egg, one-half of the resulting offspring will be males, that is, will carry only 37 chromosomes, while the other half will be females and will carry 38 chromosomes as shown in Fig. 46:

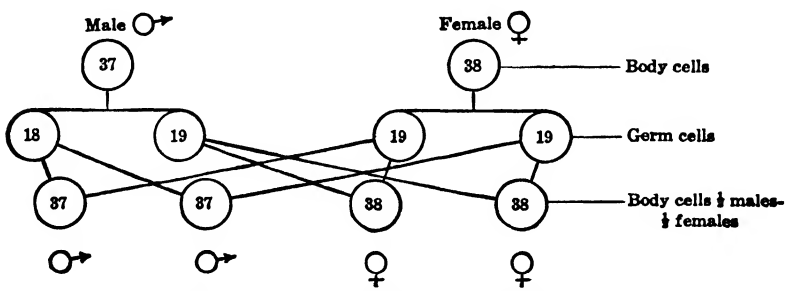

FIG. 46.—Illustration of sex determination in cattle.

There is, therefore, no way of controlling sex. It is simply a matter of chance whether the female germ cell will unite with a male germ cell containing 17 chromosomes or with one containing 18 chromosomes.

It often occurs that a breeder will obtain a preponderance of one sex or the other in a given year, but this is entirely the result of chance. If a sufficient number of animals are considered, the proportion of male and female will usually be about one to one.

Relative Importance of Sire and Dam.—It can be seen from Fig. 46 that the daughters all receive an equal number of chromosomes from each parent. The sons, however, receive 19 chromosomes from the dam and only 18 from the sire. It is quite probable that a bull receives a slightly greater inheritance from his dam than from his sire. It has not been demonstrated, however, that any of the factors which control milk production or butter-fat percentage are carried on the sex chromosome. Gowen,[5] after extensive studies with the Holstein-Friesian cows in the advanced registry, concluded that the sire and the dam are equally responsible for the milk yield and butter-fat percentage of the daughter. However, this need not mean that one parent may not give more characters to the offspring than the other. The animal that carries the greatest number of dominant factors may stamp his or her individuality upon the offspring to the exclusion of the less dominant parent. However, it must be borne in mind that the offspring of such a mating will be heterozygous, and will carry factors of both parents which may be passed on to its offspring. An animal that will pass on its characters to its offspring regardless of how it is mated is called a *prepotent animal.* Such an animal carries the factors for the expression of its characters, which may be undesirable or desirable, in a homozygous state. As noted before, milk production or butter-fat percentage is the result of the interaction of several different factors. It is therefore very unusual for an animal to carry all the factors for the expression of these characters. When this occurs it can be seen that the individual is a very valuable one. The only method of recognizing such an individual is the testing out of a sufficient number of its offspring.

Other Characters.—While milk production and butter-fat percentage are the characters which are usually considered in the breeding of dairy cattle, there are others which should be considered and which have an economic value. The most important of these are type, constitution, and fertility. These characters are probably inherited by the Mendelian law in the same manner as the others. Type is particularly important to the man who is in the show business. Every breeder, however, should give it a certain amount of consideration, or the type of his animals will become such that he will have difficulty in disposing of them.

Many families of dairy animals are notably shy breeders. This character is a very serious one. No matter what factors for milk production an animal may inherit, she will be a great economic loss if, because of failure to breed, she is not able to pass on these factors regularly to her offspring. Many kinds of sterility, however, are due to disease.

Other animals may inherit the capacity for high milk production but may not inherit the constitution to enable them to stand up under the production of which they are capable. All these factors should be considered in the breeding of animals.

The Freemartin.—There is at least one kind of sterility in cattle that is not due to disease or inheritance. When a female calf is born as a twin to a male calf, a sterile female, known as a freemartin, usually results. The freemartin is a female in which the reproductive organs have failed to develop properly. In consequence such an animal is not only sterile but also develops certain characteristics of the male. The male of such a union will breed normally.

Lillie,[6] after extensive investigation, found that this condition is due to the fact that the choria, or membranes, which surround the individuals are united in such a way that the circulatory systems of the two are joined and the blood of one individual circulates through the body of the other. While the blood of the female does not interfere in any way with the normal development of the male, the blood of the male circulating in the female seems to inhibit her full sexual development. This is thought to be due to a hormone which is secreted by the testes of the male and carried through the blood, inhibiting the full development of the female sexual organs. Such females will not breed. Occasionally a female born with a male will breed. This is due to the fact that the choria of the two animals remain distinct so that each has its own circulatory system. In this case the femaie is not a freemartin. Males born with males or females born with females should breed normally.

Fixation of Hereditary Qualities

It is necessary, then, as we have seen, to have animals that are prepotent—animals that will pass their characters on to their offspring.

It is known that all animals vary greatly in their characters; but if one is to breed prepotent animals one must breed individuals that do not have great variation from one generation to another. Variations in dairy cattle are of two general types: first, those due to environmental conditions; and second, those due to germinal recombinations. Environmental variations may affect the individual, but they in no way affect the germ plasm and so are not inherited. Most hereditary variations are due simply to recombination of the factors already present in the parents. These are the variations which the careful breeder will attempt to eliminate.

Selection.—Consistent selection, directed toward a desired type, is sometimes all that is necessary to fix a character. It is necessary in breeding operations, however, to have clearly in mind the desired type as the ideal toward which one must work. In the dairy field, it is important to select animals of the desired type and with high milk production back of them. In herds of very high milk production, it is necessary to select only those males that have been proven to carry the factors for high milk production. Otherwise, an unfortunate selection may upset the progress made. Selection alone, therefore, is not certain to result in steady progress. Even at its best, it is a slow method of effecting fixation of desirable hereditary qualities.

Inbreeding.—Inbreeding may be defined as the breeding of very close relatives, as son to dam, sire to daughters, or brother to sister. It is one method of fixing characters, whether good, bad, or indifferent. When the related animals are mated, the two parents of the resulting individual have a more nearly uniform character in their hereditary material than would otherwise be the case. The offspring, therefore, should have more of the characteristics of the parents. In other words, if the characters become more homozygous and if they are desirable characters, the resulting animal will be a desirable one. However, if they carry factors that are not so desirable, the resulting animal will become homozygous for such factors also. It is very seldom that an animal has all the desirable characters; therefore, when inbreeding is practiced, some undesirable characters may be developed along with the desirable ones. For example, in dairy cattle, the character for high milk production might become homozygous, and at the same time the character for low fertility or for poor constitution might become homozygous; thus, while a desirable character is being fixed, others that rob it of its usefulness may also be fixed. Inbreeding should not be used, therefore, without rigid selection. Success has followed the inbreeding of smaller animals, such as the drosophila, the rat, and the guinea pig, when careful selection has been practiced. Inbreeding of dairy cattle should be practiced only by the most skillful breeders.

Line Breeding.—Line breeding is the breeding of animals more or less closely related, but not as closely as those mated in inbreeding. Line breeding is the most popular form of breeding practiced to-day. It is a moderate form of inbreeding, and the advantages and disadvantages of the latter are achieved by it, although to a lesser degree. It promotes uniformity in the characteristics but brings in more hereditary influence from unrelated animals, hence homozygosity is not reached so quickly as it is with inbreeding. But while desirable characteristics are not developed so quickly, neither do the harmful ones appear so readily. Line breeding is a slower method than inbreeding for the fixation of hereditary qualities, but one which most breeders prefer as it eliminates the dangers associated with inbreeding.

Outcrossing.—Outcrossing is the system of mating in which animals of different strains, or blood lines, are mated. It is quite evident that the animals resulting from such a mating will be heterozygous for every single factor in which the two strains differ completely. If, however, the same general type has been fixed in two unrelated families, there is no reason why the crossing of these two families should result in offspring having a great variation in type. Of course, where families of distinctly different types are mated, a variation in type in the offspring is to be expected.

" If sire *A* is homozygous for dominant factors determining high production and his heterozygous daughters are bred back to him, half of his inbred offspring will be homozygous and half heterozygous. What will result if *A*'s daughters are mated to sire *B* who is also homozygous for dominant factors determining high producing capacity but is not related to sire *A*? If sire *B* has the same combination of factors that enable him to sire high-producing daughters as has sire *A* there is no reason why the results should not be the same as when sire *A*'s daughters are mated back to him."[7]

While it is not known definitely that the same combination of factors enables each of them to get the same desirable results, yet the indications from studies of advanced-registry records are that the factors controlling high producing capacity are alike in most prepotent sires of the same breed. The advantage of inbreeding or line breeding in the fixation of desirable hereditary qualities, such as milk production, is that the characters of the sires or dams definitely known to be great breeders can be concentrated. Ancestors that might be poor are eliminated to the extent of the duplication. In crossbreeding, the hereditary qualities of more animals must be known than in inbreeding; but if two animals are known to have the combination of factors for high production, good results may be expected from crossbreeding. If, however, the hereditary qualities of the animals are not known, it may be dangerous to use this method.

Grading.—With grade herds the methods of breeding discussed above are of little importance, and grading is used extensively. This term is used to describe the system of breeding by which a stock is led, generation after generation, a step nearer to a pure-bred type. The start is usually made with ordinary stock of no particular breeding; if a pure-bred sire is used in such a herd the first generation will be half-breeds. With the continued use of a pure-bred sire the second generation will be three-quarters pure-bred, and the third generation seven-eighths pure-bred, and the fourth fifteenth-sixteenths pure-bred. These would have the same types and characters as the pure-bred animals and could not be distinguished from them.

As a general policy, grading is by far the most important system used in this country. Only a very small percentage of our dairy animals are pure-bred, most of the herds being grade. The grading up of herds is a very important factor in the increasing of production in this country. Of course, pure-breds are necessary to furnish the desired seed in the grade herds.

Pedigree.—A pedigree is a record of the ancestors of an animal. The modern pedigree contains the record of the actual production of the ancestry. The pedigree, however, should not be given such prominence that defects of individuality are overlooked. Galton, an English investigator, after studying many human pedigrees, came to the conclusion that any individual is made up of 50 per cent of the immediate parents, 25 per cent of the grandparents, $12\frac{1}{2}$ per cent of the great-grandparents, $6\frac{1}{4}$ per cent of the great-great-grandparents, and so on. Galton's law, of course, is supposed to apply only to the average, as individuals will vary from this because of different combinations of hereditary factors. This illustrates, however the undesirability of paying much attention to individuals too far back in the pedigree. For example, in the third generation there would be eight

A GOOD PEDIGREE

VARSITY PIEBE LA VERTEX 302952
19–19–14–0–0
6 nearest dams with 365-day records, some at immature ages, average:
- 20424 lbs. milk
- 705.6 lbs. fat
- 882.0 lbs. butter

Sire of La Vertex Quantity of U. Neb.
- 2 yr. 20454 lbs. milk; 722.7 lbs. fat; 903 lbs. butter

N. P. Ragapple Bleske Piebe
- 2 yr. 19568 lbs. milk; 646.9 lbs. fat; 808.6 lbs. butter

N. P. Topsy King Piebe
- 2 yr. 17800 lbs. milk; 618.5 lbs. fat; 773.1 lbs butter

King Piebe Pontiac Segis 174303. . . .
(17–15–17–4–7)
Sire of Beauty Girl Gerben ReBecky
- 1 yr. @ 4 yrs. 21869.4 lbs. milk; 790.44 lbs. fat; 985.55 lbs. butter
- 7 days @ 4 yrs. 683.5 lbs. milk; 34.33 lbs. butter

Varsity Piebe Quintelle
- 1 yr. @ 3 yrs. 18840.1 lbs. milk; 683.35 lbs. fat; 854.18 lbs. butter

Varsity Piebe Kismet
- 1 yr. @ 2 yrs. 17914 6 lbs. milk; 592.06 lbs. fat; 740.07 lbs. butter
- 7 days @ 3 yrs. 612.7 lbs. milk; 25.01 lbs. fat; 31.26 lbs. butter

La Verna Lincoln 227365. . . . .
(3–1–1)
- 1 yr. 29555.5 lbs. milk; 1048.46 lbs. fat; 1310.60 lbs. butter
- 7 days 729.0 lb. milk; 27.52 lbs. fat; 34.41 lbs. butter

Dam of Varsity Derby La Vinnie
- 1 yr. 22421.0 lbs. milk; 805.97 lbs. fat; 1007.46 lbs. butter

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Piebe Laura Ollie Homestead King 110474. . . . .
(59–55–48–27–26)
Sire of: 3 over 800 lbs. fat or 1000 lbs. butter; 5 over 700 lbs. fat; 13 over 600 lbs. fat.
May Walker Ollie Homestead
- 1 yr. 31610 lbs. milk; 1218.59 lbs. fat; 1523.23 lbs. butter

Watson Segis Pontiac Homestead
- 1 yr. 25310 lbs. milk; 927.85 lbs. fat; 1159.81 lbs. butter

Beauty Girl Pontiac Segis 229260. . . .
- 1 yr. @ 3 yrs. 24924.7 lbs. milk; 890.33 lbs. fat; 1112.91 lbs. butter
- 7 days @ 3 yrs. 713.5 lbs. milk; 29.72 lbs. fat; 37.15 lbs. butter

Prince Ormsby Mercedes DeKol 47008. . . . .
(7–4–10–8)
Sire of La Verna Lincoln
- 1 yr. 29555.5 lbs. milk; 1048.46 lbs. fat; 1310.60 lbs. butter

Allie Lincoln
- 1 yr. 22159.6 lbs. milk; 846.22 lbs. fat; 1057.77 lbs. butter

7 daughters average 24 lbs. butter in 7 days

La May 122176. . . . .
- 1 yr. 26660.3 lbs. milk; 773.49 lbs. fat; 966.86 lbs. butter
- 7 days 648.3 lbs. milk; 18.10 lbs. fat; 22.63 lbs. butter

Oak DeKol Ollie Homestead 85529
(20–16–12–11–14)
Sire of 7 over 500 lbs. fat
Johanna Fayne Rue 2d
- 1 yr. 21925 lbs. milk; 790.57 lbs. fat; 988.21 lbs. butter

Wisconsin Bess Piebe Laura 97555
(4–1–3–2)
- 7 days 528.5 lbs. milk; 23.70 lbs. fat; 29.25 lbs. butter
- 1 yr. @ 12 yrs. 15113 lbs. milk; 529.47 lbs. fat; 661.83 lbs. butter

King Segis Pontiac Count 93909
(38–27–17–21)
Sire of 12 over 800 lbs. fat or 1000 lbs. butter
Princess Changeling Segis
- 1 yr. 31063 lbs. milk; 1030.05 lbs. fat; 1287.56 lbs. butter

Prince DeKol Beauty Girl 98624
- 7 days @ 7 yrs. 591.1 lbs. milk; 17.37 lbs. fat; 21.71 lbs. butter

Sir Ormsby Hengerveld DeKol 31212.
(69–20–31–50)
Sire of: 1 over 800 lbs. fat or 1000 lbs. butter; 4 over 600 lbs. butter

Daisy Mercedes Pietertje 53643
(3–1–4)
- 7 days 525.7 lbs. milk; 17.43 lbs. fat; 21.78 lbs. butter

Alma Prince Jewel 32731
(6–3–3–6)
Sire of: Alma Lincoln Garben
- 14833 lbs. milk; 509.98 lbs. fat; 637.47 lbs. butter

Mayhamb Pietertje DeKol 49751
(3–0–1)

ancestors, and since only $12\frac{1}{2}$ per cent of the hereditary influence comes from this generation each individual would count for only 1.56 per cent of the hereditary make-up. The parents, sisters, half-sisters, grandparents, and, to some extent, cousins are the important relatives upon which to base an estimate of the production worth of animals.

Care should be taken in interpreting pedigrees by those not accustomed to them. Since pedigrees are used extensively in the selling of animals, many abuses have arisen in the method of preparing them, especially in regard to the records of production. In most cases the truth is told but the statements are made in such a way that unless one is on the watch one may be fooled into thinking that an animal has a better pedigree than it really has. An illustration of a good pedigree is given on page 236.

Fallacies in Breeding

Telegony.—Many breeders believed, in the past, before some of the recently discovered laws were known, that late offspring were likely to be affected to some extent by previous impregnations of the mother. According to this belief, a pure-bred Holstein cow bred to a Holstein bull after dropping the offspring of a Jersey bull, would not drop a pure-bred Holstein calf. Fortunately, this belief has been shown to be false, and all such cases can be explained on the theory of recombination of existing factors.

Saturation.—It was also believed by many that with the persistent use of a certain sire the later offspring tended to resemble that sire more than the first ones, and also that the dam tended to become more like the sire. The theory of saturation is really a statement of the cumulative effect of telegony and there is plenty of evidence against it.

Maternal Impressions.—There is a common belief that strong mental impressions received by the dam at the time of mating or during pregnancy have in some way a specific effect upon the offspring. It has been a common practice in the past to have animals of the desired type around at the time of service so that the dam would receive the desired impression. The holding of a blanket or other object of a certain color before the dam at the time of service, in order to influence the color of the offspring, has also been practiced. There are, of course, no grounds for belief in the efficacy of these practices.

Normal Period of Gestation

The normal period of gestation for a cow is 283 days. Shaw[8] gives the extremes in the duration of the period of gestation in the cow as from 265 days to 300 days. Wing[9] made a study of 183 gestating females and found the average to be 280 days with the extremes of 264 to 296 days. He found that the sex of the offspring made no difference. Many breeders believe that the male requires a few days longer, on the average, than the female. Table G in the Appendix gives the gestation period of dairy cows.

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LECTURE XXII

THE SELECTION OF THE SIRE

Importance of the Sire.—According to Galton's law, one-half of the characteristics of the individual come from the male parent and his ancestors, and the other half from the female parent and her ancestors. Since in most herds only one bull is used, and he is mated with all of the cows, one-half of all of the characteristics of the heifers that are raised come from the sire. This has resulted in the well-known and popular statement that the sire is half of the herd. The facts are that certain excellent sires are more than half of the herd; likewise certain extremely poor ones are more than half of the herd. In other words there are prepotent sires, both for bad and for good. Since the sire is at least one-half of the herd, it can easily be seen that the main chance for the improvement of the herd lies in the introduction of good blood by means of the sire. A good cow usually has but a very small influence upon the breed, as the number of offspring which she can produce is very limited as compared with the offspring of a bull. The necessity of selecting a good sire to head the herd is therefore very evident.

Methods of Selecting the Sire.—The first point in selecting a sire to head a herd is that he must be a pure-bred of the breed which has been chosen. Pure-breds should have the factors for milk production concentrated to a much higher degree than grades or scrubs, since they have been bred with that in mind for a great number of years. That the animal is a pure-bred is perhaps all that need be considered in herds where the grading up has just begun; but in herds that are fairly well developed, or in pure-bred herds, more should be looked for in a sire than the mere fact that he is a pure-bred. The owners of such herds usually use one of the following methods, or a combination of them, in selecting the sire to head the herd.

1. Selecting by type or general appearance.
2. Selecting by pedigree (or by pedigree and type).

3. Selecting by the production of the daughters (using proven sires).

Selecting by Type and General Appearance.—Many sires are selected simply on their type. This method can be used to advantage in the beef breeds, since they show by their conformation the qualities for beef production—the thing for which they have been bred. The dairy sire, however, bred for milk production, does not show his milk-producing qualities. He may show to a certain extent the body characteristics of his daughters, but it is questionable whether we really know the fundamental relationship between the conformation of certain parts of the body and its functions. For example, we do not know for certain that a large heart girth in a cow means a large heart and lungs, or that a large heart and lungs mean a superior constitution; nor do we know that a large barrel means a large capacity for handling feed, or that there is any relation between a sloping rump and milk production.

Milk production, as we have seen, is controlled by certain factors which are carried in the germ cell and, as far as we know, are in no way related to the body conformation of the animal. In other words an animal may be ideal as far as type is concerned and still be worthless as a producer of milk or butter-fat, simply because she does not carry the factors for high production. Since we know that inheritance governing all characteristics is transmitted through the germ plasm, it does not seem possible that we will ever be able to tell by the appearance of an animal what its inheritance for production is.

Breeders who are interested in showing sometimes use this method of selection, as they are more interested in type than in production. Other breeders should not lose sight of type in selecting a bull and should not use a bull, even of good breeding, unless he has some type; but selecting entirely by type will not usually result in great improvement in production.

Selecting by Pedigree.—Most of the sires used at the head of the herds in this country are selected by pedigree or by the combination of pedigree and type. This is the best method available for most breeders, as there are very few proven sires in the country. For a great many years, therefore, this system must be the principal one used.

In using this method, only the most important things in a pedigree should be considered. Too much stress should not be laid upon ancestors too far back in the pedigree. The dam, the sire, the sisters, the half sisters, and, to some extent the cousins should be given consideration in the order named. The breeding ability of the dam should be given just as much attention as her record. If she has sons and daughters and they have all made good records, this indicates that she had the ability to transmit her desirable characteristics to her offspring and she should be given greater consideration than if she had only a high record with no proven offspring.

It is necessary also to consider the chance that any given individual has had. On many farms the number of cows is small and they are not pushed for high records to the extent that they would be on other farms. Therefore, more would be expected of a sire in a large herd known to have been pushed for high production than of a sire in a small herd where the animals are not pushed.

This method of selecting sires is not a sure one. One cannot be sure that the animal will carry the factors for milk production in a homozygous state.

"When a cow shows great producing capacity we must assume that she has at least a part of the factors in her germinal make-up that go to determine the ability for large production, otherwise she would not be a large producer—but we cannot be certain that she does not have in her germ plasm the factors that will cause low production. Then, too, the germinal make-up of the offspring of this high-producing cow will depend partly on the sire she is mated with. If the character for high production is dominant as it appears to be, then it will be difficult by basing selection on the production records of the dam to breed a strain that will be pure for high production."[1]

In the same way, the bull selected by this method may carry factors for low production. That this is true is shown by a study of the results at several of the Experiment Stations.

Lessons from the Pennsylvania Experiment Station.—In 1916, Beam made a study of the grade Guernsey herd at the Pennsylvania Experiment Station.[2] This herd was established in 1890, and from that time up to the time of the study only pure-bred Guernsey bulls had been used. All of the daughters were raised, regardless of their quality, since the object was to study the results of the continued use of pure bred sires alone, other factors being excluded as far as possible.

The bull whose breeding was the best, Cora's Deputy, proved to be the poorest bull that the college owned. He was prepotent in an undesirable way. Lucretia's Glenwood Boy of Haddon was prepotent in a desirable way. The five other bulls did not seem to have a very marked effect, one way or the other, upon the production, but with one exception they all increased it slightly.

The following summary gives the productions of the daughters of these bulls as compared with the dams of the daughters:

TABLE LVIII

SUMMARY OF FIRST YEAR'S RECORD OF THE HERD SIRES USED AT THE PENNSYLVANIA EXPERIMENT STATION, 1890–1915

Name of Sire	Number of Daughters and Dams	Production of Daughters		Production of Dams		Differences in Favor of Daughters	
		Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds
Faucette's Wonder.....	10	4995.0	239.2	4915.4	217.0	79.6	22.2
Warwickshire.........	7	4842.9	240.3	4452.1	215.9	309.8	24.4
Cora's Deputy........	29	4063.6	197.3	4938.4	250.6	−874.8	−53.3
Selectrina's College Boy	38	4993.6	246.1	4745.9	239.5	147.7	6.6
Success of Avon.......	15	4742.0	256.1	4584.0	240.2	158.0	15.9
Lucretia's Glenwood Boy of Haddon.....	13	5085.1	263.6	4602.7	231.4	482.4	32.2
Glenwood of Mapleton.	34	4857.6	257.7	5011.9	259.3	−154.3	− 1.6

It will be noted that Cora's Deputy reduced the production of the herd, on the average, by over 50 pounds of butter-fat, and also that Glenwood of Mapleton caused a slight falling off. All the other bulls brought about a slight increase in the average production of the herd.

It should be realized that in a herd of only twenty cows a bull like Cora's Deputy means from twenty daughters, 1000 pounds of butter-fat less yearly. This amount of fat, valued at 40 cents a pound, would mean $400 loss annually. One could well afford to pay a good sum for a bull that had the ability to add this amount to the profits of the herd.

Lessons from the Missouri Experiment Station.—The Jersey herd at the University of Missouri was established in 1884. In that year the institution purchased four registered Jersey cows and a herd bull of St. Lambert breeding, known as Missouri Rioter. Since that time the herd has not been increased by the purchase of females; new blood has been introduced only by the purchase of bulls, and since 1892 complete milk and butter-fat records have been kept for every cow. In 1908 one of the authors[3] of this book made a study of the breeding of this herd. At that time five bulls had been used. Records of three other bulls have since been studied.[4, 5] Table LIX, prepared in a similar manner to the one for the Pennsylvania Station herd, shows the results of the use of these bulls:

TABLE LIX

A Comparison of Pure-bred Jersey Sires in the University of Missouri Herd

Name of Sire	Number of Daughters and Dams	Production of Daughters		Production of Dams		Difference in Favor of Daughters	
		Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds
Missouri Rioter.......	4	4381	216	5380	234	− 999	−18
Hugorotus............	11	4576	216	4969	231	− 394	−15
Lorne of Meridale.....	12	6050	291	4559	221	1491	70
Missouri Rioter 3rd....	3	8005	384	4775	238	3230	146
Minnattes Pedro......	20	5376	271	5321	268	55	3
Daisy's Prince of St. Lambert...........	....	3932	198	5362	269	−1430	−71
Brown Bessie's Registrar................	....	4607	229	6069	300	−1460	−71
Fairy's Lad...........	....	6169	323	6219	299	− 50	24
Sultana's Virginia Lad *	....	7722	445	5349	277	2373	168

* Records in all cases for this bull are two-year records.

Of the nine bulls used at the head of this herd, four were poor, two medium, and three good, from the standpoint of their influence upon the production of the herd. Missouri Rioter decreased the average production of his daughters below that of their dams by 999 pounds of milk and 18 pounds of fat. His son, however, Missouri Rioter 3d, caused an increase of 3230 pounds of milk and 146 pounds of butter-fat yearly for each daughter over the dam. The value of such a bull in a herd cannot be estimated. If he had twenty daughters in the herd and they were milked one year, the increase in milk production over that of their dams would be 64,600 pounds. If this milk is worth $2 per hundred, the income for milk over that which the dams would produce would be $1292. If these daughters remained in the herd for the number of years that the average cow remains, which is five, it is easy to figure the increased income which would result from one year's service of such a bull.

Brown Bessie's Registrar had a very good pedigree. As far as his pedigree was concerned, there was every reason to expect excellent results from his use. His daughters, however, were failures. They averaged 1460 pounds of milk and 71 pounds of butter-fat less than their dams. If there were twenty of his daughters in a herd for a year they would decrease the milk production from that of their dams by 29,200 pounds of milk and 1420 pounds of butter-fat. This bull was a serious detriment to the herd. Similar lessons can be drawn with other sires, with varying results. No credit has been given for increased sale value of the offspring of the better sires, although this may be as much or even more than the profit due to the increase in production.

Lessons from the South Dakota Experiment Station.—The South Dakota Experiment Station[6] has also presented data showing the differences found in pure-bred sires. The following table shows the results of the use of five different pure-bred Holstein-Freisian sires at that station:

TABLE LX

A COMPARISON OF PURE-BRED HOLSTEIN-FRIESIAN SIRES IN THE SOUTH DAKOTA EXPERIMENT STATION

Name of Sire	Production of				Difference in Favor of Daughters	
	Daughters		Dams			
	Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds	Milk, Pounds	Fat, Pounds
Sir Cornucopia Prince.......	11,593.6	398.3	8,145.0	296.1	2448.6	102.2
King Colantha Clothilde 2nd..	11,055.8	370.0	11,340.4	393.9	−284.6	− 23.9
Sir Dakota Colantha Rue Brookings................	7,642.3	272.6	10,411.2	355.9	−2768.9	−183.3
Brookings Cornucopia........	8,039.9	296.5	9,167.3	331.2	−1127.4	− 44.7
Sir Korndyke Bess Piebe.....	16,113.9	525.8	9,382.0	307.9	6731.9	217.9

In the case of Sir Korndyke Bess Piebe, the average production of daughters is for pure-breds only, while in the other cases the production of grade animals is also included. When Sir Korndyke Bess Piebe's production is made comparable, he is seen to have about the same prepotency as Sir Cornucopia Prince in transmitting high milk and butter-fat production.

In comparing these sires the price of 40 cents a pound for butter-fat was used. On this basis it was found that each pure-bred daughter of Sir Cornucopia Prince was worth, as a butter-fat producer, $70.23 more than her dam. The pure-bred daughters of Sir Dakota Colantha Rue Brookings were worth, on the average per year, $30.02 less than their dams. The money value, from the standpoint of fat production only, between these two sires, was $100.25 for each pure-bred daughter sired. That is, each daughter sired by Sir Cornucopia Prince was worth $100.25 more each year than each daughter of Sir Dakota Colantha Rue Brookings for fat production alone, not considering the additional value for the sale of stock.

From these three studies it can be seen that the method of selecting by pedigrees is not always reliable, although it is still the best method available for most herds. Great care should be exercised, however, in selecting a bull to head the herd.

Selecting by the Production of the Daughters.—The method of using only sires that have proven their ability to increase the production of their daughters over that of the dams is the safest method to follow. Men who have well-developed herds cannot risk the chance of failure which is incurred in other methods of selection.

Until recently, however, the common practice has been to use a sire at the head of a herd for only two or three years and then sell him to the butcher. In that way the bull was gone before his value was known. This is done in many cases even at the present time. However, cow-testing associations, breed associations, and many individual breeding establishments are now attempting to prove bulls and to keep them in active service as long as possible.

It must not be considered, however, that all sires are desirable even though they have been proven. Some may transmit low production; others may give some high-producing offspring and some low-producing offspring. In the latter case the sire is heterozygous for the character of high milk production. The really worthwhile bull is one that will transmit the character of high milk production to all of his daughters, regardless of the production of their dams. Such a bull is homozygous, or pure, for high milk production. He is the prepotent sire. A

FIG. 47.—Beda's May King. A famous Guernsey sire. He had nine daughters that averaged over 500 pounds butterfat during their first lactation period. Five of them are here shown. (*Hayward.*)

FIG. 48.—Daughter of Beda's May King, Eva's Beda. 8566.2 pounds milk, 517.83 pounds butterfat.

FIG. 49.—Daughter of Beda's May King, Madge. 9094.4 lbs. milk, 448.68 pounds butterfat.

FIG. 50.—Daughter of Beda's May King, Golden Rose. 9661 pounds milk; 538.94 pounds butterfat.

FIG. 51.—Daughter of Beda's May King, Red Clover. 8817.5 pounds milk; 476.32 pounds butterfat.

FIG. 52.—Daughter of Beda's May King, Ruth. 11,167.2 pounds milk; 599.88 pounds butterfat.

bull's hereditary make-up should probably not be estimated from the producing capacity of less than six daughters.[7] This is because the cow also exerts an influence upon the offspring, and therefore, if a sire is mated only to good animals it is often a difficult matter to determine his hereditary make-up.

The following table,[7] gives an example of a prepotent sire:

TABLE LXI

AN EXAMPLE OF A PREPOTENT SIRE

Daughters			Dams			Difference in Favor of Daughters		
Milk	Fat		Milk	Fat		Milk	Fat	
Pounds	Per Cent	Pounds	Pounds	Per Cent	Pounds	Pounds	Per Cent	Pounds
14,191.8	5.09	724.7	8219.7	5.85	482.3	3971.9	−0.76	242.4
12,869.4	5.35	690.3	8503.1	4.63	385.3	4366.3	0.72	305.0
11,153.6	4.81	537.2	7728.9	5.09	393.2	3424.7	−0.28	146.0
11,190.8	5.79	635.6	9079.8	5.83	521.4	2111.0	−0.04	114.2
9,522.9	4.85	462.2	6979.8	5.72	389.3	2543.1	−0.87	72.9
9,133.7	5.59	498.7	8918.4	4.59	410.4	215.3	1.00	83.3
Av. 11,343.7	5.25	591.5	8238.3	5.29	430.3	3105.4	−0.04	161.3
Percentage increase or decrease..........................						37.69	−0.76	37.46

This sire increased the milk-producing capacity of each daughter. The percentage of fat was decreased in all but two cases, but the decrease was not sufficient to offset the increase in milk. Consequently every daughter showed an increased yield of butter-fat.

The number of really prepotent sires that are found in any of the breeds is very small, and any such animal, when found, should be kept in service just as long as possible. Hover[8] made a study of the Guernsey bulls that entered the advanced registry up to 1915. He found that only one in one thousand is likely to make a marked improvement in the breed. This does not mean that many bulls cannot improve herds. It has reference only to prepotency that will increase the average production of the whole breed. Hover found that while as many as 254 sires had produced one or more " equivalent to 600-pound" daughters, only thirty-two of them had produced as many as three. In other words, he found that thirty-two sires, or only 12.6 per cent of the total number of sires of 600-pound daughters, have three or more such daughters. He makes the following statement:

"When we observe that these thirty-two sires are only 0.092 per cent of the male animals registered in the American Guernsey Herd Books, and 2.2 per cent of the 1454 sires of advanced-registry cows, the tremendous importance of the few strong sires, from the standpoint of improving the production of the breed, becomes quite apparent."

Hunt,[9] in 1921, published the results of a study of the Holstein-Friesian sires. He found that a total of 1039 sires were necessary to sire 2039 cows with a production equivalent to or greater than 600 pounds of butter-fat. Only 178, or 16 per cent of these, sired as many as three "equivalent to 600 pound daughters."

These examples show that certain sires are able to transmit uniformly high production to their daughters, and that others have one or two high-producing daughters while their other daughters are either average or low producers.

Many breeders are now using a bull to a limited extent and then loaning him out or keeping him until they are able to test his daughters. In this way they can test out the bull and see what he will do before they use him extensively.

Other Factors in Selecting a Sire

Age of Sire.—As a general rule, a young sire is preferred to an old one because he is easier to handle. Often when a sire becomes in any way unruly he is sold to a butcher. Some breeders seem to think that an aged sire is more prepotent than a young one; but our knowledge of genetics shows that there would be nothing added to the germ cells with advanced age and so there could be no difference in that regard. Therefore, unless an aged sire has daughters in milk which are proving to be good producers, there is no advantage in using him. In fact, if a sire is to be purchased upon his type and pedigree, a young one should be chosen, because as a rule young sires are surer breeders and have their entire lives ahead of them. They are usually less trouble to handle than the aged sires.

Age of the Dam of the Sire.—Many people object to the use of a sire which is the first calf of a heifer, for the same reason that they object to a young sire, namely, because they believe that he will not be prepotent. There is no reason, however, why the first calf of a heifer should not be just as prepotent as the calf of a mature cow. The only objection to such a selection is that the heifer has not had the opportunity to show what she inherits in the way of milk production. It is often unwise to select such an animal for that reason. In selecting a sire that is the calf of an older cow, one usually has an opportunity to ascertain the producing ability of the dam.

Cost of the Sire.—As has already been seen, a good sire, which will raise the production of the herd, is worth very much more than his cost is likely to be; and a poor sire, which would decrease the production of the herd, would be expensive at any price. Fraser[10] has estimated the cost of providing every heifer with one good parent, as shown in the following table:

TABLE LXII

Comparison of the Cost of a Pure-bred and a Scrub Sire

	Pure-bred	Scrub
Cost of sire	$150.00	$30.00
Interest, three years, 5 per cent	22.50	4.50
Cost of keeping, three years	100.00	100.00
Risk, three years	50.00	10.00
Total expense, three years	$322.50	$144.50
Value at the end of three years	100.00	30.00
	$222.50	$114.50
	144.50	
Extra cost, good sire, three years	$108.00	
Extra cost, good sire, one year	36.00	
Extra cost, good sire, one daughter	3.00	

Fraser assumes that in a herd of from thirty-five to forty cows there will be seventeen heifers, twelve of which are worthy of being raised; on this basis, then, and according to his valuation, each one of these heifers cost $3 more for having had a pure-bred sire. This takes into consideration only one year's service. While these figures will not apply in every case, yet the lesson will be the same, viz., that in goodsized herds where the bull is used for several years it does not cost a large sum to give each heifer a good sire.

Cooperative Bull Associations.—Although cooperative bull associations have existed in Europe for many years, they were not started in this country until about 1908. In that year three such associations were started in Michigan. Since that time the movement has become widespread.

Cooperative bull associations are formed by dairymen for the joint ownership, use, and exchange of good pure-bred sires which they could not own individually. They are especially adapted for dairymen with small herds, where a valuable sire for each herd would constitute too large a part of the total investment. The organization makes it possible for such owners to unite in the purchase of one good sire, and in that way each has the use of a well-bred sire.

The cooperative bull association in this country is organized in "blocks." Each block contains from one to eight or ten dairymen and there are from three to ten blocks in one association. The average association will have about five blocks. The association will purchase as many bulls as there are blocks, and one sire will be assigned to each block. As many as fifty to seventy cows may be owned by the farmers in each block, and the sire should be kept on a farm conveniently located. To prevent inbreeding, each sire is moved to the next block every two years. If the sires all live and prove satisfactory the members of the association will have the use of a pure-bred sire at a very nominal cost, for a long period of time.

The association thus makes it possible for its members to use much better sires than they could provide individually for themselves. Furthermore, it enables them to establish a breed of livestock in their community and thus attract buyers.

These associations have brought about a vast improvement in dairying in the communities where they have been tried, and no doubt the movement will continue to grow.

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LECTURE XXIII

DAIRY HERD DEVELOPMENT

Methods of Developing a Herd.—There are two ways by which a dairy herd can be established: the first is to buy one, and the second is to breed one. Often, however, a combination of these two methods is used. In that case, some pure-bred or high-grade animals are purchased and added to the herd already on hand, and these are used, as foundation animals.

The best method of developing a herd, however, depends upon several factors, such as the capital available, the experience of the man starting the business, and the market for the product. In general, the man who has had no experience in the handling of dairy animals, or who has a limited amount of capital, should start with the animals he has on hand, and, by the use of a pure-bred sire, breed up his herd; while the man who has had dairy experience and who has some capital, or the man who has no animals to start with, should buy a sufficient number of high-grades or pure-breds to make up all or part of his herd.

Breeding a Dairy Herd

The disadvantage of breeding a herd from a common or beef herd is that it requires several years of time. However, in a locality where dairying has not been well developed, it is seldom wise for a beginner to take up the breeding of pure-bred or even high-grade dairy animals until he has had some experience in handling a dairy herd. He would perhaps be wise to take the common cows, with beef blood predominating, which he already has on his farm, and, with the use of a pure-bred sire, breed up his herd. He should feed the cows a good ration, weigh the milk of each cow in his herd, and raise only the calves from the best cows. Thus, by the use of a good pure-bred sire, he should be able to develop in several generations a herd of high-milking cows. By the time he has developed a high-producing herd, he will have learned the dairy business and can feed and care for his animals properly. He will also have had time to develop a market for his product. The length of time required for such an undertaking would be two or three generations (four to six years). Examples of such improvement have been shown at several experiment stations.

Results at the Iowa Experiment Station.—To demonstrate the improvement that can be expected from the use of a pure-bred bull on a scrub herd for two or three generations, the Iowa Experiment Sta-

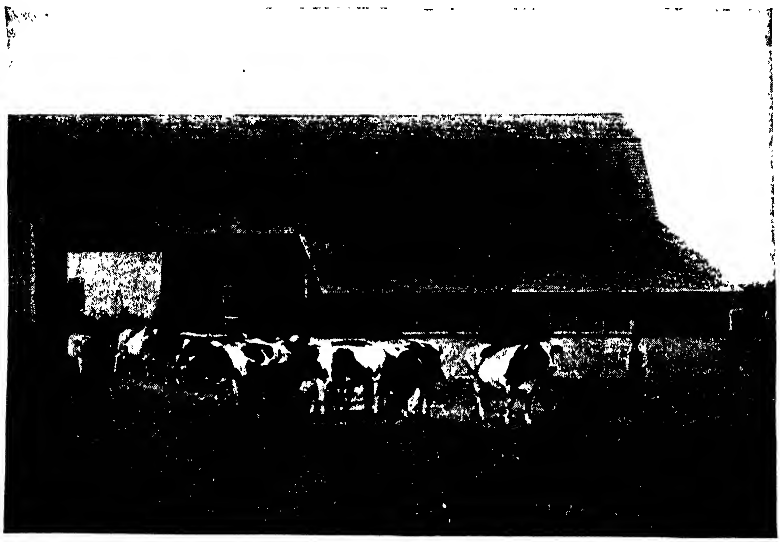

FIG. 53.—Herd of high-grade Holsteins graded up from common stock by the use of a pure-bred sire.

tion[1] purchased several very inferior scrub cows and heifers and mated them with pure-bred bulls of the three breeds, Jersey, Guernsey, and Holstein. Table LXIII shows the results secured for the first and second generations.

This table shows that the second-generation grades of the three breeds averaged 8402 pounds of milk and 358 pounds of butter-fat, or an increase of 4742 pounds of milk and 186 pounds of butter-fat over their scrub grand-dams. These animals were producing almost as much as the average of their breed, and their color markings and conformation were very similar to the breed, the blood of which they

TABLE LXIII

Two Generations of Grades Compared with their Scrub Ancestors. (Iowa Exp. Station.)

Breed	Dams			Daughters			Grand-daughters			Increase in Production			
	Number of Cows	Av. Production		Number of Cows	Av. Production		Number of Cows	Av. Production		First Generation		Second Generation	
		Milk, Pounds	Fat, Pounds		Milk, Pounds	Fat, Pounds		Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent	Milk, Per Cent	Fat, Per Cent
Holstein.........	2	3782	176	2	6840	273	2	11,127	420	81	55	194	138
Jersey...........	2	3686	168	2	5102	241	2	5,810	301	38	43	58	79
Guernsey........	1	3463	168	1	5009	264	1	5,411	287	45	57	56	71
Average.......		3660	172		5999	261		8,402	358	64	52	130	109

TABLE LXIV

Two Generations of Grades Compared with their Grade Beef Dams. (S. D. Exp. Station.)

Breed	Dams			Daughters			Grand-daughters			Increase in Production			
	Number of Cows	Av. Production		Number of Cows	Av. Production		Number of Cows	Av. Production		First Generation		Second Generation	
		Milk, Pounds	Fat, Pounds		Milk, Pounds	Fat, Pounds		Milk, Pounds	Fat, Pounds	Milk, Per Cent	Fat, Per Cent	Milk, Per Cent	Fat, Per Cent
Holstein.........	3	4007	165	5	7182	264	4	8315	304	79	60	108	84
Jersey...........	3	4007	165	3	5125	231	3	4732	241	28	40	18	46
Guernsey........	1	4748	193	1	5679	289	....	....	....	20	50		
Average.......		4155	171		6707	260		6268	268	61	52	51	57

carried. Many were considered uncommonly good representatives of that breed.

Results at the South Dakota Station.—A similar experiment was carried on at the South Dakota Experiment Station,[2] in which grade beef animals were mated with bulls of the three dairy breeds. The cows were grade Herefords and Shorthorns. The results are given in Table LXIV.

This table shows in unmistakable terms the fact that it is possible to grade up a high-producing herd from ordinary grade beef animals.

FIG. 54.—Scrub cow No. 56. Best record 4975 pounds milk; 253.13 pounds butterfat.

Results at the North Central Experiment Station (Minnesota).—In 1904, a herd of common cows was purchased at the North Central Experiment Station[3] (Minnesota), and since 1907 a pure-bred Guernsey bull has been kept at the head of the herd. In 1904, the average production of the herd was only 4700 pounds of milk and 196 pounds of butter-fat. The six-year average from 1911 to 1916, inclusive, was 5584 pounds of milk and 256 pounds of butter-fat. The six-year average from 1917 to 1922, inclusive, was 6894 pounds of milk and 334 pounds of butter-fat. This shows a gradual increase in production, due largely to the use of a pure-bred sire.

These examples show what might be expected if one were to start

FIG. 55.—No. 77. Daughter of scrub cow No. 56 by a pure-bred Holstein bull. Four-year-old record: 8689.3 pounds milk; 321.31 pounds butterfat; an increase of 75 per cent in milk and 27 per cent in fat.

FIG. 56.—No. 282. Daughter of No. 77 by a pure-bred Holstein bull. Shows the typical Holstein markings.

FIG. 57.—Scrub cow No. 52. Best record 4588.4 pounds milk and 201.67 pounds butterfat.

FIG. 58.—No. 69. Daughter of scrub cow No. 52 by a pure-bred Holstein bull. Four-year-old record: 6822.8 pounds milk, 283.75 pounds fat; an increase of 49 per cent in milk and 41 per cent in fat.

with a scrub or common herd and develop it by the use of a pure-bred sire.

Buying a Herd

The advantage of buying a herd over breeding one is that the dairyman need not wait for a number of years before beginning to make some profit. If a man knows the dairy business and has a ready market for his products, it is a waste of time to start with low-producing animals. This may be necessary in case the person desiring to start lacks suffi-

Fig. 59.—No. 281. Daughter of No. 69, by a pure-bred Holstein bull. The typical markings of the Holstein are well shown.

cient capital to go out and purchase valuable animals, but if possible he should at least purchase a few good animals so that he will have a good herd as soon as possible.

The disadvantages of buying a herd are as follows: (1) it requires considerable capital; (2) it entails danger of disease; and (3) it is difficult to purchase good foundation cows.

Capital Required.—If one wishes to purchase good animals, one must pay a good price for them. It is true that many cows can be purchased at a low price; but these are usually culls which some one else does not find profitable or, on account of disease or for some other reason, wishes to get out of his herd. Good cows are usually high in price and hard to purchase since no breeder wants to sell his best animals.

Disease.—The danger of purchasing animals with some disease, especially tuberculosis or abortion, is always great. All cows that are purchased should be tested for tuberculosis. Even this precaution does not always eliminate the danger, as animals that have been recently infected or those that are in advanced stages may not react to the tuberculin test and may later spread the disease to the rest of the herd. A person purchasing a herd should, if possible, buy the individual cows from an accredited herd or, better still, in a tuberculosis-free area. By that means he takes as little chance as is possible. It is wise also, before bringing cows into a herd, to isolate them for a period of sixty to ninety days and have them retested, after which, if they pass the test, they may be put in with the rest of the herd. This retest may not reveal those in advanced stages of the disease, known as " spreaders," and so one should always be on the outlook for such animals.

While tests have been developed to locate animals carrying the abortion germs, these tests can only be carried on in a laboratory especially equipped for such work. Moreover, this test is not as accurate as the tuberculin test and up to the present has been used to a limited extent. Abortion, however, is a very serious disease, being even more important from the economic standpoint than tuberculosis. In purchasing a herd it is always wise to find out, if possible, if there has been trouble with the disease at the farms where the cattle are to be purchased. This, however, is often very hard to discover. The number of calves on the farm will often give a person a good indication of the presence or absence of such trouble. Usually, however, one has to rely on the word of the seller. It has been found that heifers, up to the time when they become sexually mature, do not carry the abortion germ; it would therefore be safe to purchase such animals, even from an infected herd.

Should Foundation Stock Be Calves, Heifers, or Cows?—In developing a dairy herd by buying, at least three methods are available: namely, buying calves, buying heifers, and buying cows. The choice of the individual breeder will depend upon time, capital, experience, and other conditions.

The surest and quickest way to secure a high-producing herd is to buy cows with known records. This method, of course, requires a large amount of capital at the start. In most cases, however, it will be more economical than the buying of untried animals at a considerably lower price. The trouble with selecting cows by their conformation is that the conditions under which selection is made are often very unfavorable. Some cows are dry or well on in their lactation period, others are fresh; some are thin, others are fleshy; and so it is practically impossible to select animals in this manner and be sure that they will be high producers. This method must be followed in many cases, however, since cows with production records are few in number and a much higher price is usually asked for them than for those without records.

Perhaps the most common foundation animal is the heifer. The purchaser should obtain heifers at a lower cost than mature cows but would take chances on their being lower producers. By this method a greater number can be secured and, if good judgment is used in selection, the chance of getting a good producing herd is increased. Heifers can be purchased either bred or unbred. The unbred heifer, however, will not be as liable to carry the abortion germ as the bred heifer. When the purchaser does not have a good bull of his own he often prefers to have the heifers bred at the time of purchase. A breeder who is endeavoring to establish a name for his own sire usually prefers to buy unbred heifers.

The cheapest way of buying a herd is to purchase calves. In many dairy sections, especially in the market-milk section, high-grade calves can be purchased at a very low price. Pure-bred calves also can often be secured at a very nominal figure. This system requires more time, however, and the chance of getting high producers may be lessened, since it is difficult to judge the individuality of the young calf. The breeder of grade stock, with little capital, could start a pure-bred herd by buying one or more pure-bred calves each year.

Other Considerations

Breed to Choose.—One of the first questions which must be decided in establishing a herd is the choice of a breed. As a matter of fact, this decision is probably not so very important, as there is not very much difference in the efficiency of the various breeds. The dairyman should, however, decide at first which breed he wishes and then stick to his choice. If he has a common herd he should decide what breed will best fit his purposes, and then purchase a sire of that breed. The main factor to be considered is the market for the product. If he expects to sell market milk he should not choose the higher-testing breeds, such as the Guernseys or Jerseys, unless he intends to cater to a special trade which will pay for high-testing milk. The Holstein, Ayrshire, or Brown Swiss would usually be the choice, under ordinary conditions, for market milk. If, however, the market is for cream, butter-fat, or butter, the Jersey and Guernsey should be given consideration, although if the skimmilk has a value on the farm the Holstein might also be considered.

After considering the market, one should also give some weight to such other things as the breed most common in the neighborhood, one's own preference, the cost, and the probable demand for surplus stock; but usually the market for the product will be the deciding factor.

Grades Versus Pure-breds.—Only about 3 per cent of the dairy cattle in the United States are pure-breds. This means that the majority of dairymen are content with grades and that a very large part of the milk now produced comes from grade herds. Many of our grade herds have been bred up for many generations by the use of pure-bred sires, so that they are now, to all intents and purposes, as good as pure-breds. One generation with a pure-bred bull makes them half-bred; two generations, three-fourths pure-bred; three generations, seven-eighths pure-bred; and four generations, fifteen-sixteenths pure-bred. Such animals may be just as productive as pure-breds but they can never be registered as such.

When a dairy farmer becomes especially interested in livestock, he will prefer pure-breds to grades. Although, as has been shown, the grade animal in time could be developed so that she would be just as profitable, as far as milk production is concerned, as a pure-bred, it is impossible to register her progeny in the pure-bred herd books; and, generation after generation, the owner is just as far from having a pure-bred herd as he was at the beginning. It is usually desirable, therefore, for a breeder interested in pure-bred cattle to purchase a few good pure-bred animals and to replace the grades by pure-breds as rapidly as possible. All grades receive their good qualities from their pure blood. One should not lose sight of the fact, however, that all pure-breds are not good animals. The fact that an animal is pure-bred and is registered in a herd book does not mean that she will be any better as a producer than a good grade of the same breed. Pure-breds, on the average, may produce a little more milk or butter-fat than grades, as shown in the following table taken from the records of the New Jersey cow-testing association:[4]

TABLE LXV

COMPARISON OF THE PRODUCTION OF GRADES AND PURE-BREDS

	Number of Animals	Production per Cow		Feed Cost per Cow
		Milk Pounds	Butter-fat Pounds	
Pure-breds	576	8862	309	$132.62
Grades	598	7989	287	124.94

This table shows that pure-breds do not produce very much more than grades. The small advantage which they have may be partly due to better feeding and care.

An animal should be kept and bred only because of milk-producing ability, and it should be the aim of all pure-bred breeders to discard inferior animals and not to breed or sell them to other breeders simply because they are pure-breds.

A Standard of Production.—After selecting a herd, one should attempt to improve it. The breeder cannot hope to develop and improve his herd unless he has a standard of production, which means that every cow at a certain age must be able to produce a definite amount of milk or butter-fat. This definite amount must be at or above the lowest limit that is profitable under the given farming conditions. To illustrate, it might be that, under the prevailing prices in a community, a dairy cow at maturity, in order to be profitable, would have to produce 6000 pounds of milk or 250 pounds of butter-fat in a year. If a mature cow is unable to do this she should be disposed of. It is usually better, however, to keep her records during her first lactation period, as this period is a very good index of her mature production. If she is unable to produce 70 per cent of the standard set with her first calf, she should be disposed of and not kept at a loss until she reaches maturity. By constantly weeding out the low-producing cows, it is possible finally to raise the average production of the herd without buying new animals, assuming, of course, that at all times there is a good sire at the head of the herd—one whose daughters, on the average, will be better than their dams. By this method the standard can be raised from year to year.

Importance of Foundation Animals.—While, as has been noted before, great care should be taken in selecting the sire, yet it is also very important to select good foundation females. The success of the enterprise may depend upon the selection of good foundation animals. Of course, there is no way to know for certain how good an animal is as foundation stock, since much may depend upon circumstances over which the cow or breeder has no control. For example, two cows sired by the same bull were purchased at the West Virginia Experiment Station. They were both given the same chance, and both dropped four calves in the first four years they were in the herd. As it turned out, however, No. 99 dropped four heifers in that period of time, and her oldest heifer had dropped a heifer, making five females besides the cow herself in the herd. No. 98, however, dropped four bull calves and at the end of the period had no female offspring in the herd. There is no way of foretelling such results as these.

Every means of selection known, however, should be used, and all data should be gathered upon such characteristics as longevity, fecundity, and individual vigor.

Longevity.—We speak of a dairy animal as having longevity when it is able to live to a good old age and to continue to be a profitable producing animal. A dairy farmer is fortunate if his dairy animals live to an advanced age and reproduce animals with the same characteristics. It seems to be established beyond question that longevity is an inherited characteristic, and that many dairy cows are born to live much longer than others. At the Pennsylvania Experiment Station,[5] in the grade Guernsey herd, which was established in 1890, only 12½ per cent of the foundation animals were able to perpetuate themselves throughout a period of twenty-six years. The blood of 87½ per cent of the foundation animals disappeared during that period. It may be of interest to note the reasons for the disposal of the cattle in that herd. Table LXVI shows the reasons for disposal of the animals at this station.

Individual Vigor.—Vigor is undoubtedly closely related to longevity. Many animals, however, may be vigorous and profitable individuals in the dairy herd while they live, but may not last in the herd for a great number of years or perpetuate the same characteristics in their offspring. Although they are not profitable over a long series of years, yet during their own lifetime they are just as profitable as though they possessed longevity. The dairy farmer in selecting his individual animals, either at the foundation of his herd or annually, must not neglect to pay strict attention to the vigor of each one.

TABLE LXVI

REASONS FOR DISPOSAL OF ANIMALS AT THE PENNSYLVANIA EXPERIMENT STATION

	Number of Cows	Per Cent
Condemned *	15	5.9
Beef and old age	142	55.5
Barrenness	13	5.1
Tuberculosis	42	16.4
Lumpy jaw	2	0.8
Abortion	1	0.4
Died	23	8.9
No record	18	7.0
Total	256	100.0

* Records do not show why these animals were condemned—probably for tuberculosis.

Fecundity.—The character of fecundity seems to be an inherited one. Some cows seem to be shy breeders, and it often happens that such a cow passes on without leaving any female offspring in the herd. This may be due to the fact that her offspring do not possess longevity or individual vigor, or it may be due to the fact that the animal herself is a shy breeder or does not remain in the herd for a great length of time. Table LXVII, taken from Beam's study of the grade herd at the Pennsylvania Experiment Station, shows the value of the cow Handsome as a foundation animal.

Individuals like Sophia or her descendants should be selected for foundation animals. Sophia, her sister, her dam, and the sisters of her dam, all possessed longevity and were good breeders.

Another example of the importance of foundation animals was given at the Missouri Experiment Station.[6] A Holstein herd was founded at that station in 1902 by the purchase of four pure-bred Holstein heifers; and the entire herd, which now numbers more than fifty, are descendants of this original stock. No blood on the female line has been introduced since that time. One of the heifers purchased as a foundation animal freshened twice in the herd, dropping bull calves each time. She proved to be an unprofitable producer, and, after being given ample opportunity, she was sold for beef. For this reason she left no offspring in the herd. Such a cow would make a poor start for any beginner.

TABLE LXVII

DESCENDANTS FROM ORIGINAL COW, HANDSOME, IN THE PENNSYLVANIA EXPERIMENT STATION HERD

- Handsome....Purdie....
  - Sis.......
    - Niobe.........357
    - Sophia *....
      - 525*
      - 457*
      - 491
      - 615*
    - 337*........
      - 581*
      - Jolly
      - Jezebel
  - Jess........Jet
  - Tease....
    - Tess........
      - 420
      - 579*
    - Titia
    - Tillie

* In herd at time of survey.

A second heifer remained in the herd until she was fourteen years old and left three heifers in the herd. At the present time she has eighteen female descendants in the herd and might be termed an average cow, although very few of her descendants have been outstanding animals.

A third heifer remained in the herd for only two years, when she was condemned as tubercular. She left but one daughter, Missouri Chief Josephine, a cow that later won fame as the highest milk-producing college-owned cow and the second highest producer in the world. While Missouri Chief Josephine was an exceptionally high producer, and while a son of hers later wielded a considerable influence in the herd, yet the female line from her is almost extinct. Only three of her female progeny are left and they are only mediocre animals. This shows that it is never safe to put all your faith in an individual performer.

The fourth heifer, however, has had a very great influence in the development of the herd. She died with a wire in her heart at the age of five years, but in this time left three daughters in the herd. They were all high producers and good breeders, and each left five daughters in the herd. There are now three cows of the eighth generation in the herd, and not a single generation has failed to develop a number of outstanding animals. There are at present twenty-nine female descendants of this cow in the herd. Such a cow as this would be

FIG. 60.—A factor in health—dairy cows housed in an open shed.

valuable as a foundation in any herd. Table LXVIII shows her descendants.

Effect of Housing on Longevity and Thrift.—Realizing the importance of longevity and thrift in dairy animals, several investigators have attempted to find out the effect that housing has upon these qualities. It is known that a higher percentage of the cows in the northern states, where the barns are more closely built, react to the tuberculin test than those in the states farther south, where the cows remain out for the greater part of the time and the barns are not built so tight. It has been recommended that young stock be housed in open sheds. Even dairy cows have been successfully housed in open sheds at the Pennsylvania Experiment Station[7] and at the Maryland

TABLE LXVIII

Descendants of No. 201 in Missouri Experiment Station

- 201
  - 206
    - 215
      - 228
        - 247
          - 259....500....524*
          - 271....509*
            - 529
            - 556*
        - 239
        - 256
      - 265....292....519
    - 212
    - 221....232
    - 242
      - 267
        - 285*
          - 541
          - 518*
            - 563
            - 547
          - 527*...551
          - 568*
        - 501
      - 276....513
      - 283
    - 214
  - 209
    - 227
      - 238....280
        - 504
        - 534
      - 249....278*
        - 544
        - 522....551
        - 559*
        - 567
      - 272
      - 257....282
    - 295
    - 273
      - 296
      - 297
    - 261
    - 251
      - 287....512*
      - 510*
        - 557*
        - 528
        - 564*
  - 210
    - 294
    - 263
    - 279*
      - 503*
        - 535
        - 569*
        - 520*
      - 533
      - 546*
    - 226....236
      - 275*
        - 542
        - 506
          - 532
          - 545
          - 564*
        - 511*
        - 530 ...555*
      - 286
        - 521*...550
        - 531*
      - 250....288*...526*
    - 220....235....260....299

* In herd at time of survey.

Station,[8] but no studies have been made as to whether longevity and thrift will result from such methods. It was found that it required slightly more feed to produce the same amount of milk in open sheds than when the animals were housed. The total amount of milk produced, however, was not much different under the two conditions. If a milking room is provided wherein the cows can be turned during milking, the discomfort of milking in the open can be avoided.

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LECTURE XXIV

KEEPING RECORDS ON THE DAIRY FARM

Necessity for Keeping Records.—A successful business establishment always has a system of keeping records of transactions. Business cannot be conducted efficiently without such methods. This is just as true of the dairy business as it is of any other. A dairyman who does not have a fairly accurate record of the amount of feed given to the cows in his herd, and of the amount of milk and butter-fat which they produce, is certainly not conducting his business upon the most efficient basis.

The actual time required to keep such records is much less than might at first be expected. Their value is clearly seen when it is realized that the selection of the herd for improved production is based upon the results of records. Cows should be valued largely by the amount of milk and butter-fat that they produce. Other factors, such as regularity in breeding and ability to produce offspring of equal or greater producing power than the dam, should also be considered in placing a value on a cow. Unless accurate records are kept, the best cow in a herd is likely to have equal rank with the poorest, at least in the mind of the owner.

Preservation of Permanent Records.—One essential of records is that they be simple, though they should contain all necessary information. Many dairymen have become discouraged in the keeping of records because too complicated a system was inaugurated. As many records as possible should be final and not require copying. This is not possible with all forms of records, however.

There are three general methods of preserving records. Individual conditions will determine which one is best suited to each case. Records may be kept in any of the following ways:

1. In books with permanent leaves.
2. In loose-leaf books or files.
3. In envelopes.

There are advantages in using books with permanent leaves for some records, while the loose-leaf books, files, or envelopes are better for others. For breeding records, the permanent-leaf book has the advantage of being safer, as the separate pages cannot be lost; but it is cumbersome, as old records must be handled frequently and exposed to the danger of being lost in case of the loss of the whole book. The loose-leaf records, however, may be divided and only those records that are in use at a particular time need be kept at hand, while the records that are used only for reference, such as those of cattle that have gone out of the herd, can be put away for safe keeping. The loose-leaf records also have the advantage that all the data relating to an individual animal may be kept together so that when it is desired to get any information upon a certain cow all of such information will be together in one book. The files have the same advantages as the loose-leaf book, but are not so easily carried around, nor are they so convenient to handle.

When the envelope system is used, one envelope is provided for each cow, and in that envelope all records pertaining to the cow are kept. This system is not as convenient as some of the others, but is often used for the filing of registration and advanced-registry papers.

Kinds of Records.—There are several kinds of records which may be kept on the dairy farm. Some of them are more important to the pure-bred breeder than to the breeder of grade animals. The record of production should be kept by all dairymen, however.

The important records to be kept are as follows:

1. Production records.
2. Feed records.
3. Breeding records.
4. Health records.
5. Growth and weight records.

Production Records

If one is to know the production of individual cows, there are two things which must be ascertained, namely, the pounds of milk produced, and the percentage of fat in the milk. From these the pounds of butter-fat can be calculated. It is important that both the pounds of milk produced and the percentage of fat in the milk be known. However, if it is possible to ascertain but one of these, the pounds of milk is much the more important. The variation between individuals is from two to five times as great in milk yield as in fat percentage. It has been found that the milk yield will usually bear a very close relationship to the butter-fat yield. The high-testing cows are not always the best cows. The mere fact that a cow has a high butter-fat test in no way determines that she is a profitable cow. A high test along with high milk production insures a good cow; but the high test may just as readily be accompanied by a low milk yield, and

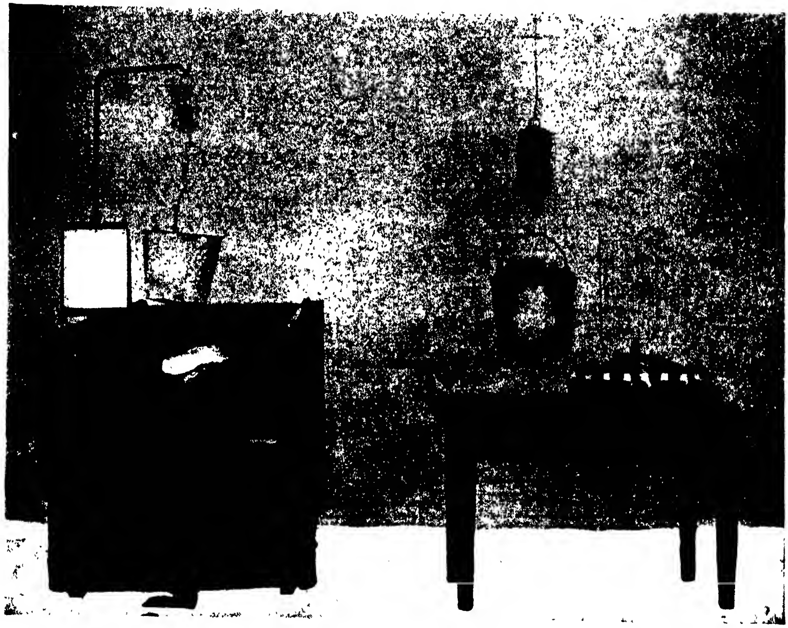


Fig. 61.—Apparatus for the determination of profit and loss of each cow in the herd.

in that case the cow may be an unprofitable one. Within a herd there is but little relationship between the percentage of fat in the milk and the total milk yield. However, it is always wise, when possible, to secure a test on the cows along with the milk production. This is particularly true when the milk is being sold upon a butter-fat basis, so that an exact account can be kept with each cow.

Reasons for Keeping Production Records.—The first reason for keeping accurate production records is that such records show the production of the individual cows and this may enable the dairyman to discard those that are not paying a profit and to keep the calves from those of high production. As has been brought out before, there is a vast difference in the inherent ability of different cows to produce milk. One cow may produce three times as much milk or butter-fat as another, on one-third to one-half more feed. One cow may be causing the dairyman to lose as much money as another in the next stall is making for him. Cows that do not produce a profit are known as "boarder cows." Without records of production, it is practically impossible to pick out the boarder cows from those that are yielding a good income. Milkers often believe that they can tell a good producer from a poor one without keeping records of production, but this has not proven to be true. Often those selected as the best turn out to be the poorest, or the ones selected as the poorest prove to be the best. It is the production for the year that determines the value of a cow, not the quantity she may give for a few months. In order to determine her true value she must be fed and cared for throughout the entire year. Herd records show that cows that produce a moderate amount of milk persistently are usually more profitable than those that milk heavily for a few months but are dry for a large part of the year. It has been found that practically one-third of the cows in the ordinary herd are unprofitable. The milker is more likely to remember how easy a cow is to milk and how much she gives when she is fresh than how many months she will milk before going dry. It is necessary, then, to determine the actual amount of milk and butter-fat that a cow produces during the year, as well as the actual amount of feed she consumes, in order to keep a complete financial balance with each cow.

Another reason for keeping a record of the milk production of the individual cow is in order to feed her properly. In a previous lecture it was stated that cows should be fed according to their production. In order to do this it is necessary to know what the individual cow is producing. Feeding by guess is always wasteful. By the use of the milk sheet, a feed chart can easily be made up at intervals and the amount fed to each individual cow can be based upon her production.

The third reason why daily records of production should be kept is that they enable the herdsman to detect any abnormal condition which may at any time occur in the herd. Often a cow suddenly becomes indisposed. The milk sheet will tell this to the herdsman at a glance. Otherwise the indisposition might go unnoticed until it developed into a serious sickness. The daily record also serves to call to the attention of the herdsman the ability of the different milkers and makes it possible to pick out those that are careless and indifferent.

A fourth reason for the use of a milk sheet is to keep up the interest of the milkers. The records of production often add considerable interest to the otherwise monotonous job of milking. The milkers and feeders are able to watch the variations on the milk sheet and will attempt to feed and milk in such a way that the production will increase, especially for those cows in which they are especially interested.

Equipment Necessary.—The equipment needed for keeping daily production records is a good spring balance, a milk sheet, and a Babcock milk-testing outfit. Besides these, some form of permanent record of production should be provided.

Scales or Balances.—A good scale to use for weighing milk is one in which the dial is divided into pounds and tenths. This style of balance is provided with a pointer which can be adjusted to stand at zero when an ordinary milk pail is hung on it. This enables the weight of the milk contained in the pail to be read directly. The scale should be hung at some convenient place near where the milker must pass in order to strain his milk.

Milk Sheet.—Close to where the scale is hung, a place for the milk sheet should be provided, so that as soon as the milker ascertains the weight of the milk, he can easily put it down on the milk sheet. The milk sheet should be fastened on a firm, smooth wall or board especially provided for the purpose. Special holders for sheets have been devised, and are especially valuable when they are provided with a movable shield to protect the record from being soiled.

Sometimes sheets for recording the milk production for one week are used, but usually a monthly sheet is preferred. This may vary considerably in detail, but Form A is a convenient one to use. Form B shows a sheet arranged for seven days. This form is used more often in large or experimental herds where the record of production is desired at frequent intervals. Form A, however, may have spaces for ten days' totals, which can be further added so that the monthly total can easily be ascertained. In the ordinary dairy, the monthly sheet without ten days' total is commonly used. These sheets can be made in any size to accommodate from five to thirty cows. The time required to weigh the milk and record it on the milk sheet need not exceed one-half minute[1] for each cow at each milking, and the value of the record obtained is worth that amount of time many times over.

Adding the Milk Sheet.—By totaling the milk produced by each cow during the month, her monthly production may be secured. This, however, where one does not have access to an adding machine, is a tedious task. Under such circumstances, it has been found that fairly accurate results may be obtained by adding three days of the month, say the fifth, fifteenth and twenty-fifth, dividing the total by three, and multiplying this by the number of days in the month. The days selected should always be well distributed throughout the month. This will give a very accurate yield for the month. Even when using this system, however, one should weigh the milk for each milking because of the many other advantages which will accrue from this habit.

Obtaining the Percentage of Fat and Pounds of Fat.—Samples for testing for butter-fat should be taken at least once a month. The sample should represent at least twenty-four hours, and better forty-eight hours, of complete milking, and should be taken at fairly regular intervals.

The essential feature in taking samples of milk for testing is to obtain milk which will be representative of the whole lot. The milk should be thoroughly mixed by pouring from one vessel to another several times, after which the sample should be taken immediately. The sample should be put in a bottle, and a small amount of preservative, such as corrosive sublimate or formalin, should be added.

After the samples have been tested by the Babcock test, the percentage of fat in the milk is known. The total number of pounds of milk which a certain cow has produced during a month, multiplied by the percentage of fat in the milk, will give the total number of pounds of butter-fat which that cow has given during the month.

The Permanent Record.—After the total amounts of milk and butter-fat for a month have been obtained, they should be put in a permanent record of some kind. Form C gives an example of such a record. It will be noted that this form is arranged so that each cow has a page and that the record can be tabulated for each lactation period. After the lactation period is finished the record can be totaled—not only for the lactation period, but also for a yearly record. An individual may also use a regular cow-testing association book for keeping such records. A page of such a book is shown in Form D. The man with a small herd, or the one who is just beginning, may use any simple note book. The main thing is to have some permanent place to keep the records so that they may be kept in a neat and convenient form.

Method of Calculating Herd Averages.—Several different methods of calculating the herd average are now in use. There is need of a standard method so that whenever the herd average is given it will always mean the same thing. The method suggested here was devised by Becker[2] and has been given the name "Lactation average" method. It includes all lactating cows and heifers but bases their records upon the length of the average lactation period of the normal cows in the herd instead of the number of feeding days or cow months, and calculates the remaining part-time producers according to the normal length of lactation of the herd cows.

To illustrate, Becker used an actual herd owned by a member of a cow-testing association. The following table gives the record of this herd:

TABLE LXIX

CALCULATING THE HERD AVERAGE OF A HERD OF DAIRY COWS

Cows in Herd During Entire Year

Number of Cow	Notes	Days in Milk	Feeding Days	Milk	Fat, Pounds
2	Grade H	321	365	10,217	408.8
3	Grade H	347	365	10,069	357.9
4	Grade H	281	365	6,452	257.7
5	Grade H	334	365	7,726	307.9
6	Grade H	303	365	8,612	294.8
8	Grade H	321	365	9,027	296.7
9	Grade H	349	365	11,199	439.1
10	Grade H	324	365	11,758	415.9
11	Grade H	319	365	9,468	345.7
17	Grade H	279	365	6,319	237.4
18	Grade H	202	365	5,367	217.6
D	Reg. H	334	365	10,732	374.3
E	Reg. H	312	365	10,019	364.5
J	Reg. H	303	365	8,480	313.1
Cows in Herd Part of Year					
1	Culled	133	133	2,449	71.4
7	Culled	dry	95		
12	Died	228	228	4,552	157.8
16	Died	304	304	7,132	333.7
19	Culled	123	140	2,163	107.1
20	Heifer	172	172	5,002	194.4
21	Heifer	165	165	4,671	158.7
22	Heifer	158	158	4,544	147.9
23	Died	67	67	2,498	84.6

Fourteen cows were in this herd for the entire year.

" They averaged 309 days in milk. Considering 309 days as the length of a normal lactation period in this herd, it is found that the nine cows of producing age in the herd only part of the year, are equivalent to 4.37 cows in milk 309 days. In other words the herd production for the year represents the work of 18.37 full lactation periods of 309 days each (representing present methods of breeding management in the herd). Based on 18.37 full lactation periods the lactation-average-production would be 8621 pounds of milk and 320.5 pounds of butter-fat.

" The lactation-average method, as devised, is not above criticism. It assumes that in this particular herd, the part-time producers would average 309 days in milk. This is only approximately true. The three heifers are credited with the highest part of their lactation period. Two of the cows were culled at the close of their lactation period, offsetting to some extent the three heifers. Three cows died from various causes during the year. One cull was fattened and slaughtered for beef but was not in milk during the fiscal year."

This method has many advantages and should be adopted more widely.

Feeding Records

To know how much profit a cow is making, it is necessary to know not only the production of the cow but the amount of feed which she has consumed as well. It is also necessary, especially in large herds, to have some form on which to put down the amount of feed that each cow should receive. It is almost impossible for any individual to carry in his head the amount of feed that should be given to each individual cow. Usually such a record should be changed at weekly intervals but sometimes it is arranged to run for ten days or even two weeks. Form E is one that has been used successfully. This should be filled out according to the production of the individual cows and should be fastened to the feed cart or near the feed bin. The amount of grain given on the sheet should be carefully weighed at each feeding. The roughage need not be weighed at each feeding but should be weighed at least once a month so that some idea of the amount will be obtained.

It is a good plan to number each definite grain mixture that has been fed to the herd. A permanent record of these mixtures should then be kept so that the number of the mix may be put on the feed sheet. In this way a definite record will always be kept.

At the end of the month the amount of feed consumed may be totaled and put in a permanent record as shown in Form F. Such records are sometimes kept in the regular cow-testing association book along with the milk records, as shown in Form D. At the end of the year the total cost of the feed which each individual cow has consumed can easily be calculated.

Calf feeding requires a somewhat different form, since calves are fed whole milk, skimmilk, grain, and hay. These can easily be made to conform to the conditions.

Breeding Records

Every cow should be given several weeks of rest before freshening in order that she may be in shape for her best production before the next lactation. Unless the exact date that each cow is due is known, some cows will be milked too long while others will be turned dry too soon. It is also important to know the exact date of freshening so that the cow may be fed and cared for properly before and at the time of freshening. It is very important, then, that a breeding record of some sort be kept.

Since the herdsman does not always keep the books, it is sometimes necessary to have him report in order to get the necessary information on record. His report should be simple but complete. Form G is one that can be used successfully. The herdsman should put down at once the date, the cow bred, and the bull to which she has been bred. This report should then be kept in a safe place until it can be entered in a permanent record.

Form H is for the permanent record. This form also has a place for the date of birth of the calf, its sex, weight, name, and disposal. The reverse side of the sheet can be provided with pedigree and identification marks to be used especially in pure-bred herds. This is shown in Form I. It is well to put in the breeding record each breeding date so that it can be seen when a cow is a slow breeder or when she becomes sterile.

FORM A

MONTHLY MILK SHEET

FEED ACCORDING TO KNOWN PRODUCTION. WELL-KEPT RECORDS TAKE THE GUESSWORK OUT OF DAIRYING

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF DAIRYING

USE A HIGH-CLASS PUREBRED DAIRY BULL. COMPARE THE RECORDS OF HIS DAUGHTERS WITH THOSE OF THEIR DAMS

DAILY MILK AND FEED RECORD FOR MONTH OF __________, 192__

Owner of herd, __________; *Post Office,* __________; *State,* __________

NAME OR NUMBER																							REMARKS
1	A. M.																						
	P. M.																						
2	A. M.																						
	P. M.																						
3	A. M.																						
	P. M.																						
4	A. M.																						
	P. M.																						
5	A. M.																						
	P. M.																						
6	A. M.																						
	P. M																						
7	A. M.																						
	P. M.																						
8	A. M.																						
	P. M.																						
9	A. M.																						
	P. M.																						
10	A. M.																						
	P. M.																						
11	A. M.																						
	P. M.																						
12	A. M.																						
	P. M.																						
13	A. M.																						
	P. M.																						
14	A. M.																						
	P. M.																						
15	A. M.																						
	P. M.																						
16	A. M.																						
	P. M.																						
17	A. M.																						
	P. M.																						
18	A. M.																						
	P. M.																						
19	A. M.																						
	P. M.																						
20	A. M.																						
	P. M.																						
21	A. M.																						
	P. M.																						
22	A. M.																						
	P. M.																						
23	A. M.																						
	P. M.																						
24	A. M.																						
	P. M.																						
25	A. M.																						
	P. M.																						
26	A. M.																						
	P. M.																						
27	A. M.																						
	P. M.																						
28	A. M.																						
	P. M.																						
29	A. M.																						
	P. M.																						
30	A. M.																						
	P. M.																						
31	A. M.																						
	P. M.																						

Total pounds milk.																						Prices of dairy products:
Test (per cent butterfat).																						
Total pounds butterfat,																						
Value Whole milk, Butterfat.																						
Value skim milk.																						
Total value of products,																						

AVERAGE DAILY FEED RECORD

Pounds.																						Prices of feeds:
Pounds.																						
Pounds.																						
Pounds																						
Pounds.																						
TOTAL COST OF FEED																						
INCOME ABOVE COST OF FEED.																						

Form A - Monthly Milk Sheet

To face page 281.

This form of record, while important with grades, is almost necessary where pure-breds are kept, as breed associations require the date on which the animal was bred, when registering it. As soon as a pure-bred calf is born, it is necessary to take the requisite steps to have it registered.

Health Records

It is often desirable to have a record of the health of the herd. This may be included in the herdsman's report and can become a part of the permanent record, as shown in Form J. This includes a place for the tuberculosis test, the abortion test, and the general health. Often, by a study of the health record of an animal, the reason for an unexpected result may be explained.

Growth and Weight Record

It is often advantageous, especially with young animals, to keep a record of growth. This may consist of the weight of the animal or its height at withers or both. By this means one can tell whether an animal is growing normally. With mature animals, the weight is of more importance. If the animal is below weight, she can be fed so that she will return to normal. The best place to keep such a record is with the feed record, as shown in Form F.

Inventory

Of all the records kept on the farm the inventory is the most valuable from the standpoint of keeping posted concerning the profits. In the case of fire or loss in any other way of animals or apparatus, an inventory is often of great assistance. The inventory, together with the bank balances at the beginning and end of any period, is sufficient information from which to calculate the profits.

For the inventory, a sheet with the items at the left side of the paper and several columns at the right is a good form. Opposite each item is placed the number or quantity of times, and in the first column, its value. The different columns are used for consecutive years. Such a sheet shows at a glance the relative value of each item year by year.

FORM B

WEEKLY MILK SHEET

DAIRY HUSBANDRY DEPARTMENT

THE PENNSYLVANIA STATE COLLEGE

Milk Record for Week Beginning.................................191.... Milked by...

NAME OR NUMBER																													
DATE		LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH	LBS.	10TH
	A. M.																												
	P. M.																												
	A. M.																												
	P. M.																												
	A. M.																												
	P. M.																												
	A. M.																												
	P. M.																												
	A. M.																												
	P. M.																												
	A. M.																												
	P. M.																												
	A. M.																												
	P. M.																												
Total for week																													
Per cent. Fat																													
Pounds Fat																													

Remarks

Week Beginning.................................191.. Page...............

FORM C

PERMANENT RECORD FOR KEEPING MILK AND BUTTER-FAT PRODUCTION OF INDIVIDUAL COWS

WEST VIRGINIA UNIVERSITY COLLEGE OF AGRICULTURE

DAIRY DEPARTMENT—MILK AND BUTTER FAT RECORD

Name *No.* *Herd No.* *Breed*

Year..................															
For Month of	Lbs. Milk	% Fat	Lbs. Fat	Lbs. Milk	% Fat	Lbs. Fat	Lbs. Milk	% Fat	Lbs. Fat	Lbs. Milk	% Fat	Lbs. Fat	Lbs. Milk	% Fat	Lbs. Fat
January................															
February..............															
March................															
April................															
May..................															
June.................															
July.................															
August...............															
September............															
October..............															
November.............															
December.............															
January..............															
February.............															
March................															
April................															
May..................															
June.................															
July.................															
August...............															
September............															
October..............															
November.............															
December.............															
Yield per Period........															
Number of days in Milk.															
Record 365 Days.......															
Age at Start Test.......															

FORM

RECORD OF INDIVIDUAL COW AS

Individual Cow Record

Cow's name and number .... *Breed* .... *Age* ....

Testing period from ...., *192* , *to* ...., *192* *Months on test, including dry period* ....

Cow's sire { *Name* .... *Is sire purebred?* ....
Number .... *Is sire a bull-association bull?* ....

TESTING PERIOD	Testing day	Number of days in testing period	Pounds milk daily	YIELD DURING TESTING PERIOD						FEED CONSUMED DURING					
				Pounds milk	Average test	Lbs. butterfat	Price {Milk / Butterfat}	Value of product		Succulent roughage		Dry roughage			
								$	c.						
Total to date															
Total to date															
Total to date															
Total to date															
Total to date															
Total to date															
Total to date															
Total to date															
Total to date															
Total to date															
Total to date															

BREEDING RECORD OF COW

DATE BRED	NAME OF BULL USED	PUREBRED?

RECORD OF CALVES BORN DURING YEAR

Date of birth ....
Sire ....
Sex ....
Raised or sold ....
For what purpose ....
Selling price ....

D

KEPT IN COW TESTING ASSOCIATIONS

Individual Cow Record

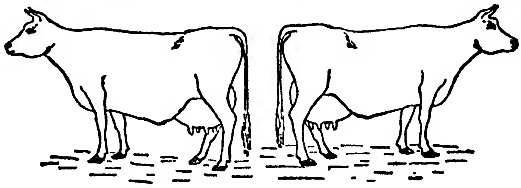
Weight ______ *Date fresh before testing year* ______ *Date bought* ______
Date dry ______ *Date fresh during testing year* ______ *Date sold* ______ *Died* ______

Cow's dam { *Name* ______ *Number* ______ } *Yearly record of dam* { *Pounds milk* ______ *Pounds butterfat* ______ } *Age of dam when tested, yrs.* ______ *Is the dam purebred?* ______ *Number of months in milk* ______

TESTING PERIOD						Days on pasture	Cost of pasture	Cost of roughage, including pasture		Cost of grain		Total cost of feed		Value of product above cost of feed		Value of product below cost of feed		REMARKS
Concentrates																		
								$	c.	$	c.	$	c.	$	c.	$	c.	

DESCRIPTION OR DISTINGUISHING FEATURES OF COW

______
______
______
______
______



FORM E

BI-MONTHLY FEED SHEET

West Virginia Agricultural Experiment Station

Number of Cow	Date											192
	Grain Ration No......			.........Hay			Silage			Beets or Beet Pulp		
	A.M.	N.	P.M.	A.M.	N.	P.M.	A.M.	N.	P.M.	A.M.	N.	P.M.

FORM F

PERMANENT FEED-RECORD BLANK

West Virginia University College of Agriculture

DAIRY DEPARTMENT—FEED AND GROWTH RECORD

Name *No.* *Herd No.* *Breed*

Month	Weight, Lbs.	Height, C. M.	Whole Milk, Lbs.	Skim Milk, Lbs.	Ration No.	Grain, Lbs.	Hay, Lbs.	Silage, Lbs.	Beet, Lbs.	Pasture Days	Weight, Lbs.	Height, C. M.	Ration No.	Grain, Lbs	Hay, Lbs.	Silage, Lbs.	Beet, Lbs.	Pasture Days	Weight, Lbs.	Height, C. M.	Ration No.	Grain, Lbs.	Hay, Lbs.	Silage, Lbs.	Beet, Lbs.	Pasture Days
January																										
February																										
March																										
April																										
May																										
June																										
July																										
August																										
September																										
October																										
November																										
December																										
Total																										
January																										
February																										
March																										
April																										
May																										
June																										
July																										
August																										
September																										
October																										
November																										
December																										
Total																										

FORM G

BLANK FOR HERDSMAN'S REPORT

WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

HERDSMAN REPORT

DATE________________

	NUMBER	BULL		
COWS BRED				
		SEX	WEIGHT	REMARKS
COWS CALVED				
		DISEASE	TREATMENT	
COWS SICK				

	BOUGHT	PRICE	SOLD	PRICE
MATERIAL				
	BORROWED	BY WHOM	RETURNED	TO WHOM

REMARKS: ________________

SIGNED________________

FORM H

PERMANENT BREEDING RECORD

WEST VIRGINIA UNIVERSITY COLLEGE OF AGRICULTURE—DAIRY DEPARTMENT

Name H. B. No. Herd No. Born 19

Sire H. B. No. Color

Dam H. B. No. Sex

Bred by P. O. Breed

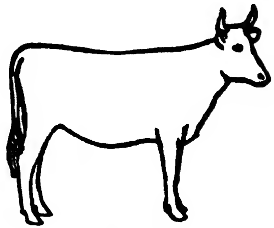
Date Bred	Sire	No.	Date Due 285 Days	Date Born	Weight at Birth	Sex	Name of Offspring	No.	Disposition

FORM I

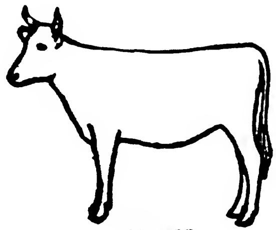
PEDIGREE BLANK FOR HERD BOOK

PEDIGREE OF______________________________ **H. B. No.**__________________

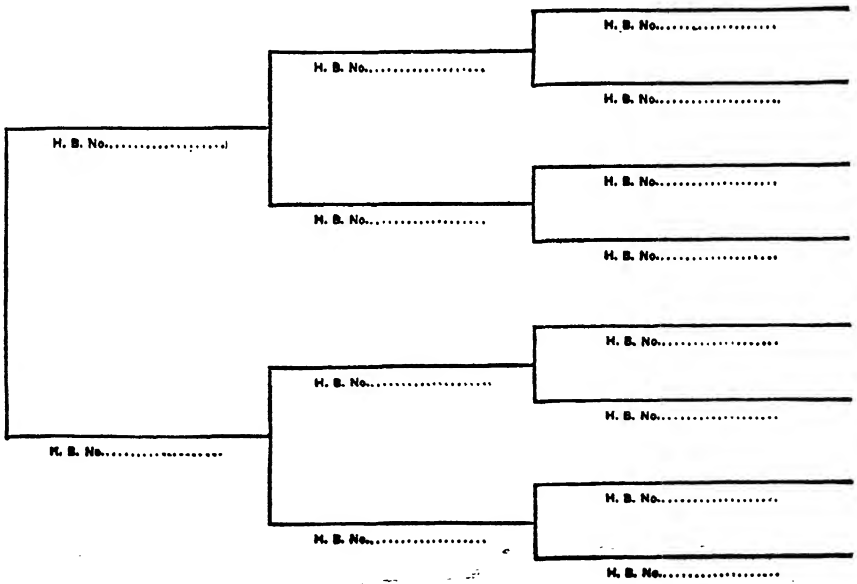
DATE OF BIRTH______________________ **BREED**________________________



RIGHT SIDE



LEFT SIDE



FORM J

HEALTH RECORDS FOR PERMANENT RECORD BOOK

WEST VIRGINIA UNIVERSITY COLLEGE OF AGRICULTURE

DAIRY DEPARTMENT—HEALTH RECORD

Name No Herd No. Breed

Tuberculosis Tests		General Health				
Date	Results	Date	Disease	Treatment	Duration	Effect
Abortion Tests						
Date	Results					

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3. Milk Testing in Practice, Jones and Wright, S. D. Exp. Sta. Bul. 197.
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LECTURE XXV

PRODUCTION RECORDS

Cooperative Cow-Testing Association

While the individual dairyman, by using the method outlined in the preceding lecture, can successfully keep production records with his own herd, this has not been a very general practice, because on most dairy farms other work often interferes with a systematic and regular keeping of the records. In certain seasons of the year, especially during harvest, the testing is very likely to be neglected and the work will go undone. Furthermore, the testing and the keeping of records entail a considerable amount of figuring, and usually it will be put off until it becomes so great a task that it is never done. For these reasons many dairymen prefer to have this work done for them, and so the cooperative cow-testing associations have been developed.

History of Cooperative Cow Testing.—The first cow-testing association was organized in 1895 in Denmark, where it rapidly grew in popularity. It spread throughout Denmark and other Northern European countries until hundreds of such associations were formed. It has been stated that these associations more than anything else are responsible for the rapid development of dairying and the improvement of the dairy cows in these countries.

The first cooperative cow-testing association in this country was started in Fremont, Michigan, in 1905. Helmer Rabild was largely instrumental in getting this association started and was its first tester. The number of associations has grown quite rapidly and in 1927 there were 837 in the United States.

Method of Organization.—The cow-testing association, as ordinarily conducted in this country, is an organization of about twenty-six dairymen who cooperatively employ a man to keep a milk production record of their cows and to test them for production of butter-fat. As a tester can ordinarily test only one herd a day, the twenty-six dairy herds furnish employment for each working day in the month.

The cost of conducting such tests varies considerably. In some places the cost is based upon the number of cows which a man has to test, while in other places it is on a per diem basis. The dairymen usually furnishes room and board for the tester while he is at his farm.

The Tester and His Duties.—The man employed to make the tests is called " the tester " of the association. Upon his personality and ability the success of the association largely depends. He should be a man who is congenial and trustworthy; he should know how to figure the cheapest and best rations for a particular locality. He must know how to test accurately for butter-fat, and be able to keep correct records. Above all, he must be industrious, accurate, and neat. The job is not an easy one, if it is well done. A good tester will do more than give a man a record of his cows.

Routine of Tester.—The tester arrives at the farm, usually before the evening milking. He weighs both the grain and the roughage given to each cow and also the milk produced by each cow. These weights are recorded, and a sample of milk from each individual cow is taken and put away until the following morning. The next morning he again weighs the feed and milk, and takes another sample of milk. These two samples are poured together and all the samples are tested. The data are then recorded, and the record of production for the month is calculated for each cow, this one day being used as the average. This is recorded in the cow-testing book, which contains a page for each cow as shown in Form D. The tester makes suggestions as to the improvement of the feeding, if he can, and gives whatever other assistance may be shown to be desirable by the results of his observations.

With this record of the production and feed for one day repeated each month, the tester at the end of the year can furnish complete information about each cow. The amount of milk and fat produced during the year, the amount of feed eaten, its cost, and also the returns from each animal are computed, as well as the cost of producing 100 pounds of milk, the return for each dollar's worth of feed, and the profit or loss above feed cost.

Number of Cows Tested.—While this method of testing is being adopted quite rapidly, yet only a very small percentage of the cows in the country are being tested. Less than 2 per cent of the cows in the United States are now under test. In California the percentage is as high as 10, but in many of the states less than 1 per cent are being tested.

Value of Cooperative Testing.—Besides the very great importance of knowing the production of each cow, the richness of her milk, and

FIG. 62.—A "boarder cow." The owner of this cow milked her twice a day, fed, housed and cared for her for a whole year for $6.80. (*Sloan.*)

FIG. 63.—A profitable cow. This cow was kept in the same herd as the "boarder" (Fig. 62) and handled and cared for in the same way but returned a profit of $45 above feed cost. (*Sloan.*)

the amount of feed she eats to produce it, there are a number of other reasons why dairymen should cooperate. Dairymen, and other farmers for that matter, seem to lack the spirit of cooperation. Instead of working together to promote the industry in the entire community, they do their work separately. This is a mistake. A breeder of high-class cattle is at a disadvantage in a community where his neighbors are not also breeders of good animals. In general, the best herds and the most prosperous dairies are in localities where the farmers have cooperated and where there are many breeders of good animals in the same community. The cow-testing association enables neighbors to work out these problems and difficulties together. Where there is a cow-testing association, it is easier to select cows for what they are worth than in communities where records are not kept.

The main reasons why cow-testing associations are valuable are the following:

1. The "boarders," or unprofitable cows, can be found and sold.
2. Calves from the good cows can be kept to form the future herd, making improvement of the herd much more rapid.
3. More intelligent feeding can be done, as each animal can be fed according to her production. Also, help can be secured in forming good rations.
4. Bulls that are producing good offspring can be located and kept in active service as long as they will breed.
5. The value of the best cows will be increased. Cows with good records will usually sell for considerably more than similar cows without records.
6. The herd will get better care, as invariably when a man begins testing he gives his cows a little better attention.
7. Community interest in better livestock may be aroused, with widespread effects.

Advanced Registry Testing

When the breed associations were started, the fact that a pure-bred animal was registered with them was considered an evidence of superiority. However, after several years of registering in this manner, it became apparent that the law of variation operated in pure-bred herds just as it did in grade or scrub herds. The result was that the associations registered many inferior animals. At that time many large private records were reported by various breeders, but the word of the breeders was the only check on their accuracy. For these reasons the various breed associations conceived the idea of having a registry of dairy cows based entirely upon the individual merits of the cow, and of making the records official by having them supervised by some disinterested party.

The first of these systems in this country was established by the Holstein-Friesian Association of America in 1885. The other breed associations, seeing its possibilities, soon organized systems of their own; the American Guernsey Cattle Club in 1901; the Ayrshire Breeders' Association in 1902; and the American Jersey Cattle Club in 1903. The last-named association called their registry the Register of Merit, while the others are called Advanced Registry. Later, the Brown Swiss Breeders' Association organized a Register of Production; the Shorthorn Breeders' Association, a Record of Merit; and the Red Polled and Dutch Belted, an Advanced Register. These are all conducted in very much the same manner and differ only in name and in requirements. Because of the cost of making these tests, the growth of such associations was naturally slow at the beginning, but after the public was educated to the fact that milk production and butter-fat production are inherited characteristics, such work became popular. To-day it is difficult to sell pure-bred individuals for a good price unless they or their ancestry have been entered in the Advanced Registry.

Kinds of Tests.—Two general terms are applied to Advanced Registry tests. These terms, however, are not used with the same meaning by different associations. In all except the Holstein-Friesian Association, the term " official " is used when a test has been checked or supervised by an official appointed for that purpose. With the Holstein-Friesian Association, however, only the records made while the supervisor is present are called official, those tests made at intervals being known as semi-official.

Tests are also classified by the length of time for which they continue. For instance, there are seven-day, thirty-day, 305-day, and yearly tests. The 305-day tests also have a calving requirement. The short-time tests have been gradually giving way to those extending over longer periods. The Holstein-Friesian Association is the only one now that recognizes the short-time test. The 305-day test with a calf within fourteen or sixteen months is the most popular at the present time.

With the long-time tests, the supervised period varies from one to two days a month, besides one preliminary milking for observation to see that the cow is milked dry. The fat test during this period forms the basis for calculating the fat production, and the weights of milk are used to check the weights obtained from the owner. The owner's weights are used for other days when they are reasonably near the weights reported by the supervisor.

The Supervision of Tests.—In order to make the tests of the various associations of equal value to the public, all tests within the state are supervised by the state agricultural experiment station. If a breeder desires to test he should first get in touch with the breed association and then with the dairy department of the state experiment station.

Objections to Short-time Tests.—The objection has been raised that the short-time test does not represent the real worth of an animal. A cow can be so fed before freshening as to give abnormally high percentages of fat and thus make a good short-time record, but during the remainder of her lactation period her fat test may be so much lower that she will make but an average yearly record.

In studies by Eckles,[1] in which he tabulated the percentage of fat in milk of Holstein-Friesian cows early in the lactation period and compared the results with the average test for the year, it was found that the average for the seven days was 4.35 per cent fat while the average of the same cows for a year was 3.42 per cent fat, as shown in Table LXX.

In connection with these data Eckles made the following statement:

"These records . . . illustrate the fact that a short-time test made at the beginning of a short lactation period may give an entirely erroneous idea as to the real average fat content of the milk produced by the animal in question."

Table LXXI by Eckles gives the result for one cow (No. 207) which was under his observation.

"At the time of parturition in 1908 this cow was thin or perhaps normal. It should be observed that while she was in this condition the per cent of fat at the beginning of the test and the average for the year were practically the same. In 1910 she was fat, weighing about 200 pounds more than in 1908. It should be further observed that for the first sixteen days the per cent of fat was much higher than the average for the year. During this time this cow made the Advanced Registry Official seven-day record with a test of 4.09 per cent fat. It should further be noted that the average test for the year was practically the same in 1910 as in 1908."

TABLE LXX

COMPARISON OF THE PERCENTAGE OF FAT DURING A SEVEN-DAY RECORD AND DURING A YEAR RECORD

Name of Cow	Per Cent Fat During	
	7-Day Record	Year Record
Cedar Lawn DeKol Johanna 11805	4.02	3.35
Marcella Late 6094	4.21	3.33
Victoria V 8827	3.92	3.45
A. and G. DeFreule DeKol 2nd 11783	4.32	3.72
Mermaid Gerben 5057	4 50	3.23
Artasia Korndyke 8031	4.30	3.64
Gracie DeKol Korndyke 8030	4 01	3.54
Daisy Lincoln 7984	4.22	3.71
Edith DeKol Burke Hengerveld 11814	4.64	3.36
Lady Bak Homestead Brinsley 8482	4.51	3.44
Pontiac Pyrrlia 3775	4 01	3.31
Winona Pietertje DeKol 3rd 9543	5.93	3.89
Missouri Chief Josephine 6912	4 09	2.76
Carlotta Pontiac 10469	4.15	3.10
Average	4.35	3.42

These experiments show that a much higher test can be obtained by having the cow fat at the beginning of the test. This would indicate that these records are not a true measure of the cow's ability and do not correctly represent the value of an animal for milk and butter-fat production.

That a seven-day record may be a fairly accurate measure of a cow's yearly record, if the feeder will take her normal production, has been shown by Woll[2] as illustrated in Table LXXII.

This table gives the result of the records for the Holstein-Friesian cows that were in the Wisconsin cow competition. The production of the cows during the official seven-day test is compared with the yearly production of the same cows. The table shows that there was a relation, with one exception, between the weekly production and the total production for the year. While a large enough number of cows has not

TABLE LXXI

Comparison of Tests on One Cow Made when the Cow was in Different Degrees of Flesh

Days after Calving	1908		1910	
	Milk, Lbs.	Fat, Per Cent	Milk, Lbs.	Fat, Per Cent
3	....	....	....	5.68
4	....	....	57.2	5.35
5	....	....	53.1	4.81
6	69.0	2.8	58.7	4.13
7	59.0	2.4	60.0	4.34
8	68.5	3.9	65.8	4.16
9	65.8	3.5	64.2	3.87
10	70.8	2.8	67.3	3.89
11	74.1	2.6	74.7	3.63
12	67.8	3.1	79.4	3.28
13	69.3	2.7	88.2	3.11
14	83.5	3.03	84.5	2.85
15	81.9	2.65	88.0	3.20
16	80.4	2.69	90.5	3.00
17	77.4	2.80	93.9	2.80
Average for year.........		2.80	....	2.76

TABLE LXXII

The Seven-day Period as a Measure of a Cow's Yearly Record

Group	Yearly Record		Seven-day Record		Average Fat Content	
	Average Fat, Lbs.	Average Fat, Lbs.	Average Fat, Lbs.	Average Fat, Lbs.	For Year, Per Cent	For 7 Days, Per Cent
1	656.3	569.5–888.2	17.799	13.9–23.0	3.57	3.83
2	543.0	516.9–568.4	15.801	9.9–22.0	3.44	3.70
3	485.1	468.3–515.2	16.204	11.7–23.5	3.39	3.64
4	439.2	412.8–465.4	14.350	8.8–24.3	3.39	3.73
5	369.8	291.9–409.9	13.332	10.7–17.7	3.44	3.70
Av. 142 cows..	505.9	....	15.620	....	3.39	3.67

been tabulated to give a satisfactory average, yet this table shows that these cows on the average gave one-thirty-second of their yearly production during their best week. It should be observed that these cows were not fitted especially for a short-time test; it was known before the contest was started that it was to continue for a year.

Advantages of Advanced Registry Testing.—The advantages of Advanced Registry testing are much the same as those of other forms of testing already discussed. It has the further advantage, however, that it provides bulls with proven ancestry for use on other pure-bred herds and in grade herds. All the bulls in use should be pure-breds; but it is a well-known fact that not all pure-bred bulls are good ones. For this reason, only bulls with tested ancestry should be used in pure-bred or high-grade herds. Advanced Registry has provided a means of securing such bulls.

Advanced Registry has also served to prove the worth of individual sires and has kept them in use for a great many years. It has stimulated better feeding and care of animals.

Disadvantages of Advanced Registry Testing.—One of the chief disadvantages of Advanced Registry testing is that it encourages individual records rather than large herd averages. Most dairymen put on test only their best cows—those that are fairly sure to make creditable records. They then give them the best of care and attention in order to get the very largest possible production from them. The poorer cows in the herd are not tested. By this means the breeder often builds up a reputation for his herd with the aid of a few outstanding animals. A certain bull may also gain a reputation with a few high-producing daughters, while perhaps many of his daughters have not been tested and if tested could not make the Advanced Registry requirements.

Another disadvantage of Advanced Registry testing is that, as it is commonly practiced, in order to secure the very largest production possible from individual cows, they are not bred until late in the period of lactation. In many cases the result is that the breeder is unable to have the cow bred successfully again and hence there is the loss to the breed of an otherwise excellent animal. This disadvantage has been lessened by the encouragement of the 305-day test with a calving requirement.

Still another disadvantage of Advanced Registry is that it has been an expensive method of testing. The smaller breeders could not afford to test, and when they did test they could not afford to give the animals the care and treatment which was possible with wealthy breeders. For these reasons Advanced Registry testing did not reach as many people as it should. The expense was increased in many cases by the over-jealous supervision required to prevent fraud. This objection has recently been lessened by the reduction of the length of the test from two days with preliminary milking to one day with preliminary milking.

The Herd Test

In order to overcome some of the disadvantages of the Advanced Registry test and to increase the number of animals tested, the Ayrshire Breeders' Association started, in 1925, a test known as the Herd Test, which gives promise of being a successful means of raising the herd averages. The Holstein-Friesian Association adopted a similar test in 1927 and other breed associations are now becoming interested in this method of testing.

Method of Test.—The test is conducted by the same supervisors who conduct the Advanced Registry test or by cow-testing association testers, and is supervised by the state agricultural experiment station. The length of test is one day only, without preliminary milking. By the Ayrshire Association rules the test is available for either grades or pure-breds, but all cows in the herd must be tested. The cows may be milked only twice per day, except when producing over 40 pounds for mature cows, 35 pounds for four-year olds, 30 pounds for three-year olds, and 25 pounds for two-year olds. The Holstein-Friesian Association provides for testing only pure-breds and there is no limit on the number of milkings.

After the association has secured all data for the month a report is sent to the dairyman, and at the end of a year he is given a book containing the complete records of each cow. The record thus obtained is somewhat similar to the cow-testing association record.

Relation between Age and Fat Production

It has long been observed that milk and butter-fat production gradually increase as the dairy cow matures and then gradually decrease with the onset of old age. A heifer is expected to increase in production with each succeeding lactation until she reaches maturity. The breeds do not seem to increase at quite the same rate, nor do they reach maturity at the same age. Table LXXIII, adapted from work done at the Missouri Experiment Station,[3] gives the age conversion factors for each of the four main breeds. Knowing the production of an animal at any age, one can easily convert it into a mature equivalent by multiplying the production by the factor for the given age.

TABLE LXXIII

AGE CONVERSION FACTORS FOR DIFFERENT BREEDS

Age	Conversion Factors			
	Jersey	Guernsey	Holstein	Ayrshire
Under 2 years...	1.484	.....	1.473	
2 – 2½ years....	1.448	1.313	1.365	1.402
2½– 3 years....	1.344	1.251	1.269	1.343
3 – 3½ years....	1.248	1.194	1.196	1.283
3½– 4 years....	1.164	1.142	1.140	1.226
4 – 4½ years....	1.115	1.100	1.099	1.172
4½– 5 years....	1.083	1.064	1.066	1.123
5 – 5½ years....	1.052	1.041	1.041	1.084
5½– 6 years....	1.034	1.023	1.023	1.050
6 – 6½ years....	1.023	1.013	1.009	1.028
6½– 7 years....	1.014	1.006	1.003	1.012
7 – 7½ years....	1.008	1.000	1.000	1.000
7½– 8 years....	1.004	1.000	1.000	1.000
8 – 8½ years....	1.000	1.004	1.003	1.002
8½– 9 years....	1.000	1.009	1.005	1.008
9 – 9½ years....	1.004	1.017	1.011	1.019
9½–10 years....	1.008	1.029	1.018	1.030
10 –10½ years....	1.012	1.041	1.031	1.044
10½–11 years....	1.025	1.058	1.046	1.059
11 –11½ years....	1.038	1.075	1.064	1 077
11½–12 years....	1.052	1.093	1.085	1.094
12 –12½ years....	1.065	1.113	1.106	1.114
12½–13 years....	1.093	1.137	1.131	1.135
13 –13½ years....	1.096	1.162	1.156	1.157
13½–14 years....	1.110	1.191	1.204	1.180
14 –14½ years....	1.127	1.219	1.227	1.205
14½–15 years....	1.147			
15 –15½ years....	1.164			

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LECTURE XXVI

FITTING DAIRY ANIMALS FOR SHOW

THE breeder of dairy cattle should consider not only the production of his cows but also their type. Production and type go hand in hand in the best breeding establishments. One of the most effective means of establishing type and of advertising a herd is by the public exhibition of dairy animals. The standard of type of the different breeds is largely set at the great exhibitions. Although the score card is supposed to be followed at the shows, yet the different breed associations sometimes change their score cards as the result of experience secured by the competition of the animals of their breed at these exhibitions.

The great dairy shows in this country, such as the National Dairy Exposition and the different state fairs, and to a lesser extent the county fairs, are excellent educational institutions. If one wishes to become acquainted with the desired type of any particular breed, one can do so by watching the placements as made at some of the good dairy fairs.

The fairs in the United States are not conducted as they are in Europe. It was the privilege of one of the authors to visit some of the agricultural fairs in Europe. At Cooper, when the West Highland Cattle Show had been in progress only one day, it was possible to buy a catalog in which could be found the placement of all the cattle in the different classes. The animals were placed the day before the opening of the fair so that even those persons who attended only the first day might know how the different classes were placed. In this country, it often happens that some of the breeds are not placed until the last day of the exhibition, and unless one remains until then it is impossible to learn all the lessons taught by actual placement in the ring. Here, however, we have the pleasure of watching the judge working and of forming our own opinions of the placements before he has actually made them. Under the European system this is not possible. In this country more emphasis is laid upon advertising the breeder and less upon the educational features of the exhibition than in the European countries. However, the exhibitions in this country have recently been improved in this respect.

Two Classes of Showmen.—It is not a difficult problem for a man willing to spend large sums of money—provided he knows the type that wins, or can employ someone who does—to buy a herd of cattle that will win prizes at the shows. Such a man is known as "a fancier." Probably, so far as advertising the breed is concerned, he does as much good as though he were a breeder, but from the standpoint of perma-

FIG. 64.—Students trimming the hoofs, clipping the hair, and polishing the horns of a cow for exhibition purposes.

nent improvement of the breed he can do it little good. Such a person often disposes of his herd at the close of the show season, and thus no permanent good results.

A more constructive type of showman is the "breeder." The advisability of making it a prerequisite to the showing of animals that they be bred by the exhibitor, or at least that they be in his possession many months, has been considered. The result of such a restriction would be the establishment of more breeding centers upon which the public might depend for animals that would continue to breed true to type. The breeder type of exhibitor is the one that benefits not only himself and his herd but the breed as well. He should be given all the encouragement possible.

Winning Animals.—For many years the judges at our fairs have been selected under conditions that warrant their ability to give unbiased decisions, and that compel them to be well informed about the desired type of winners. The result is that, within minor degrees of difference, the most desirable animals win to-day in the show ring. There was a time when breed types were less well known, judges were less carefully selected, and, as a result, the placement was somewhat of a lottery, and animals inferior in type and quality were often placed first. Fortunately, that day is past; no one can now hope to win with cattle, even though they have been well fitted, unless they possess the true breed characteristics. All animals exhibited are supposed to be typical of the breed, and this is as it should be.

Early Preparation of the Show Herd.—The man who is going to exhibit his herd on a show circuit should select among his milking animals the prospective winners—those that seem to possess in the highest degree the desired characteristics of the breed—and give them special attention, as their condition at the time of the show depends largely upon the care which has been given them. In the first place it is very desirable to breed the cows so that they will freshen at the right time. It is usually best to have them freshen a short time before they are to be exhibited. They should not freshen, however, so long in advance of the fair season that their surplus fat has been milked off, so that they will look unduly thin and show lack of capacity and thrift. Sometimes animals are bred to freshen while on the fair circuit. This is often very satisfactory, as a cow usually looks her best just before and a few weeks after freshening.

It is very important, in selecting the young animals for the show circuit, that they be dropped at the right season of the year. The classes for young animals in the show ring usually include all animals within a range of six months or one year in age. The young animals should then approach the upper limit rather than the lower one, as the larger animals will always be given a preference over the smaller ones, everything else being equal.

It is well to fit several animals of each class that one intends to exhibit, as it is not always possible to determine just how an animal will respond to fitting until after the fitting season is over. All animals that are to be exhibited should also be tested for tuberculosis, as very few fair associations allow cattle to be exhibited without first being tested.

Feeding the Show Herd.—The feeding of show animals is very important if the best results are to be obtained. It is not desirable to have dairy animals excessively fat for exhibition purposes. It is desirable, however, for all animals to carry a fair amount of flesh, as a very

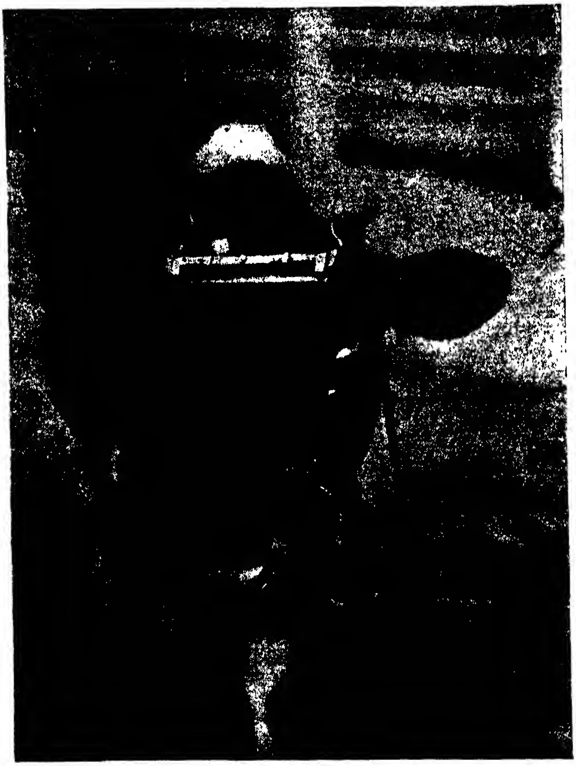

FIG. 65.—Training the horns inward.

thin animal will be discriminated against. The animal that is reduced in flesh will require a longer fitting period than one that is well nourished. This fact should be borne in mind when one selects animals for the show ring.

There are many different grain rations which can be used successfully in fitting animals for show. In general, such feeds as wheat bran, ground oats, corn meal, and linseed meal make up the larger part of the ration. The grain ration should be fed with good legume hay, silage, and beet pulp. Molasses is often fed also. The amount of grain to feed will depend upon the size, condition, and individuality of the animal. As a general rule, the cows should be fed all that they will clean up with relish. If they are thin in flesh, the amount of corn meal should be increased. Linseed meal is a very popular feed for use at this time as it seems to add a gloss to the hair and quality to the hide. Toward the end of the fitting period, beet pulp should be substituted for silage, as it is practically impossible to secure silage on the show

FIG. 66.—Training the horns inward and upward.

circuit and it is best to have the animals on the same feed that they will receive during the exhibition period.

Training the Horns.—While animals without horns often win in the show ring over those with horns, it is, nevertheless, a distinct disadvantage to an animal not to have a good set of horns. This is especially true with certain of the breeds. An Ayrshire without horns is certainly at a disadvantage in the show ring. It is necessary, however, in order to make the best appearance, that the horns be shapely and well formed.

There are certain shapes that are favored in the different breeds, and it is important that the horns, when they do not develop normally, be trained to grow in these shapes. Special devices have been provided in order to get the desired shape. The horns of the Guernsey, Jersey, and Holstein breeds are required to turn in. The usual means of accomplishing this result is to use a clamp which fastens on to the horns and pulls them together. With the Ayrshire breed, on the other hand, it is desired that the horns turn out and up. The apparatus for producing this effect may be of several types: each horn may be trained independently by the use of clamps, or both may be trained

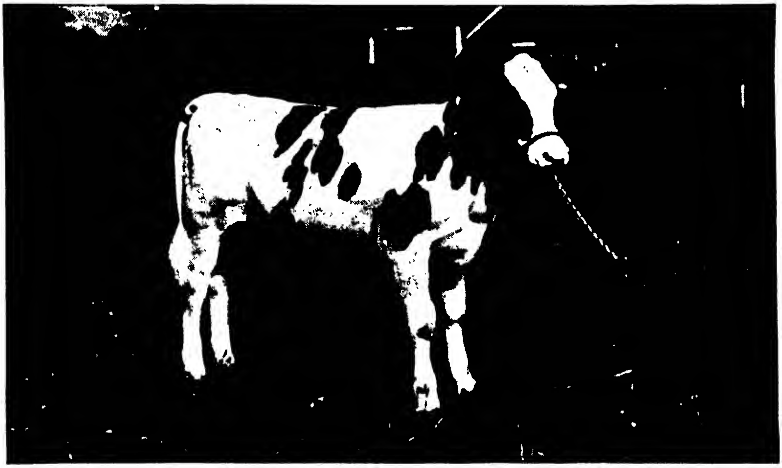

Fig. 67.—A well-trained heifer will poise itself.

together by the use of clamps and weights. The clamps are fastened to the ends of the horns and pull the horns up and in.

It is very important that the training of the horns be started early so that they will be trained in plenty of time for the exhibition. The horns should be trained when the animals are between the ages of one and two years.

Training.—In order that the cattle may be shown properly in the ring, it is essential that they be given good training before starting on the circuit. Any show animal should lead readily and stand in a position that will display its good points. The younger the animal the more easily it can be taught to lead and stand properly. At any age, however, a large amount of time is required to train the animals to lead, back, stand, repose, or change position. There are many points in posing an animal which can be learned only through showing. It should be remembered, however, that all the effort expended in fitting an animal may go for naught if it is not properly trained.

Clipping.—If the hair is long, the animal should be clipped all over some weeks before showing. Care should be taken to see that the clipping is done evenly, and smoothly, as a nice sleek coat adds greatly to the attractiveness of an animal.

Clipping is often done in such a way as to cover up some defect or to bring out some desirable characteristic. For example, the hair is clipped close on the high points and left as long as possible on the low

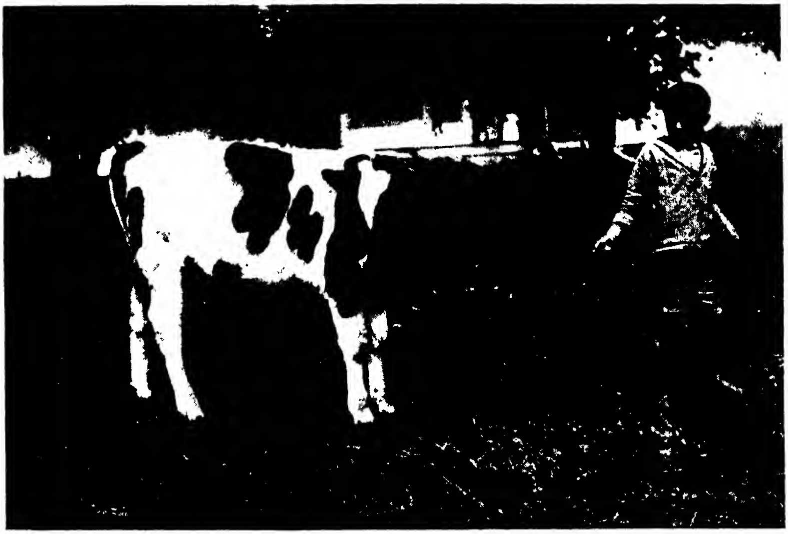

FIG. 68.—A poorly trained heifer is hard to poise.

points. An uneven top line may be covered up in this way with careful clipping. The under line is often clipped as close as possible, except on the milk veins, where the hair is left a little long, in order to make the veins appear larger. The hair around the withers and the shoulders of the dairy cow should be clipped close, in order to magnify the front wedge appearance. In cattle in which dished heads are desired, the dish should be clipped very close, and on the outer margin of the dish the hair should be left a little longer. This gives the appearance of a better dish. The trimming of the hair around the horns and ears demands great care. Much of the facial expression depends upon the proper appearance of these parts. The udder should be trimmed to maintain the balance of its different quarters and to make the blood vessels on its surface appear as large as possible. Animals should never be clipped and turned out on pasture, as the sun will make the hair very rough.

Brushing.—Brushing stimulates the circulation of the blood and helps to make a glossy coat of hair. A mellow skin is evidence of good feeding and thorough brushing. A common horse brush may be used, although a stiffer brush is to be preferred. The brushes should always be kept clean.

FIG. 69.—Proper showing of the animals is very important.

Washing.—Frequent washing is another means of obtaining and maintaining a good condition of hide and hair. Throughout the entire fitting season the animals should be washed regularly. During the last fortnight or so before going out on the show circuit, they should be washed two or three times a week. In washing, plenty of water and soap should be used, after which they should be thoroughly rinsed. In the case of the Guernsey breed, where stress is placed on the yellow secretion, this washing should, of course, be conducted with special attention to the preservation of the secretion.

Blanketing.—The animals should be blanketed after washing in order to keep the coat clean and the hide in good condition. Blanketing raises the temperature and retards the hair growth somewhat. It helps to make the coat smooth and gives an animal a smooth, finished appearance which cannot be obtained otherwise. Blanketing of show animals is universally practiced in this country.

Polishing Horns and Hoofs.—The horns and the feet of the animal have an important effect upon its appearance. The hoofs of all animals should be carefully trimmed and properly shaped. This can be done with the use of the chisel, rasp, sandpaper, and emery cloth. After

FIG. 70.—A young stock show in Denmark. (*Rasmussen.*)

the hoofs have been put in shape they should be polished with linseed oil, rubbed in with a flannel cloth or a chamois skin.

In like manner, the horns should be carefully smoothed and polished. Sometimes metal polish is applied to the horns and they are then rubbed thoroughly until they shine.

The feet and horns should be put in shape several months in advance of the show season, so that when the season approaches it will only be necessary to keep them properly polished.

Shipping.—The shipping of the animals is a very important part of successful competition on the fair circuit. The herd should be given just as much comfort as possible while being moved from one exhibition to another. Usually a car will be furnished by the railroad, to be used during the entire showing season. It is possible to prepare stalls in the car and to keep them well padded with burlap and bedded with straw so that the animals will be comfortable. The cattle should be carefully blanketed so that they will be protected from all drafts.

The person in charge of the car should provide himself with complete equipment, such as buckets, forks, shovels, etc., and with the necessary feed. He should be so equipped that he can take care of his animals without assistance from anyone.

One should always ship a show herd so that they will arrive at the place of exhibition several days before the time of showing. There will thus be ample time to get the animals in the best of shape before showing.

Final Preparations.—When the herd has arrived at the place of exhibition, care should be taken to see that everything has been properly provided. The stalls and pens should be thoroughly clean at all times, and a large amount of bedding and feed should be at hand. The entries should be carefully examined to see that they have been properly made out; the rules and methods of the particular fair should be studied and every detail carefully watched. This is particularly true in the case of the beginner, because it may be discovered that on account of some rule an animal will be barred from entering a class.

In order to develop the appearance of great capacity, the animals are sometimes denied water for some hours before being shown. They are given some salt, and then, before going into the ring, some water. Being very thirsty, they drink a large amount of water and hence should show a somewhat greater capacity than normal.

Bagging Up.—Animals in milk are usually brought into the show ring with distended udders. They are generally milked very little, if any, for twenty-four hours or more before being shown, with the result that the udder becomes greatly distended. This is known as "bagging up." By milking a quarter that naturally gives a little more milk than the others, a uniform effect may be given to the udder. In the large shows this practice does very little good, as the judge usually requires that the cows be milked out while in the ring. This exposes any defects of the udder, either permanent or temporary, which may have been covered up. Some exhibitors use collodion at the ends of the teats in order to keep them from leaking.

Care should be taken that the cow is not bagged too much. Many cows look better when the udder is not too much distended.

Showing.—At the call of the class, the animal should be led into the ring by an attendant, with an attractive, properly fitting halter and a strap that is not too long. It is the better practice to lead the animal, holding the halter in the right hand. From the time the animal enters the ring it should be the business of the attendant to see that it is exhibiting itself to the best advantage at all times. Exhibitors often attempt to place their animals in high or low positions, whichever is necessary to show them to the best advantage. Most judges, however, require that the animals be walked, causing them to lose any advantage thus gained.

FIG. 71.—Selecting the best herd at the National Dairy Exposition.

The exhibitor should never remove his eye from the animal longer than is necessary, and should poise his animal even although the judge is not looking at the moment. When the line is ready the attendant should face the animal, taking a position that will permit him to observe both the judge and the animal. By a gentle touch of the foot it should be possible, by "previous training," to properly pose the animal at all times. The importance of proper training is in evidence at this time.

When the placings have been made the animals should be taken from the ring without a word, even though the placement has not been

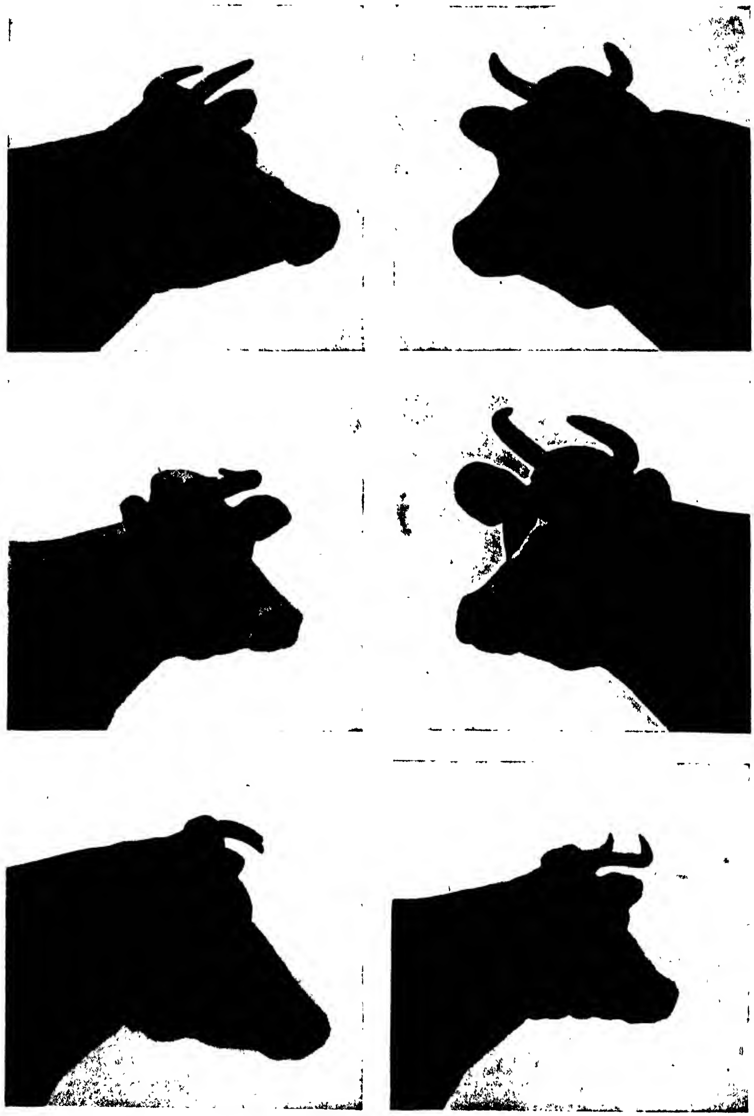

FIG. 72.—Types of Jersey horns.

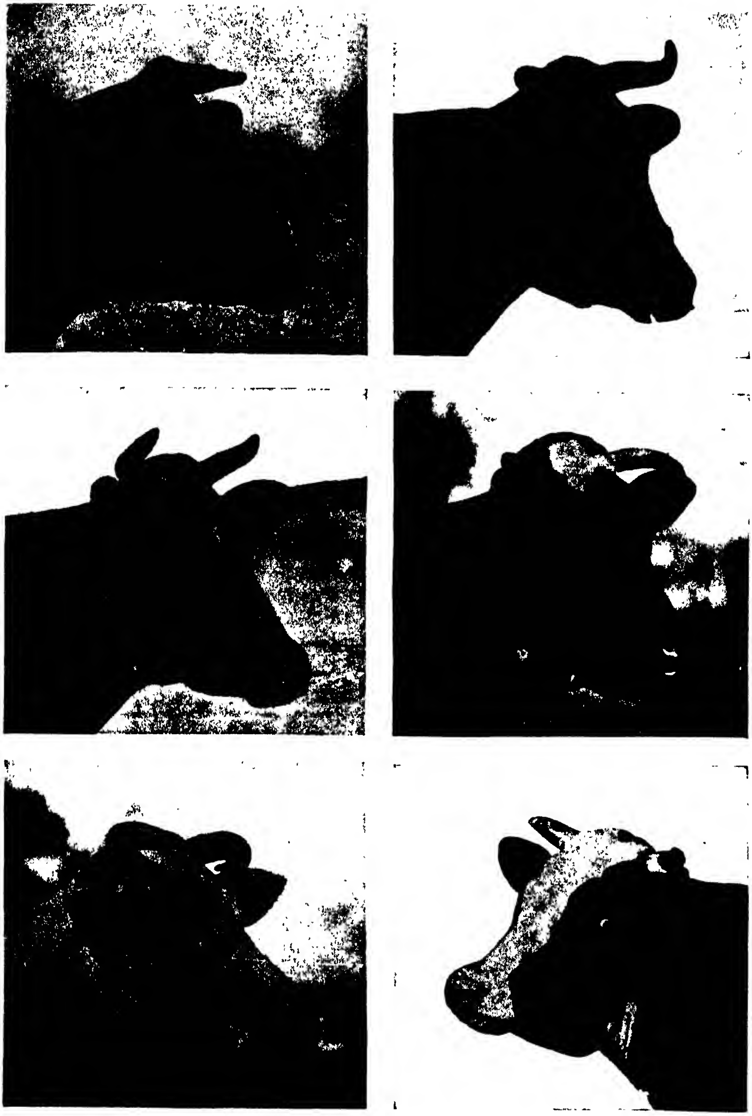

Fig. 73.—Types of Holstein horns.

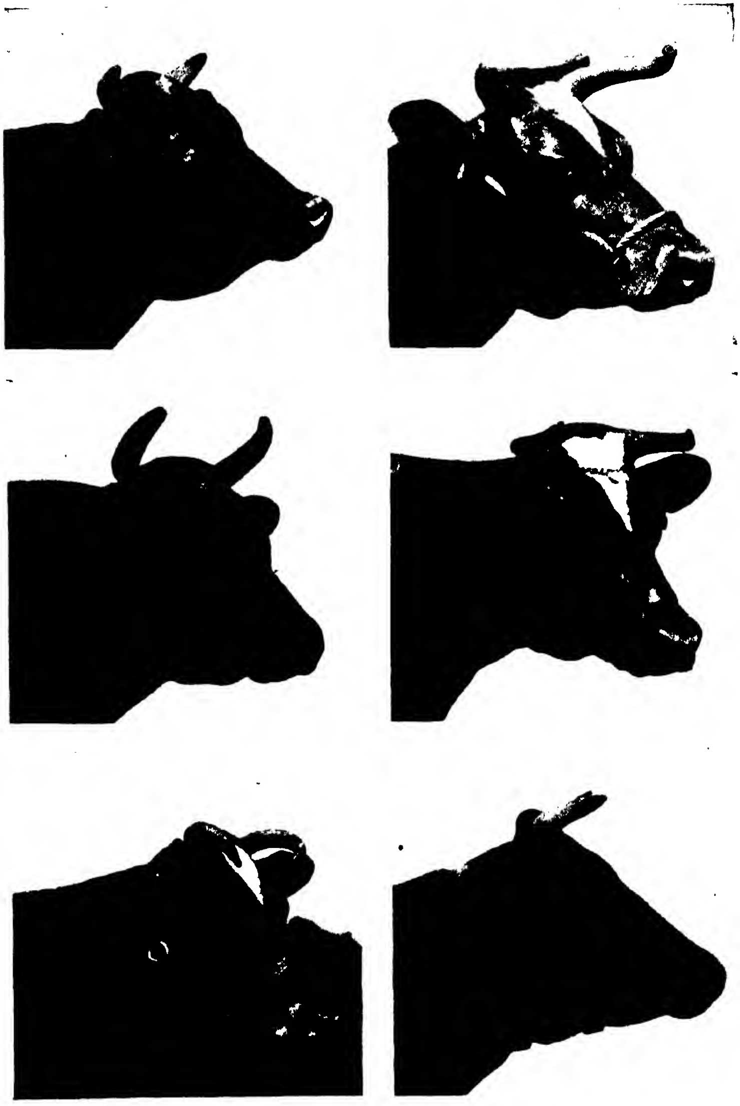

FIG. 74.—Types of Guernsey horns.

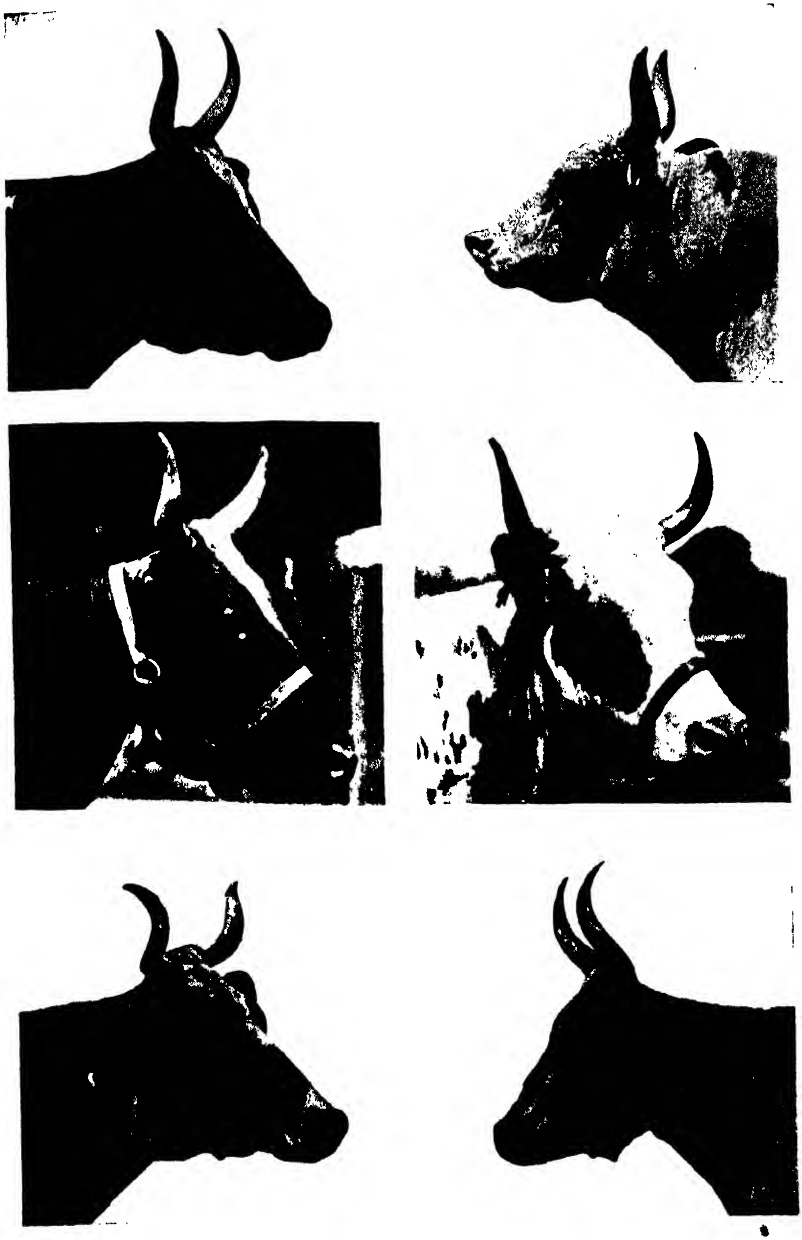

Fig. 75.—Types of Ayrshire horns.

to the liking of the exhibitor. To be a good showman, a man must first learn to be a good loser.

Showing Out of the Ring.—Breeders are appreciating more and more the value of showing the animals when they are not in the ring. There are always prospective buyers or men who are attending the shows to determine the breed of cattle they wish to develop. It is important, therefore, that such men have an opportunity to see the animals outside the ring. This is especially true of the winning animals. It is usually profitable to have a good showman and salesman with the animals at all times when visitors are about. Unless the animals are about to be shown, the attendant should be willing to remove the blanket and show them at any time.

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LECTURE XXVII

COMMON DISEASES OF DAIRY ANIMALS

FROM a study of the dairy records at the Pennsylvania State College[1] it was found that 16.4 per cent of the animals were killed because of tuberculosis, 8.9 per cent died, 5.8 per cent were condemned for reasons unknown (undoubtedly in most cases for some form of disease not definitely known), 5.7 per cent were condemned for barrenness, 0.8 per cent for lumpy jaw, and 0.4 per cent for abortion. It is thus seen that a total of 37.4 per cent, or more than one-third of the animals in the herd during a period of twenty-six years, were disposed of on account of some form of disease. One of the greatest ravages of the profits of dairy farms is disease, particularly tuberculosis and abortion.

The dairyman and dairy student should know the symptoms of some of the most common of the dairy diseases so that they may employ preventive measures whenever necessary.

In the present lecture, a few of the most common diseases of dairy cattle will be mentioned. Usually it will be well to get the services of a a veterinarian when the trouble is serious, but often help must be given before a veterinarian can be reached. One of the first treatments to give any cow when she first goes off feed is a dose of 1 to 2 pounds of epsom salts. This should be dissolved in 3 to 4 quarts of water and given as a drench.

EQUIPMENT NECESSARY

Every dairy farmer should have a medicine chest containing the following instruments and medicines. If the herdsman is one who has a liking for the veterinary side of the work he can profitably add to this list, but the average herdsman prefers to place serious cases in the hands of a competent veterinarian.

Clinical Thermometer.—A high temperature or an extremely low one, together with other symptoms, gives an indication that the condition of an animal is abnormal. The temperature of a cow ranges from 100 to 103° F. and may go 1° above or below these figures without causing worry. Each individual seems to have a temperature peculiar to itself. In case of fever, a rise in the temperature of from 4 to 6° should have careful attention. Likewise, any falling below normal is serious. The temperature is taken through the rectum.

Trocar and Cannula.—A trocar and cannula should always be on hand in case of an attack of bloat. One of moderate diameter should be obtained as too large an instrument cannot be used on smaller animals.

Drenching Bottle.—Medicine is usually given to a cow as a " drench " from a bottle. It is usually mixed with water. The bottle should have a long, strong neck so that it can be run back into the cow's mouth. Sometimes a glass bottle is used, but a rubber one is preferred on account of the danger of breaking the glass bottle. To drench a cow, two men are usually required. The head of the animal is raised by one of the men while the other runs the neck of the bottle into the side of the mouth between the cheek and the teeth and allows the medicine to run down into the throat. Care should be taken not to strangle the animal, as sometimes the medicine will run down into the lungs rather than into the stomach.

Milk-fever Outfit.—A profitable dairy herd cannot afford to be without a milk-fever outfit. This should always be kept in condition ready for use. If a milk-fever outfit is not available, an automobile pump and milk tube can be used as a substitute.

Milking Tubes and Teat Plugs.—Several milking and teat plugs of different sizes and lengths should always be on hand and in perfect condition.

Other articles, such as a syringe, a funnel, rubber hose, and a measuring glass, should be provided for use when needed.

Medicines.—The following medicines and disinfectants should be at hand:

Epsom salt	Creolin (or other disinfectant)
Castor oil	Tincture of iodine
Raw linseed oil	White pine tar
Vaseline	Sulphate of copper
Carbolized vaseline	Saltpeter
Boracic acid	

Pulse and Respiration.—While the thermometer is depended upon by the herdsman to a greater extent than are the pulse and respiration, it is well also to consider them. The normal pulse of the cow is from 40 to 50 beats per minute, and the respiration from 10 to 20 breaths per minute. In general, there is some relation between the two; when the pulse is fast the respiration also is fast.

Common Diseases of Dairy Cattle

Tuberculosis.—One of the most important diseases in the dairy industry is tuberculosis. Its importance is due not only to the seriousness of the disease, as it affects the animals themselves, but more particularly to the fact that the organism causing tuberculosis in cattle is also known to cause it in humans, especially in children under fifteen years of age.

Cause.—Tuberculosis is caused by the tubercle bacillus, *Mycobacterium tuberculosis.* This bacillus gains entrance to the body, lodges somewhere in the tissues, most commonly in the lungs and the lymph glands, and begins to grow and multiply at this point. As the organisms grow they excrete poisonous substances which act as irritants and cause the formation of small nodules, called tubercles. As time goes on, enormous numbers of these tubercles are formed, resulting, in some cases, in the formation of large masses of tubercular material.

While the disease itself is not inherited, there are no doubt certain conditions which contribute toward its development, such as a run-down condition brought about by insufficient feed or heavy milk production, and environmental conditions, such as poor ventilation or damp stables.

How the Tubercle Bacillus Enters the Body.—The tubercle bacillus may find its way into the body by being inhaled into the lungs, by being taken into the digestive tract, or by entering through the sexual organs. The first two modes of infection are the most important. The disease is usually spread by one animal which is brought into the herd having tuberculosis and passes it on to the others. The bacillus may be spread from the manure of such animals, from all exhalations, from discharges from the mouth or nose, and from the milk. Such an animal is known as a "spreader," but all animals that have the disease are not spreaders. Some may have a closed type and be harmless as far as the spreading of the disease is concerned. This type, however, cannot be distinguished from the " spreader."

Calves or children, when fed milk from tubercular cows, may contract the disease. This is especially true when the cows have tuberculosis of the udder; but even when this is not the case, the milk may become contaminated by small particles of dust or manure which may drop into the milk at the time of milking or in handling.

Symptoms.—Many animals may have tuberculosis and show no outward signs of it. The beginning of the disease usually passes unnoticed, and the infected cow may remain in a good state of flesh for several years. After the disease has progressed for some time she may lose in flesh and appetite and gradually decline in milk secretion. Occasionally the disease will run its course rapidly and the cow will die within a short time. Usually, however, the symptoms are not marked and cannot be thus detected.

Tuberculin Test.—Tuberculin is an extract prepared by sterilizing, filtering, and concentrating the liquids in which the tubercle bacillus has been allowed to vegetate. It is absolutely sterile and hence no harm can come from using it on healthy animals. By its use one can ascertain, in more than 90 per cent of all cases, whether a cow has tuberculosis. The failures in diagnosis are due to cows in advanced stages of the disease who do not react because they already have so much natural tuberculin in their system that the ordinary-sized dose of tuberculin does not have any effect on them. The same immunity may be secured by injecting tuberculin into cattle several days before the test is to be run. Another class of failures are those that give a reaction due to some abnormal condition, such as advanced pregnancy, the excitement of oestrum, other diseases, and changes in methods of feeding or handling, and still do not have the disease. With extreme care, a very high degree of accuracy can be obtained. The few exceptions, however, often cause a lot of trouble.

There are three standard methods of testing cows for tuberculosis by means of the tuberculin test.

1. *Subcutaneous Test (under the Skin).*—The subcutaneous test was formerly the most frequently used. It consists of injecting a certain amount of tuberculin under the skin of the animal, usually back of the shoulder. If the animal has the disease, a rise in temperature usually occurs at any time between the eighth and twentieth hours after the tuberculin is injected. The temperature is taken at least

three times before injection, at two-hour intervals to get the normal range of temperature, and after injection at two-hour intervals beginning at about the eighth hour, until the test is complete. This test requires considerable time and trouble, as all cattle must be tied up and their temperatures taken frequently until the test is complete. It should be done only by an experienced veterinarian.

2. *The Intradermic Test (Into the Skin)*.—The intradermic test has recently been very widely used as it is quick and easy to perform. In this test the tuberculin is injected between the layers of skin, usually at the base of the tail where the skin is soft and nearly hairless. The reaction consists of a swelling, varying from the size of a pea to that of a walnut, at the point of injection. It is observed 72 to 150 hours after injection.

3. *The Ophthalmic Test (Into the Eye)*.—The ophthalmic test has been used only as a check test or as a comparison test with one or both of the others. The tuberculin, in the form of a tablet, is placed in one eye, and the other eye is used as a check. A reaction is indicated by the characteristic discharge from the eye, which may occur in from three to ten hours after the application.

Treatment of Tuberculosis.—After the disease has developed, there is no known treatment that is satisfactory. It is recommended that all reacting and suspicious animals be slaughtered and the premises thoroughly disinfected, after which no animal should be purchased until it is known to be free from the disease as denoted by the tuberculin test.

Bang's System.—Dr. Bang, of Denmark, appreciating the costliness of killing all animals that react to the tuberculin test, conceived the idea of isolating all valuable breeding animals that so react. By placing these animals in separate barns with separate attendants, it is possible to breed them and remove the new-born calves from the mothers before the latter have had a chance to lick them. In this way it is possible to raise a good herd free from the disease. Several good breeding herds in America have used this system, but the average farmer cannot use it because of the great expense of keeping up two establishments. It has never gained widespread use in this country.

The Accredited-herd Plan.—In order to establish tuberculosis-free herds and to encourage the testing of animals, the Bureau of Animal Industry has started the practice of giving certificates to the owners of all herds that have passed two successive annual tests under their supervision. The herds are then tested each year and given a new certificate. No new animals are brought into the herd except from another accredited herd or after being held in quarantine for sixty days and carefully tested and found free from the disease. By this means breeders can sell their stock with a guarantee that they are healthy. Such a guarantee also serves as an advertisement for their milk.

Area Testing.—While the accredited-herd plan was useful in establishing herds free from tuberculosis, it did not in itself give a means of eliminating the disease from the country. Lately, area testing is being done in many states. By this means the cattle in entire districts or counties are tested and all reactors eliminated. This lessens the danger of infections being carried from one farm to another, and establishes an area where buyers can go to purchase tuberculin-free cattle.

While the accredited-herd plan was only introduced in 1917, and the modified accredited-area work in 1922, their use has increased very rapidly. During 1926, 1,989,048 cattle were tested under the accredited-herd plan and 6,661,731 cattle under the area plan. Of these, 3.4 per cent were reactors. There were 203 modified accredited areas, with many other areas now under supervision. The work is progressing as fast as possible with the available help.

Abortion.—Abortion in dairy cows may be either infectious or accidental. While probably 90 per cent of all abortions are infectious, yet premature births may be due to other causes, such as injury by hooking, kicking, or falling, strong medicine, improper feeding, etc. As such causes are not frequent, it is always a good practice to assume that every case is infectious and treat it accordingly.

Infectious Abortion.—Infectious abortion has been known for a great many years, but not until 1896 was the bacterium causing the disease discovered. *Bacterium Abortus* first discovered by Bang is now recognized as the chief causative agent, although recently other bacteria thought to be able to produce the disease have been isolated. Abortion is one of the most important diseases of dairy cattle and causes great loss every year, perhaps as much as tuberculosis. The damage is not due alone to the loss of the calf, but also to such things as the loss of many cows due to weakened condition or complete sterility, loss in flesh of the cows which abort, loss in the milk flow, shy breeding, lowering of the value of the animal, and extra care in caring for and handling an infected herd.

Symptoms.—Infectious abortion is a very insidious disease and may be developing for several months before its presence is noted. The premature expulsion of the calf is simply an indication—possibly the first one—of the presence of the disease. For this reason the disease may have gained quite a foothold in the herd before its presence is suspected. Furthermore, many cows may carry the disease and never abort. Such cows are known as "carriers" and are even more dangerous in spreading the disease than those that abort, because they are not suspected. Abortion occurs most frequently from the third to the seventh month after the animal is bred. Cows of all ages are susceptible to it, but heifers most frequently abort. Some will abort the second time, and a few as often as three times, after which they usually become immune to abortion and carry the calf the full time, but may still carry the germ and so be "carriers." Some animals seem to be naturally immune to the disease.

Mode of Infection.—It has been pretty well demonstrated that the chief mode of infection is through the digestive tract, the germs entering the system by means of the feed or water which is consumed. From there they are taken into the blood and are carried to the genital organs where they find conditions suitable to their development. They attack the membrane which surrounds the fetus and separate it from the maternal membrane, cutting off all food and thus causing the expulsion of the fetus. Formerly it was thought that the bull was the chief source of infection, but this has been shown not to be the case.

Tests for Abortion.—Two laboratory blood tests for diagnosing this disease have been found fairly satisfactory. These are the complement-fixation test and the agglutination test.

The complement-fixation test is fairly complicated, slow, and expensive, and for this reason has not been used extensively. The agglutination test is much simpler and, in the hands of a careful person, has been just as satisfactory. It will not foretell an abortion, but will tell the animals that carry the *Bacterium Abortus* in their blood.

This test is conducted[2] by taking blood samples from the jugular vein of the cow to be tested and allowing the blood to clot. After the clot grows older, it contracts and the clear liquid (serum) comes out. In the laboratory the abortion germs are grown and suspended in a weak salt solution. Enough germs are placed in this solution to make it slightly cloudy. Measured amounts of this suspension are then placed in a series of test tubes and the serum added in such quantities that the first test tube will contain 1 part of serum to 50 parts of suspension, the second 1 part to 100, etc., until the desired number of dilutions are obtained. The tubes are then put in a dark place and examined at the end of twenty-four hours. If a cow is infected her serum will cause the bacteria to agglutinate or clump together. Otherwise the suspension will remain cloudy.

These are the only methods of detecting the " carriers." Any intelligent systematic effort at the eradication of the disease must be carried on with the use of some such laboratory test.

Treatment and Prevention.—No medicine has been found that has proven successful in the control of this disease. Control measures are confined entirely to herd management and sanitation. The disease may be eradicated from the herd by using the following methods with the strictest care.

1. Have the entire herd tested at frequent intervals to determine which animals carry the disease germ, and dispose of all reacting animals that are not of especial value.

2. Three weeks before any reacting animal is due to freshen, or at the first sign of an abortion, remove the animal to a separate barn and keep her so isolated until all discharge has disappeared after freshening. This will be at least six weeks.

3. Destroy all dead calves and afterbirths by burning or burying deeply. If the cow has aborted in the barn, thoroughly disinfect the stall where she stood.

4. Have a separate attendant care for such cows, or have the attendant wear different clothes when caring for them, so that the infection will not be carried on the shoes and clothes from one barn to another.

5. Before returning the cow to the regular barn, be sure that she has no discharge and give her a thorough washing with some disinfectant.

6. Take care that no manure or refuse from the stall of the isolated animals be placed where the other cows can have access to it.

7. If it is not possible to have the herd tested, treat all animals in an affected herd as if they had the infection.

Herds free from the infection have been built up by isolating all reacting animals, since calves do not retain the germ after they are weaned from the milk. It is thought that they cannot become permanently infected until after they have become sexually mature

Calves from infected cows can therefore be put into a diseased free herd without danger, after a short period of isolation.

Other troubles are often found in connection with abortion, such as retained afterbirth, shy breeders, complete sterility, and mastitis.

Garget, or Mastitis.—One of the worst diseases that the dairyman has to contend with is inflammation of the udder, commonly called garget. This may vary in severity from a mild case where the cow's udder swells slightly and the milk contains some clots, to a severe case where the udder is badly swollen and no milk can be gotten out of it. Very often one or more quarters are lost.

The trouble is caused by such things as exposure to cold and wet, standing in cold drafts, injury of some form to the udder, overfeeding, sores on the teats, and insufficient stripping of the udder in milking. In some cases it is due to a bacterium (*Streptococcus pyogenes*), in which case it is contagious and may be carried from one cow to another on the hands of the milker or otherwise. Usually the first indication of the trouble is a thickening of one or more of the quarters. The milkers should always be on the lookout for any such symptom and should be ready to give treatment at once. In this way the trouble can often be broken up before it gets a good start.

The treatment consists of first giving the cow a dose of epsom salts, which may be followed, after the purging has ceased, with a dose of 1 ounce of saltpeter. The application of heat to the affected quarters is one of the best treatments. A bucket of very warm water, replenished as it cools, may be set beneath the udder, and with hot cloths the quarter may be kept bathed in this for an hour or two several times a day.

In severe cases a sheet may be passed around the body with holes cut in for the teats, and soft rags packed in between it and the udder. This should be kept warm by pouring hot water on it every ten to fifteen minutes.

The affected quarters should be milked at frequent intervals—from three to five times per day until the trouble is over. Care should be taken, however, that the disease is not carried from one cow to another by the milking machine, on the hands of the milker, or by milking on the platform where the cows may come in contact with the milk.

Often the use of the affected quarter is lost, but if the case is not too severe it may come into milk at the next lactation period.

Milk Fever.—Milk fever is really a misnomer, as there is no fever when the animal has this disease, the temperature really being below normal. The disease usually occurs only after calving and then generally only in the case of high-producing animals. Very seldom does it attack heifers at the first or second calving. The trouble seems to be due to a lack of sugar in the blood. The feeding of sugar, especially glucose, to cows predisposed to this trouble, for several weeks before parturition, lessens the danger of milk fever.

This disease is indicated by staggering, dullness of the eyes, and a fall in temperature. The cow becomes paralyzed and falls down. Usually she will lie on her side with her head turned to one side, resting on her chest with the muzzle pointing toward the flank.

Formerly this was a very serious disease and most animals that contracted it would die. However, since the discovery of the air treatment, the danger has largely been removed. By means of a milk-fever outfit the udder can be pumped up with air, and soon the disease will pass off. It may be necessary to pump the udder up a second or even a third time, but usually once will be sufficient. After the udder is distended until it is as hard, or nearly as hard, as a bicycle tire, the teats should be tied with tape to keep the air from escaping. The milk should not be removed from the udder before pumping.

Medicine should never be given a cow when in this condition as her throat is paralyzed and the medicine may go down the windpipe and cause pneumonia.

Care should be taken, in the use of the milk-fever outfit, that the tube that goes into the teats is sterile and that only sterile air is pumped into the udder.

Hoven or Bloat.—Whenever dairy cows are turned into clover, alfalfa, or any other leguminous pasture, care must be taken to guard against bloat. In pasturing cattle on leguminous crops it is best not to turn them into the pasture until after the dew or rain has dried off. Cattle that have been kept on such pastures for a period of time are not so susceptible to bloat as are those newly pastured. Any condition of feed which causes an unusual amount of fermentation, such an amount, in fact, that gases are created faster than the blood can carry them off, will bring about bloat. In feeding soiling crops, the half-dried material often brings about this condition.

Treatment for severe cases of bloat consists in the use of the trocar and cannula; the animal should be tapped on the left side, half-way between the hip point and the last rib. The best position to take in tapping is to stand at the animal's left side with the trocar pointing toward the heart. If a trocar and cannula are not at hand, an ordinary pocket knife may be used, but the use of the cannula is to be desired as it retains the opening and allows the gas to pass off as it forms.

In mild cases of bloat, the treatment is to give a physic, and to use various devices to help the animal to pass the gases out by way of the mouth. This may be done by prying the mouth open, by holding the head high, or even by inserting a rubber tube.

Foul Foot.—Foul foot is an infectious disease, generally occurring between the toes of cattle. Most dairy farmers are troubled to a certain extent by this disease. When once a farm has had a case, it is difficult to eradicate it, because the soil about the barn becomes infected and in this way the disease seems to be passed from one animal to another. This disease spreads very rapidly in muddy yards. The first symptom is lameness, which, together with the characteristic odor, is sufficient to show the presence of foul foot.

The first thing to do is to clean the affected part thoroughly, washing it with a strong solution of disinfectant, and to keep the infected animal in a clean place. Powdered copper sulphate, dusted over the affected part or dissolved to form a paste and then put on, has proven very satisfactory. Sometimes a poultice of bran and oil meal is necessary to relieve excessive fever and pain.

Many ill-shaped hoofs are the result of this trouble.

Cow Pox.—Blisters containing a yellow fluid on a cow's udder are signs of cowpox. This disease is not generally very serious and does not give the animals a great deal of pain or the milker a great deal of inconvenience. However, the milker can spread it from one cow to another, especially if there are any scratches. For this reason cows having cowpox should be milked last, or the milker should thoroughly disinfect his hands after milking one with the disease before milking any other cow. The milker, if he has not been vaccinated, and has a scratch on his hand, may vaccinate himself against smallpox by milking a cow with cowpox. The best remedy for the udder with this disease is carbolized vaseline or zinc ointment.

Warbles.—In many parts of the country, warbles appear in the backs of cattle in the spring of the year and do considerable damage. The egg is laid by the warble fly. After hatching, the young warble burrows into the skin and migrates through the body, ultimately reaching the back, where it grows and develops into a full-grown larva in the early spring. Warbles do considerable damage by decreasing the milk flow or diminishing the growth of the infected animals and by injury to the hides.

The best method of controlling this trouble is to extract the warbles from the backs of the cattle and kill them. A community can rid itself of warbles if it will destroy all of them in this way.

Lumpy Jaw (Actinomycosis).—This disease is caused by a fungus, *actinomyces*, which gains access to the animal tissue and is supposed to be directly traceable to certain forms of fungus that grow on plants or grasses. It may appear in many parts of the body, although it is most commonly found on the jaw, perhaps because it can find access by way of the teeth. The disease is not very contagious.

So long as the infection is in the soft tissue it is not serious, and the growth can be removed by a surgical operation which removes all diseased portions. This should be done by a veterinarian. When the disease has advanced until the bone is affected, little can be done. Some degree of success has been obtained by the administration of iodide of potassium.

Difficult Parturition.—Cases of difficult parturition are comparatively few, and it is best not to interfere with a cow in the act of calving until it is definitely known that assistance is needed. The normal presentation is the appearance of the fore legs with the head in a straight line over them. When this presentation occurs as it should, it is seldom indeed that the cow needs any help. Sometimes other presentations occur, such as the failure of one fore leg to appear, or the hind legs may come first, etc. In such cases the herdsman can often render sufficient assistance.

In more complicated cases, unless the herdsman has had experience with other cows, he may need the assistance of a veterinarian. Much care should be taken in giving assistance to a cow. When assistance is given by pulling, it should be done slowly and only when the cow is cooperating.

Removing Afterbirth.—It occasionally happens that the afterbirth of an animal is retained, on account of its connection being firmly attached to the womb. This is especially common after abortion. Unless the afterbirth is removed, serious complications will arise.

If the afterbirth has not come by itself within twenty-four to thirty-six hours, it should be removed either by the herdsman or by a veterinarian. Care should be taken in removing the afterbirth that the cow is not injured in any way.

Teat Trouble.—Teats often become scratched or cut. Carbolized vaseline, creolin solution, or hydrogen peroxide will prove satisfactory remedies. Care should be taken to remove from the pasture and lots everything which will cause scratches.

Leaky teats are very hard to cure, and a veterinarian should be called to judge the possibilities of curing them. Nothing can be satisfactorily done for them while the cow is giving milk. Collodion will close them up from one milking to the next, but such a treatment is not satisfactory.

A condition known as " closed teat " sometimes occurs at the end of the teat. Sometimes this is spoken of as " spider teat." It is simply the forming of a scab at the opening and is often the beginning of a case of garget. At the time of each milking, this should be treated with vaseline and a disinfectant.

Wooden, silver, and lead plugs are all used at times on hard milkers. These will stretch the sphincter muscle at the end of the teat, and by so doing cause the cow to milk much more easily. Milk tubes are often used on hard milkers, but they should be used with care, and should always be thoroughly disinfected before being used. A bistoury can also be used to cut the muscle; the result is sometimes satisfactory but more often it is not. Only a veterinarian should perform this operation.

Common Calf Ailments

Common Scours.—Common scours is one of the ailments that occur most frequently in calves. The most frequent cause of scouring is overfeeding. If the calves have not been overfed, the condition can probably be traced to feeding from dirty pails, feeding cold and warm milk alternately, feeding sweet and sour milk alternately, feeding milk too rich in fat, irregular feeding, or unsanitary and damp pens. The first symptom usually noted is a stain on the tail of the calf, caused by semi-fluid and foul-smelling discharges, after which it can be noted that the calf is listless and has little appetite.

Prevention of this trouble is easier than its cure. A dose (1 to 3 ounces) of castor oil should be given in order to move the bowels properly. This may be followed by 1 teaspoonful of a mixture of equal parts of salicylic acid and tannin, twice daily until the symptoms are removed. Hand-fed calves should have 1 tablespoonful of limewater added to each quart of milk fed. Care should be taken in getting the calves back on full feed, so that they will not come down with another attack. While common scours is not considered infectious, it is a good practice to keep sick calves away from the other calves, so that they can be given better treatment.

White Scours.—White scours is an infectious disease caused by a germ which enters the body, most frequently through the digestive tract. It attacks calves at birth or soon thereafter. The symptoms are dullness, weakness and prostration, sunken eyes, short, hurried breathing, and very low temperature, the calf lying on its side with the head resting on the ground. The discharges of the bowels are profuse, yellowish white, and very offensive in odor. The disease is usually fatal within twenty-four to thirty-six hours after birth.

Prevention is the best means of combating white scours. All cases should be isolated, the carcasses of the dead calves should be burned, and the stable thoroughly disinfected. When the herd is small, the disease can usually be prevented by removing the dam to clean quarters a few days before the time of freshening and keeping her there for four or five days afterward. With large herds this is impossible. Some degree of success has been obtained by injecting anti-white-scours serum into all calves immediately after birth. This, however, must be done just as soon as the calf is dropped, otherwise it is not successful.

Pneumonia.—Pneumonia is brought on by chilling and is sometimes associated with calf scours. It is characterized by lack of appetite, rapid breathing, constipation, and high temperature (105 to 106° F.). Severe cases are usually fatal. The calf should be blanketed and placed in a clean, well-ventilated box stall which is free from drafts. Some stimulant is often given. A mustard plaster may be applied over the lungs and a laxative given to keep the bowels open.

Inflammation of the Joints.—This trouble sometimes occurs in young calves within the first month after birth. It is caused by infection which enters the body through the navel and settles in the joints. The joints become swollen and are hot and tender. The calf becomes stiff and lame, loses appetite, has a high fever and accelerated breathing, and often discharges at the navel. Treatment of the navel of the new-born calf with a disinfectant at the time of birth will usually prevent this trouble.

Ringworm.—Ringworm is a fungous growth quite common in calves. Besides detracting very much from their appearance, it affects the thrift of the animals. The disease is characterized by ring-like spots on the skin, usually on the head, neck, shoulders, and rump, where the hair has come out and scabs have formed.

The treatment consists of removing the crust by washing with soap and water and using a stiff brush. The affected part should then be treated with tincture of iodine or with one or another of the sulphur or mercury ointments or other disinfectants. The barn, stalls, etc., should be thoroughly cleaned, disinfected, and whitewashed to destroy the spores.

Lice.—Lice cause a great deal of trouble for the dairy farmer, especially among the calves, which are more susceptible to them than are the grown animals. When calves are affected with lice they are often seen rubbing themselves, and if they are examined carefully the lice can be seen. However, one may not suspect lice. In such cases the calves fail to gain and are not thrifty. One should examine all such animals to ascertain the cause of the trouble.

The best treatment is to wash the affected animals with kerosene emulsions or tobacco sprays at intervals of several days until the lice are killed. A mixture of ½ pint of kerosene and 1 pound of lard can be applied in weather that is too cold to allow washing or spraying. This treatment should be repeated as often as necessary.

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LECTURE XXVIII

DAIRY BARNS—CONSTRUCTION AND ARRANGEMENT

THE dairy barn, more than any other building on the farm, requires special and somewhat definite details of arrangement and construction. It is not the purpose of this lecture to discuss the strength of materials or the size of the timbers that should be used, but to give the details of size and construction of the floor plans, so as to enable the architect or builder who is unfamiliar with such structures to construct a barn that will meet the requirements of dairy animals.

There is no standard dairy barn. Dairymen do not agree as to the best shape and arrangement. There are, however, various principles and requirements that apply to all, and it is the purpose of this lecture to point out these important details. Before the plan is completed it must be viewed from various standpoints: from that of the bacteriologist, who wishes to know whether it is sanitary, clean, and safe for the production of milk; from that of the veterinarian, who is concerned with the health and comfort of the animals; and finally from that of the herdsman, who wants the barn to be constructed so that the cows will be comfortable and produce well, and at the same time to be made so convenient that his work can be done in the shortest time and with the least expenditure of energy.

For the architect, there is hardly any limit to the possibilities. With tall silos, large storage barns for hay and grain, and low barns for the cattle, pleasing combinations are possible. Simplicity is essential. It is the specialized dairy barn that will be discussed here, and not the general-purpose barn. Custom and city regulations are demanding more expensive barns for the production of special grades of milk.

Location.—The hilltop furnishes an ideal situation, but on account of cold winds and the occasional difficulty of securing sufficient level ground for a group of buildings, it may not be so desirable from a practical standpoint. The difficulty of hauling hay and grain to a high location should also be considered. The side of a hill, especially one with a southern slope, is excellent for a small to medium-sized group. Whatever the location, the problem of drainage should be kept in mind. When a high grade of milk is to be produced, a site should be selected that will permit of a good supply of running water in the barn.

Grouping.—In the arrangement of the buildings, convenience is an important consideration, though the feed barns and silos should not connect directly with the milking barn, for the former would admit dust and the latter odors to the barn. The large storage barns should

FIG. 76.—Buildings and outlay for a large dairy herd.

not be so located that they will exclude light and sun from the animals. The cow barns should, if possible, have the long axis running north and south, or northeast and southwest, so that the sunlight will reach both sides of the barn at some time during the day. The arrangement of the buildings should also be planned to protect the cow barns and the animals from winter winds. Young stock and dry cows should not be housed with the milking animals.

Shape.—The round barn is, according to Fraser,[1] one of the cheapest to construct. He has the following to say relative to that style.

"The circular structure is stronger than the rectangular, and the latter requires 22 per cent more wall and foundation, to enclose the same space; and the cost of the material is from 34 to 58 per cent more for the rectangular than the round barn. The silo is usually placed in the center. The round barn can be built cheaper because lighter timber can be used. A large barn of this shape cannot be built to an advantage on account of light."

This saving in cost applies especially to frame buildings, and to the roof, which can be constructed of much lighter material than in the rectangular form of barn. On account of the scarcity of men who can

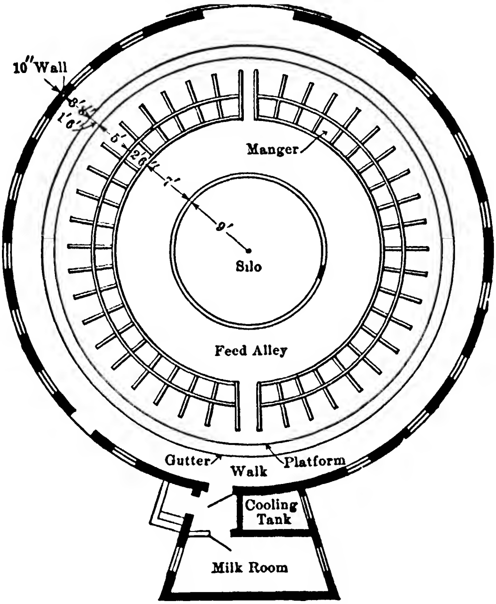

FIG. 77.—Floor plan of round barn for forty cows. (Ill. Exp. Sta.)

construct the round barn, because of the difficulty of getting sufficient light into the center, and because of its limitation to one row of animals, it is not suitable for certain conditions.

In a barn of the rectangular type, a one-row arrangement can be used to advantage if the herd is small; but if a large number of cows are kept, two rows are preferable from the point of view of convenience, light, and expense. A four-row barn is objectionable because there must be many large posts to support the floor, and there is also difficulty in lighting and ventilating such a barn. When the herd is large enough to carry four rows, it is better to build the barn longer or to build two separate cow barns. The expense would be somewhat greater, but it would be justified. The one-story cow barn is preferable for dairy animals for the reason that it is safer in case of fire, and when it is properly connected with the hay and feed barn, and proper trucks and carriers are provided, the animals can be attended to almost as easily as in the two-story barn. In this type the hay barn can be built more cheaply by allowing the hay to go to the floor; this eliminates the heavy timber necessary in the construction when hay is stored on the second floor. When the cows are housed below the storage barn it is necessary to have the walls and timbers much heavier, and

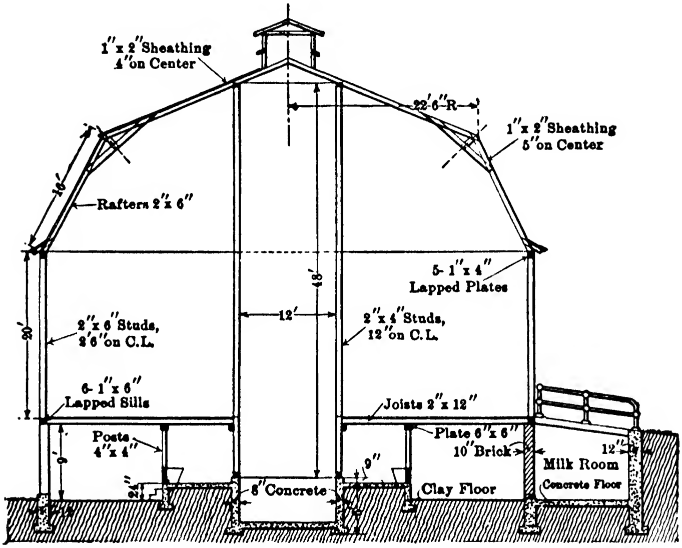

FIG. 78.—Cross-section of round house. (Ill. Exp. Sta.)

when the hay is allowed to go to the ground, a higher barn can be built with much less expense; this saving can be used for the extra roofing of the one-story cow barn.

It is especially important, when a high-producing herd has been developed, to house them in a barn that is safe from fire. The open-shed system is being practiced in some localities, and from experiments conducted at the Pennsylvania Experiment Station[2] it is evident that dairy animals can be housed in open sheds during the winter. The results of these experiments indicate that the animals produce practically as well as in a good stable; that while the decrease in milk during a cold period was greater, the rate of increase during a warm period was also greater than in the closed barn. Slightly more feed was consumed by the cows in the open shed than by those kept in the modern stable.

There is another system of stabling which consists of a covered yard or a large shed in which the cows are at liberty, except during milking and feeding time, when they are tied in a separate barn which can be kept clean and comfortable during the milking. The closed-yard system requires more bedding. With this system, however, the cows can no doubt be kept more comfortable and the milk is perhaps produced at a lower cost.

Size.—For calculating the size of a barn for both feed and animals, some suggestions are offered herewith. The average cow will not consume more than 1 to 1½ tons of hay yearly. A ton of loose hay requires about 525 cubic feet of space, but when settled it only requires about 512 cubic feet. Straw requires a little more space by the ton, and about 1 ton is required yearly for bedding for an animal. A ton of sawdust requires 144 cubic feet of space and 1½ tons are required by a cow for a year. Baled shavings require 160 cubic feet per ton, and ½ to ¾ ton is required by a cow yearly. A cow will eat from 3 to 5 tons of silage yearly, and a cubic foot of silage weighs 40 pounds. A storage capacity of 600 cubic feet is necessary for a whole year's supply of the grain feed of a cow.

In considering the size of the animal barns, 600 to 800 cubic feet of air space should be provided for each cow. When the cows are arranged in two rows, the cow barn should be from 34 to 36 feet wide if they face toward the outside, and at least 2 feet wider if they face the interior. In determining the length of the barn, 3 to 4 feet must be provided for each cow, the space depending upon the size of the cow. This does not make provision for alleys, which should be from 3 to 5 feet wide. Maternity pens should have 90 to 100 square feet of floor space, and individual calf pens from 12 to 15 square feet.

There should be one box stall for every five or six cows, according to the cows in the herd and the degree of success attained in having the cows freshen at intervals throughout the year. Bull pens should be at least 12 by 12 feet. In the northern sections of the United States the height of the ceiling should rarely be over 8 or 9 feet, otherwise the cubic feet of air allowed for each cow will be too great to be maintained at the proper temperature; in the southern sections it may be 8 or more feet.

Ventilation.—It is important that proper change of air take place in the cow barn. A well-ventilated barn is essential. Upon the factors of temperature and moisture depends the whole problem of the proper ventilation of dairy barns. There is no difficulty in getting pure air into the barn during the summer, when windows and doors are constantly open; but it is a problem in winter to secure the proper change of air without making the barn too cold.

The air changes readily during the cold weather. The difficulty is to control it. The problem of ventilation would be simple, where artificial heat is applied to keep the barn warm, were it not for the dif-

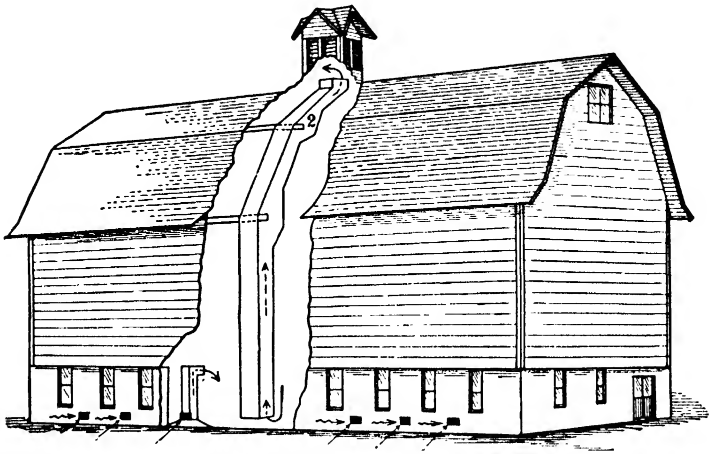

Fig. 79.—Showing details of the King ventilating system.

ficulty of keeping the moisture in the air from condensing. The heat that radiates from the animal bodies is relied on to keep the room warm. If the space is not too great, and the walls are tight, sufficient heat is given off in this way to warm the air; but unless there is an exchange of warm, moist air for cold, dry air, condensation will take place, and a damp, unhealthy stable will be the result.

The system of ventilation suggested by King, of Wisconsin,[3] or a slight modification of it, is the one now most generally used. It is based upon the principle that warm air rises, while the carbon dioxide or the foul air, which is heavier, settles to the floor. These conditions make possible circulation, which is essential to ventilation. Cold, fresh air enters at the ceiling, and foul air is drawn off at or near the floor. In order to have this system work successfully, the walls, doors, and windows must be tight.

Theoretically, this idea is correct, but because of the heat given off by the cows the air in the barn is constantly in motion, so that there is little difference in the composition of the air in different parts of the barn. This fact has led to the plan of drawing the air off at the ceiling, in the center of the barn, and allowing the incoming air to enter at the walls near the ceiling. The heavy, cold air, as it enters through the small intakes, drops toward the floor; after it becomes warm the suction of the outtake carries it away. It is upon this idea that the modern system of ventilation is based. With this arrangement of intakes and outtakes, it is desirable to have numerous small openings for the admission of air, and few and large openings for its escape.

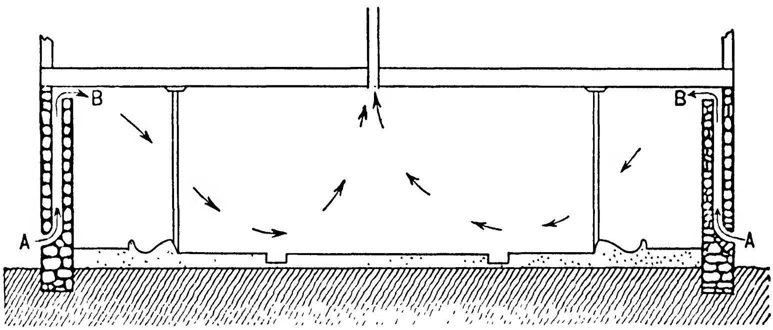

FIG. 80.—A modification of the King system of ventilation. The outlets are at the ceiling and in the center of the barn.

The square surface of the intakes should be slightly in excess of that of the outtakes. One square foot for every five or six cows should give ample ventilation. The outside opening of the intake should be at least 3 feet below the inside opening in order to prevent the warm air from flowing out. Theoretically, the outtake of the King system would draw off the heavier, impure air and less of the warm air when the outtake extends to or near the floor. This is true, although the difference between the two systems is slight, amounting to only a few degrees. It is inconvenient for the herdsmen to have the large flues extending into the interior of the barn. The ventilating flues should be tight; if of metal they should be insulated to prevent condensation. The intake, if of metal, should have a board or some other non-conducting material between it and the inside plaster, if plaster is used. Unless this precaution is taken the cold air will cause condensation on the inside wall, and a wet streak will form along the wall at each intake.

It is well to have an excess of intakes and to provide them with dampers, so that those not needed can be closed. The outside openings should be screened to prevent birds or mice from entering. The outtake can be constructed from two thicknesses of boards, with the grain in opposite directions, and with one or two thicknesses of tar paper between. This flue should be as straight as possible and also as long as practicable.

The following method of calculating the size of the flue, devised by King,[3] will be of assistance for different conditions:

A 1000-pound cow requires 59 cubic feet of air a minute. Assuming that air travels through a flue at the rate of 300 feet a minute, the size of flue can be easily computed for any number of cows. For example, we may assume that we wish to ventilate a barn for 50 cows. The formula will be

$$59 \text{ cubic feet} \times 50 = 2950 \text{ cubic feet of air.}$$
$$\frac{2950}{300} = 9.83 \text{ square feet of outtake.}$$

If two outtakes are used, they must contain 4.91 square feet, or 706 cubic inches each. A little more than this would be supplied in a flue 27 inches square.

Materials.—The selection of materials will be largely controlled by the locality. The frame barn is perhaps the most common type. It can be easily constructed and made attractive; but there is greater danger of fire from wood than from some other materials, and in many localities the expense is almost as great. A frame building can be made sanitary and comfortable for the animals.

In some parts of the United States hollow tile or concrete blocks can be secured almost as cheaply as wood; they are safer from fire, and, if provided with the proper air space, furnish a dry and satisfactory wall. They can be made dry and warm, and they are less expensive to keep in repair. Either of these materials offers excellent opportunities for stucco, which makes an attractive wall for farm buildings. Metal lath is sometimes used on a frame building for placing stucco on the outside and cement plaster on the inside. Stone or brick is satisfactory when plenty of air space is provided within the wall. A solid wall should not be used because of the condensation that is certain to take place on it.

Facing the Cows toward the Interior or the Outside.—There are advantages in both systems, and both are used. With the mangers together, work is saved in feeding; with the gutters together, the work of cleaning is lessened. More time is required to feed the cows than to clean out the stables.

With the system of overhead carriers there is perhaps no advantage to be gained in cleaning by facing the cows toward the outside. If

Fig. 81.—Stable with cows facing toward the center.

the herd is large, however, and it is the practice to drive into the barn to get the manure, it is preferable to have them face toward the outside; even then, unless the herd is so large that a load, or nearly a load, of manure is obtained, the extra work of hitching up a team would hardly be justifiable. When the milking machine is used there is some advantage in facing cattle outward, since with it cows on opposite sides of the alleys may be milked at the same time. The presumably greater danger of contamination among cows, because of their breathing into one another's faces, has been offered as an objection to facing them inward. This is perhaps not an important matter in a well-ventilated barn, especially if the barn is wide enough to permit the cows to be reasonably far apart. One of the disadvantages of facing the cows inward is that, unless the alley back of them is quite wide, the wall may become soiled. The chief advantage of this position, however, besides convenience of feeding, is that the light comes where it is most needed, and the sun may shine into the gutter, drying it out and keeping it more sanitary.

Alleyways.—The width of the alleyways in the cow barn should be about 5 feet from the edge of the gutter to the edge of the wall when the cows face the interior, and about 4 feet from the manger to the wall when they face outward. The alleyway between the

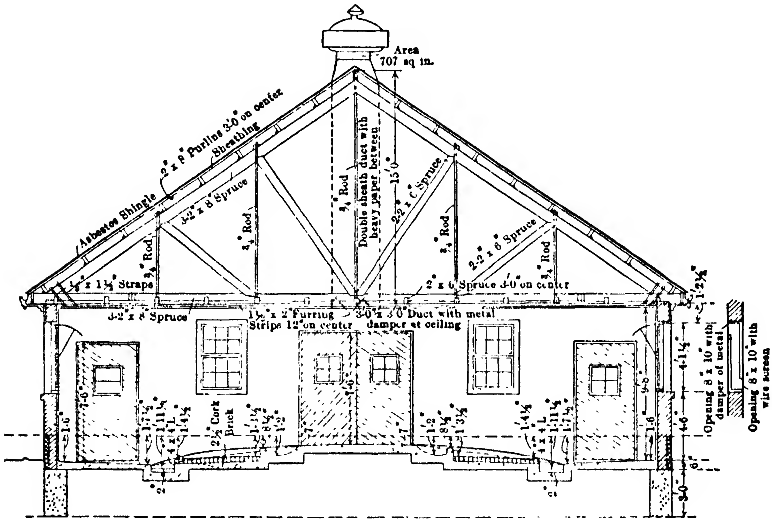

FIG. 82.—Cross-section of stable. Cows facing center.

cows when they face inward should be at least 6 feet from manger to manger, and when they face outward about the same from gutter to gutter, unless the system of carrying the manure out with the manure spreader is practiced. There should be a slight slope of about 1 inch in 4 feet to the gutter. The feed alleyways should be smooth, while the alleyways through which the cows walk should be made rough so that they will not slip. Cork or creosoted blocks are sometimes used for that purpose. If the surface is properly roughened there is little danger that the animals will slip, even on cement.

Platforms.—The platforms on which the cows stand are an important part of the barn construction. They should be of the proper length so that the manure will drop into the gutter and not on the platform. The length will depend upon the size of the cow. Adjustment can be made either by having the platforms longer at one end of the row than at the other, and by placing the larger animals at the longer end, or by the use of adjustable stanchions. Platforms of a suitable size for Jerseys are 4 feet 4 inches to 4 feet 7 inches; for Ayrshires and Guernseys, 4 feet 6 inches to 4 feet 10 inches; and for Holsteins, 4 feet 10 inches to 5 feet 6 inches. The platform should slope slightly toward the gutter. A slope of 1 inch in the total distance of the platform is sufficient.

A number of different materials are used for the floor of the platform. The dirt floor is objectionable because it is hard to keep clean, though it is comfortable for the animals. A further disadvantage is that it is soon cut up by the hoofs and the surface made irregular. Wood floors are not durable; they absorb liquids, and are difficult to keep clean. Concrete has been more generally used during recent years, but it is slippery and cold, especially if not properly underdrained, and is hard on the knees and hocks of the cows. The use of a coat of tar on a layer of tar paper, an inch or so below the upper surface of the concrete, practically cuts off the movement of the warmth of the animal below the point of insulation. The use of creosoted wood blocks or cork bricks for cow-barn platforms is increasing. Cows are not so likely to slip on them; they are not so cold; and there is less danger of injury to the udder, knees, and hocks. When properly laid they are sanitary and will last a long time.

There are other compositions that are being suggested for floors, such as a combination of cement and wood sawdust; also asphalt, although neither of these has come into much use. Some barns are provided with a plank surfacing that is put over the cement floor in the winter and taken up during the summer. Unless these floors are taken up and cleaned they become unsanitary.

Mangers and Curbs.—A concrete manger is sanitary and satisfactory. The bottom of the manger should be at least 1 inch above the platform on which the cow's front feet rest. The depth of the manger need not be over 6 inches, while a width of 26 to 36 inches is sufficient when the alleyway in front of the manger is on a level with the top of the manger. Some cows will push their feed out of mangers that are as wide as 4 feet and as high as 3 or 4 feet, but when the feeding platform is on a level with the top of the manger it is an easy matter

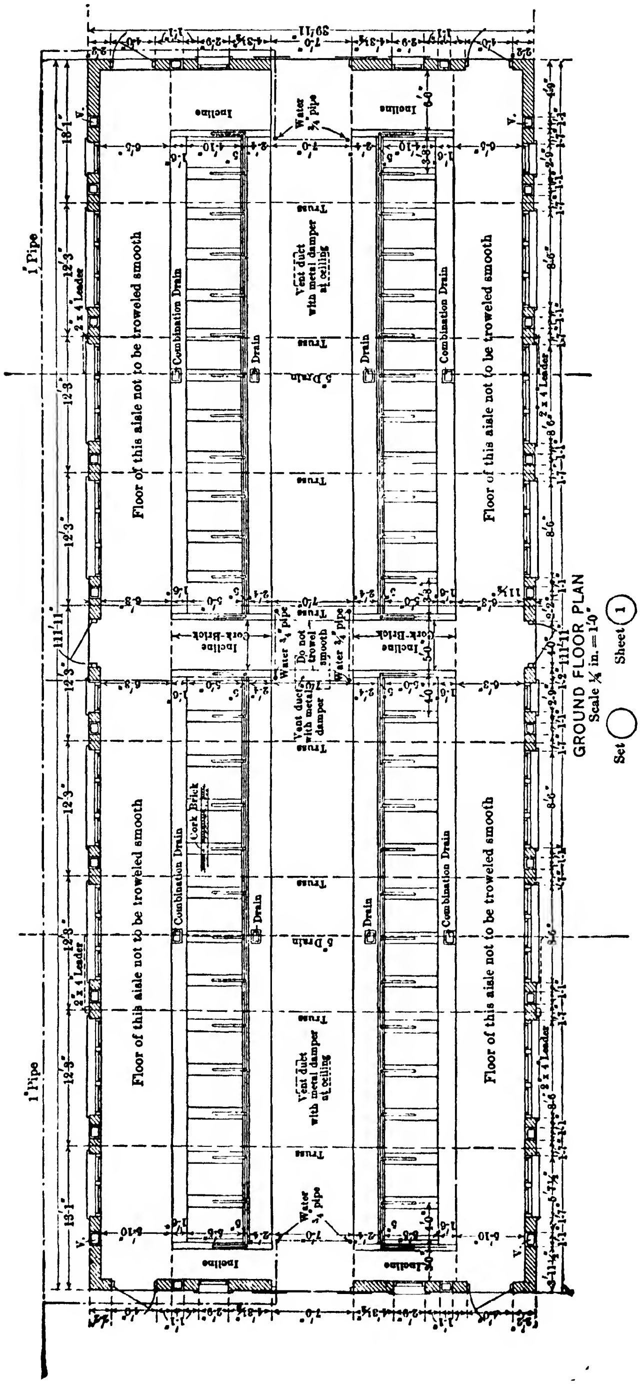

FIG. 83.—Ground floor plan of stable for fifty cows.

to push the feed back into the manger. A disadvantage of having the manger built higher than the alleyway is that it is difficult to put the grain back when it has once been pushed out over the edge. An advantage, however, is that dirt and trash, which are carried in on the feet and trucks, do not get into the mangers.

The curb dividing the platform and manger and supporting the stanchions should be about 5 inches thick, and should have rounded corners to protect the cows from injury. The height of the curb should not be over 7 inches at the point where the cow's neck extends over it. It may be higher at the sides. The plan of building a curb 11 or 12 inches high, and cutting out a semicircular piece to a depth of 5 or 6 inches, is satisfactory.

Partitions of some sort should be provided in the mangers, so that one animal cannot take the feed intended for her neighbor. Partitions that can be raised, making the manger continuous, are desirable from the standpoint of sanitation, but most of those that are on the market are not substantial enough. An iron rod simply run between the mangers, 12 or 14 inches from the bottom, will be sufficient to keep the animals from eating each other's grain, but it will not prevent the exchange of hay.

Wood, steel, and galvanized iron are also used for mangers and manger partitions, although many of the barns in which high grades of milk are being produced have the continuous concrete mangers already described. Some practical dairymen, however, believe that by the use of such mangers there is greater danger of spreading disease in the herd. Those who favor the concrete manger believe that because it can be thoroughly cleaned it is less likely to harbor disease germs. The advocates of the concrete system believe, further, that if contagious diseases are in the herd they are as likely to be transmitted in the yard or at watering places. The higher individual mangers, built of wood or metal, hold the feeds better, but are difficult to keep clean.

Windows.—There should be as many windows as the construction of the barn will permit. Windows cost no more than the same amount of wall, and the more light in the barn the better. The windows should be made flush with the inside wall so that there will be no ledges. They should extend almost to the ceiling, but should not be lower than 4 feet from the floor, when the cows face in, because of the danger of their being struck by the cows. A single sash with double panes of glass about $\frac{1}{4}$ inch apart adds little to the expense and very much to the value of the windows. If a single pane of glass is used, cold winter air on the outside condenses the moisture of the inside air and forms a heavy coating of ice on the glass. Not only does this coating exclude the light, but when the sun melts the ice a wet wall is the result. With a double-glass window this condition is avoided.

The plan of fitting the upper sash into cheeks on either side and tipping it inward at the top admits air to the barn without a direct

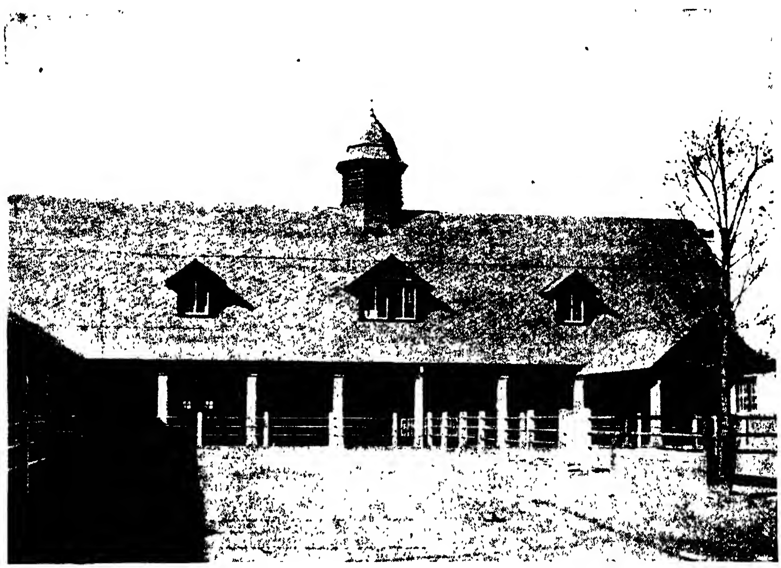

FIG. 84.—A clean dry yard made of crushed rocks.

draft upon the cows. These windows are only resorted to when the weather is warm enough to admit more air than is furnished by the King system. In certain barns they are the only intakes used. This method of ventilation is known as the "Sheringham system." The windows are sometimes covered with muslin and the air and light admitted in that way. The air readily passes through the muslin, but not as a draft. It should be kept in mind that this system makes a barn cold in northern climates, though where the King system is not used the muslin curtain is advantageous.

Drains.—The dairy barn should be provided with drains so that the floors and corners can be thoroughly washed with a large quantity of water. These drains, however, should be so constructed that they can be closed entirely, so that the liquid manure will not flow away; or they should be provided with a double opening so that the liquid manure can be caught and carried to a cistern, and when the stable is being cleaned the washings can be run out into the general drains. The drains are best located in the gutters, mangers, and feed alleys. A 2½ to 3-inch slope from the ends to the center of a fifteen-cow row is sufficient to carry off the liquid through the gutter.

Gutters.—There are a great many different suggestions for gutters. The main considerations are that they be deep enough to prevent the manure from piling up high and soiling the cow, and wide enough to keep the manure from dropping on the platform across the gutter. It seems desirable to have the edge of the gutter that is nearest the cows higher than the edge that borders the alley, for the cow easily steps up; in fact, she is more apt to step than to jump when there is a rise than when the two platforms are on a level. The gutter should be at least 6 inches deep, and there is no objection to a depth of 9 inches nearest the cows, with a height 2 to 3 inches less on the alley side of the gutter. The gutter should not be too narrow, 18 to 22 inches being a desirable width.

Some gutters are made with round bottoms; others are sloped toward the back, in the belief that the liquid will be carried away better, and hence not soil the tail of the cow. The result is not always satisfactory, and such gutters are harder to clean.

Even a dirt floor should be provided with gutters, either of wood or of cement.

Steel gratings, made of bars about ¼ inch thick by 2 inches wide, placed on edge about 1 inch apart, are used to some extent in the gutter. It is believed that the cows can be kept clean by the use of these; the manure and liquid are supposed to pass through to the gutter and to prevent the tail and hind quarters of the cow from getting soiled. Grating, however, is only effective when fine shavings or sawdust are used for bedding. Straw would keep the manure from falling through.

Some barns are constructed with platforms so short that the cows are obliged to stand on the grating. This has a tendency to cause sore feet. One thing to be said for the grating is that the cows can go in and out much more easily and safely than when they are obliged to cross an open gutter. The construction of the grating should be simple; it should be hinged throughout its entire width, or constructed to be removed entirely, so that thorough cleaning is possible.

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LECTURE XXIX

DAIRY BARN EQUIPMENT

The equipment of dairy barns is so far from being standardized that no attempt will be made to enumerate all the different devices that are on the market, or to discuss the advantages and disadvantages of different kinds of equipment. Some of the more common devices and their principles and uses will be discussed. Because of the constant changes in particular makes of equipment, the trade terms will not be used in this discussion.

Ties for Dairy Animals.—The most common method of tying cows in dairy barns in this country is with stanchions. These are simple and sanitary. The cows can be tied easily and quickly with them, and can be kept in alignment with the platform, a condition which tends to keep the animals clean. The stanchions should be so constructed and arranged as to allow the cows the greatest possible freedom. There should be several links of chain at the bottom and top of the stanchion and sufficient room on both sides of it to permit the animal to move its head from side to side. Comfort is as important as proper alignment.

Another method of tying the cows is to use two posts, one at each side of the cow, to which the cow is fastened by means of a ring and chains. This method permits considerable freedom, and at the same time keeps the cow in alignment. It is not so convenient, however, as are the stanchions.

The single chain or rope method is sometimes used. The objection to this is that it permits the cows to move backward and forward to such an extent that it is impossible to keep the stall clean. Cows are sometimes kept in box stalls, but when this is done much more bedding and labor are required in order to keep them clean.

Partitions.—Although partitions between the cows are not necessary, they are desirable. Without them, one cow may occupy a part of the stall of another, making it impossible for the latter to lie down;

it is also easy, under these conditions, for one cow to trample on the udder or teats of the cow next to her, thus causing trouble.

The simple bent-rod partitions are satisfactory. For heifers or small cows, these partitions should be from 3 feet to 3 feet 6 inches apart; for the smaller breeds, such as the Guernseys, Jerseys, and Ayrshires, they may be from 3 feet 4 inches to 3 feet 8 inches; and for large animals, they may be as far apart as 4 feet.

Sometimes solid wooden partitions are used, but they prevent proper circulation of air, make the stable dark, and are very difficult to keep clean.

FIG. 85.—A sanitary box stall.

Feed Carts and Carriers.—The three-wheeled cart forms a simple device for the distribution of the grain. This should be provided with scales and a board to which the feed sheet may be attached so that the feeder can easily determine the amount of feed to be given to each cow in the herd.

Some barns are provided with an overhead track on which the feed carrier is run. This is also a convenient method of feeding the grain.

The hay is usually slid along the floor to where it can be easily distributed, but when it is stored some distance from the stable special carriers must be provided. A low truck with the regular hay-rack body is very convenient. Hay is sometimes carried on a special platform suspended from a track.

The conveyors used for silage may be similar to these used for grain, but larger. Beet pulp may be fed from similar conveyors but they must be able to hold water, otherwise when the dried beet pulp is soaked the water will run out.

Litter Carriers.—In some barns, the cows are turned out each day and the manure is disposed of by driving through and loading it directly on the spreader. If the herd is large enough to supply a load of

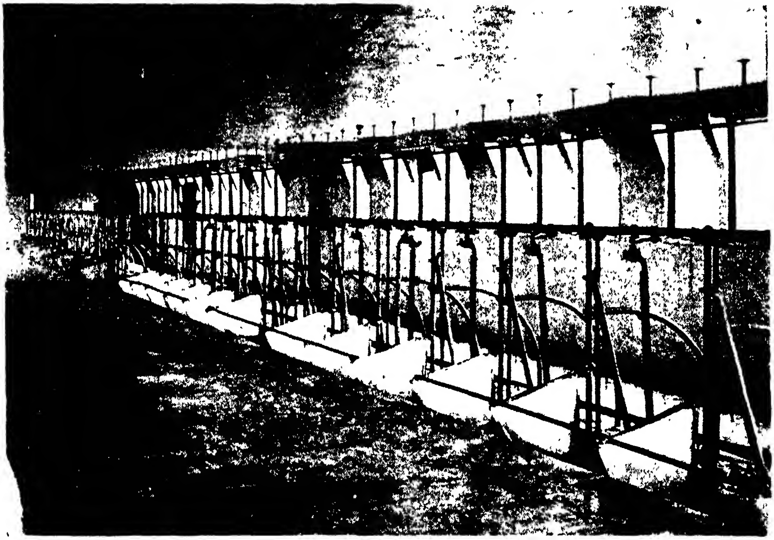

FIG. 86.—Manger partitions are handy, but not essential.

manure each day, this is a saving of labor, otherwise it will require more time to do this than to store the manure.

In a small herd, a wheelbarrow or small truck may be used. A smooth walk should be made leading to the manure pit, which should be located at least 50 feet from the barn.

The most common system used in dairies of any size is the litter carrier, which runs on an overhead track. A large quantity can be moved more easily in this way than on a wheelbarrow. The manure may be dumped directly into a spreader or may be emptied into a manure pit where it may be stored until a convenient time for spreading.

For the rapid cleaning of barns a special device has been used. The gutter is deep and provided with a grating, and by the use of a special scraper and cable the contents are drawn to one end of the barn and loaded directly on to a wagon or put into a pit. The chief objection to the grating is that it is harder to keep clean than is the open gutter. The special scraper for cleaning by machinery is a saving of time in cleaning the manure from a large barn. An engine, however, must be kept in running order for each cleaning and, though the scrapers do remove practically all the manure, yet the deep gutter with a large surface requires additional cleaning when high-grade milk is produced.

Watering Devices.—The system of turning cows out to drink once or twice a day is used quite extensively. Some dairymen water once or twice a day by running water in a concrete manger in front of the

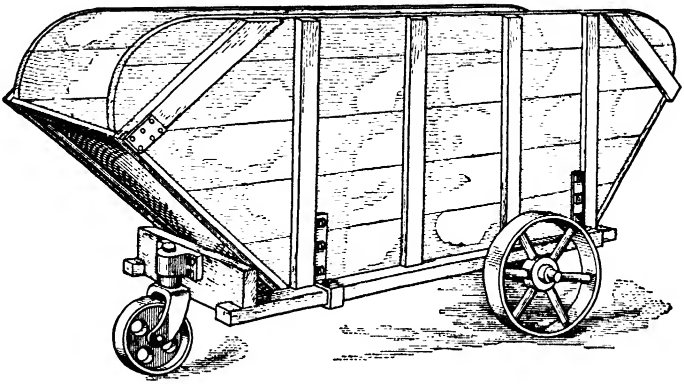

Fig. 87.—A handy feed cart.

cows. Cows, however, will produce a little more milk if they are given access to water at all times; also there is less opportunity for diseases to be transmitted from one to another when they have individual drinking cups. For these reasons, there are now in use in many dairies individual watering cups which give the cows access to fresh water at all times. There are two general systems of supplying water to watering cups. One is the gravity system, in which water is kept at a certain level in the cups by means of a large tank, provided with a float, at one end of the building; the other is the pressure system, in which the water is forced to the cups and let in by a valve, which the cows soon learn to operate. The latter is to be preferred where the water system is such that it can be used. The objection to the gravity system is that when the water in the tank becomes low the water from

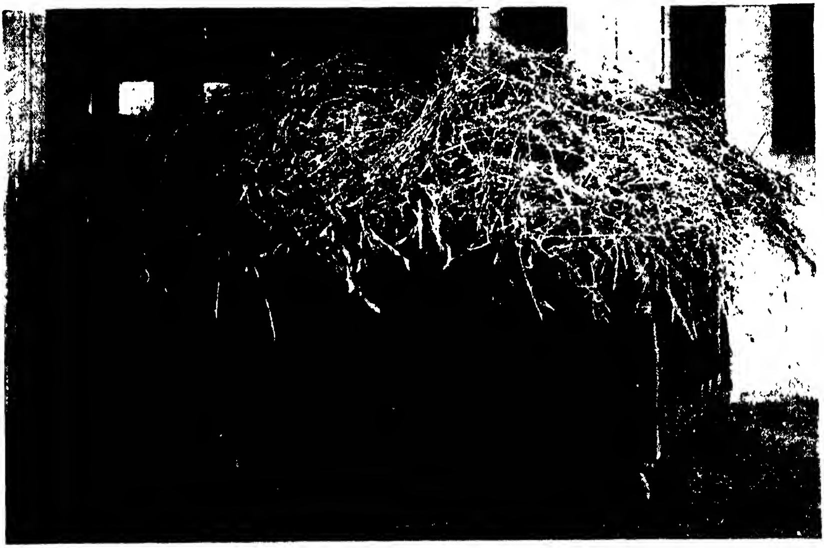

FIG. 88.—A hay wagon.

FIG. 89.—A litter carrier saves labor.

the drinking cups flows back so that if any of the cows have an infectious disease it may be spread throughout the entire herd in this way. The same objection was found in the old-type pressure systems, but the modern drinking cup of this type has the valve at which the water enters the bowl above the normal level of water in the cup so that it is impossible for the water to flow back.

Many different types of cups have been used. One type is provided with lids which when open allow the water to flow in, and when closed empty the cup. Cows often learn to play with cups that have

FIG. 90.—Automatic watering cups. Water flows in when lid is open and out when lid is closed.

covers, raising and dropping them, and thus causing great confusion. Lids have the advantage, however, of keeping the feed and dirt out of the cups. Sometimes the valve will stick and the barn will be flooded. Some cups without covers collect feed in the valves and thus become unsanitary. Care should be taken to keep the cups clean. There are many cups now on the market which give good satisfaction.

Calf Pens.—Calf pens should be dry and well ventilated, but care should be taken that they are free from drafts. They should be provided with stanchions or ties, so that the calves may be tied to prevent them from sucking one another after they have finished drinking their milk. In the summer calves are often allowed to run in an open lot. This should also be provided with stanchions where the calves may be tied after being fed. This makes it much more convenient to feed and at the same time insures every calf its required ration.

Milking Machines.—One of the most important problems on the dairy farm is that of labor, especially the labor involved in the milking. For this reason much effort has been made to perfect a machine that will perform this operation satisfactorily. Mechanical devices for milking cows have been in process of invention and improvement for the past fifty years, but it is only within the past twenty years that

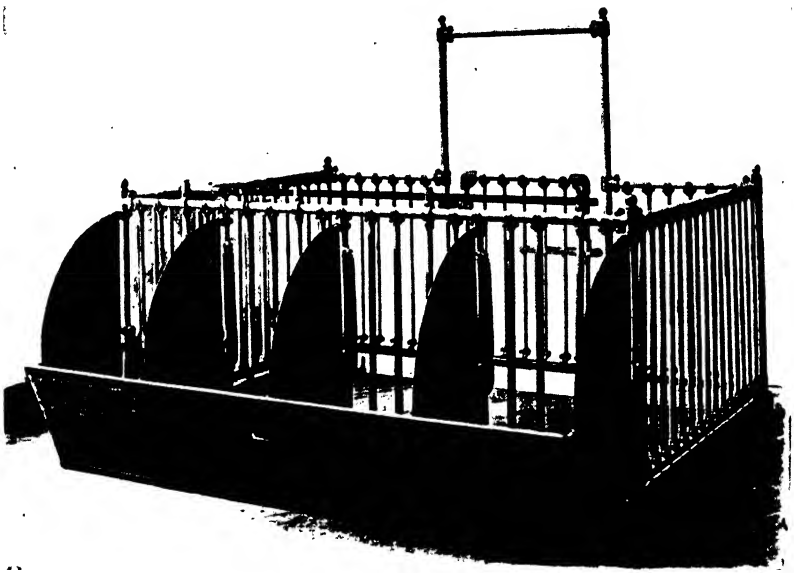

Fig. 91.—Manger partitions for calf pens.

they have appeared on the market in forms reliable and efficient enough to warrant their serious consideration for ordinary farm or commercial use.

There are many makes of milking machines on the market to-day, but they practically all use the same system of operation. They all employ the vacuum principle, although a few use both the vacuum and pressure. They differ principally in construction. All models have pulsators which are operated by air pressure

The principal advantage of a milking machine is that it saves labor. At the Kentucky Station[1] it was found that the average time required to milk a cow with a machine was 3.99 minutes. The machine did not draw the milk from the cow much faster than a fast hand milker, but one man could operate two or three units at a time. It required two men with four units 43.4 minutes to feed, milk, strip, and weigh the milk from twenty-eight cows, while the same operations, when the milking was done by hand, required 1 hour and 20 minutes. The average time required to milk a cow at the Texas Station[2] with a milking machine was 4.643 minutes, and by hand it was 7.269 minutes. The care of the machine required on the average 23.7 minutes per day.

Milking machines seem to keep up the milk flow just as well as does hand milking. The Kentucky Station tabulated the milk yield from the thirty days preceding and the thirty days after the beginning of the use of the milkers, and found that there was no appreciable or permanent decrease in milk production due to their use. The same result has been secured at other experiment stations.

With regard to the effect of the milking machine on the quality of the milk, it has been found that when the machine is thoroughly sterilized and kept in proper condition, there is practically no difference in the number of bacteria in the hand-drawn and machine-drawn milk. Experiments seem to indicate also that the machines as now constructed have no bad effect upon the udder or the health of the cows, provided the teats and udders are normal at the beginning and the cows are properly stripped after the milking. It is always necessary to strip the cows after the machine has been removed, as the machine will not get all of the milk from all of the cows.

The success of a milking machine depends largely upon the operator. With a careful operator—one who takes care of all details and watches his machine closely—it is fairly certain that the machine will give perfect satisfaction. With the careless operator trouble will always be experienced. The milking machine is simply a machine and must be treated as such.

Breeding Rack.—The breeding rack is used for two purposes:

1. For the breeding of small cows or heifers by a large bull, or of large cows by a small bull.
2. For the breeding of animals that do not readily stand.

Occasionally, also, a bull will serve to better advantage when a rack is used. The breeding rack should probably be used more than it is, but because of the inconvenience of adjusting it for each animal, and because of the trouble of bringing both animals to it, most herdsmen do not usually use it until it is absolutely necessary. The stanchion of the rack should be adjusted so that a small animal can be held back and a large animal allowed to go forward. It is well to have the sloping part on which the bull's front feet rest provided with cross strips, as well as a strip along the outer side to keep the bull's feet from

FIG. 92.—Breeding Rack. Dimensions, floor planks 9 feet long, front posts 4 feet, and rear posts 1½ feet. One and one-half feet between floor planks in front and 2 feet in rear.

sliding off. The dimensions and method of construction are shown in Figure 92.

Stocks.—Stocks are strongly made crates in which animals can be held successfully during the trimming of hoofs or dehorning, or while other operations are being performed, when it is necessary to have the animal under full control. Stocks are especially useful for the handling of bulls. They should be constructed of good material and well bolted together. They should be made adjustable so that they can be used to hold animals of different sizes. This can be done by having several slots for the timber inserted at the back to hold the animal in place, and also for the stanchion. It is sometimes difficult to get animals into a stock. This is especially true of bulls. The difficulty

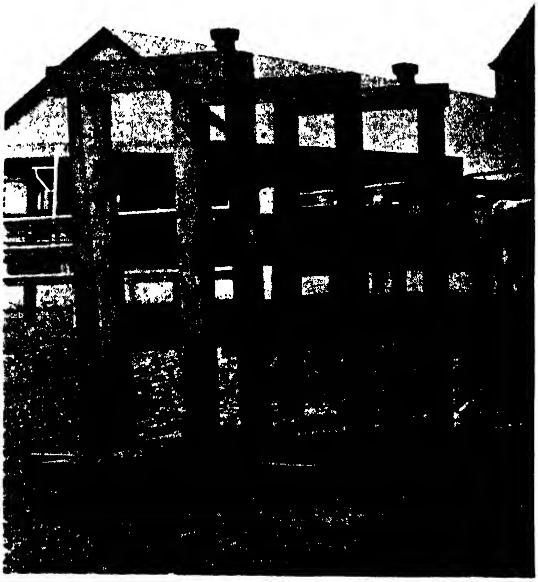

FIG. 93.—Stocks. Dimensions, total length 9 feet, height 6 feet. Width inside 2 feet 4 inches, and 2 feet 8 inches from stanchion to floor ring.

can be overcome by going slowly and, if necessary, tying the obstinate one for a little while at the entrance to the stock. Figure 93 shows the construction and dimensions of a satisfactory cattle stock.

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LECTURE XXX

THE PRODUCTION OF HIGH-GRADE MILK

WITH the proper barn and equipment, as described in previous lectures, it should not be a difficult task to produce high-grade milk. The equipment, however, is not all that must be considered in this connection. Proper methods must also be used if the best results are to be obtained. In fact, high-grade milk may be produced in very ordinary barns and with mediocre equipment, if good methods are used. In order to produce clean, high-grade milk, the dairyman must understand what constitutes cleanliness and be willing to watch all details which are necessary for the production of such milk.

Milk is easily contaminated with dirt, bacteria, and odors. When the proper temperature is maintained it furnishes an excellent medium for the growth of bacteria. Great care is necessary in the production and handling of milk as a food product, in order to put it in the hands of the consumer in satisfactory condition.

INSPECTION OF MILK

There are two general methods of inspection to determine whether milk is being produced in the proper manner. One is to examine the milk itself, as it reaches the market, by means of acid tests, reductose tests, sediment tests, or bacteria counts. Sometimes two or more of these tests are used together.

The second method of inspection consists of an examination of the conditions on the farm. Such things as the health of the cows, the condition of the stable, the methods used, etc., are taken into consideration. Many cities use a combination of the two systems.

Examination of the Milk.—Milk that contains considerable sediment, as indicated by the use of the sediment tester, shows very plainly that it has been produced under conditions that are unclean. The acid test and the reductose test may indicate the age of the milk rather than its cleanliness. The presence of a large number of bacteria may be due to the age of the milk or to the number of bacteria in the milk when it was drawn from the cow. A small number of bacteria, however, indicates that the milk has been produced under clean conditions. The number of bacteria found in a sample of milk depends upon three factors: the number of bacteria in the udder at the time the milk was drawn; the number that have gained access to the milk since it was drawn; and the amount of growth or increase that has taken place previous to the examination. If milk is properly produced and carefully handled it should contain only a few bacteria, even though it is held for some time before being put on the market. The ordinary method of counting the bacteria in milk is the plate method. This method, however, is slow and takes considerable equipment. A direct microscopic method has been devised whereby a direct count may be made by the use of the microscope[1] in a very short time.

Examination of the Conditions at the Farm.—When the conditions at the farm are examined they are usually rated by means of a score card. While many score cards have been used, the one devised by Pearson and modified by the Official Dairy Instructors' Association has been used most extensively. This score card is shown on page 366.

It will be noted that 40 points have been given for equipment and 60 points for methods. The different values are merely arbitrary, and the score card is chiefly useful in indicating the various points to be considered in the production of high-grade milk. In this way it not only serves as a guide for the inspector but also helps the dairyman to know how to equip his stable and what methods to use in order to produce good, clean milk.

PRODUCING HIGH-GRADE MILK

Milk, to be high-grade, must be clean and of good flavor, and have only a few bacteria, none of which must be harmful. In order to produce such milk, very careful methods have been devised. These methods do not require elaborate or expensive equipment but they do require the greatest care and cleanliness.

Healthy Cows.—Milk should be produced from cows which are known to be free from disease. As stated in a previous lecture, tuberculosis in dairy cows, especially when the udder is affected, may be the cause of tuberculosis in humans. Cows should be tested for tuber-

Equipment	Score: Perfect	Score: Allowed
Cows		
Health	6	....
Apparently in good health 1		
If tested with tuberculin within a year and no tuberculosis is found, or if tested within six months and all reacting animals removed...... 5		
(If tested within a year and reacting animals are found and removed, 3.)		
Food (clean and wholesome)	1	....
Water (clean and fresh)	1	....
Stables		
Location of stable	2	....
Well drained............ 1		
Free from contaminating surroundings......... 1		
Construction of stable	4	....
Tight, sound floor, and proper gutter......... 2		
Smooth, tight walls and ceiling.............. 1		
Proper stall, tie, and manger.............. 1		
Provision for light: Four sq. ft. of glass per cow	4	....
(Three sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1. Deduct for uneven distribution.)		
Bedding	1	....
Ventilation	7	....
Provision for fresh air, controllable flue system. 3		
(Windows hinged at bottom, 1.5; sliding windows, 1; other openings, 0.5.)		
Cubic feet of space per cow, 500 ft........... 3		
(Less than 500 ft., 2; less than 400 ft., 1; less than 300 ft., 0.—		
Provision for controlling temperature.......... 1		
Utensils		
Construction and condition of utensils	1	....
Water for cleaning	1	....
(Clean, convenient, and abundant.)		
Small-top milking pail	5	....
Milk cooler	1	....
Clean milking suits	1	....
Milk room or milk house		
Location: Free from contaminating surroundings	1	....
Construction of milk room	2	....
Floor, walls, and ceilings. 1		
Light, ventilation, screens 1		
Separate rooms for washing utensils and handling milk	1	....
Facilities for steam	1	....
(Hot water, 0.5.)		
Total	40	....

Methods	Score: Perfect	Score: Allowed
Cows		
Clean	8	....
(Free from visible dirt, 6.)		
Stables		
Cleanliness of stables	6	....
Floor................. 2		
Walls................. 1		
Ceilings and ledges..... 1		
Mangers and partitions.. 1		
Windows............... 1		
Stable air at milking time	5	....
Freedom from dust..... 3		
Freedom from odors.... 2		
Cleanliness of bedding	1	....
Barnyard	2	....
Clean.................. 1		
Well drained........... 1		
Removal of manure daily to 50 feet from stable	2	....
Milk room or milk house		
Cleanliness of milk room	3	
Utensils and milking		
Care and cleanliness of utensils	8	....
Thoroughly washed..... 2		
Sterilized in steam for 15 minutes.............. 3		
(Placed over steam jet, or scalded with boiling water, 2.)		
Protected from contamination.............. 3		
Cleanliness of milking	9	....
Clean, dry hands....... 3		
Udders washed and wiped............... 6		
(Udders cleaned with moist cloth, 4; cleaned with dry cloth or brush at least 15 minutes before milking, 1.)		
Handling the milk		
Cleanliness of attendants in milk room	2	....
Milk removed immediately from stable without pouring from pail	2	
Cooled immediately after milking each cow	2	....
Cooled below 50° F	5	....
(51° to 55°, 4; 56° to 60°, 2.)		
Stored below 50° F	3	
(51° to 55°, 2; 56° to 60°, 1.)		
Transportation below 50° F.	2	....
(51° to 55°, 1.5; 56° to 60°, 1.)		
(If delivered twice a day, allow perfect score for storage and transportation.)		
Total	60	....

Equipment.............. + Methods.................. = ...Final Score

Note 1.—If any exceptionally filthy condition is found, particularly dirty utensils, the total score may be further limited.

Note 2.—If the water is exposed to dangerous contamination, or there is evidence of the presence of a dangerous disease in animals or attendants, the score shall be 0.

culosis at least once a year, and if the disease is found the test should be made twice a year. All reacting animals should be removed from the herd, and the stables and premises thoroughly disinfected.

Milk that is in any way abnormal should be discarded. Ropy milk, slimy milk, or milk which comes from an animal that appears sick or out of condition should not be used for human consumption. As a general rule, milk from a cow two weeks before calving or five days after calving should not be used. Only milk from healthy, normal cows should be used.

FIG. 94. Clean, healthy cows are the first essential in clean milk production.

Clean Cows.—Much of the dirt and dust that gets into the milk comes from the cow's flanks, udder, or belly during milking time. For this reason the cows should be cleaned before they are milked. The amount of labor required to keep a cow clean is lessened by having the platform of the right length, by using sufficient bedding, and by keeping the hair clipped from the udder, flanks, and part of the belly. When long hairs drop they carry with them large numbers of bacteria. Dust also is removed with greater difficulty if long hair is allowed to grow on the parts mentioned. When kept in the barn the cows should be given at least one complete grooming daily. This should be done some time before milking so that there will be time for the dust to settle.

It is also desirable to wipe the udder and flank with a clean, damp cloth immediately before milking. This materially reduces the bacteria count, as shown by Table LXXIV.[2]

TABLE LXXIV

EFFECT OF BRUSHING, WASHING, AND DRYING OF COW'S UDDER AND FLANKS ON BACTERIA COUNT

Housing of Cows	Conditions of Cows	Number of Experiments	Average Count per Plate
Summer—all cows out	Untouched..................	7	440
Summer—all cows out	Udder and flanks washed and brushed..................	3	170
Winter—cows indoors	Untouched..................	3	4752
Winter—cows indoors	Udder and flanks brushed	3	1752
Winter—cows indoors	Udder and flanks brushed, washed and left moist......	6	230
Winter—cows indoors	Udder and flank brushed, washed and dried..........	3	440

Milk always contains some bacteria when drawn from the cow. The number of bacteria found in the udders of different cows varies considerably. In studies by Sherman[3] on udder flora, it was found that certain animals produced milk containing not more than 300 or 400 bacteria per cubic centimeter, while the milk of others did not go below twenty or more thousand. This may possibly be caused by the fact that the opening of some teats is larger than that of others, or that the sphincter muscle of the teats closes imperfectly, allowing a greater number of bacteria to enter the udder. Udder trouble, such as garget, also results in more bacteria being given off in the milk. Some cows may have chronic udder trouble which is not generally noticeable, but which causes them to give off large numbers of bacteria. Whatever the cause, it is necessary in the production of the highest grade of milk to make a study of the individual animals and to eliminate those that constantly produce milk with many bacteria. As there are slightly more bacteria in the milk first drawn than in that drawn later, it is the practice of some to discard the first few streams from each teat.

Clean Stables.—Whenever possible, the barn should be located on high ground with good natural drainage and at a good distance from poultry houses, hog pens, manure piles, or other surroundings which might pollute the barn air and furnish breeding grounds for flies and bacteria.

The floor of the barn should be non-absorbent and smooth so that it can be easily cleaned. Drains should be provided so that the floors and walls can be washed. The stalls and mangers should be such that they offer the least surface for collecting dust and dirt and the least obstruction to the circulation of air. Good ventilation should be provided so that the air will always be kept pure and clean, both for the health of the cows and to avoid the effect of impure air on the milk.

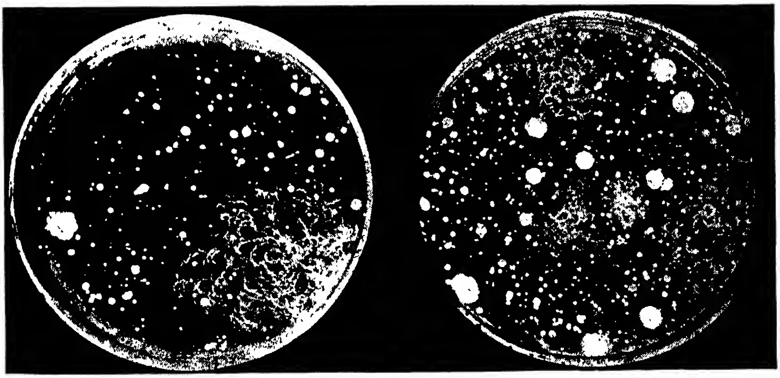

FIG. 95.—Plates exposed to the air of a stable. The plate on the left was exposed five minutes and the one on the right for ten minutes. (*Troul*)

Too much light cannot be provided; bacteria do not live well in bright light, especially sunlight. The light not only shows the presence of the dirt but also helps to keep the barn in a sweet condition.

The stable air should be kept clean. Dust carries bacteria, and hence it is necessary in the production of clean milk to have the barn as free from dust as possible. Feeds containing dust should not be fed for some time before milking nor should dusty bedding be used. Figures 95 and 96[4] show the effect of dust in the stable air. Figure 95 shows agar plates exposed to the air of a stable for five and ten minutes, while Fig. 96 shows agar plates exposed to the air of the same stable for five and ten minutes just after hay had been put down the chute. Studies by several experimenters[5, 6] seem to indicate that the methods of management and air control as generally practiced in well-managed dairies have less influence upon the number of bacteria contained in the milk than was formerly believed.

Care should be taken in the feeding of cows to protect the milk from contamination, both while it is being drawn and after it has been drawn. Certain feeds impart a good flavor to milk, and others an objectionable flavor. None of the feeds with strong odors, such as turnips or silage, should be fed immediately before or during milking.

Clean Milker.—The methods of the milker are important in the production of clean milk. A man who is clean in his milking opera-

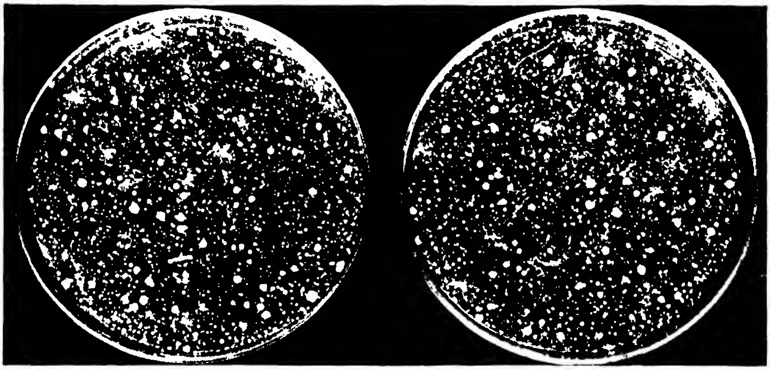

FIG. 96.—Plates exposed to the air of the same stable as those in Fig. 95, but just after hay had been put down the chute. The large number of colonies of bacteria indicate the presence of enormous numbers of bacteria on hay dust. The plate on the left was exposed five minutes and the one on the right ten minutes. (*Trout*)

tions can produce high-grade milk in almost any barn, while the careless milker cannot produce good milk under the best barn conditions.

The milker should be healthy, and should avoid exposure to communicable diseases. When a high-grade milk is being produced, especially if it is not pasteurized, it is desirable that the men doing the milking be examined for evidence of septic sore throat, typhoid, or other disease germs, as often healthy people may be " carriers " of certain disease germs.

The milker should take especial care of his hands and should always milk with clean, dry hands. If the teats are hard and dry, and it seems necessary to moisten them, a small quantity of vaseline may be applied after they have been washed. The milking should be done

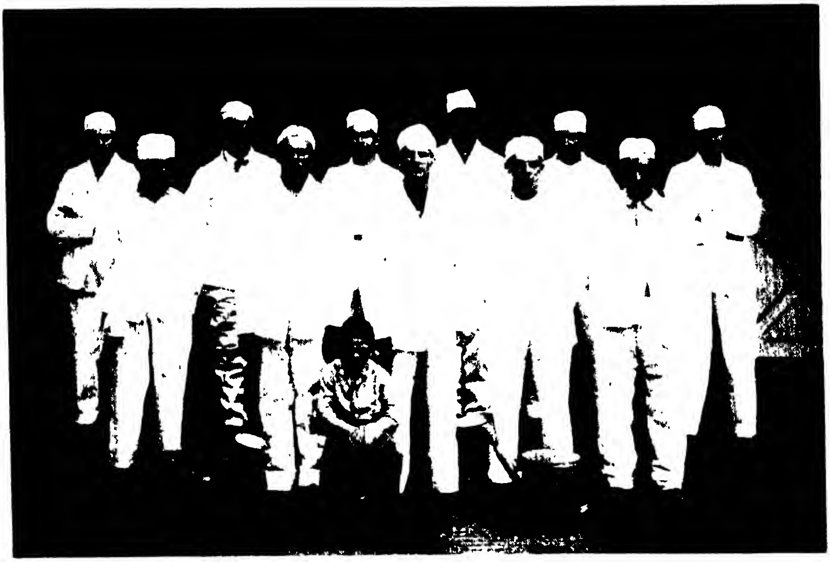

FIG. 97.—Clean healthy milkers are also essential for clean milk production.

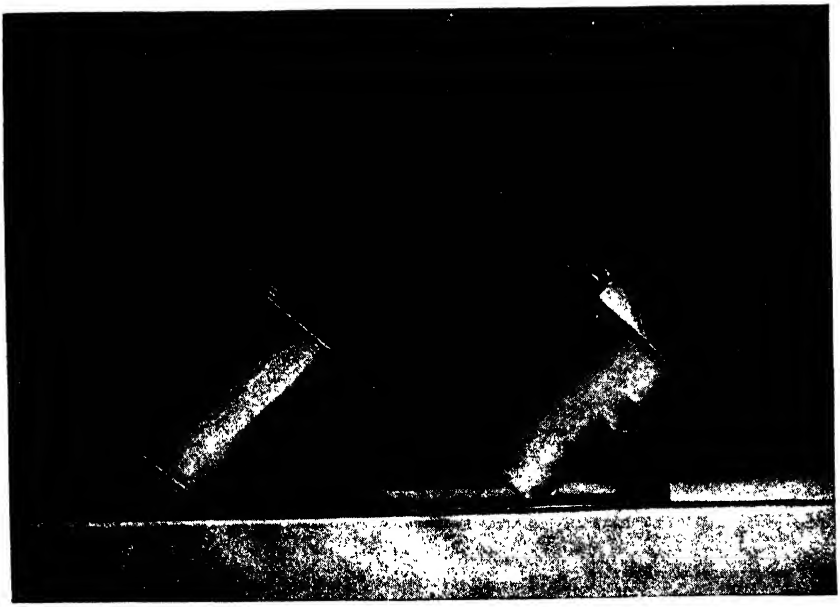

FIG. 98.—A small top milk pail keeps much dirt out of the milk.

quickly and thoroughly. Clean clothes should always be worn by milkers.

Small-top Milk Pails.—A large part of the dirt in milk falls from the body of the cow into the pail at milking time; hence it is easy to see the advantage of a small-top milk pail. The use of such a pail results in a cleaner milk and a lower bacteria count, because it keeps much of the dirt from getting into the milk. In a study of the effect of a covered pail in a stable where but little attention is given to cleanliness, the Connecticut Experiment Station[7] obtained the results shown in Table LXXV.

TABLE LXXV

EFFECT OF COVERED PAIL IN STABLE WHERE BUT LITTLE CARE IS GIVEN TO CLEANLINESS

A—Open Pail

Number of Experiment	Total Bacteria	Acid Bacteria	Liquefying Bacteria
1	811,900	761,660	23,790
2	9,100,000	9,087,900	4,160
3	3,113,000	2,025,000	26,660
4	3,025,000	314,600	30,000
5	4,470,000	2 443,000	26,660
6	115,400	21,040	10,000
Average.......	3,439,200	2,442,200	18,550

B—Pail with Cover

Number of Experiment	Total Bacteria	Acid Bacteria	Liquefying Bacteria
1	19,790	13,330	0
2	219,160	189,800	0
3	64,580	27,000	14,580
4	90,000	32,000	4,000
5	220,800	81,600	15,830
6	7,250	3,500	166
Average.......	103,600	57,800	5,760

The use of a small-top pail may seem awkward at first, but with a little practice one will find that it can be used very satisfactorily.

Handling the Milk.—The milk should be removed to the dairy house immediately after it is drawn. Contamination will take place if it is left in the barn. Milk readily absorbs the odors of the stable.

The milk should then be strained into cans. If the cows are carefully milked the straining should not be necessary as it is impossible to strain bacteria out of milk. However, it is usually desirable to strain the milk in order to remove any hairs or particles of bedding or feed which may have happened to get into it. The strainer should be of the cotton-pad type, and a clean pad should be used at each milking.

FIG. 99.—A milk house for a small dairy.

This will remove more of the sediment than the wire gauze or cloth type of strainer.

Cooling the Milk.—Proper cooling is one of the essential features in the production of high-grade milk. Even though milk has been carefully produced, it will contain a large number of bacteria when it reaches the consumer unless it is properly cooled and held at a low temperature until it is delivered. It is impossible to produce milk without some bacteria; the point to observe is to prevent the multiplication of the bacteria that have already gained access. If the temperature is held below 50° F. the increase in the number of bacteria will be very slow, while a temperature much above 50° F. will cause them to increase rapidly. Table LXXVI[8] shows the importance of keeping milk cool:

TABLE LXXVI

EFFECTS OF VARYING TEMPERATURES UPON THE BACTERIA GROWTH IN MILK

Temperature Maintained for 12 Hours	Bacteria per c.c. at End of 12 Hours
40 degrees F.	4,000
47 degrees	9,000
50 degrees	18,000
54.5 degrees	38,000
60 degrees	453,000
70 degrees	8,800,000
80 degrees	55,300,000

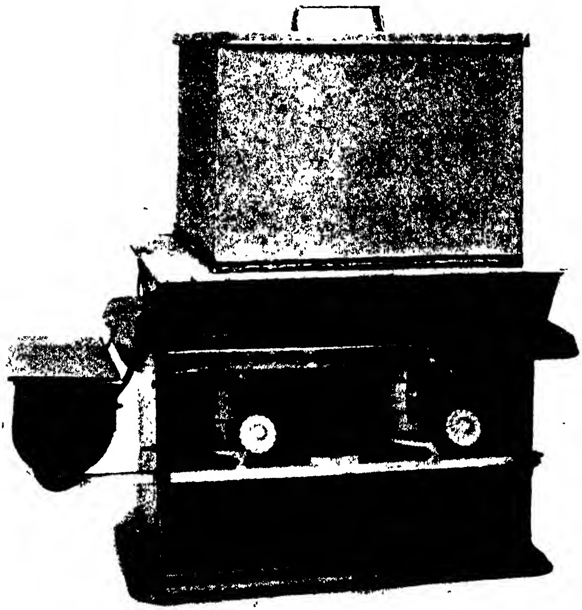

FIG. 100.—A cheap sterilizer for a small dairy.

Utensils.—It is important that the dairy utensils be constructed with smooth, filled joints and corners, so that it will be easy to keep them in good condition. Rusty tinware should not be used. One of the most common sources of contamination of milk is the utensils. In one experiment, milk drawn into sterilized pails had an average bacterial count of only 6306 per cubic centimeter, while samples from a pail which had not been sterilized contained, on an average, 73,308 bacteria per cubic centimeter. Even when the utensils are well washed and presumably well cleaned, bacteria may exist and increase very rapidly in them.

Utensils should, therefore, be thoroughly washed and then sterilized. Sterilization is best done by exposing the utensils to steam for several minutes in a home-made sterilizer or by placing them in a sterilizer under pressure.

Utensils should first be washed with lukewarm water, then with hot water and washing powder, preferably an alkaline powder, not soap. They should then be rinsed and sterilized. The proper sterilization of utensils is, no doubt, the most important single factor in the production of milk with a low bacterial count. The effect of sterilization of dairy utensils is shown in Table LXXVII.[9]

TABLE LXXVII

EFFECT OF STERILIZATION OF DAIRY UTENSILS UPON PRODUCTION OF CLEAN MILK

Sample Number	Bacteria per c.c. in Milk When Utensils Were:		Sample Number	Bacteria per c.c. in Milk When Utensils Were:	
	Sterilized	Not Sterilized		Sterilized	Not Sterilized
1	9,000	45,000	9	35,000	200,000
2	20,000	60,000	10	32,000	340,000
3	11,000	150,000	11	240,000	750,000
4	16,000	450,000	12	2,500	350,000
5	2,500	200,000	13	3,800	750,000
6	23,000	130,000	14	2,600	400,000
7	2,400	160,000	15	12,500	600,000
8	45,000	175,000	16	2,800	550,000

These comparisons were not made on the same day, but the conditions were maintained as nearly uniform as possible throughout the test.

Sterilizing Milking Machines.—Clean milk can be produced by the use of a milking machine if the parts are properly sterilized after each milking. The machine should first be rinsed in cold water and then washed thoroughly, just as the other utensils are, after which it should be sterilized.

There are three common methods of sterilizing milking-machine parts, namely: heat, chloride of lime, and a mixture of a brine and chloride of lime. Burgwald[10] found that, of these three methods, sterilization by heat gave more uniform and appreciably lower bacterial counts than did the other two methods. There was practically no difference in the results obtained by the chloride of lime method and the brine and chloride of lime method during the colder weather. Neither gave as good results in warm weather as in cold weather, but brine and chloride of lime gave a much better result than did the chloride of lime alone.

Heating the rubber in a sterilizer caused it to deteriorate very rapidly; but putting the rubber parts in water[11] at a temperature of 160 to 167° F. for twenty to thirty-five minutes, and then removing them to a refrigerator or placing them in a weak chloride solution between milkings, not only kept the rubber from deteriorating, but resulted in a low bacterial count. Care must be taken at all times if high-grade milk is to be produced with the use of a milking machine.

Delivery and Transportation.—The condition of the milk on its arrival at the place of its disposal governs its acceptance or rejection. No matter how much care may be used on the farm to produce good milk, poor delivery methods may result in unsatisfactory milk at the delivery point. Milk, once cooled, should be maintained at a low temperature until delivered, but should not be permitted to freeze. Milk for human consumption should be sent to market every day.

When milk is transported from the farm the cans should be covered, either by blankets or by individual can covers. Milk left on the roadside platform should be protected from heat, dust, or freezing.

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LECTURE XXXI

METHODS OF MARKETING MILK

THE marketing of the products of the dairy is, from the financial standpoint, of the greatest importance. In some localities only one method of disposing of the milk is available; the producer must sell it to a creamery, a cheese factory, a condensery, or a city milk plant. Again, none of these may be available, and he must, because of his location, manufacture his milk into butter or separate the cream, which he can deliver at less frequent intervals, and carry some distance to the market. Usually, however, there is more than one market for the product.

It is not the purpose in this lecture to discuss the best method of disposing of the milk, but rather to point out a method of calculating the relative values of the various ways of disposing of it. The dairyman should be alert to these possibilities, as often greater returns can be derived from selling in one form than in another. A dairyman often sells his product in one form at a much lower price than he could obtain for it in another, because he is unfamiliar with the methods of calculating the relative values of the different forms of selling. No attempt will be made in this lecture to discuss every possible method of selling.

Selling Whole Milk.—Perhaps the greater part of the milk of this country, especially that of the East, is sold for direct consumption; and, in general, it may be said that it brings the highest price in that form. This is especially true when the milk is produced under conditions that are sanitary, and when it can be delivered in high-class condition. Special milks, of course, can be sold at a price that cannot be obtained for any of the other products.

There are various ways of disposing of whole milk. One of the most common is to sell it at a certain price per 100 pounds. For this discussion we shall start with a price of $2 a hundred for 4 per cent milk, and calculate all the other products on the basis of that price. This is not an average price, but will be used simply as an example.

The 4 per cent milk is taken because it is about the test of the average milk.

When milk is sold at a flat price of $2 a hundred for 4 per cent milk, it is, of course, an advantage to the producer to deliver milk that contains no more than 4 per cent of fat. In some states it is not permissible to standardize the milk by separating and adding skimmilk. Where it is not permissible to standardize and where cows produce milk richer than 4 per cent, the dairyman who is producing the richer

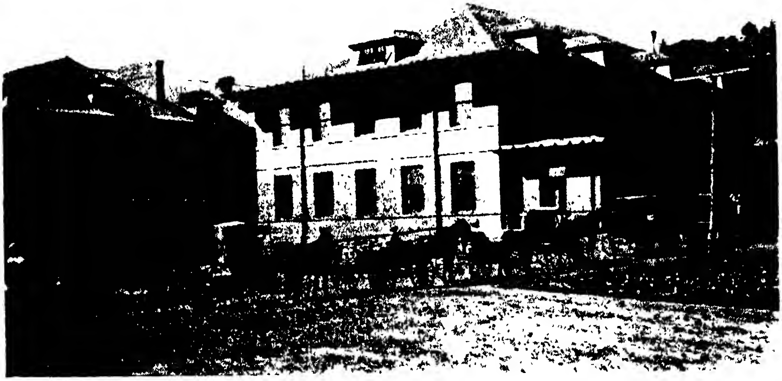

FIG. 101.—Marketing of milk or cream. Patrons waiting to unload.

milk is at a disadvantage. It will, therefore, be to his advantage to include the milk of cows that test less than 4 per cent, so that the excess of fat, which is more expensive to produce, is not sold on the basis of 4 per cent milk.

The common practice is to pay a premium for milk that tests over 4 per cent, and deduct a flat rate from milk testing below this amount. To illustrate, one method is to pay 3 cents a hundred more than the regular rate for each tenth that the milk tests above 4 per cent, and 3 cents less a hundred for each tenth that the milk tests below 4 per cent. Let us suppose we have milk testing 4.5 per cent. This milk would contain 0.5 per cent in excess of the standard required, which, at the rate of 3 cents for each tenth, would be 15 cents, so that such milk would sell for $2.15 a hundred. In the same way, milk that only tested 3.5 would sell for only $1.85 a hundred.

Another method is to dispose of whole milk by the quart. Average milk weighs about 2.15 pounds to the quart, so that 100 pounds of milk would be equivalent to approximately 46.5 quarts. If, therefore, we divide $2, the price per hundred, by 46.5, we get an equivalent price in quarts of 4.3 cents. If the milk were sold by the gallon, 17.2 cents a gallon would be equivalent to $2 a hundred.

Still another method of selling milk is at a certain price per pound of butter-fat contained in it. If, therefore, 4 per cent milk were sold at $2 a hundred, it would be necessary to receive 50 cents a pound for the butter-fat in order to obtain an equivalent price. A modification of this form is the payment of a definite price for the fat and a definite price for the skimmilk in addition.

In disposing of the milk in bulk, the expense of delivery must be considered when it is necessary to deliver it. The cost of shipping is also a material item, as is the cost of the cans. Many milk companies now, however, collect the milk at the farms, which is sometimes a very material advantage and a considerable saving. This depends upon the market and the city.

The disposition of milk directly to the consumer by the dairyman is a business in itself. Most cities now require that milk be sold in bottles; when the expense of bottling, cost of bottles, cost of cleaning them, and cost of delivery and of collection are considered, the total cost of marketing milk in this form is considerable—often amounting to as much as from 4 to 8 cents a quart.

Selling to Creameries, Cheese Factories and Condenseries.—Various methods of purchasing milk are used by creameries, cheese factories, and condenseries. All of the methods described above are used; and, in addition, some cheese factories simply pool the milk, paying a flat price regardless of test, while others pay according to test, and still others pay what is known as the "fat plus two method." This consists simply of adding two to the test, and paying on the basis of this test. This is done for the reason that in cheesemaking the casein is as important as the butter-fat. The addition of two is to bring the relative price a little nearer to what is supposed to be a fair method of paying. For instance, one farmer delivers 3 per cent milk and another 6 per cent milk; if both were paid on the strictly butter-fat basis, one would receive twice as much as the other, although the 6 per cent milk might not make twice as much cheese. By adding two to each test, the ratio would be five to eight, instead of three to six.

Another method is actually to test both the fat and the casein. This, however, is done only to a limited extent. It has been suggested by Van Slyke[1] that the amount of casein be calculated on the basis of the fat content. In either case the actual advantage of disposing of the milk in this way should be calculated.

The condensery usually pays for milk by one or the other of the methods previously suggested. The creamery, on the other hand, usually buys milk on the basis of the fat it contains, and allows the producer the skimmilk, returning, as a rule, about 80 pounds for each 100 pounds of milk delivered. In calculating the price that should be received for a pound of butter-fat when milk is disposed of in this way, it is necessary to determine the value of the skimmilk. Its value depends largely upon the use to which the producer can apply it. In the feeding of calves it is worth more than can well be estimated, as it is difficult to get a satisfactory substitute for it. When pure-bred animals are being raised and sold, the value of skimmilk is considerable. There is no substitute that will produce the size and keep the thrift in calves that skimmilk will. As calf feed, at the present price of other feeds, it is probably worth at least 40 cents a hundred pounds, although some have shown that it is worth slightly less than this. For the purposes of this lecture, we shall assume that skimmilk is worth 30 cents a hundred. If, therefore, 80 pounds is returned per hundred delivered, the value of the skimmilk returned will be 24 cents. The price that should be received for a pound of fat when the skimmilk is returned is determined by subtracting 24 cents from $2 and dividing the remainder $1.76, by the test given; the result in this case will be 44 cents. On this basis, therefore, 44 cents per pound must be received as an equivalent for whole milk at $2 per hundred.

Selling Cream.—Cream can often be sold for direct consumption at a higher price than that received for the whole milk from which it came. It is also often sold to centralizers for buttermaking, either sour or sweet. Of course a premium is paid for the sweet cream. The following formula may be applied in calculating the pounds of cream that can be produced from a specified quantity of milk of a given test:

Let x = pounds of cream,
a = pounds of milk,
b = test of milk,
c = test of cream.

$$\text{Then } x = \frac{a \times b}{c}.$$

If we desire to make 18 per cent cream from 100 pounds of 4 per cent milk, by applying the above formula we can find the pounds of cream that would be obtained, thus,

$$x = \frac{100 \times 4}{18}$$

or

$$x = 22.2 \text{ pounds of cream.}$$

Therefore, 22.2 pounds of 18 per cent cream can be made from 100 pounds of 4 per cent milk. Table LXXVIII shows that a gallon of 13 per cent cream weighs approximately 8.465 pounds, or a quart 2.116 pounds. By dividing 22.2 by the weight per quart, or 2.116, it is evident that 10.4 quarts of 18 per cent cream can be produced from 100 pounds of 4 per cent milk. If we then divide 200 cents by 10.4 we get 19.2 cents per quart, the price which must be received without including the value of the skimmilk. Table LXXVIII prepared by Babcock, gives the weight by the gallon of milk and cream.

It is essential that cream be carefully standardized so that it will be certain to contain the full amount of fat specified, no more and no less. Even in selling a small quantity, the cream should be tested and standardized daily. Only a short time is required to make the test and to do the standardizing, and even though a very small percentage of excess fat is included, the loss amounts to many dollars a year. In producing cream of a definite standard the best plan is to skim a little heavier cream than the standard sold. By the use of the following formula the amount of skimmilk to be added can be easily determined:

Let x = pounds of skimmilk to be added,
a = pounds of cream produced,
b = test of cream produced,
c = test of cream desired.

$$\text{Then } x = \frac{a \times b}{c} - a.$$

TABLE LXXVIII

WEIGHT OF CREAM

Per Cent of Fat in Cream	Specific Gravity of Cream	Weight of One Gallon, Lbs.	Per Cent of Fat in Cream	Specific Gravity of Cream	Weight of One Gallon, Lbs.
0	1.0360	8.6391	39	0.9919	8.2714
10	1.0243	8.5417	40	0.9908	8.2624
15	1.0136	8.4938	41	0.9897	8.2534
16	1.0174	8.4843	42	0.9886	8.2444
17	1.0163	8.4749	43	0.9885	8.2354
18	1.0152	8.4654	44	0.9864	8.2265
19	1.0140	8.4560	45	0.9854	8.2176
20	1.0129	8.4465	46	0.9843	8.2087
21	1.0118	8.4372	47	0.9832	8.1998
22	1.0107	8.4278	48	0.9821	8.1909
23	1.0096	8.4184	49	0.9811	8.1821
24	1.0085	8.4090	50	0.9801	8.1733
25	1.0073	8.3997	51	0.9790	8.1646
26	1.0062	8.3995	52	0.9780	8.1558
27	1.0051	8.3812	53	0.9770	8.1470
28	1.0040	8.3719	54	0.9760	8.1382
29	1 0029	8 3626	55	0 9749	8.1294
30	1.0017	8.3534	56	0 9738	8.1207
31	1.0006	8.3443	57	0.9728	8.1121
32	0.9995	8.3352	58	0.9718	8.1035
33	0.9984	8 3260	59	0.9707	8.0948
34	0.9973	8.3168	60	0.9697	8.0861
35	0 9963	8.3076	70	0.9595	8.0007
36	0.9952	8.2985	80	0.9494	7.9172
37	0.9941	8.2894	90	0.9396	7.8353
38	0.9930	8.2804	100	0.9300	7.7552

If it is desired to produce 18 per cent cream and the cream has a test of 22 per cent, and there is 18 pounds of this cream, by substituting in the formula we can obtain the number of pounds of skimmilk which must be added in order to reduce it to 18 per cent.

$$x = \frac{18 \times 22}{18} - 18,$$

or

$$x = 4 \text{ pounds of skimmilk.}$$

The number of pounds of skimmilk which must be added to produce cream testing 18 per cent in this case is 4.

There are a number of advantages in selling cream. There remains the fresh skimmilk for the calves, chickens, or hogs, and there is less product to care for and to deliver to the market than if whole milk were sold. Even though cream is properly taken care of on the farm, daily delivery will be necessary in order to place the best grade of cream on the market.

Making Butter.—The manufacture of butter on the farm adds another enterprise to the dairy industry. The production of milk and the making of butter are two separate enterprises, and the success of the second will depend upon the amount of butter made and price that can be secured for it. Milk is sometimes produced in sections so far from the railroads that it is not practical to deliver either milk or cream. In such cases it may be most profitable and convenient to manufacture the milk into butter, which need not be delivered more than once a week. The making of butter requires considerable labor and care in order to make a good, profitable product. Proper care and skill often turn out a product that sells for a price so high as to be the most economical method of disposing of the milk. We shall not discuss here the amount of labor required, nor the equipment, except to say of the latter that it is not very elaborate.

In calculating quantities, the amount of butter that can be made from a given quantity of milk will depend upon the composition of the butter itself. Butter varies in its composition, according to the amount of salt and water incorporated, and to some extent according to the casein content. The law does not allow the manufacture of butter containing more than 16 per cent of water. If we assume 15.9 per cent of moisture with a salt content of 4 per cent, a larger quantity of butter of such composition per 100 pounds of milk will be made than of the grade containing, say, 10 per cent of moisture and 2 per cent of salt. There is some loss of butter-fat in the skimmilk and in the buttermilk; but if care is taken, in the manufacture of farm butter, to keep the composition under reasonable control, by the addition of such amounts of salt and water as will insure a good product day after day, about one-sixth increase of butter over the amount of butter-fat may be secured. From 100 pounds of milk testing 4 per cent, we may expect about 4.66 pounds of butter.

In this case we must make allowance for the skimmilk and the buttermilk. The buttermilk is usually slightly higher in fat than the skimmilk, otherwise their composition is very similar, as will be seen from the analysis in Table XLIV. Figuring the value of buttermilk on the same basis as that of skimmilk, and assuming that the two together will be in the proportion of 90 pounds to 100 pounds of whole milk, and that the price will be 30 cents (it may be higher on some farms), 90 pounds would be worth 27 cents. Subtracting 27 cents from $2, we obtain $1.73; this number divided by 4.66 gives us 37 cents, the price that must be obtained for a pound of butter as an equivalent of the price of $2 a hundred for the milk.

This does not take into account the labor required to make the butter, nor the salt and use of equipment. If butter is made it is not necessary to make daily delivery of milk. If the distance is appreciable and the amount of milk small and very little labor and time are required, then it may be profitable to make butter. It may be said, therefore, that if a price of 37 cents or more can be secured for butter, and the skimmilk and buttermilk can be used at a value of 30 cents a hundred, it is as good financially to make butter as to sell milk at $2 a hundred.

The practice of making butter on the farm is fast falling into disuse. Most people are now shipping the cream to centralizers. They need to ship only once or twice a week and so have to go to market their product only about as often as they would if they sold butter. Of course, some butter will always be made on the farm.

Making Cheese.—Cheese is made to a limited extent on farms. The necessary equipment costs about the same as that for making butter, while the labor is relatively more unless the product is made on a larger scale. The actual labor is perhaps not greater, but the time required daily is longer. The entire operation of making American cheese covers a period of about seven hours. On the average, about 10 pounds of cheese can be made from 100 pounds of 4 per cent milk. The whey should be considered a credit item, though it is not worth as much as buttermilk or skimmilk. It has somewhat more fat, but lacks the important constituent casein. Most of the sugar, however, is contained in the whey. It may be fed to fattening animals, but is not good for growing animals unless proper feeds are included with it. Assuming an allowance of 20 cents for the whey in 100 pounds of milk, on the basis of 10 pounds to 100 pounds of milk, it would be necessary to get 18 cents a pound for the cheese in order to obtain the equivalent of the milk at $2 a hundred pounds. This does not include the labor involved. Soft cheese, such as cream cheese and cottage cheese, may also be made. Some of the foreign varieties of cheese may be made, though these form highly specialized industries, require special skill, and also require special prices in order to be profitable unless they are made on a very large scale.

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LECTURE XXXII

MILK PRODUCTION, COST ACCOUNTS, PRINCIPLES AND METHODS

THE efficiency wave that has swept our factories in recent years is reaching the farms and dairies of the country. Cheap land, the abundant fertility of the soil, and the opening of new lands almost every year have enabled the farmer to succeed without efficient management; he has been the last, therefore, to make a systematic study of operation and cost of production. Cost determination is essential to efficiency. It not only furnishes a guide to a profitable selling price, but also enables the producer or manager to direct and control the different factors of cost. A complete and properly arranged cost statement enables the dairyman to study and to compare methods and finally to determine by which method milk can be produced most cheaply.

Importance of a Cost Method.—A cost method is important for more than one reason; it shows the individual producer whether his dairy is profitable, and whether some operations cost more one year than another, and suggests possible means of producing milk more cheaply. A definite and correct system, used as a standard, should make it possible to compare cost in different sections of the country, and eventually to determine a price that will be fair and reasonable to the producer and at the same time satisfy the consumer that he is paying only what is equitable for the capital, labor, and other expenses necessary to produce milk. Rough estimates contain errors and are not to be relied upon.

Although in a great many localities surveys show actual losses in dairying when all costs are included, the fact remains that dairymen are usually successful farmers, and dairy sections and dairy communities are, almost without exception, prosperous.

The Functions of a Cost System.—A cost system possesses not only a direct benefit for the particular dairyman who keeps accurate accounts, but also an indirect benefit for the public, by helping to put the dairy business on a sound basis throughout the country.

The benefits to be attained by a system of cost accounts for milk production are as follows:

1. Regulation of selling price.

2. Detection, location, and elimination of waste in material, labor, and other expenses incident to production.

3. Change of operations and determination of actual effect of such on cost.

4. Direction of work by the manager with greater efficiency.

5. Standardization of work.

6. Computation of costs at different times and under different conditions.

7. Provision of reliable statistics for comparisons and studies in different states and localities.

Almost every dairy in the United States is a part of a general farm proposition. Without cost accounts for the dairy itself it is impossible to determine to which enterprise profits or losses are due. Although a dairy farmer may be getting a fair interest on his capital and a fair wage for his labor, surveys or cost records of his dairy often show that the profits are not derived from the cows. When it is apparent that the feeds are obtained at prices for which they could be sold, and that the labor is actual extra labor that must be paid for, it is evident that profits are derived from the farm rather than from the herd.

These facts should prompt the dairyman to be more careful in his cost estimates and to endeavor to learn wherein his various cost items are higher than they should be, or higher than formerly. It is to his interest to seek for a remedy. He may discover that a change of rations would reduce expenses, that fewer or more cows should be kept, or that his cows are poor producers. There are the chances that the cows are too expensively pastured, or not sufficiently pastured; that he could buy his cows cheaper than he is raising them; that he keeps his calves too long or veals them at a loss. Where the feed prices are figured on a basis of sale or market price or the price at which they could be purchased in the community, perhaps it would be more profitable to market the crops in the raw state rather than as finished dairy products. In some localities labor also makes the production of milk unprofitable, and many dairies are overcapitalized.

These are only suggestions as to some of the factors which may not be known unless accounts are kept. The efficiency of individual cows is, of course, of great importance. Cows of the same size require about the same feed for maintenance, so that a cow that produces 6000 pounds of milk annually produces it more cheaply per pound than a cow of equal weight that produces 3000 pounds.

Division of Cost of Production.—The cost of production will be discussed under three main divisions: feed expense, labor expense, and indirect expense. "Overhead" or indirect expense will be further subdivided. The following outline indicates the method of treatment:

1. Feed.
2. Labor.
3. Indirect or overhead expense:
    - *a.* Buildings.
    - *b.* Cattle.
    - *c.* Bedding.
    - *d.* Sire.
    - *e.* Miscellaneous.

The credit items which should be deducted as special credits in order to determine the net cost of production are as follows:

1. Calves.
2. Manure.

Relation of Different Cost Items to Net Cost.—Figure 102 is given to show the relation of cost items to net cost of production under certain conditions. The feed and labor costs are spoken of as prime costs; they constitute about 90 per cent of the total cost of production.

Figure 102 is given simply to show the cost factors and their approximate relative proportions to the total cost under particular prices and conditions. Although this figure represents actual conditions in some sections at the present time, it is not the purpose here to show average conditions. Instead of attempting to give any average costs, the authors wish to emphasize the fact that costs vary greatly and that they are determined by certain definite conditions.

Reason for Variation in Cost of Producing Milk.—It is no more reasonable to say that it costs 5 cents to produce a quart of milk than to say that it costs 5 cents to make a box. The manufacturer of boxes, before stating a price asks the size of the box; the kind of material to be used; whether the sides are to be planed; whether the box is to be made and used in the lumber and mill region of Washington State or in New York City, and also whether 10 boxes are to be made in spare time or 10,000 made at once.

Likewise, the milk producer should consider, in quoting or estimating a price, whether it is for 3 or 5 per cent butter-fat milk; whether the milk is to be produced from tuberculin-tested cows, and in clean barns by clean labor, under clean methods, or by any cows and without particular care in production; whether it is to be produced

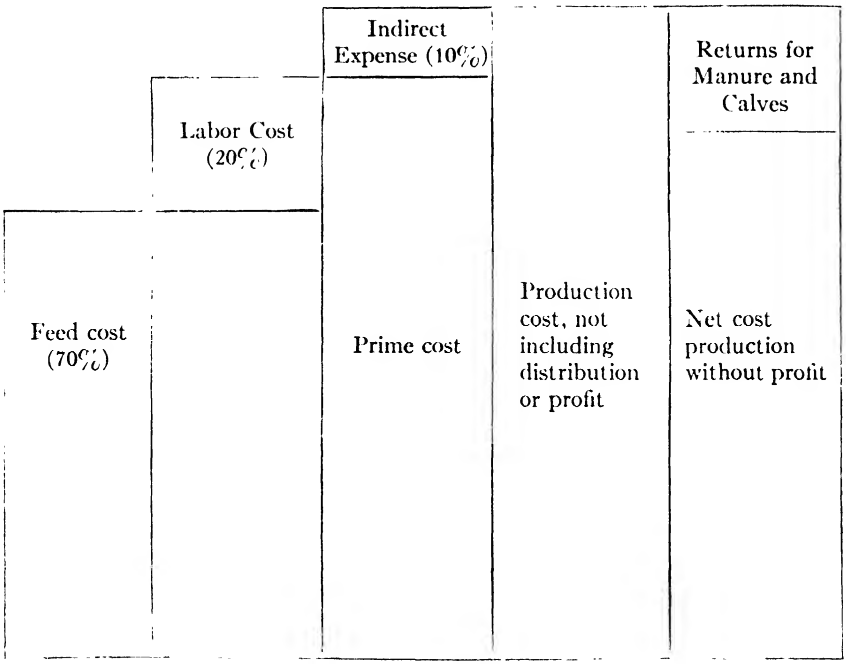

FIG. 102.—Relation of Cost Items to Net Cost of Production.

where hay is worth $10 or $20 per ton and grain $25 or $35; whether conditions are such that the cows must be kept in the stable all or nearly all the year for lack of pasture, or whether they can feed on grass six or more months of the year, and perhaps on land unfit for other crops. He should also know whether his price is based on a small quantity produced as a side line or on a large quantity produced as a specialty. It is to obtain an accurate knowledge of these very items of cost, etc., that a cost system is needed.

Figure 102 applies where an intensive feeding system is practiced, that is, where considerable grain is included in the ration. Where summer dairying is the practice and where roughage forms a large part of the feed, the proportion of labor and indirect cost of production would be greater. Also, in regions where intensive systems are practiced and a soiling system is followed, the feed may cost less and the labor more. Expensive cattle and buildings increase the proportion of indirect cost. The overcapitalized dairies are shown by the amount of overhead cost. Some cows are bought at such high prices and housed in such expensive buildings that no system of feed, no possible production, and no reasonable price for the milk could make them profitable.

Importance of Record.—As stated in a previous lecture, there is greater direct benefit from keeping records of cost in milk production than in other lines. The most important records and those that require the most time are absolutely necessary to intelligent feeding. It is necessary for a feeder of milch cows to know just how much each cow consumes and how much milk she produces. He must have a record of previous days. Records of the weight of the milk, together with the weight of feeds, make accurate and efficient feeding possible.

The statement that one can no more feed a cow intelligently without a record of production each day and of the weight of feed than a fireman can attend a boiler without a steam gauge is true. It is economy to increase the supply of coal if the boiler responds with sufficient increase of steam power, but there is danger from an overload of coal. It is profitable to increase the feed of a cow as long as she responds with a sufficient increase in milk, but there is danger in overfeeding of "throwing the cow off feed." The most profitable production of a cow is only secured by intelligent feeding and a careful study of the milk and feed records, and it is these records that form a large part of those necessary in milk cost accounting.

Amount of Time Required to Keep Records.—The amount of time required to keep these records is slight. Milk scales near the milk tank, and a simple chart with the cows' names or numbers, and blanks for the different days, are all that is needed for the milk record; and the same scales and a feed chart which can be attached to the feed bin or cart, for keeping a record of the quantity of feed used, as described in a previous lecture, are all that is needed for the feed records. The other items of cost can be kept with even less labor. An occasional weighing of the bedding, simple labor records, and records of expenditures for special apparatus cover the other chief factors of cost that require definite and special accounts. These data can be calculated with little trouble.

The standards given are offered only as a guide. Although local conditions may make it possible to bed the cows more cheaply with sawdust than with shavings or straw, the relative amounts given will apply, and when other material is substituted in the formula the actual cost may still be given.

The Cost of Feed

The largest and most important item of cost is the feed. This varies greatly with different cows and with different methods of feeding. The kinds of feed used, the amounts consumed, and the cost have a marked influence on the total cost of producing milk.

Price at which Feed Should be Charged.—One of the first questions encountered is whether feed should be charged at cost of production or at market price, the market price, of course, being considered as the price at which it could be purchased. There is considerable difference of opinion as to which cost should be used. Hawkins,[1] in discussing this factor from the factory standpoint, sums up his conclusions as follows:

"The advocates of cost price claim that by means of it they show the actual cost of manufacture and not what might have been the cost, and that it does not interfere with the balancing of the stores accounts in money value. Those who uphold market price claim that it furnishes a sounder basis for estimating and for competitive purposes by dealing with actual value rather than with former value, and that it rightly causes the effect of fluctuations to be seen in the stores accounts rather than in the job accounts, so that profits or losses due to chance or speculation are distinguished, as they should be, from ordinary trading results."

In the production of milk it is a question whether the cost of producing the feeds on the farm or the price they could be sold for on the market should form the basis of cost calculation. Unless the latter is used as the basis, the dairy cost accounts may be lost in the profits or losses of the farm operations. If the cost-of-production price is assumed, a difference in cost of milk production may be more influenced by the cost of production of the feeds than any other factor, and besides it is the profit of the dairy that is directly the result and purpose of these accounts. Also, if cost calculation is based on cost of production, there is no profit for the work one puts into theproduction of these feeds. If the production cost of feeds is high on a particular farm, it is reflected in the dairy accounts; and if by efficient management of the farm the feeds are produced cheaply, than the dairy receives undue credit.

When the dairy is considered as a separate enterprise from the farm, there is no doubt that it should be charged with feeds at market prices; but when the dairy farm is small or when the dairy is distinctively a necessary part of the whole farm scheme, then perhaps the cost price should be used. Mr. Nicholson, an authority on cost accounting,[2] stated in an interview that it was his practice in large plants that have several departments to charge material from one to another at market price, but with small plants to use actual cost of materials.

The Cost of Roughage.—The amount of roughage that a cow will eat depends largely upon the kinds used and upon the size of the cow, also to some extent upon the amount of other feeds or grain used. Some cows are fed little grain, and must depend almost entirely upon roughage for maintenance and milk. Such cows cannot produce a maximum for a long period, especially if they have the ability to produce large quantities of milk. When good silage and alfalfa hay are fed, fairly large yields may be secured. Good silage contains a considerable amount of corn, but careful feeders have found it advantageous to add some grain to this ration.

As a guide in computing roughage, the following rule is offered: To determine how much hay to feed, multiply the weight of the cow in hundreds of pounds by 0.6; the product will be the number of pounds of hay required. For example, 1000 pounds equals ten 100 pounds; therefore, 10 multiplied by 0.6 equals 6 pounds of hay. To calculate the quantity of silage to be fed, multiply the weight of the cow in hundreds of pounds by 2.5. A 1000-pound cow then would be fed 25 pounds, and a 1200-pound cow 30 pounds of silage.

Cost of Pasture.—Of all items of cost, that of pasture is most important although it has received small mention in most previous writings on cost records. In establishing a cost for pasture the steps are: (1) to reduce the pasture to a unit basis, that is, the number of acres needed per cow, and the months that a cow can be fed on such pasture; (2) to estimate the land rental, which should be charged on the basis of a legitimate interest on the value of the land. Five per cent is the basis used throughout this lecture. All authorities do not agree that interest, or rent, should be charged on land that is owned. If interest were not charged on land that is owned, it would be better for the farmer to have his money invested in good bonds which would return dividends and pay interest on a farm mortgage, and to include this interest in the farm cost or rent. The interest must be borne by the owner of the land in some way, so that if it is not included in the cost it must be deducted from the profit; (3) to estimate the general expense, which includes taxes, making and repairing fences, seeding or reseeding, and fertilizing. Pasturage, therefore, would be computed as follows:

1. Value per acre multipled by 5 per cent, which may be considered as rent.

2. General expense, which, on the average, will be about $1 per acre.

3. Acres required by a cow for a season, or estimated on the basis of cost for one cow for one month.

The formula for pasture cost on land worth $50 per acre, that would pasture one cow on 2 acres for five months, would be as follows:

Rent	$2.50
General expense	1.00
Cost per acre	$3.50
Two acres to a cow	$7.00

The cost of pasture for the season would be $7, or, on a basis of five months, $1.40 a month.

Cost of Grain Ration.—Now that the items of roughage and pasture, which have such an important effect upon the cost of production, have been determined, the grain ration must be considered. This in turn is dependent upon the size of the cow, and has a direct relation to the quantity and quality of milk produced.

The theory of the precalculated cost account for milk probably will be accepted without question, except for the part that undertakes to determine the feed costs. The feed cost is based on scientific feed-requirement standards. It is assumed that, given the size of the cow and the amount and quality of milk produced, the amount of protein and energy necessary to maintain the cow and to supply these elements to the milk can be accurately determined. The first question naturally asked is: Are all cows equally efficient? They are not, because not all produce the same amount of milk; but those that produce the same quantity are practically equal in efficiency. Stating this in another way, a cow of a certain size requires for maintenance practically the same amount of feed as any other cow of the same size, and the amount of food required per unit quantity of the same quality of milk is practically the same.

Eckles and Reed[3] found that " the superior dairy cow is simply one with a larger capacity for using food above the maintenance requirement and one that uses this available food for milk production."

It is obvious from these conclusions that of two cows of the same size the one that will produce the greater amount of milk is the more profitable, for the feed required for maintenance is practically the same. Two cows, each producing 10 pounds of milk per day, produce it at a greater cost than one of the same size that produces 20 pounds. This is important in figuring feed costs.

When it is agreed that we have feeding standards that can be relied upon for determining the requirements of cows, it is certainly reasonable to use them in calculating feed cost. In this connection, however, it must be kept in mind that the calculations are based upon the cows keeping constant weight. If it is the practice to underfeed the cows during the winter, and to depend upon the stored-up energy accumulated by them while on pasture, less feed might be given with a return in milk greater than the feed given would supply. This practice is followed by many dairymen, and an allowance must be made when this is done. This is primarily summer dairying; the data which follow are based upon a year-round production.

The writer has applied the following method to a number of actual cost calculations of feed required, and the results are remarkably near the actual figures—as near no doubt as the actual weight records could be kept in a practical way.

The difficulty in applying this method to actual records that have been published, except in a very few instances, is that the amount of food secured from pasture is not stated. A definite price charged for pasture and the actual amounts of the feed are given; but unless it is known what amount of the total feed was furnished by the pasture, the results cannot be checked. It is important that records give the returns from pasture, or the time the cows were supplied with feed by the pasture. Under some circumstances and conditions the pasture would furnish an even greater part of the feed for the year than is suggested above.

Method of Ascertaining Cost of Grain.—To illustrate the application of this method, certain conditions may be assumed: suppose that we have a herd of Guernsey cows which average 1000 pounds in weight, which give on an average 8500 pounds of milk per year, and whose milk contains 5 per cent of butter-fat, these conditions being similar to those used by Woll[4] in his study. The first step is to calculate the amount of protein and energy required by the cows. Assume that 20 per cent of the year's feed is secured from pasture. The cows will no doubt be on pasture more than 20 per cent of the days in the year, but they will secure some other feed a part or all of the time they are on pasture. We have then to provide feed for 280 days. By referring to Tables XVIII and XIX and to Table A in the Appendix, we determine the following needs for cows of this sort:

	Protein	*Energy*
Maintenance............	0.5 × 280 = 140	6 × 280 = 1680
8500 pounds 5 per cent milk.	0.062 × 8500 = 467	0.36 × 8500 = 3060
Total amounts required.	607 Pounds	4740 Therms

The cows must be supplied with 607 pounds of digestible protein and 4740 therms of net energy. Now let us assume that we are feeding silage and clover hay for roughage. Referring to the formula suggested above, we find that a 1000-pound cow would consume 6 pounds of hay and 25 pounds of silage, or 1680 pounds of hay and 7000 pounds of silage for the 280 days. By referring to Table A we find that 1680 pounds of red clover hay supply 90.89 pounds of digestible protein and 583.63 therms of net energy. In like manner, the protein and energy supplied by the silage can be computed.

	Lbs.	Protein	Therms	Energy
Amount needed............		607.00		4740.00
Supplied by hay...........	90.89		583.63	
Supplied by silage..........	61.60		1159.20	
Total supplied in roughage		152.49		1742.83
To be supplied by grain.....		454.51		2997.17

Now, by turning to Table A, we can select a ration that has a ratio of protein to energy equal to that of the part to be supplied by grain, which is about 1 : 6.5. Such a mixture is supplied by the following ration:

	Protein, Lbs.	Energy, Therms
150 pounds corn or hominy	10.5	132
100 pounds distillers' grains	22	79
100 pounds bran	10	48
100 pounds oats	8	66
450 pounds mixture	50.5	325

This ration supplied 50.5 pounds of protein and 325 therms of energy. If we divide 454.51, the amount of protein needed, by 50.5, the result is 9, the amount of this mixture needed for the year. Expressed in another way, each cow of the size and production indicated would require, besides the hay and silage, nine times each of the different quantities of feeds used in the foregoing mixture. These feeds would not furnish the cheapest ration at the present time, but they were commonly used by the dairymen from whom Woll gathered his data. The size and production of the cows assumed here are also the averages for the Guernseys in these studies, and the prices here assumed are the same as those used by Woll.

Summarizing the feed cost, we have the following:

1680 lbs. of hay at $0.80 per 100	$13.44
7000 lbs. of silage at $0.15 per 100	10.50
1350 lbs. of corn at $1.00 per 100	13.50
900 lbs. of distillers' grains at $1.50 per 100	13.50
900 lbs. of bran at $1.05 per 100	9.45
900 lbs. of oats at $1.10 per 100	9.90
Pasture for season at $5.00	5.00
Total cost of feed for year	$75.29

The average cost of feed for a year for 157 cows included in the studies made by Woll was, for Guernsey cows of this class, $70.95. These cows averaged 8500 pounds of milk; the two results, therefore, differ by less than one-fifth of a cent a quart. Some of the rations contained less distillers' grains, making a cheaper ration, and some of the cows received more than 20 per cent of their total food from pasture, both of which tend to reduce the average cost. Others got some stover and straw.

This method requires considerable space for discussion, but the calculations based upon it can be done quickly and easily, and can be applied to any system of feeding. The accuracy of the method cannot be questioned, and it will not only simplify cost estimates, but will make them applicable under definite conditions at any time. A further benefit from its use is that the advantages and disadvantages of different systems may be studied. Generally it is not definitely known how valuable pasture really is, and in some cases it is not considered economical to pasture cows at all. A glance at the summary of feed cost will show that although pasture was charged at $5 for the season, still Woll's figures indicate that the Guernsey cows in the contests derived from 16.2 to 20.9 per cent of their total feed units for the year from pasture. It is obvious that the pasture was really worth several times $5.

As a further suggestion of the value of precalculated feed cost, we find, by referring to the bulletin by Woll, that, in comparing the different breeds of cows, for the best 25 Holsteins the ratio of cost of feed to net returns was 100 : 107, while for the best Jerseys the ratio was 100 : 143. The pasture was charged at $5 per season, but on page 74 of Woll's publication the 25 best Holsteins are shown to have received 12.8 per cent of their feed units from pasture, while the Jerseys secured 25.4 per cent and at the same charge. This is simply cited as an instance in which such a method as is suggested can be used in calculating feed costs, and in showing the advantages or disadvantages of different systems.

Although in general it is well to have high production to counterbalance the cost of maintenance, the last few pounds of production of many cows cost too much. Often, if one feeds a cow less grain and does not attempt to force her to the very limit, she will produce somewhat less milk, but the total amount of milk secured will be produced at proportionately less cost. A cost calculation, month by month, will show when the cows are most profitable and how expensive they are, or even how much of the profits of some months are consumed by expensive or forced feeding during other months.

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LECTURE XXXIII

MILK PRODUCTION, COST ACCOUNTS, PRINCIPLES AND METHOD—(*Continued*)

THE COST OF LABOR

LABOR, although not the largest item of cost, is of considerable importance in dairy-herd management. It is of peculiar interest because of its various phases and its effects upon the dairy industry. Some dairymen claim to have been driven out of the business because of the difficulty of getting men to work on farms where cows are kept, while others continue in the business because it enables them to keep help the year round, although it may not pay in full for the labor.

On dairy farms where milking is considered merely as a task with which to begin and conclude a day's work in the field, competent steady labor is a problem. Where the milking is considered an essential part of the day's work, there is no more difficulty in keeping good men on a dairy farm than on any other kind of a farm. On large dairy farms, where the hours are definite and the work is regularly performed, labor is not a perplexing question. On small farms the labor is performed at no extra cost and in addition to the field work. When cost records on these farms show that the milk is produced at a loss, it simply means that labor is performed at a lower wage than the figure used in the cost account. Often, however, the farmer is willing to do the work for the increase in income, although it is less than a good wage.

In some cases the women and children do the milking and care for the cows; children that are not at school during the busy season can be helpful in the dairy. Women and children are usually better milkers than men, because their hands and muscles are not so hard. The use of child labor on the farm is not to be compared with its use in the factory, since on the farm the children work with their parents and under conditions that are to a certain degree beneficial. The dairy farm is a good medium for the labor of the farm children. It may not, however, be out of place to say here that the dairy farms, more than any other farms, are driving the boys to the cities. Inferior cows and barns, and milking as extra work, form a depressing environment. In brief, with good cows in convenient, comfortable barns, and their care as a part of the day's work, or, better still, assigned as the sole occupation of one or more, as conditions require, dairy work is not objectionable to most boys.

Cause of Variation in Labor Costs.—Labor cost is not so variable on different farms as is feed cost, assuming, of course, that milk of equal quality is produced. The system of management and the number of cows kept are important factors. Where labor that could be otherwise used is used and paid for in caring for cows, labor cost can be reduced by increasing the herd to a number of cows that would make it profitable for one man to devote all of his time to the dairy. There would be less time lost, the man would be better satisfied, and the cattle would receive better care.

It often happens, however, that the cows must be cared for on extra time, or by women and children, or that the herd is increased so much that extra labor for the dairy must be employed. These factors decrease the profits of the business and make it difficult for some dairymen who are producing milk from large herds to compete with the smaller producer, even with the same grade of milk as a basis. Some dairymen succeed with the larger herd by turning to the production of a higher grade of milk, for which they demand a higher price.

From the standpoint of the actual time required by each cow and the efficiency of labor, the larger dairy is to be preferred. The man who devotes all his time to the cows can give them better care and loses less time. On dairy farms where men are required to combine work in the field with work in the dairy, much time is lost in changing from one task to another; and a man cannot do as good work in the barn when he also does heavy work in the field.

The number of cows in the herd is a factor to be considered. Certain operations demand about the same amount of time whether many or few cows are kept. In general, it takes five times as long to milk five cows as to milk one, but twenty cows can be fed or brought from the pasture in about the time required by five. The amount of milk a cow gives is also important; only a little more time is necessary to milk a cow that gives a large quantity of milk than one that produces less.

One man can do the work in a barn where there are 20 to 25 cows, but he cannot perform all the different operations necessary in the time stated. Where a system of soiling is followed, even fewer cows could be attended by one man. Under conditions where 20 or more cows are kept and where pasture is used for several months, a figure of 180 hours for a cow will be required. With ordinary care this figure may be reduced considerably. This accounts for the full time of a man, 365 days at 10 hours a day for 20 cows. Time must be deducted, of course, for vacation and holidays, but these are compensated by the decrease in labor when the cows are dry or on pasture. It is, therefore, a fair and practical procedure to calculate the cost of labor on a basis of 20 cows to a man, or to precalculate labor cost by dividing the cost of one dairyman for a year by 20 to get the cost for a cow. At a price of $45 a month, without board, the cost for each cow is $27.

The cost of labor varies widely in different sections and also with the seasons, but the dairy furnishes employment fairly constantly throughout the year. The study of labor cost is also desirable to show the returns for labor performed by members of the family who are employed in the dairy.

Does Cost of Manure Offset Labor Costs?—It is the practice of some dairymen in figuring milk cost to assume that the manure offsets the cost of labor. This may not be far from correct on farms where summer dairying is practiced and the cows are allowed to go dry in the fall and gather their winter maintenance from corn fields and straw stacks. Sheppard and Richards,[1] in their cost estimates, state that:

" Only the cost of feed is included in the cost of production. The value of manure is taken as offsetting the cost of labor, as is customary to do in preparing estimates of this kind. If the cows were credited with the value of the manure, it would no doubt offset the cost of labor required to care for the herd."

With winter feeding and care, and especially where clean milk is produced, the manure is not worth the cost of labor.

The Milking Machine.—The milking machine is being used to a considerable extent in some sections in an attempt to solve the labor problem. In herds of 20 or more cows the machine will be likely to come into more general use. There is not at present, however, any accurate record, covering long periods, in which actual time expended shows a decrease in cost by the use of these machines. It has been shown in experiments that the machine in the hands of a careful man will milk a cow well and apparently have no injurious effect upon her.

It has also been shown that, with especial care, milk with low bacterial content can be produced with the machine.

The Cost of Buildings

In dairy accounting a charge must be made for the use of the buildings. This is best figured from costs which include interest on investment, repairs, insurance, taxes, and depreciation. It is a rent charge. Several problems present themselves in the calculation of this cost. The first question to be answered is: Which buildings should be charged to the cows?

Buildings to be Charged to Cows.—It has been customary to include the stables for cows and the storage barns for hay as the buildings to be charged to the cows. When hay is charged to the cows at market price it is not just to charge them with the storage barns also. The hay barn is necessary, even if cows are not kept. If the price of hay charged to the cows, however, is based on the price of purchase of the year's supply in haymaking season, the storage will of necessity be included in the cost of milk production. We shall not consider the storage-barn cost a proper charge to the cows, for we have charged hay at market price, and it is necessary to have the barn to store the hay for market even though it is not fed to cows on the farm.

Causes of Variations in Cost of Barns.—The cost of a barn for dairy cows varies widely, according to its durability, construction, convenience, and sanitary condition. Whether it pays to build, at present, more substantial barns, barns that will depreciate less and be less subject to destruction by fire, is a question. Methods of housing have changed frequently. The best shape or size of barn has not yet been definitely determined. There has been a tendency to construct, for the housing of dairy cattle, expensive barns, in which especially clean milk can be produced. In some cases cows are kept in barns so expensive that the overhead charges of interest, taxes, and insurance have made profitable milk production an impossibility.

The comfort and health of the animals, however, must be maintained. The present tendency is to build less expensive barns or to provide only open sheds for dairy cows. In most sections this will greatly decrease the overhead expenses, keep the cows in a healthier condition, and decrease the cost of labor. Some large producers have one central milking and cleaning barn and allow the cows to run in open sheds or in closed yards. This arrangement will do away with expensive milk barns and greatly reduce the cost of labor, since it will reduce the amount of space to be kept clean for the milking. A certain amount of expenditure for the sake of convenience in barns, however, often lowers the total cost of production by decreasing the cost of labor.

The open-shed system has not come into general use, and the calculations given herein are based on the cost of permanent closed buildings. Stone, brick, cement, hollow-tile, and other permanent buildings for dairy cows have come into general use in recent years. The cost in some sections is only a little more than that of frame buildings, and the depreciation and danger from fire are considerably reduced. The latter item is important, especially where a good strain of cows has been developed.

Concrete floors with cement-plastered walls are desirable from the standpoint of sanitation. They can be cleaned easily and thoroughly. Cork and creosoted wood blocks also are used. These make the bed for the animals more comfortable; they are not so cold, and the cows are less likely to be injured by slipping. It should also be noted that these floors require less bedding than do those of concrete, a fact which in some sections warrants the additional expense, in view of the relatively high cost of bedding. The interest per cow on well-constructed buildings is comparatively high, but the depreciation is low. It has been the practice to build two-story barns, with the feed stored above. In a study of this problem made by one of the authors, it was found that no saving in cost results from the arrangement if the safety of the cattle is considered; also that with the proper arrangement of feeding facilities the labor required is not made greater by having separate buildings for the feed and for the cows.

A two-story barn must be built strong enough to hold the hay, and if a fireproof floor is included the expense is considerable. By storing the hay on the ground floor the cost of the storage barn is greatly reduced. The cows can then be housed in a separate one-story barn, which can be kept more sanitary and safer from fire.

Number of Cows a Factor in Cost of Buildings.—The number of cows to be kept in a herd is a factor in the unit cost of buildings. The cost for a cow is less in a 50-cow barn than in a 20-cow barn of the same construction. The cost by the cow for the barn varies in good dairies from $25 to $100 or more per head. A 50-cow barn of modern construction, such as a hollow-tile or concrete barn with concrete floors, walls, and ceiling, can be built for about $80 per head. This is for a good barn with a proper ventilating system and modern sanitary arrangements, for a specialized dairy capable of meeting all requirements for the production of a high grade of milk.

Interest, Insurance, Depreciation, and Taxes.—Interest on the investment may be figured at 5 per cent. The insurance will be from 0.2 to 0.4 per cent, according to the relation of the barn to other buildings, etc. The taxes will vary considerably according to the locality and method of assessment, and whether the enterprise is taxed separately or included in the whole farm tax. If assessed at one-half value, at a rate of 2 per cent, the item of taxes would be 80 cents per cow per year. The depreciation and annual repairs on a building of this kind would not amount to more than 4 per cent. A summary of the cost of the building under these conditions would be as follows:

Interest, $80 at 5 per cent	$4.00
Insurance, $80 at 0.3 per cent	.24
Taxes, $40 at 2 per cent	.80
Depreciation, $80 at 4 per cent	3.20
Total unit cost of housing	$8.24

The Cost of Cattle

Basis of Figuring Cost of Cows.—The charge for cattle or for their use is the most disputed item of milk cost. The first question that arises is: Shall the cows be invoiced at cost of production or at a price at which they could be bought or sold as milch cows? Most cost accounts make use of the latter figure. The cows are valued at the beginning of each year at what is believed to be a fair sale or purchase price, even if they have been raised at less than actual cost. This is not good business, for it inflates the capital really invested and does not represent actual cost.

In a previous chapter the feed charge was based on selling price of feeds raised on the farm; with cows, however, the cost of production is recommended as a basis for computing the cost. This may seem inconsistent, but the charges are not on the same basis, for the farm is independent of the dairy. The cost records are kept for the purpose of learning the income from the dairy itself. Profits may be secured from the farm, and it is unfair to give to the cows the credit for the management and risk of that enterprise. The raising of cows, on the other hand, is a part of the work of the dairy, and, if the animals are sold, the business is that of raising cows and not of producing milk.

Cost of Raising Cows.—In calculating the cost of cattle in milk production, therefore, the depreciation, interest, insurance, and taxes should be based on the cost of producing the cows if they are raised by the dairyman, or on purchase cost if bought. When the cost of production is less than the purchase price for the same grade of cows, the advantage of raising the cows is apparent. Often, however, cows can be purchased for less than it would cost to raise them. To build up permanent dairies it is necessary to raise the cows, especially if a high-producing, healthy herd is to be maintained. When high-priced cattle are purchased the overhead expense of the cows is greatly increased.

In the raising of dairy cows to the age of two years the studies of Bennett and Cooper[2] furnish material for precalculating the cost. Careful records of cost for a period of five years were kept. The following amounts of feed were consumed, on the average, during the first two years:

TABLE LXXIX

AMOUNT OF FEED CONSUMED BY HEIFERS BEFORE THEY ARE TWO YEARS OF AGE

	First Year Lbs.	Second Year Lbs.
Whole milk	342	
Skimmilk	3165	
Mixed hay	857	1120
Corn silage	352	3250
Grain mixture *	547	
Days pastured	123	
Corn stover	....	672

* Bran 4 parts, oats 5 parts, and oil meal 1 part.

With these data the feed cost can be calculated. If we assume the same prices for feeds as we used in figuring the cost of feeds for cows, with skimmilk at 20 cents a hundred, whole milk at $2 a hundred, mixed hay at $15 a ton, corn silage $3 a ton, corn stover $6 a ton, and the grain mixture $1.15 a hundred, we find that with the above amounts consumed the feed cost to raise a heifer to two years of age is $47.51.

These prices will not all apply to present conditions; but the system is the same in all instances. They are used in order that the same basis of prices may be carried throughout this study.

The labor required to care for these animals during the first year was 40 hours, and during the second year 23 hours. At a price of 15 cents an hour, used above, the labor cost would be $9.45 a head for the two years.

The other expenses, including interest, buildings, equipment, bedding, loss by death, and miscellaneous expenses, amount to $16.67 for the two years. This makes the total cost of raising the heifers, including feed, labor, and overhead charges, $73.63. A credit of $12 for manure for the two years makes the net cost of a two-year-old heifer $65.63. This corresponds very closely to other cost records. Trueman[3] figured the total cost of a two-year-old heifer to be $70, but he added $4 as the initial value of the animal, while Lindsey[4] found the cost under conditions of higher prices of feeds and with an initial charge of $4 to be $74.24.

An initial charge for the calf should not be included, since there is no actual cost. The calves would be produced even if it were necessary to slaughter them at once. When a cost price for the calves is not allowed, the cost price of milk is more nearly accurate. Male calves not needed to maintain the herd represent a credit instead of a charge. The amount of credit to the herd for calves is discussed in a later paragraph.

Length of Time a Cow Remains in the Herd.—With the heifer coming into the herd at a cost of $65, it must next be determined how long she will probably be in the herd as a profitable producer of milk and how much she will be worth at the end of her period of profitableness as a milk producer. The amount of yearly depreciation will depend upon the number of years the cow is profitable, and it is represented by the difference between the cost of the cow at her entry into the herd and her sale price as beef. A high-cost cow depreciates more than a cheaper one, since both are worth about the same when sold for beef. Often the less expensive cow sells for more on account of her more beefy conformation.

The period of usefulness of cows varies, but on the average the economic life of a dairy cow is much shorter than is generally believed, and is a large item of expense, especially if high-cost animals are kept. Various estimates have been made of the length of time a cow should remain in the herd. The average life of a cow, according to Rasmussen,[5] is about six years. According to actual records made by Thompson[6] in herds of Delaware County, N. Y., changes were made which indicated that the average productive life of a dairy cow was only 3.6 years, while in a survey of opinions of 174 farmers in the same county the average is estimated as 5.8 years. The statement is made by Thompson that this is perhaps a more reliable figure.

Studies in farm management by the United States Department of Agriculture[7] show that the dairy cows of Chester County, Pa., remained in the herd 4.34 years, while in Lenawee County, Mich., they remained 4.52 years. Four, five, six, and seven years are given by different authors as the average life of a cow in the dairy herd. There is no doubt considerable difference in the productive life of cows, due to varying standards of production. By one dairyman under certain conditions a cow may be considered a profitable animal, while with another under different conditions the same cow might prove unprofitable. However, five years may be considered about the average length of time the cows will remain in the herd.

There are many factors that shorten the economic life of a cow. Death is a small factor which accounts for only 1.69 per cent in Pennsylvania dairies and 1.31 per cent in Michigan. Udder troubles, tuberculosis, failure to breed, and accidents are some of the other causes for a shortened period of usefulness in milk production. Some valuable cows which continue to breed are kept after they are not profitable as milk producers, but this number is very small. In the formula which follows account is not taken of the cows that die or of those that cannot be sold for beef; in general, this relatively small number would have little effect on the average.

With a figure for the probable length of usefulness of a cow with which to determine the yearly depreciation, all that is necessary is to subtract the final sale price of the cow for beef from the cost upon entry, and to divide the result by five, the average length of life in the herd. The formula would be

$$\frac{\text{first cost} - \text{final price}}{\text{length of life}}.$$

With a cow weighing 1000 pounds, a selling price of 4 cents a pound, and a first cost of \$65, the formula for the yearly depreciation is

$$\frac{65-40}{5} = \$5.$$

The depreciation would be quite different if \$200 cows were bought. In that case it would be $\frac{200-40}{5}$ = \$32 per year.

A few good calves may soon repay this extra cost, but when it is charged to the cost of milk it is an important factor. Depreciation is least when large, common stock is kept, for at the present high price of beef large cows can be sold for beef for almost as much as they could be raised or bought for as dairy cows. Some make it a practice to be constantly buying and selling cows, but this encroaches upon another business and should not be included in the cost of producing milk.

Interest, taxes, and insurance are other charges in the cost of dairy cows. Interest may be figured at the same rate as above, 5 per cent, and taxes also at the same rate, although in many sections it is a common practice to base the taxes on the land, no greater taxes being charged when 50 cows are kept than when there is only one. Dairy cows are seldom insured against death by disease, except in the case of particularly valuable animals. Insurance against fire and storm is a small item. The total annual cost of cows is, therefore, as follows:

Depreciation, $\frac{65-40}{5}$	\$5.00
Insurance, \$65 at 0.3 per cent	0.20
Taxes, \$32.50 at 2 per cent	0.65
Interest, \$65 at 5 per cent	3.25
Total cost per cow per year	\$9.10

The Cost of Bedding

The problem of bedding is a small factor on a farm with a small dairy, especially if the location is at some distance from the city or from markets. In localities where straw can be sold at a good price and where a large number of cows are kept, bedding is a material item of cost. A great many substitutes are being used for bedding for dairy cows, sawdust and shavings being the most common. These are in quite general use on farms where high-quality milk is produced, because of the difficulty of getting straw that is free from dust. It is thought by some that sawdust and shavings are injurious to the soil, though this has not been demonstrated. It is certain, however, that the manure is not so valuable as when straw is used. Waste hay and stover are also used for bedding, but usually these materials contain too much dust.

When the cows are kept tied in rows and on a platform, the shavings and sawdust do not involve so much work and they will keep the cows cleaner. Baled shavings are preferred to all other kinds of bedding, for they can be handled with less labor, will absorb the liquid manure well, will stay where placed, making it possible to keep the cows cleaner, and are relatively freer from dust than straw or stover. Where the floor is tight and smooth, both sawdust and shavings can easily be removed.

The amounts of the various beddings needed will depend upon the management, the length of time the cows are kept in the stable, and the nature and condition of the floor. (See Lecture XVI.)

The Cost of the Sire

There are two factors that determine the cost of the sire for a cow, namely, the expense of keeping the sire and a number of cows served. The first cost of bulls varies greatly, and ranges from the cost of raising to hundreds and even thousands of dollars. It requires, for a particular herd, no more expenditure to raise a good bull than a poor one, but the initial cost is more, and if the bull gives especial promise or has been tried and has produced especially good animals, his sale price and also his intrinsic value may be very high. The influence of a sire that will get daughters with greater productive ability than their dams is worth more to the herd that is being developed.

From the standpoint of cost of production of milk of a particular generation, it is not correct to figure the cost of the sire on the basis of an expensive animal, for a cow will be no better as a producer and no more economical in her production because of the use of a good sire in getting her calves. The calves are of greater value, and they will increase the cost price of cows in the next generation. A bull that will be likely to give calves equal to or better than the 8500-pound producers, taken as a basis of calculation in a preceding chapter, would cost perhaps $50 when a few days old. It would cost somewhat more to raise a bull to two years of age than to raise a heifer to that age, but the bull could be used moderately during its second year. It is reasonable, therefore, to assume a cost of $100 for the bull at one year to one and a half years of age.

The expense of keeping a bull is somewhat different from that of keeping a cow. More room and more bedding are required, but the feed will be somewhat less than that required by a high-producing cow. The taxes, interest, and insurance should be considered on the same basis as in the case of the cow. The depreciation is greater because the initial cost is higher; and the period of usefulness in a herd is no longer, on the average, though the bull may sometimes be sold, at a price greater than he would bring as beef, for use in another herd. A bull is usually heavier, and, unless old, will sell for more as beef than a cow. On the average, four years is as long as a bull can be used to advantage in one herd unless a large herd is kept and several bulls are used. In this case the bull could be used with cows descended from other bulls.

On the basis of $100 for the sire, the following cost for a year must be charged as a part of the expense of producing milk:

Feed	$50.00
Labor, 160 hours at 15 cents	24.00
Depreciation, $100 to $60 in 4 years	10.00
Interest on $100 at 5 per cent	5.00
Insurance, $100 at 0.3 per cent	.30
Taxes, $50 at 2 per cent	1.00
Total cost per year	$90.30
Credit for manure	20.00
Net cost per year	$70.30

The number of cows served by the bull is the greatest factor in the cost per cow. A bull will serve as many as 100 cows during the year, or even more, but in practice the service is not regular, although an attempt is commonly made to have fresh cows at different seasons. It should also be remembered that there are seldom as many as 100 cows in the herd. The greater part of the milk of this country, as already suggested, is produced by small herds, and it is in these that the cost of bull service is so high, especially where expensive bulls are kept.

Following the foregoing table, with a herd of 10 cows the service for each cow would be $7.03 a year, while in a herd of 20 cows this cost would be only one-half as much. The manure produced by the bull must be considered as a credit. It is not quite so high in value as is that from a cow fed for large production. More bedding is required for a bull, but the labor is about the same as that required for a cow. The bull is usually kept in a separate pen, so that more time is required to groom him and to clean his stall, but the amount of time thus expended is less than that used in milking the cows.

Miscellaneous Expenses

In a well-equipped dairy the miscellaneous expenses are considerable. One or more of the items mentioned below may not be necessary as costs for a particular dairy. For example, some dairies are located near good springs or are supplied with an abundance of cold water, so that ice is not needed. Under conditions, however, where the milk must be prepared for shipment in a short time, ice may be needed, even with a good supply of cold water. In some sections ice can be stored at a small cost, while in other sections it is necessary to buy it at relatively high prices. According to Rasmussen,[5] about one ton of ice is needed yearly to cool the milk of a cow producing 8500 pounds, which was the amount produced by the cows in the Wisconsin herds to which these formulas have been applied. This makes a rather large item under conditions of high cost of ice, but the amount cooled is almost twice the production of the average cow. The actual cost of ice in the 174 herds of Delaware County, N. Y., was only about 50 cents a year for each cow.[6] More than one-half the dairies of this country use no ice at all. Wood and coal for heating water, and for steam where sterilizers are used, add another annual expense item of 25 to 75 cents a cow.

Tools and special equipment, such as scales, currycombs, brushes, cards, clippers, forks, shovels, and carts and carriers constitute another expenditure, which will amount to 50 cents to $1 a head in a well-equipped dairy. The utensils needed, including pails and strainers, sterilizers, cans, and other tinware, will cost $1 a year for a cow. Supplies, such as medicine, salt, soap, disinfectant, and fly exterminator, cost from a few cents to $1 or more for one cow. In surveys in New Hampshire, Rasmussen[5] found that medicine alone amounted to 45 cents a cow.

Another incidental expense is that of veterinary services and of the service of the supervisor of the cow-testing association, where such is patronized. In the average dairy the dairyman should be able to treat ordinary diseases and should seldom be obliged to call a veterinarian. An occasional visit from a veterinarian, however, is necessary. The supervisor of a testing association does a necessary work in herd management, and he can usually do it cheaper and better than the dairyman. The cost of this service depends upon the size of the herd. An average charge of $1.50 for each cow annually will cover it in most localities, while the veterinary fees ought not to exceed 50 cents to $1 a cow yearly.

Where the milk must be delivered to a station or creamery, or even to a city, which involves the expense of hauling and railroad transportation, a very material expense is incurred. In the investigation of conditions in New England by the Boston Chamber of Commerce,[8] the average cost of collecting and hauling to the station was one-half cent a quart, while the cost of railroad transportation on different lines averaged the same. With the 8500-pound producers, the cost of hauling and transportation at these rates would be over $18 a year for each cow. Long hauls with small quantities of milk, in some cases, are made at a cost that makes the milk business unprofitable. Cooperation in hauling greatly reduces the cost to small producers. In studies by Hopper and Robertson,[9] the average cost for delivery of 100 pounds of milk was 11.7 cents, with an average hauling cost of $145.16 to a farm for one year.

This, although another item of legitimate charge to the cost of production of milk, is not in some cases an actual extra cost. Often the country boy delivers a can or two of milk on his way to school, so that, although an actual expense would otherwise be connected with the delivery of the milk, it is done in this way at no real cost. The total of $18 for hauling seems high, but it is a reasonable charge. At 11.7 cents a hundred, hauling 8500 pounds of milk costs $9.80, leaving about $8 for railroad transportation. When this amount is paid at the farm this item should be considered in determining the selling price of the milk.

All these costs may be brought together as follows:

Ice, 1 ton at $1	$1.00
Wood and coal	.75
Utensils	1.00
Supplies	1.00
Veterinary services and tester	2.50
Hauling and transportation	18.00
Total miscellaneous expenses	$24.25

These items cover conditions that are above the average, but no better than are necessary for the production of high-grade milk, such as is now being demanded. Most farms use no ice, no wood or coal for steam, and no sterilizers. The items of tools, utensils, and supplies may be reduced in some cases; and the cow tester is not an expense on most tarms, since the cost of his services is in most cases returned many times by the increased efficiency of the herd. Not only do the records of the supervisor of the cow-testing association show the profitable and unprofitable cows, but the tester is a great help in the selection of calves to be used in future herds, thus making intelligent breeding and herd improvement possible. The large item of $18 for hauling and transportation should be deducted if the milk is sold at the farm and is received there by the dealer.

Credits

Calves.—It is difficult to determine an average credit for calves, as they range in value from almost nothing to $50 or more at birth. The calves that can be sold for the high prices, of course, add an expense to production, namely, the cost of phenomenal breeding stock with very high-bred high producers. The added expense of caring for such animals, the expense of advertising and selling, and the great increase in depreciation and risk must all be included when the larger credit for calves is allowed.

It is assumed for present purposes that the primary business is the production of milk. From an ordinary milk herd the calves are usually sold as veal. The number of calves to be credited to the herd each year will not exceed four-fifths of the number of milch cows; and when failures to breed, accidents, and death of calves are considered, the number to be disposed of will not average more than three-fourths of the number of cows in the herd. Some calves must be kept to replace the cows which, it has been estimated, must be replaced on the average every fifth year. This gives a credit per cow of three-fourths of the price at which calves are valued at initial cost. The one-fourth is not credited to the cows, for no charge is made as the initial cost of the calves raised. When all the calves are credited to the cows, the initial cost must be included in the calculation of cost of cows.

The price at which a dairy calf can be sold when the milk of the cow becomes normal—usually three or four days—is in most instances very small. For veal, a large calf, when fed and marketed at best advantage, may bring a price that will warrant the expenditure of $5 to $6, and in exceptional cases a little more for raising, but many calves do not pay for the milk they consume and the labor invested in them. With a fair-sized cow, such as is assumed in this discussion, an average of $4 a calf, is a fair selling price; and if the calf were fed six weeks its value for veal would probably not warrant an initial charge of more than this. Three-fourths of this gives a credit of $3 a year for each cow in the herd. Under conditions prevailing in many sections, the demand for heifer calves, from cows as good as the standard assumed herein, would command as much as $10; but of the three-fourths that could be sold about one-half would be male calves, so that the credit possible under these conditions would add but little to the credit for each cow allowed above.

Manure.—The actual value of the manure produced by dairy cows depends upon the kind of concentrates and roughage fed, the nature and condition of the soil, the productive value of the land, and the value of the crops grown. In making cost estimates, various methods have been used to calculate the credit to be allowed each cow for manure, and values of $8 to $36 are given. Perhaps the most commonly used figure is $15. Rasmussen[5] arrives at this figure by assuming that 13 tons are produced, and that the fertilizing value of fresh manure is $1.90 per ton, making a total value of $25. From this he deducts two-fifths for hauling and loss due to leaking and fermenting. The cows, however, should not be charged for careless handling of manure, but should be given credit for it to the limit of practical methods of conserving the material.

Rasmussen, like most authors, bases the value of the manure upon the cost of mineral fertilizers required to supply the fertilizing elements in similar amounts. If the soil of a particular dairy farm needs these elements, and if they must be purchased in the form of mineral fertilizers, the method of basing the value of the manure on the cost of the commercial fertilizers required to supply an equal quantity of the fertilizing elements is correct. The humus furnished by manure is of considerable value on some fields, while others seem to respond as well as commercial fertilizers when a proper rotation is followed and green crops are turned under.

The value of manure is thought by some to be overestimated when based on the fertilizing elements it contains. Where the full amount is credited at the cost price of the elements, and where the cows are fed a heavy grain ration, a large figure for manure is obtained. In an experiment by Roberts[10] in which eighteen cows were kept in the stable and given a fairly liberal ration, the results indicated in Table LXXX were obtained. The liquid manure is included. The value is based upon a price of 7 cents a pound for phosphoric acid, 15 cents for nitrogen, and 4.5 cents for potash.

TABLE LXXX

AMOUNT AND VALUE OF MANURE OF A DAIRY HERD

	18 Cows for One Day	Average for 1 Cow per Day
Weight of cows, pounds	20,380	1132
Food consumed, pounds	1,347	75
Water drunk, pounds	876	49
Total excretions, pounds	1,452.5	81
Nitrogen, pounds	7.35	.41
Phosphoric acid, pounds	5.01	.28
Potash, pounds	7.40	.41
Value of nitrogen	$1.10	$0.06
Value of phosphoric acid	.35	.02
Value of potash	.33	.02
Total value	$1.78	$0.10
Value per ton	$2.27	
Value per animal per day	.093	
Value per 1000 pounds live weight per day	.082	
Value per 1000 pounds live weight per year	29.82	

From this must be subtracted the cost of hauling the manure to the field. At 50 cents a ton[11] and on a basis of 12 tons, the deduction is $6, leaving the value for manure at about $23. Some loss takes place, even under the best-known system of handling manure, but the value of the humus and of the straw used for bedding is not charged. The amount[12] and kind of grain fed to the cows are factors in manure value, feeds high in protein making more valuable manure. A summary of studies in the manurial value of excreta of milch cows by Sweetser[13] shows the relation of feeding to manure value.

"1. The feces from milch cows contains one-third of the nitrogen, three-fourths of the phosphoric acid, and one-sixth of the potash of the food.

"2. The urine contains one-half of the nitrogen, almost no phosphoric acid, and three-fourths of the potash of the food.

"3. The milk contains less than one-sixth of the nitrogen, one-fourth of the phosphoric acid, and one-tenth of the potash, or less than one-sixth of the manurial value of the food.

"4. When the urine is allowed to waste, more than one-half of the food, or 63 per cent of the manurial value of the solid and liquid manure, is lost."

Another method is to compute the value of manure on a basis of increase in the value of crops. In farm-management studies by the United States Department of Agriculture[7] this plan is being followed. The average value of crops—corn, potatoes, wheat, oats, and hay—on well-stocked farms in Pennsylvania is given as $15.80 for each animal unit more than on similar farms with few animals. The animals, however, included animals other than dairy cows, which supply more fertility than any other domestic animals. In similar studies in Michigan the corresponding figure has been estimated as $8.22. The difference is accounted for by the greater need for mineral matter in the Pennsylvania soil and by the better care given manure in Pennsylvania because of its higher value. This difference shows that the value depends upon the conditions and the needs of the soil of the dairy farm and must, to a large extent, be calculated with respect to each particular case. The increase in crop value, however, is usually underestimated when long periods of time are considered. Where cows are well supplied with concentrated feeds, and where the manure is properly cared for, a cow of 1000 pounds weight will furnish $20 worth of added fertility a year.

The practice in England,[14] which is covered by a law affecting landlord and tenant, gives a tenant credit for all manure resulting from purchased feeds given to stock, on a basis of three-quarters of the total value of the phosphoric acid and potash in the feed, allowed for all unused manure. A credit of 70 per cent of the total value of nitrogen is allowed when the stock is fed on pasture, and of only 50 per cent when it is fed in the barnyard. When one crop has been grown after application of the manure, a credit of one-half the above amounts is allowed.

There are tables, in the English publications referred to above, giving the amounts of nitrogen, phosphoric acid, and potash voided from the various grains fed to dairy cows. Given the quantities of feed consumed and the prices for the elements needed on a particular farm, the real value of manure under particular conditions of soil and feeding can be definitely ascertained.

Application and use of Formula

The costs and credits incident to milk production may now be summarized. Under the conditions stated for each item, which include a particular size and kind of cow producing 8500 pounds of 4 per cent milk with feeds at stated prices, with the system of management given, and with a good barn well equipped for the production of high-grade milk, cost records will show the following as actual costs in the production of milk:

Total Cost		
1. Feed	$75.29	
2. Labor	27.00	
3. Buildings	8.24	
4. Cattle	9.10	
5. Bedding	3.25	
6. Sire	3.51	
7. Miscellaneous expenses	24.25	
		$150.64
Credits		
1. Calves	$3.00	
2. Manure	20.00	
		$23.00
Net cost per cow per year		
		$127.64

Cost.—The average standard of production of these cows is assumed as 8500 pounds a year, which was also the average production of the 985 Guernsey cows used in the Wisconsin test, upon which the data in this study are based. Figuring 2.15 pounds to the quart, the production is 3441 quarts. Thus the cost of production by the quart is $3\frac{3}{4}$ cents. The cost of 100 pounds, therefore, is $1.50.

Cost of Milk Production with Low Producers.—For the standard herein adopted, however, unusually high-producing cows were selected. If the average production considered were only 3000 pounds, then there would be a very difficult outlook for the business. By referring to a preceding paragraph we find that the food for maintenance would be the same, and for 3000 pounds of milk would be as follows:

		Protein		Energy
Maintenance	5 × 280 =	140	6 × 280 =	1680
3000 pounds milk	962 × 3000 =	186	.36 × 3000 =	1080
Total amount needed		326 pounds		2760 therms
Supplied by hay		90.89		583.63
Supplied by silage		61.60		1159.20
Total amount supplied		152.49		1742.83
To be supplied by grain		173.51		1017.17

A ration with a ratio of 1 : 6 would supply this need. Using the same feeds in slightly different proportions to give the needed balance of 1 to 6, the following amounts of feed would be required by cows of this production:

Feed Required, with Costs

1680 lbs. of hay, 80 cents per 100	$13.44
7000 lbs. of silage, at 15 cents per 100	10.50
450 lbs. of corn, at $1.00 per 100	4.50
300 lbs. of distillers' grains, at $1.50 per 100	4.50
300 lbs. of bran, at $1.05 per 100	3.15
300 lbs. of oats, at $1.10 per 100	3.30
Pasture for season, at $5.00	5.00
Total cost of feed for the year	$44.39

The cost of feed, therefore, would be $30.90 less yearly than with the higher producers. The cost of labor, buildings, bedding, and miscellaneous expenses would be the same, while the cost of sires and cows would be decreased only by the initial cost of the latter, which would decrease the cost per unit cow by only a few cents. It would cost as much to raise the cow, but she could be purchased at a lower price. The total annual cost, then, of keeping cows of this kind would be $97.26. The milk, at the same price, $2 per 100 pounds, would bring $60, which would result in a loss of $37.26 for each cow each year. This is what may be expected at the above prices of feed and labor from cows that produce no more than 3000 pounds, when a dairyman attempts to produce milk of good grade, in good barns, using full grain rations, and practicing year-round feeding.

A further analysis may be made: Let us assume that the cows are kept in a building worth only $1000; that the cattle are kept on pasture and fed chiefly straw and stover during the winter; that the bedding could not be marketed; that much of the hay could not be sold at $16 a ton on account of being damaged by rain; that the equipment is relatively incomplete and inexpensive; that the cows are fed less grain, producing most of the 3000 pounds while on pasture; and that they are only given stover, straw, and perhaps a little grain in the winter. The item of labor under this system would be less. Under these conditions the annual cost of keeping cows could be decreased to $60, or the selling price of the milk. Some dairymen would continue under these conditions for the return for labor of $27 a cow for a year.

With the data in the preceding paragraphs, comparisons can be made of each item of cost, so that they may be taken as a guide to cost under any condition of management or prices.

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APPENDIX

LABORATORY EXERCISES

In the teaching of dairy cattle feeding and management, the practicum should form an important part of the work. Usually only one laboratory period is given per week, but sometimes two are given. A sufficient number of exercises are outlined in the following pages to occupy two laboratory periods for a full semester. In cases where only one laboratory period is given each week, certain exercises may be omitted without in any way interfering with the continuity of the work. These exercises are marked with a (*). Others may be added if necessary.

In some exercises it may not be possible, with large classes to schedule all the students to meet at the same time. This applies to such exercises as milking, calf feeding, etc. In such cases, the class may be divided into groups and assigned to work at various times outside of regular scheduled periods. With other exercises, such as figuring rations, it is believed desirable that all work be done by the students, independently, in a classroom, under the supervision of an instructor.

In the calculation of rations any one of the various systems may be used, whichever is used in the particular state in which the instruction is given. In these exercises the Morrison Standard will be used except when otherwise stated.

Feeding

Exercise I. Identification of Feeds.—As many feeds as can be obtained should be placed in convenient containers so that the students can observe and study them. During the laboratory period the names of the different feeds are placed on the containers and the student is required to make a study of the characteristic appearance, odor, weight, bulk, and any other property which the feed may possess. Defects of any particular feeds or characteristics that distinguish grades or qualities of a particular feed should be discussed. Ready-mixed feeds that are common in the state may also be used. After the students have had time thoroughly to familiarize themselves with the feeds, certain of the feeds should be prepared with labels removed and a test given on identification of feeds.

Reference.—Lecture V.

Exercise II. Cost of Feeds.—A list of all the common feeds and roughages in common use in the state and the current price per ton should be given to each student. The student should obtain the pounds of digestible protein and total nutrients of each feed from the tables and from these calculate the cost of 100 pounds of feed, of 1 pound of digestible protein and 1 pound of digestible nutrients. This should be kept for calculation of feed costs in the following exercises.

Reference.—Lecture IX.

Exercise III.* Requirements for Maintenance and Milk Production.—The requirement for maintenance of cows of varying weights, and for milk production of cows giving various amounts of milk with different fat percentages, by the different standards, should be calculated.

Problems.—1. Calculate the requirements of a 900-pound cow giving 30 pounds of 5 per cent milk daily, by the Wolff–Lehman, Haecker, Morrison, Scandinavian, and Armsby standards.

2. Calculate the requirements of a 1300-pound cow giving 45 pounds of 3.5 per cent milk daily, by the same standards as in Problem 1.

Reference.—Lecture VII.

Exercise IV.* Calculating Rations.—Rations should be calculated by the more common standards, to familiarize the student with the different standards.

The Scandinavian System

Problems.—1. Calculate a ration for a 1000-pound Jersey cow giving 16.5 pounds of 5.5 per cent milk, when the following feeds are available:

Corn stover	Wheat bran
Clover hay	Cottonseed meal
Corn meal	Gluten feed

2. Calculate a ration for a 1200-pound cow giving 35 pounds of 3.8 per cent milk when the following feeds are available.

Red-clover hay	Corn and cob meal
Corn silage	Ground oats
Buckwheat middlings	Linseed meal

Reference.—Lectures VII, VIII.

Exercise V. Calculating Rations.

MORRISON STANDARD

Problems.—1. Calculate a ration for a 1050-pound cow giving 32 pounds of 4.2 per cent milk when the following feeds are available:

Timothy hay	Wheat bran
Corn silage	Cottonseed meal
Corn meal	Gluten feed

Calculate also the cost of the ration, the feed cost of 100 pounds of milk, and the feed cost per pound of butter-fat.

2. Calculate a ration for a 1300-pound cow giving 45 pounds of 4.1 per cent milk with the following feeds available:

Corn silage	Corn and cob meal
Alfalfa hay	Gluten feed
Beet pulp	Hominy
Wheat bran	Ground oats
Cottonseed meal	Linseed meal

Figure the cheapest ration, using only such feeds as are necessary for proper balancing. Figure also the cost of 1 pound of digestible protein and one pound of digestible nutrients.

References.—Lectures VII, VIII.

Exercise VI. Calculating Rations.

ARMSBY STANDARD

Problems.—1. Calculate a ration for an 850-pound cow giving 18 pounds of 4.8 per cent milk with the following feeds available:

Mixed hay	Ground oats
Corn stover	Wheat bran
Corn meal	Linseed meal

Figure the returns for $1 expended for feed when milk sells at $2 per hundred.

2. Calculate a good ration, using any feed on list for a Guernsey cow weighing 1100 pounds and producing 32 pounds of 4.7 per cent milk.

Consider the characteristics of a good ration. Other things being equal, the cheapest ration is the best. Discuss reasons for using various feeds.

Reference.—Lecture VII, VIII.

Exercise VII.* Calculating Rations for the Herd. Usually it is not practical to calculate a ration for every cow in the herd and it is therefore necessary to calculate a ration for the entire herd. The student should familiarize himself with the method.

NUTRITIVE-RATIO METHOD

***Problems.*—1.** Calculate a grain ration for a herd of Jersey cows averaging 20 pounds of 5 per cent milk. The roughage available is corn silage and alfalfa hay. Corn meal and ground oats are available, while the other concentrates must be purchased.

2. A man has a herd of 12 Ayrshires cows, averaging 35 pounds of milk per day. He has the following feeds available:

Timothy hay	Corn and cob meal
Corn silage	Ground oats
Corn stover	

Figure the cheapest grain ration to feed, using all of the above feeds and making any additional purchases necessary. Figure the cost of the grain mixture per 100 pounds. Make enough of the mixture to last two weeks. Discuss amount of roughage and grain to feed and reason for purchasing such feeds as are purchased.

Reference.—Lecture IX.

Exercise VIII. Calculating Rations for the Herd.—This method is somewhat simpler even than the one shown in Exercise VII. Since there is seldom a deficiency in total nutrients when the herd has all the roughage that they will eat, a roughly balanced ration can be formulated by balancing the protein of the grain mixture to suit the kind of roughage available.

Balancing for Protein

Problems.—1. A dairyman has a herd of 20 Holstein cows averaging 38 pounds of milk per day. He has on hand timothy hay, corn silage, corn and cob meal, and ground oats. Figure a good grain mixture for this herd, using the feeds available and any others necessary. Give reason for the different ingredients, and figure costs. Calculate amount of all feed that will be required in such a herd for a six months' feeding period.

2. A man has a herd of 9 Jersey cows with an average production of 22 pounds. The feeds available are:

Oat straw	Linseed meal
Mangels	Cottonseed meal
Corn and cob meal	Dried beet pulp
Hominy	Wheat bran
Alfalfa hay	Gluten feed

Calculate a good grain mixture, using any of the above feeds. How much feed will be necessary for feeding this herd from Sept. 15 to May 15? Calculate the storage room necessary to store this amount of feed. Give method of feeding, amount fed, and cost of ration.

Reference.—Lecture IX.

Exercise IX.* Economy of Heavy Feeding.

Problem.—Assume a 1200-pound Holstein cow with a capacity for producing 50 pounds of 3.5 per cent milk. Will it be economy to feed her enough for only 35 pounds of milk per day? For 25 pounds? Calculate a ration for such a cow by the Morrison Standard for 25, 35, and 50 pounds daily, and include the cost of the ration, the cost of 100 pounds of milk, and of 1 pound of butter-fat.

Reference.—Lectures, VI, VIII.

Exercise X.* Law of Diminishing Returns.—Does it pay to get the greatest production possible from a cow, or is there a point above which it is not profitable to go?

Problem.—Using the feeds and prices as figured in Exercise II, calculate rations for a Jersey cow weighing 900 pounds and with milk testing 5 per cent, under the following conditions, considering pasture worth $2.50 per month:

Production, Pounds Fat	Amount of Pasture	Overhead Expenses Other than Feed
150	Pasture only for 5 months	$50.00
250	Pasture only for 5 months	50.00
350	Pasture and $\frac{1}{3}$ grain ration for 5 months	55.00
450	Pasture and $\frac{1}{4}$ grain ration for 5 months	60.00
550	$\frac{2}{3}$ pasture and $\frac{1}{3}$ roughage, $\frac{3}{4}$ grain ration for 5 months	75.00
650	$\frac{1}{2}$ pasture and $\frac{1}{2}$ roughage, full grain ration for 5 months	85.00
750	$\frac{1}{4}$ pasture and $\frac{3}{4}$ roughage, full grain ration for 5 months	100.00

Find the feed cost per 1 pound of fat; the total cost of 1 pound of fat; the percentage digestible nutrients in roughages; and the percentage digestible nutrients in concentrates. Explain the results by means of graphs.

References.—Lecture XII.

Exercise XI. Calcium and Phosphorus Requirements.

Problems.—1. A 1200-pound cow producing 35 pounds of milk daily is fed the following ration:

Corn silage	40 pounds	Wheat bran	1 pound
Timothy hay	10 pounds	Gluten feed	3 pounds
Corn meal	7 pounds		

Calculate the calcium and phosphorus content of such a ration and compare with requirements.

Hart has given the daily requirements for 1 pound of milk as 6 grams CaO (4.26 grams Ca) and 6 grams P_2O_5 (2.58 grams P).

2. Substitute alfalfa hay for timothy hay and make the same comparisons. Explain the results.

References.—Lectures VI, XII.

Exercise XII.* Mixing Rations.—The students should be given one exercise in the proper mixing of a ration. The feeds should be laid out on the floor in the required amounts and thoroughly mixed.

Reference.—Lecture IX.

Exercises XIII, XIV, XV, XVI. Feeding Practice.—Four laboratory periods are devoted to actual feeding practice. One cow or more is assigned to two students, who are required to figure a good ration for this cow, using the feeds available. The students are required to weigh out the feed necessary and to have the cow fed according to their directions. The cow should be weighed at frequent intervals. At the end of a ten-day feeding period, a full report should be submitted.

References.—Lectures V, VI, VIII.

Exercise XVII.* Calf Feeding.—One laboratory period should be devoted to calf feeding. A schedule should be arranged in which the students are required to prepare the feeds and to carry out the complete work of feeding calves. This is done under the supervision of the instructor.

References.—Lectures XVII, XVIII.

Exercise XVIII.* Milking by Hand.—The student should demonstrate his ability to milk a cow quickly, completely, and in a satisfactory manner. Those who have had experience in milking before taking the course can demonstrate in one milking whether or not they can do the work satisfactorily. Students without such experience require several milking periods in order to be given credit for this exercise. The work should be done under the supervision of the instructor.

Reference.—Lecture XVI.

Exercise XIX.* The Use of a Milking Machine.—The students should be given an exercise in the operation of the milking machine. They should be required to assemble the machine, do the milking, and then thoroughly wash and sterilize the machine.

Reference.—Lectures XVI, XXIX.

Exercise XX.* Valuation of Dairy Animals.—The students should have had a course in dairy-cattle judging before this laboratory exercise. For this, several animals of each class are used, and the student is required to give his estimate of the money value of each of the animals, which should include cows, bulls, heifers, and calves. This exercise should train the student in the purchase of animals and enable him to use his previous training in the determining of age and to make practical application of his ability to judge production. In case the records and the pedigrees of the animals are known, this information should be given. At the end of the period the inventory value of the animal is given to the student.

References.—Lectures XXI, XXII, XXIII, XXV.

Exercise XXI. Marking and Sketching Cattle.—The students should be familiarized with the different methods of marking cattle and with the method of tattooing and putting tags in the ear.

They should also be furnished with special blanks for registration of animals of the different breeds, and each should be required to make drawings and fill out in full application for registration.

Reference.—Lecture XVI.

Exercise XXII.* Herd Development.—As many animals as the herd has of one family should be compared with a family that has multiplied but little, thus emphasizing the value of vitality and reproduction. The inheritance of certain characteristics can well be brought out. The daughters of one bull may also be studied, especially in regard to type and production.

References.—Lectures XXII, XXIII.

Exercises XXIII, XXIV.* Fitting for Show.—Students are assigned animals to be fitted for show. A careful inspection of the animals is made by the instructor before the fitting begins. Some students are given cows, others bulls, and others heifers or calves. A sufficient supply of the necessary equipment for fitting for show should be on hand and the students should be shown how to use it. It is often desirable at the end of the last period to hold a show so that lessons in fitting may be pointed out. Also the methods of handling cattle in the show ring can be shown.

Reference.—Lecture XXVI.

Exercises XXV, XXVI. Barn Plans.—Two exercises in drawing a barn plan are given. Each student is required to hand in drawings according to the following suggestions and specifications. The work can be done either in the classroom or elsewhere. The former is preferable if equipment is available.

Requirements for Dairy Plans

Drawing must be made on regulation-size, white drawing paper (18 by 24 inches). It must be made to a scale of not more than 1 inch equals 6 feet. A margin of $\frac{3}{4}$ inch must be left on the drawing paper. The drawing must be inked in with regulation black drawing ink. All dimensions of the barn must be shown. A space at the lower right-hand corner of the drawing must be saved for the name, date, scale, and grade. The size of the space should be 4 by $2\frac{1}{2}$ inches. The elevation and floor plan should be given.

Reference.—Lecture XXVIII.

Exercise XXVII.* Barn Equipment.—A list of all the equipment in the dairy barn should be made. This should include kind of ties, stalls, feeding arrangement, method of ventilation, and all other equipment. Drawings should be made of such equipment as ventilators, etc. If possible, prices of equipment should be obtained.

Reference.—Lecture XXIX.

Exercises XXVIII, XXIX, XXX, XXXI, XXXII. Dairy-farm Problem.—The object of this dairy-farm problem is to bring together in a fairly comprehensive way some of the factors which must be considered in laying out a dairy-farm business. All points which have a direct and definite bearing upon the dairy problem should be considered. The farm used may be the home farm of the student, some farm with which he is acquainted, now used as a dairy farm, or one that he may be interested in converting into a dairy farm, or the farm may be purely imaginary. The latter, however, is not desirable. The barn plans and equipment in Exercises XXV, XXVI, XXVII may also be made with the same farm in view.

The Dairy Farm Problem

1. *The Layout.*

   A. The farmstead.

   1. Layout of farm, size, etc. To scale, notebook size paper.
   2. Make a list of fields and total expected crop yields.
   3. Location of the house, barn, etc.—to scale.
   4. Estimated value of the dairy barn and equipment.

2. *Give Area, Yield (in pounds), Use and Sales of all Crops Grown on the Farm.*—Use a form like the following: (Following tables are only sample tables to show character of work and forms to be used.)

Crops	Area	Yield per Acre	Total Yield, Pounds	Sales, Pounds	Used, Pounds	Value of Crop

3. *The Livestock.*—Show the numbers and values of animals that you would start with at the beginning of the year, the estimated sales, purchases, and deaths, and the numbers and values at the end of the year, by a table like the following: Indicate the date of sales and of purchases that greatly affect the numbers of animals.

Cows, Heifers, Bulls, and Calves

Number, Beginning of Year			Sales			Purchases			Died	Number End of Year		
No.	Value	Total	No.	Value	Total	No.	Value	Total		No.	Value	Total

4. *Feed Used.*—Decide upon the rations to be fed the different animals during the year Base the rations on good feeding practices and current feed prices. Fill out a table, like the following, to show the feed, pasture, and bedding requirements. Include each kind of feed and each kind of roughage separately. If the animals are fed different rations during different parts of the year, give the ration for each period on a separate line.

Number of Animals	Feed Fed During Year								
	Days	Per Day	Total	Per Day	Total	Per Day	Total	Per Day	Total
______ cows..............									
______ heifers 1–2 yrs.......									
______ heifers under 1 yr....									
______ bulls..............									
Total for 12 mos.........									
Home raised.............									
Feed used...............									
Bought feed used.........									

5. *Cost of Production.*—Considering feeding practice and management on the farm. what would be the probable cost of keeping the dairy herd?

Use the form given below:

Cost:

Feeds—Grain.................................... $__________
Hay.................................... __________
Other dry forage.................................... __________
Silage.................................... __________
Other succulence.................................... __________
Pasture.................................... __________

Labor—Man______ hrs.______ per hr.................. __________
Horse______ hrs.______ per hr.................. __________
Interest on average investment.................. __________
Depreciation on dairy cows.................. __________
Bedding.................................... __________
Miscellaneous.................................... __________
Use of building, 4 per cent value.................. __________
Depreciation.................................... __________
Bull service.................................... __________
Other costs__________ __________
__________ __________

Total... __________

6. *Receipts.*—The receipts from cows should include milk and milk products sold or used on the farm, manure produced, and value of calves at birth; also hides, etc. Use a form like the following:

Milk sold ________lbs.	Cost per 100 lbs.........	$________
Milk used on farm ________lbs.	....	________
Manure ________tons.	Cost per ton............	________
Calves ________		________
Other receipts ________		________
Butter ________		________
Cream ________		________
Total......		________

7. *Costs.*—The products of the dairy herd consist of milk, manure, calves, and miscellaneous receipts. In order to find the cost of producing milk, we must assume that manure, calves, and miscellaneous receipts are valued at cost. Subtract the value of manure, calves, and miscellaneous receipts from the total cost to find the cost of producing milk. Use the following form:

Total cost from 5...	$________
Value of manure, calves, etc. from 6...............	________
Cost of producing milk..........................	________
Cost per cwt..................................	________
Cost per qt...................................	________
Cost per lb. butter-fat..........................	________

8. *Dairy Management Methods* (thesis about 1000–1500 words).

A. Dairy cows

(*a*) Best time for breeding
(*b*) Methods of feeding, stabling, etc.

B. Bulls

(*a*) Scheme for stabling, feeding, handling, etc.

C. Heifers

(*a*) Best time for breeding
(*b*) Methods of feeding, stabling, etc.
(*c*) Age bred

D. Calves

(*a*) Scheme for stabling, feeding, handling, etc.

E. Methods of disposal of dairy animals and products.

9. *Balance Sheet.*—Make a balance sheet showing net returns of whole farm, considering other side lines, expenses, and increase or decrease in total capital.

References.—Lectures XXX, XXXI, XXXII, XXXIII, and most other lectures.

APPENDIX TABLES

The following tables are taken from several sources and are needed for reference:

TABLE A*

AVERAGE DRY MATTER, DIGESTIBLE CRUDE PROTEIN, DIGESTIBLE TRUE PROTEIN AND NET ENERGY VALUES PER 100 POUNDS FOR RUMINANTS

	Dry Matter, Pounds	Digestible		Net Energy Value, Therms
		Crude Protein, Pounds	True Protein, Pounds	
DRIED ROUGHAGE				
Hay and Fodder from Cereals				
Brome grass, smooth	91.5	5.0	3.5	40.83
Corn fodder (ears included, medium dry)	81.7	3.0	2.3	43.94
Corn stover (ears removed, medium dry)	81.0	2.1	1.6	31.62
Millet, Hungarian	85.7	5.0	3.9	46.96
Mixed timothy and clover	87.8	5.3	3.6	40.85
Oat hay	88.0	4.5	3.9	32.25
Orchard grass	88.4	4.7	3.3	44.93
Red top	90.2	4.6	3.9	51.22
Timothy, all analyses	88.4	3.0	2.2	43.02
Timothy, before bloom	92.8	4.7	2.9	43.52
Timothy, early to full bloom	87.2	3.6	2.5	47.40
Timothy, late bloom to early seed	85.1	2.4	1.8	37.54
Timothy, nearly ripe	87.5	2.2	1.8	38.59
Hay and Fodder from Legumes				
Alfalfa, all analyses	91.4	10.6	7.1	34.23
Alfalfa, before bloom	93.8	15.4	10.3	36.23
Alfalfa, in bloom	92.5	10.5	6.7	32.33
Alfalfa, in seed	89.6	8.5	6.2	32.23
Clover, alsike	87.7	7.9	5.3	34.42
Clover, crimson	89.4	9.7	6.9	36.21
Clover, red, all analyses	87.1	7.6	4.9	38.68
Clover, red, before bloom	89.6	11.6	5.4	42.17
Clover, red in bloom	86.1	8.1	5.3	39.12
Clover, red after bloom	77.9	6.8	4.5	34.51
Clover, sweet white	91.4	10.9	6.7	38.98
Cow peas, all analyses	90.3	13.1	9.2	37.59
Cow peas, before bloom	92.2	17.8	12.8	33.54
Cow peas, in bloom to early pod	89.4	12.6	9.5	39.11
Soy beans	91.4	11.7	8.8	44.03
Straws				
Barley	85.8	0.9	0.6	36.61
Buckwheat	90.1	4.2	2.8	4.55
Oat	85.5	1.0	0.8	34.81
Rye	92.9	0.7	0.5	17.59
Wheat	91.6	0.7	0.3	7.22
FRESH GREEN ROUGHAGE				
Green Cereals, etc.				
Barley fodder	23.2	2.3	2.0	14.08
Blue grass, Kentucky, before heading	23.8	3.7	2.8	14.82
Blue grass, Kentucky, headed out	36.4	2.8	2.2	17.77
Blue grass, Kentucky, after bloom	43.6	1.9	1.6	21.01
Buckwheat, Japanese	36.6	2.2	1.5	17.78

* Pa. Exp. Sta. Bul. 142.

TABLE A—*Continued*

	Dry Matter, Pounds	Digestible Crude Protein, Pounds	Digestible True Protein, Pounds	Net Energy Value, Therms
Green Cereals, etc.—Continued				
Cabbage	8.9	1.9	1.3	8.87
Cabbage, waste, outer leaves	14.1	1.7	1.1	7.05
Corn fodder, dent, all analyses	23.1	1.0	0.8	14.60
Corn fodder, dent, in tassel	14.9	1.1	0.8	9.52
Corn fodder, dent, in milk	19.9	1.0	0.8	13.64
Corn fodder, dent, dough to glazing	25.1	1.3	1.0	17.35
Corn fodder, dent, kernels glazed	26.2	1.1	0.8	16.74
Corn fodder, dent, kernels ripe	34.8	1.5	1.1	22.48
Corn fodder, flint, all analyses	20.7	1.0	0.8	13.53
Corn fodder, flint, in tassel	10.6	0.9	0.7	6.89
Corn fodder, flint, in milk	15.0	0.9	0.7	10.39
Corn fodder, flint, kernels glazed	21.0	1.0	0.8	13.49
Corn fodder, flint, kernels ripe	27.9	1.2	0.9	17.84
Corn fodder, sweet, before milk stage	10.0	0.8	0.6	7.82
Corn fodder, sweet, roasting ears or later	20.3	1.2	0.9	13.38
Corn fodder, sweet, ears removed	21.5	1.0	0.8	14.26
Millet, Hungarian	27.6	1.9	1.1	17.24
Oat fodder	26.1	2.3	2.0	14.06
Orchard grass	29.2	1.7	1.1	15.81
Rape	16.7	2.6	1.7	13.07
Dry fodder	21.3	2.1	1.4	15.99
Sweet sorghum fodder	24.9	0.7	0.4	15.37
Timothy, before bloom	24.2	1.8	1.1	18.36
Timothy, in bloom	32.1	1.3	0.8	18.89
Timothy, in seed	46.4	1.5	1.1	26.36
Wheat fodder	27.4	2.8	1.9	18.75
Green Legumes				
Alfalfa, before bloom	19.9	3.5	1.9	9.20
Alfalfa, in bloom	25.9	3.3	1.8	11.50
Alfalfa, after bloom	29.8	2.1	1.3	11.10
Clover, alsike	24.3	2.7	1.5	14.56
Clover, crimson	17.4	2.3	1.6	10.83
Clover, red, all analyses	26.2	2.7	1.7	15.87
Clover, red, in bloom	27.5	2.7	1.8	16.74
Clover, red rowen	34.4	3.3	2.2	17.30
Cow peas	16.3	2.3	1.7	10.42
Peas, Canada field	16.6	2.9	2.1	9.78
Soy beans, all analyses	23.6	3.2	2.4	12.53
Soy beans, in bloom	20.8	3.0	2.3	10.44
Soy beans, in seed	24.2	3.1	2.5	12.70
Vetch, hairy	18.1	3.5	2.4	11.95
SILAGE				
Corn, well matured, recent analyses	26.3	1.1	0.6	15.99
Corn, immature	21.0	1.0	0.4	11.96
Corn, from frosted ears	25.3	1.2	0.6	14.27
Corn, from field-cured stover	19.6	0.5	0.3	8.98
Clover	27.8	1.3	0.8	7.26
Cow peas	22.0	1.8	1.1	11.05

TABLE A—*Continued*

	Dry Matter, Pounds	Digestible		Net Energy Value, Therms
		Crude Protein, Pounds	True Protein, Pounds	
SILAGE—*Continued*				
Soy beans	27.1	2.6	1.5	11.59
Sugar-beet pulp	10.0	0.8	0.5	9.32
ROOTS, TUBERS, AND FRUITS				
Apples	18.2	0.4	0.1	15.92
Beets, common	13.0	0.9	0.1	7.84
Beets, sugar	16.4	1.2	0.4	11.20
Carrots	11.7	0.9	0.5	9.21
Mangels	9.4	0.8	0.1	5.68
Potatoes	21.2	1.1	0.1	18.27
Pumpkins, field	8.3	1.1	0.6	6.05
Rutabagas	10.9	1.0	0.3	8.46
Turnips	9.5	1.0	0.4	6.16
GRAINS				
Cereal Grains				
Barley	90.7	9.0	8.3	89.94
Buckwheat	87.9	8.1	7.2	59.73
Corn, dent	89.5	7.5	7.0	89.16
Corn, flint	87.8	7.7	7.2	87.50
Corn and cob meal	89.6	6.1	5.7	75.80
Corn meal	88.7	6.9	6.4	88.75
Oats	90.8	9.7	8.7	67.56
Oat meal	92.1	12.8	11.5	86.20
Rye	90.6	9.9	9.0	93.71
Wheat, all analyses	89.8	9.2	8.1	91.82
Wheat, winter	89.1	8.7	7.7	91.66
Wheat, spring	89.9	9.2	8.1	91.41
Leguminous Seeds				
Beans, navy	86.6	18.8	16.4	73.29
Cow peas	88.4	19.4	16.9	79.46
Peas, field	90.8	19.0	16.6	78.72
Pea meal	89.1	19.8	17.2	77.62
Peanut, with hull	93.5	19.4	16.9	83.15
Peanut kernel	94.0	24.1	22.2	109.04
Soy bean	90.1	30.7	27.3	81.29
Oil Seeds				
Cottonseed	90.6	13.3	11.9	78.33
Flax seed	90.8	20.6	19.2	83.17
Sunflower seed	95.5	23.3	20.2	95.77
Sunflower seed, with hulls	93.1	13.5	11.7	92.49
Dairy Products				
Buttermilk	9.4	3.4	3.4	13.32
Cow's milk	13.6	3.3	3.3	29.01
Skimmilk, centrifugal	9.9	3.6	3.6	14.31
Skimmilk, gravity	9.6	3.1	3.1	15.43
Skimmilk, dried	91.7	34.4	34.4	103.91
Whey	6.6	0.8	0.8	10.39

TABLE A—*Continued*

	Dry Matter, Pounds	Digestible Crude Protein, Pounds	Digestible True Protein, Pounds	Net Energy Value, Therms
BY-PRODUCTS				
Fermentation Industries				
Brewers' grains, dried	92.5	21.5	20.2	53.38
Brewers' grains, dried below 25 per cent	91.8	18.7	17.5	50.93
Brewers' grains, wet	24.1	4.6	4.4	14.53
Distillers' grains, dried, from corn	93.4	22.4	18.3	85.08
Distillers' grains, dried from rye	92.8	13.6	11.1	56.01
Distillers' grains, wet	22.6	3.3	2.8	22.05
Malt	94.2	15.8	11.8	87.82
Malt sprouts	92.4	20.3	12.5	72.72
Milling				
Buckwheat bran	88.8	10.5	9.1	30.59
Buckwheat hulls	89.7	0.4	?	−7.69
Buckwheat middlings	88.0	24.6	20.8	72.19
Hominy feed	89.9	7.0	6.5	81.31
Rye bran	88.6	12.2	10.5	79.35
Wheat bran	89.9	12.5	10.8	53.00
Wheat middlings, flour	89.3	15.7	14.0	75.02
Wheat middlings, standard	89.6	13.4	12.0	59.10
Oil Extraction				
Cocoa-nut meal, low in fat	90.4	18.8	18.3	83.49
Cocoa-nut meal, high in fat	92.3	18.4	18.0	100.31
Cottonseed hulls	90.3	0.3	?	9.92
Cottonseed meal, choice	92.5	37.0	35.4	93.46
Cottonseed meal, prime	92.2	33.4	32.0	90.00
Germ oil meal, corn	91.1	16.5	14.3	83.88
Linseed meal, new process	90.4	31.7	30.9	85.12
Linseed meal, old process	90.9	30.2	28.5	88.91
Palm-nut cake	89.6	12.4	12.0	94.18
Peanut cake from hulled nuts	89.3	42.8	41.4	93.55
Peanut cake, hulls included	94.4	20.2	19.5	42.57
Soy bean meal, fat extracted	88.2	38.1	37.3	99.65
Sunflower seed, cake	90.0	32.0	29.1	88.87
Starch Manufacture				
Gluten feed	91.3	21.6	20.1	80.72
Gluten meal,	90.9	30.2	28.1	84.15
Starch feed, dry	90.7	11.2	9.2	77.64
Starch feed, wet	33.4	4.1	3.7	30.45
Sugar Manufacture				
Molasses, beets	74.7	1.1	0.0	57.10
Molasses, corn or black strap	74.2	1.0	0.0	55.38
Molasses, beet pulp	92.4	5.9	3.5	76.28
Sugar-beet pulp, dried	91.8	4.6	0.7	75.87
Sugar-beet pulp, ensiled	10.0	0.8	0.5	9.32
Sugar-beet pulp, wet	9.3	0.5	0.5	8.99
Packing House				
Dried blood	90.3	69.1	68.6	68.12
Tankage, over 60 per cent protein	92.6	58.7	55.6	93.04
55–60 per cent protein	92.5	54.0	51.1	83.58
45–55 per cent protein	92.5	48.1	45.5	72.96
Below 45 per cent protein	93.5	37.6	35.6	54.16

TABLE B *

AMOUNTS OF DIFFERENT FEEDS REQUIRED TO EQUAL ONE FEED UNIT

Feeding Stuff	Feed Required to Equal One Unit	
	Average, Pounds	Range, Pounds
Concentrates		
Corn, wheat, rye, barley, hominy feed, dried brewers' grains, wheat middlings, oat shorts, peas, Unicorn Dairy Ration, molasses beet pulp	1.0	
Cottonseed meal	0.8	
Oil meal, Ajax Flakes (dried distillers' grains), gluten feed, soy beans	0.9	
Wheat bran, oats, dried beet pulp, barley feed, malt sprouts, International Sugar Feed, Quaker or Sugarota Molasses or Dairy Feed, Sucrene Dairy Feed, Badger Dairy Feed, Schumacher Stock Feed, molasses grains	1.1	
Alfalfa meal, Victor feed, June Pasture, alfalfa molasses feeds	1.2	
Hay and Straw		
Alfalfa hay, clover hay	2.0	1.5– 3.0
Mixed hay, oat hay, oat and pea hay, barley and pea hay, redtop hay	2.5	2.0– 3.0
Timothy hay, prairie hay, sorghum hay	3.0	2.5– 3.5
Corn stover, stalks or fodder, marsh hay, cut straw	4.0	3.5– 6.0
Soiling Crops, Silage, and Other Succulent Feeds		
Green alfalfa	7.0	6.0– 8.0
Green corn, sorghum, clover, peas and oats, cannery refuse	8.0	7.0–10.0
Alfalfa silage	5.0	
Corn silage, pea-vine silage	6.0	5.0– 7.0
Wet brewers' grains	4.0	
Potatoes, skimmilk, buttermilk	6.0	
Sugar beets	7.0	
Carrots	8.0	
Rutabagas	9.0	8.0–10.0
Field beets, green rape	10.0	
Sugar-beet leaves and tops, whey	12.0	
Turnips, mangels, fresh beet pulp	12.5	10.0–15.0

The value of pasture is generally placed at 8 to 10 units per day, on the average, varying with kind and condition.

* From Wis. Exp. Sta. Circ. of Information 37.

TABLE C *

DRY MATTER AND DIGESTIBLE FOOD INGREDIENTS IN 100 POUNDS OF FEEDING STUFF

Feeding Stuff	Total Dry Matter, Pounds	Digestible Nutrients			
		Crude Protein, Pounds	Carbohydrates, Pounds	Fats, Pounds	Total Nutrients, Pounds
GRAINS AND OTHER SEEDS					
Corn (average of dent and flint)	81.1	7.14	66.12	4.97	84.4
Kaffir corn	87.5	5.78	53.58	1.33	62.4
Barley	89.1	8.69	64.83	1.60	77.1
Oats	89.0	9.25	48.34	4.18	67.0
Rye	88.4	9.12	69.73	1.36	81.9
Wheat (all varieties)	89.5	10.23	69.21	1.68	83.2
Cottonseed (whole)	89.7	11.08	33.13	18.44	85.7
MILL PRODUCTS					
Corn meal	85.0	6.26	65.26	3.50	79.4
Corn and cob meal	84.9	4.76	60.06	2.94	71.4
Oat meal	92.1	11.53	52.06	5.93	76.9
Barley meal	88.1	7.36	62.88	1.96	74.7
Corn and oats (equal parts)	88.1	7.01	61.20	3.87	76.9
Pea meal	89.5	16.77	51.78	0.65	70.0
BY-PRODUCTS					
Gluten meal	90.4	29.70	42.40	6.10	85.8
Gluten feed	90.8	21.30	52.80	2.90	80.6
Hominy chops	88.9	8.43	61.01	7.06	85.3
Malt sprouts	89.8	18.72	43.50	1.16	64.8
Brewer's grains (dry)	92.0	19.04	31.79	6.03	64.4
Distillery grain (dried from corn)	93.0	21.93	38.09	10.83	84.5
Distillery grain (dried from rye)	93.2	10.38	42.48	6.38	67.2
Rye bran	88.2	11.47	52.40	1.79	67.9
Wheat bran	88.5	12.01	41.23	2.87	59.7
Wheat middlings	84.0	12.79	53.15	3.40	73.6
Wheat shorts	88.2	12.22	49 98	3.83	70.8
Buckwheat bran	88.5	19.29	31.65	4.56	61.2
Buckwheat middlings	88.2	22.34	36.14	6.21	72.5
Cottonseed feed	92.0	9.65	38.57	3.37	55.8
Cottonseed meal	91.8	37.01	16.52	12.58	81.8
Cottonseed hulls	88.9	1.05	32.21	1.89	37.5
Linseed meal (old process)	90.8	28.76	32.81	7.06	77.5
Linseed meal (new process)	90.1	30.59	38.72	2.90	75.8
Sugar-beet pulp (fresh)	10.1	0.63	7.12	......	7.8
Sugar-beet pulp (dry)	93.6	6.80	65.49	......	72.3

*Adapted from Farmers' Bul. 22 and Minn. Exp. Sta. Bul. 130.

TABLE C—*Continued*

Feeding Stuff	Total Dry Matter, Pounds	Digestible Nutrients			
		Crude Protein, Pounds	Carbohydrates, Pounds	Fats, Pounds	Total Nutrients, Pounds
MILK AND ITS BY-PRODUCTS					
Whole milk	12.8	3.38	4.80	3.70	16.5
Skimmilk (gravity)	9.6	3.10	4.61	0.90	9.8
Skimmilk (separator)	9.4	3.01	5.10	0.30	8.8
Buttermilk	9.0	2.82	4 70	0.50	8.6
Whey	6.2	0.56	5.00	0.10	5.8
DRIED ROUGHAGES					
Legume Hays					
Alfalfa	91.6	10.58	37.33	1.38	51.0
Clover (red)	84.7	7.38	38.15	1.81	49.6
Clover (alsike)	90.3	8.15	41.70	1.36	52.9
Clover (white)	90.3	11.46	41.82	1.48	56.6
Clover (crimson)	91.4	10.49	38.13	1.29	51.5
Cow pea	89.3	10.79	38.40	1.51	52.6
Soy bean	88 7	10.78	38.72	1.54	53.0
Mixed grasses and clover	87.1	6.16	42.71	1.46	52.2
Non-legume Hays					
Barley	89.4	5.11	35.94	1.55	44.5
Hungarian grass	92.3	4.50	51.67	1.34	59.2
Kentucky blue grass	78.8	4.76	37.46	1.99	46.7
Meadow fescue	80.0	4.20	43.34	1.73	51.4
Mixed grasses	87 1	4.22	43.26	1.33	50.5
Oats	84.0	4.07	33.35	1.67	41.2
Orchard grass	90.1	4.78	41.99	1.40	49 9
Red top	91.1	4.82	46.83	0.95	53.8
Rowen (mixed)	83.4	7.19	41.20	1.43	51.6
Timothy (all analyses)	86.8	2.89	43.72	1.43	49.8
Straws and Fodder					
Corn fodder (field-cured)	57.8	2.34	32.34	1.15	37.3
Corn stover (field-cured)	59.5	1.98	33.16	0.57	36.4
Kaffir-corn stover (field-cured)	80.8	1.82	41.42	0.98	45.5
Oats straw	90.8	1.20	38.64	0.76	41.6
Rye straw	92.9	0.63	40.58	0.38	42.1
Soy-bean straw	89.9	2.30	39.98	1.03	44.6
Wheat straw	90.4	0.37	36.30	0.40	37.6
SILAGES					
Corn	25.6	1.21	14.56	0.88	17.75
Sunflower*	23.8	0.91	14.21	0.88	17.32

* W. Va. Exp. Station.

TABLE C—*Continued*

Feeding Stuff	Total Dry Matter, Pounds	Digestible Nutrients: Crude Protein, Pounds	Carbohydrates, Pounds	Fats, Pounds	Total Nutrients, Pounds
Roots and Tubers					
Beets	13.0	1.21	8.84	0.05	10.2
Carrots	11.4	0.81	7.83	0.22	9.1
Mangel wurzels	9.1	1.03	5.65	0.11	6.9
Potatoes	21.1	1.36	16.43	....	17.8
Rutabagas	11.4	0.88	7.74	0.11	8.9
Turnips	9.5	0.81	6.46	0.11	7.5
Green Fodder					
Alfalfa (at different stages)	28.2	3.89	11.20	0.41	16.0
Corn fodder (average of all varieties)	20.7	1.10	12.08	0.37	14.0
Cow pea	16.4	1.68	8.08	0.25	10.3
Crimson clover	19.3	2.16	9.31	0.44	12.5
Hungarian grass	28.9	1.92	15.63	0.36	18.4
Kaffir-corn fodder	27.0	0.87	13.80	0.43	15.6
Kentucky blue grass	34.9	2.66	17.78	0.69	22.0
Meadow fescue (in bloom)	30.1	1.49	16.78	0.42	19.2
Oat fodder	37.8	2.44	17.99	0.97	22.6
Orchard grass (in bloom)	27.0	1.91	15.91	0.58	19.1
Rape	14.3	2.16	8.65	0.32	11.5
Red clover (at different stages)	29.2	3.07	14.82	0.69	19.4
Red top (in bloom)	34.7	2.06	21.24	0.58	24.6
Rye fodder	23.4	2.05	14.11	0.44	17.2
Soy bean	28.5	2.79	11.82	0.63	16.0
Timothy (at different stages)	38.4	2.01	21.22	0.64	24.7

TABLE D *

Average Weights of Different Feeding Stuffs

Feeding Stuff	One Quart Weighs	One Pound Measures
Barley meal	1.1 lb.	0.9 qt.
Barley, whole	1.5 "	0.7 "
Brewers' dried grains	0.6 "	1.7 "
Corn and cob meal	1.4 "	0.7 "
Corn bran	0.5 "	2.0 "
Corn meal	1.5 "	0.7 "
Corn, whole	1.7 "	0.6 "
Cottonseed meal	1.5 "	0.7 "
Distillers' grains, dried	0.5–0.7	1.0–1.4
Germ oil meal	1.4 lb.	0.7 qt.
Gluten feed	1.3 "	0.8 "
Gluten meal	1.7 "	0.6 "
Hominy meal	1.1 "	0.9 "
Linseed meal, N. P.	0.9 "	1.1 "
Linseed meal, O. P.	1.1 "	0.9 "
Malt sprouts	0.6 "	1.7 "
Oats, ground	0.7 "	1.4 "
Oats, whole	1.0 "	1.0 "
Rye meal	1.5 "	0.7 "
Rye, whole	1.7 "	0.6 "
Wheat bran	0.5 "	2.0 "
Wheat, ground	1.7 "	0.6 "
Wheat middlings, flour	1.2 "	0.8 "
Wheat middlings, standard	0.8 "	1.3 "
Wheat, whole	1.9 "	0.5 "

Note.—2150.42 cubic inches equal one bushel. 67.2 cubic inches equal one quart–D. M.

* Farmers' Bul. 222.

TABLE E *

MINERAL ELEMENTS OF FEEDING STUFFS—PARTS PER 100 OF FRESH SUBSTANCE

Feeds	Ash	Calcium	Phosphorus	Magnesium	Potassium	Sodium	Sulphur	Chlorine
Wheat	1.64	.050	.373	.130	.520	.031	.198	.084
Wheat bran	6.06	.125	1.110	.531	1.320	.201	.267	.090
Wheat middlings	4.12	.096	.876	.383	1.021	.165	.234	.025
Red dog flour	3.72	.120	.830	.290	.380	.660	.260	.140
Corn	1.21	.012	.260	.108	.340	.026	.147	.063
Corn bran	1.18	.027	.139	.078	.365	.000	.110	.046
Pearl hominy	.53	.004	.098	.032	.135	.000	.160	.046
Gluten feed	3.18	.247	.542	.220	.250	.424	.585	.090
Distillers' grains (corn)	1.38	.043	.290	.050	.013	.142	.470	.060
Distillers' grains (rye)	3.39	.130	.420	.179	.041	.071	.374	.026
Malt sprouts	5.70	.147	.690	.180	.203	1.350	.800	.360
Oats	3.38	.102	.395	.118	.419	.168	.195	.070
Kaffir corn	1.18	.012	.239	.125	.254	.058	.164	.014
Rice	.28	.008	.093	.025	.036	.029	.102	.036
Soy beans	5.06	.210	.592	.223	1.913	.343	.406	.024
Cow peas	3.69	.100	.456	.208	1.403	.162	.240	.040
Linseed meal	5.80	.362	.705	.488	1.098	.253	.408	.058
Cottonseed meal	6.98	.266	1.352	.548	1.656	.259	.490	.038
Beet pulp	2.91	.660	.062	.256	.314	.167	.125	.043
Mangel wurzel	1.18	.015	.030	.041	.444	.082	.026	.158
Clover hay	6.76	1.142	.169	.270	1.701	.062	.176	.239
Alfalfa hay	6.38	1.046	.221	.370	.770	.453	.276	.149
Soy-bean hay	7.67	1.232	.212	.619	1.586	.130	.231	.075
Cow-pea hay	10.76	1.814	.253	.980	.780	.646	.315	.149
Timothy hay	3.20	.177	.113	.102	.564	.317	.149	.183
Millet hay	5.60	.310	.165	.249	1.273	.094	.151	.117
Corn stover	6.52	.472	.095	.086	1.718	.061	.174	.287
Blue-grass hay	4.82	.308	.222	.220	1.290	.129	.307	.215
Wheat straw	3 45	.205	.036	.060	.796	.224	.150	.198
Skimmilk	.69	.128	.094	.014	.122	.047	.034	.091
Whey	.56	.044	.039	.008	.167	.028	.008	.118
Bone flour	......	23.900	14.940	1.160	.065	.091		

* Ohio Exp. Sta. Bul. 255.

TABLE F *

Estimated Weight of Settled Silage †

Depth of Silage, Feet	Est. Wt. of Silage to the Cu. Ft. at this Depth	Av. Wt. of Silage to the Cu. Ft. to this Depth	10 Ft. Diameter	12 Ft. Diameter	14 Ft. Diameter	16 Ft. Diameter	18 Ft. Diameter	20 Ft. Diameter
	Lbs.	Lbs.	Tons	Tons	Tons	Tons	Tons	Tons
1	32.0	32.0	1.26	1.81	2.46	3.22	4.07	5.03
2	32.7	32.4	2.54	3.66	4.98	6.51	8.23	10.17
3	33.4	32.7	3.85	5.54	7.55	9.86	12.46	15.40
4	34.1	33.1	5.19	7.48	10.19	13.31	16.81	20.79
5	34.8	33.4	6.55	9.45	12.85	16.78	21.21	26.22
6	35.4	33.7	7.94	11.44	15.56	20.32	25.68	31.75
7	36.0	34.1	9.37	13.50	18.37	23.99	30.31	37.48
8	36.6	34.4	10.80	15.56	21.19	27.66	34.95	43.21
9	37.4	34.7	12.26	17.66	24.04	31.39	39.66	49.03
10	38.0	35.0	13.74	19.79	26.95	35.18	44.45	54.95
11	38.4	35.3	15.25	21.95	29.85	39.02	49.31	60.96
12	38.8	35.6	16.77	24.15	32.89	42.93	54.25	67.07
13	39.2	35.9	18.32	26.38	35.93	46.90	59.27	73.27
14	39.6	36.2	19.90	28.65	39.02	50.93	64 34	79.57
15	40.0	36.4	21.44	30.88	42.04	54.87	69.34	85.72
16	40.2	36.7	23.05	33.21	45.21	59.02	74.57	92.19
17	40.4	36.9	24.63	35.47	48.30	63.04	79.67	98.49
18	40.6	37.1	26.22	37.76	51.42	67.11	84.81	104.84
19	40.8	37.3	27.83	40.07	54.56	71.22	90.00	111.27
20	41.0	37.5	29.45	42.41	57.75	75.38	95.27	117.75
21	41.2	37.6	31.00	44.65	60.79	79.35	100.28	123.97
22	41.4	37.8	32.65	47.02	64.03	83.58	105.61	133.56
23	41.4	38.0	34.32	49.41	67.29	87.84	110.50	137.22
24	41.8	38.1	35.90	51.70	70.40	91.90	116.13	143.56
25	42.0	38.3	37.60	54.15	73.72	96.23	121.60	150.33
26	42.2	38.4	39.20	56.46	76.87	100.34	126 80	156.75
27	42.4	38.6	40.92	58.94	80.24	104.74	132.36	163.63
28	42.6	38.7	42.55	61.28	83.43	108.90	137.62	170.13
29	42.8	38.9	44.30	63.79	86.86	113.37	142.27	177.11
30	43.0	39.0	45.94	66.08	90.09	117.69	148.59	183.69

* Mo. Agr. Exp. Sta. 154.

† When extreme conditions of any kind prevail it is wise to make some allowances, and the following are suggested:

1. When the corn is put in the silo in a less mature condition than usual, for example, in the milk stage, or at the beginning of the dough stage, add 10 to 15 per cent to the weight given in the table.
2. If the grain is unusually heavy in proportion to the stalk, add 5 to 10 per cent to the figures as found by the table.
3. If the corn is considerably past the usual stage of maturity and clearly contains less water than usual, deduct 10 to 15 per cent.
4. If very little or no grain is present, deduct 10 per cent.

TABLE G

Gestation Table for Dairy Cows

Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve	Date of Service	Due to Calve
Jan.	Oct.	Feb.	Nov.	Mar.	Dec.	Apr.	Jan.	May	Feb.	June	Mar.	July	Apr.	Aug.	May	Sept.	June	Oct.	July	Nov.	Aug.	Dec.	Sept.
1	10	1	10	1	8	1	8	1	7	1	10	1	9	1	10	1	10	1	10	1	10	1	9
2	11	2	11	2	9	2	9	2	8	2	11	2	10	2	11	2	11	2	11	2	11	2	10
3	12	3	12	3	10	3	10	3	9	3	12	3	11	3	12	3	12	3	12	3	12	3	11
4	13	4	13	4	11	4	11	4	10	4	13	4	12	4	13	4	13	4	13	4	13	4	12
5	14	5	14	5	12	5	12	5	11	5	14	5	13	5	14	5	14	5	14	5	14	5	13
6	15	6	15	6	13	6	13	6	12	6	15	6	14	6	15	6	15	6	15	6	15	6	14
7	16	7	16	7	14	7	14	7	13	7	16	7	15	7	16	7	16	7	16	7	16	7	15
8	17	8	17	8	15	8	15	8	14	8	17	8	16	8	17	8	17	8	17	8	17	8	16
9	18	9	18	9	16	9	16	9	15	9	18	9	17	9	18	9	18	9	18	9	18	9	17
10	19	10	19	10	17	10	17	10	16	10	19	10	18	10	19	10	19	10	19	10	19	10	18
11	20	11	20	11	18	11	18	11	17	11	20	11	19	11	20	11	20	11	20	11	20	11	19
12	21	12	21	12	19	12	19	12	18	12	21	12	20	12	21	12	21	12	21	12	21	12	20
13	22	13	22	13	20	13	20	13	19	13	22	13	21	13	22	13	22	13	22	13	22	13	21
14	23	14	23	14	21	14	21	14	20	14	23	14	22	14	23	14	23	14	23	14	23	14	22
15	24	15	24	15	22	15	22	15	21	15	24	15	23	15	24	15	24	15	24	15	24	15	23
16	25	16	25	16	23	16	23	16	22	16	25	16	24	16	25	16	25	16	25	16	25	16	24
17	26	17	26	17	24	17	24	17	23	17	26	17	25	17	26	17	26	17	26	17	26	17	25
18	27	18	27	18	25	18	25	18	24	18	27	18	26	18	27	18	27	18	27	18	27	18	26
19	28	19	28	19	26	19	26	19	25	19	28	19	27	19	28	19	28	19	28	19	28	19	27
20	29	20	29	20	27	20	27	20	26	20	29	20	28	20	29	20	29	20	29	20	29	20	28
21	30	21	30	21	28	21	28	21	27	21	30	21	29	21	30	21	30	21	30	21	30	21	29
22	31	......	Dec.	22	29	22	29	22	28	22	31	22	30	22	31	.....	July	22	31	22	31	22	30
......	Nov.	22	1	23	30	23	30	.....	Mar.	...	Apr	...	May	.....	June	22	1	.....	Aug.	.....	Sept.	.....	Oct.
23	1	23	2	24	31	24	31	23	1	23	1	23	1	23	1	23	2	23	1	23	1	23	1
24	2	24	3	......	Jan.	.....	Feb.	24	2	24	2	24	2	24	2	24	3	24	2	24	2	24	2
25	3	25	4	25	1	25	1	25	3	25	3	25	3	25	3	25	4	25	3	25	3	25	3
26	4	26	5	26	2	26	2	26	4	26	4	26	4	26	4	26	5	26	4	26	4	26	4
27	5	27	6	27	3	27	3	27	5	27	5	27	5	27	5	27	6	27	5	27	5	27	5
28	6	28	7	28	4	28	4	28	6	28	6	28	6	28	6	28	7	28	6	28	6	28	6
29	7	29	8	29	5	29	5	29	7	29	7	29	7	29	7	29	8	29	7	29	7	29	7
30	8	......	......	30	6	30	6	30	8	30	8	30	8	30	8	30	9	30	8	30	8	30	8
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