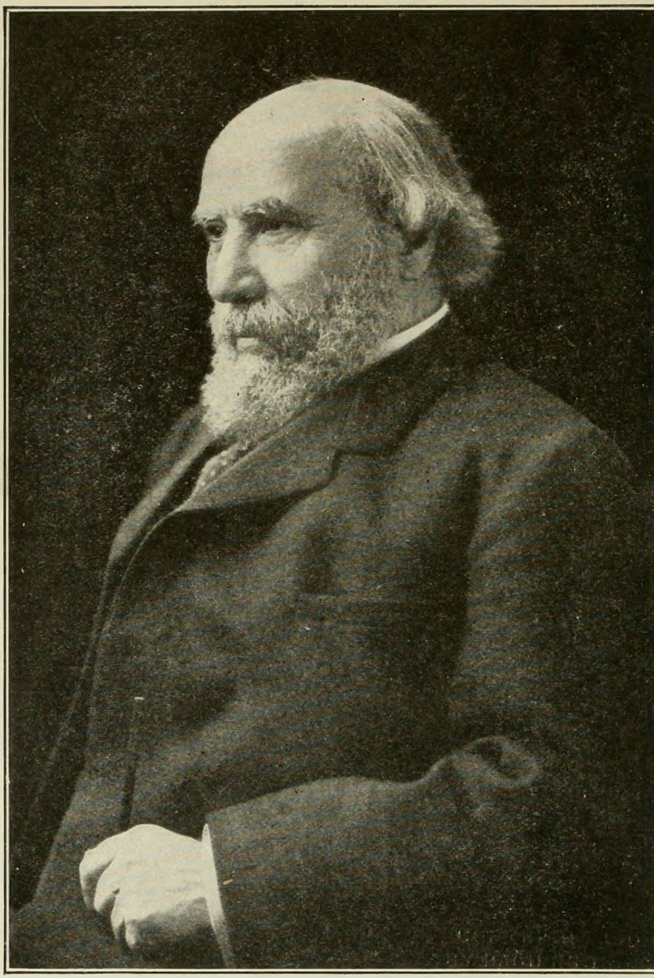
FEEDING FARM ANIMALS

THOMAS SHAW



James J. Hill.
President Great Northern Railroad Systems.

Feeding Farm Animals

By

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To JAMES J. HILL

President
of the Great Northern Railroad Systems

This Book
is Respectfully Dedicated

in recognition of the great work that he has accomplished for the development of agriculture in the United States.

ACKNOWLEDGEMENTS.

In preparing this book, the author freely consulted works previously written on the subject, more especially, "Manual of Cattle Feeding," by Dr. H. P. Armsby, 'Feeds and Feeding" by Prof. W. A. Henry, and "Profitable Stock Feeding" by Prof. H. R. Smith; also various bulletins issued by the experiment stations and the United States Department of Agriculture. To all these sources he desires to express his indebtedness for the aid thus rendered.

THE AUTHOR'S PREFACE.

Several valuable books have been written on the subject of feeding live stock, and those interested have reason to be grateful to the men who wrote them. But the criticism has been made, that some of these are too scientific in their treatment of the subject to meet the needs of the practical feeder, that the discussions in some are so general and diffuse and so lacking in sequence, that the labor involved in securing specific information from them is too great, and that others more specific in their methods of treatment, are helpful chiefly to those only who live in areas where certain leading foodstuffs are abundantly grown. The need, therefore, for something additional on the subject will be at once conceded by those who are familiar with its needs.

Those who have thought carefully upon the subject of feeding farm animals will subscribe to the statement, that it is one of the most comprehensive and difficult questions to discuss that pertain to the broad field of agriculture. So comprehensive is it that in the judgment of the author, no single treatise can cover a field so broad with sufficient fulness. An attempt, therefore, will not be made to produce such a book, as it must result in more or less of failure.

To cover the whole subject the author has planned, if spared, to write five books, the present being the first of the series. In it the aim has been to prepare a work adapted to the needs of the student and stockman that would succinctly and fully cover the subject of feeding and foods in a general way, by dwelling, first on the leading principles or laws that govern feeding; second, on type in the animals to be fed and the balancing of foods for them; third, on the foods used in feeding; and fourth, on the more important considerations that apply to successful feeding. It has also been the constant aim to observe that sequence in treatment that would be natural, orderly and complete; to discuss the subject with a comprehensiveness that would cover conditions in all parts of the United States and Canada; and in a manner so simple that any reader may readily understand what is read.

The books that will follow will discuss the feeding and management of cattle, sheep, swine and horses, respectively, one volume being devoted to each, and each book being complete in itself. In preparing these, special emphasis will be laid on the selection, preparation and feeding of foods and to all essentials that relate to successful management. The hope is cherished, that in this way something will be done that may render some aid to those who may engage in the growing of live stock.

THOMAS SHAW.

St. Anthony Park, Minn.

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CHAMPION HERD OF SHORTHORNS AT CHICAGO IN 1905

[By courtesy of the owner, W. H. Dunwoody, Minneapolis, Minn.]

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Part I embraces Chapters I-IX. Chapter I which is introductory discusses Live Stock and Successful Farming. Chapters II to IX discuss the laws or principles which govern the feeding of farm animals.

The successful feeding of farm animals is governed by certain laws or principles, some of which are reasonably well understood. It may be that there are other laws relating to this great subject that are not yet evolved, or are only in the process of evolution. The attempt to formulate those first referred to in regular sequence, and in the order of relative importance, will now be made. That this is no easy task in the present state of knowledge of the subject will be apparent from the statement that, so far as the author can ascertain, the attempt to enumerate these principles as such has never yet been made. The attempt, therefore, to formulate these laws in the manner stated may be so far impossible as not to preclude the necessity for some revision of the order of arrangement with the further rolling backward of the mists which, during long centuries, have shrouded this subject of subjects in practical agriculture.

As now understood by the author, the following are the chief of the laws or principles that govern successful feeding, and they are given in the order of relative importance. They are such as relate: (1) To selection in the animals to be fed; (2) to the selection of foods for feeding them; (3) to development in the animals; (4) to habit in digestion and assimilation; (5) to keeping the animals at rest; (6) to prolonging the period of usefulness; (7) to pregnancy. These inexorable laws will now be discussed. Like the laws of the Medes and Persians, they can never be changed, except by Him who made them, hence, the great importance of understanding them on the part of those who engage in keeping domestic animals.

In addition to these laws or principles is a long array of considerations that have each a more or less important bearing upon the successful feeding of animals. They have not the rank or force of laws or principles, and yet so nearly allied are some of them to the latter, that it is not easy to determine the border line between them. Each has a more or less important bearing on the successful feeding of animals. That none of them have quite the rank or force of laws is evidenced in the fact that neglecting them will not be followed by consequences so direful as those that would follow non-conforming to the requirements of laws or principles, and yet the feeder whose work is to be successful cannot afford to ignore any one of them in the prosecution of his work. These will be discussed in Chapters XVII. to XXI.

CHAPTER I.

LIVE STOCK AND SUCCESSFUL FARMING.

In one respect the story of agriculture is the same in every country. History has shown that the relation between highest success in farming and the growing and fattening of live stock is so close as to be inseparable. It has further shown that the measure of the success attained is proportionate to the extent to which live stock is kept and maintained, and to the high quality of the same. It follows, therefore, that every legitimate encouragement should be given to the live stock industry, and that every legitimate effort should be made to deepen the farmer's interest in live stock production. Make it clear to the farmer that maintaining live stock on his farm will increase his profits and promote in many ways his best interests, and in ninety-nine cases out of a hundred, he will invest in the same. If the demonstration cannot be made clear to him that these results may be expected to follow where the work is properly conducted, he should not be urged to engage in such work. To make it clear that such results may be expected is the purpose of this chapter.

The following are prominent among the benefits that accompany the judicious keeping of live stock on the farm: (1) It increases profits; (2) aids greatly in the maintenance of fertility; (3) benefits rotation; (4) utilizes cheap foods; (5) insures cheaper transportation of farm products; (6) distributes labor more evenly throughout the year; (7) promotes industry in the farmer's household; (8) advances intelligence in the same; (9) tends to moor the young people in the farm home to farm life, and (10) is essential to the highest development in the nation.

Bearing on profits.—The relation between the growing of live stock and live stock products in any country is so close and intimate that the statement is safe which claims that the profits from agriculture increase or decrease with the increase or decrease of the live stock kept. The only exceptions, probably, are new areas with virgin soils, and limited areas with high natural adaptation to some special line of production in which fertility may be maintained for a time through the use of commercial fertilizers. An illustration is furnished in the growing of certain fruits and nut-bearing trees. The most prosperous rural communities in any state or country are those which devote the largest share of attention to live stock and live stock products; as shown by the United States census of 1900, the profits per acre rose and fell with live stock values in the same. The relation between land values and the value of live stock kept upon the land, is close and intimate. In every state the highest land values are found almost invariably where live stock values are relatively the highest. Among the few exceptions are tide lands which may be enriched by sediment brought to them from the regulated overflow of tide waters. The richest agricultural countries in the world are those which are richest in live stock production. Results so uniformly invariable cannot be the outcome of accident. They are effects which are produced by certain causes always operative in live stock producing areas, under any system of mixed husbandry in which live stock is an important feature The chief of the causes that produce these results are discussed in succeeding paragraphs.

Bearing upon fertility.—The extent to which the soils of the United States are being depleted of their fertility is probably the saddest feature in relation to their cultivation. This results first from the extent to which the elements of fertility are removed in the products sold from the farm, chiefly in form of grain and bread stuffs. The larger portion of these products are sold in lands where the fertility purchased in them is used in growing crops which compete with those sent to these countries from the United States. Thus, the United States becomes its own competitor. This suicidal policy may be compared with drawing on the principal deposited in a bank from year to year, until all is gone, rather than living on the interest.

As a result of this system, the evidences of a waning fertility are everywhere present in localities where the soil has been tilled during successive years. On the major portion of the lands in the New England, Atlantic and Middle States, good crops cannot now be grown without first dressing them with artificial fertilizers The rich lands of the middle West are giving indications of a gradually waning productiveness. Some of the mountain valleys of the far West are less productive than when they were first tilled. Continue the process of selling the food products grown upon the farm and a time will come when profitable crops cannot any more be obtained from the same.

Marked depletion in soil fertility is the greatest calamity, material in its nature, that can happen to any country. In some respects it is worse than famine, pestilence or war. When carried far enough it leads to abandoned farms. A region of abandoned farms is, in a sense, a wilderness, a desert. There are but three ways in which soil depletion may be prevented. These are, first, by maintaining equilibrium in fertility where crops are sold through applying commercial fertilizers; second, by stocking the land to its full capacity, and third, by combining the two systems. The occasional burying of green crops may also be introduced as an adjunct to each of these systems.

There are two strong objections to maintaining equilibrium in fertility through commercial fertilizers alone. These are first, the cost, and second, that they do not materially improve the physical condition of the soil.

They do not add to the humus in the soil, except through increase which they cause in root production in the crops grown. The presence of humus is necessary to insure the most efficient action possible from the fertilizers, hence, in the absence of long continued applications of farmyard manure or of buried crops, they do not stimulate growth as they otherwise would.

When the crops grown are sold and shipped away from the farm, all the fertility which they contain of course goes with them. When these are fed to live stock and the fertilizer resulting is put back upon the land, it is possible in this way to restore to the land from, say 85 to 90 per cent of the fertilizing elements that were taken from it. The keeping of the live stock also necessitates, more or less, the growing of legumes to be fed to them, a process which tends to increase the nitrogen content in the soil, since these crops deposit in the soil more nitrogen gathered from the air than is sold in the meat, milk or wool made from feeding them.

In some instances, the fertility may be sufficiently maintained through keeping live stock only, at least for a long term of years. In other instances it may be maintained through the application of commercial fertilizers only. The former finds illustration in the rich lands of the prairie states, the latter in the grass producing lands of the alluvial river bottom lands of the eastern states. On ordinary soils, however, fertility may be most evenly maintained by the moderate and judicious application of commercial fertilizers in conjunction with the judicious maintenance of live stock.

The equilibrium of fertility can thus be maintained and increased. The limit to such increase is the capacity and desire of those who cultivate the soil. With increase in fertility, the cost of growing crops will decrease, and there will be a proportionate increase in profits. To maintain such equilibrium in fertility is probably the most important question pertaining to the agriculture of this country.

Bearing upon rotation.—By rotation is meant the growing of different classes of crops in succession. Crops differ more or less in their food requirements, that is, in the extent to which they draw on certain food elements in the soil. Some call for more nitrogen than others, and so of the different food elements, hence, when one crop is grown successively on the same land, the equilibrium or balance in fertility is disturbed, to the extent of reducing some of the elements of plant food in the soil so much that good crops of that class cannot longer be grown upon the land without it is in some way renewed. Other evils accompany such a process, as for instance, increase in certain forms of weed growth, increase in insects which prey upon the particular crop grown, and injury to the mechanical condition of the land through depleting it of humus.

These evils may be lessened, and in a great measure prevented, by practicing a judicious rotation. Some forms of rotation will not, in a marked degree, prevent or very much lessen the evils mentioned. Such is a rotation which consists in the growing of such crops only as the small cereals, wheat, oats, barley, rye, speltz and flax. This is owing to the general similarity of the food elements on which they feed, and to the fact that they all reduce the humus supply in the soil.

Rotation, in the true and helpful sense, implies that live stock shall be kept. Where kept, they consume the unsalable roughage grown, along with other food, and thus give back to the land each of the elements of fertility taken from it. They do this in proportion to the extent to which the food is fed which has been grown upon the farm, and to the care and promptness exercised in putting back again upon the land, the fertilizer resulting.

The fertilizer thus applied tends to maintain an equilibrium in the humus supply in the land. It does this through the admixing of the manure with the soil when cultivating it. The humus thus supplied improves the soil mechanically by making it more friable or firm, according to its texture. It also increases the power of the soil to hold moisture and the nominal elements thus applied improve the chemical condition of the soil while in process of decay. Should the question be asked, why may these results not be accomplished as well by growing hay to be marketed or by burying an occasional green crop, the answer is found in the soil depletion to which the first leads, and in the expense involved in the use of the land while the green crop is being grown.

Again, the keeping of live stock compels the maintenance of pastures on the farm. In this fact is found one of the most beneficial influences. Pasturing land does not always completely hinder soil depletion, but it greatly reduces it, since the product removed consists mainly of soil fertility used in making meat, milk or wool, as the case may be. The same is true of hay crops grown and fed on the farm.

Both pasture and hay crops lessen the labor and expense of cultivation in proportion as they are grown, but the saving in both respects is greater by far in pasture crops. The economy of maintaining pastures, and of properly maintaining them, has never been fully appreciated in American agriculture. The expense involved in maintaining fences to some extent lessens the economy in maintaining pastures, but in ordinary mixed farming their maintenance is an absolute necessity in order to properly rotate the crops.

The influence of pastures temporary in character in supplying the land with humus is very great. They furnish soil with sod or vegetable matter, which in its slow decay benefits the soil as described above. As a result, the crops which follow the breaking up of the pastures will probably be benefited for several years. Results similar in kind, but frequently less in degree, follow the breaking up of meadows. These usuallv have a less dense sod than pastures

Bearing on cheap foods.—On every farm more or less food is grown that is of but little value when sold in the open market. In some instances, it is quite unsalable, and yet, if fed to animals, its value would be considerable. It would seem correct to say that on many farms the revenue derived from thus utilizing what would otherwise be waste material, makes up the principal, if not the entire, of the net revenue derived from the farm.

On farms devoted mainly or exclusively to producing grain which is sold, the straw, the gleanings amid the stubbles, and the screenings of the grain are entirely lost to the farm where no live stock are kept. The straw, much of which has a considerable feeding value, is burned. The weeds and the grass which grow amid the stubbles and which sheep could turn into good mutton, are not only practically valueless, but become a positive menace to clean farming. The numerous grain heads which fall to the ground while the grain is being harvested, and which swine could turn into good pork, molder in decay. The screenings, consisting of small and shriveled kernels and weed seeds, become the property, and without any exchange, of those who buy the grain.

Where mixed farming is practiced, large quantities of fodder and low grade grain are grown, which can only be turned to good account by feeding it out to live stock. Such is straw of various kinds, hay that is coarse, weedy or much damaged by rain, corn stover, and grain that is so light or injured in harvesting that it grades low. Some of these products will, under some conditions, not pay the labor of marketing, others will be in a manner sacrificed because of the low price paid, and for some there is virtually no market, other than that which the farm furnishes. To the first class belong such products as oat and pea straw, which, when cut at the right season and well cured, have a higher feeding value than poor hay, To the second belong such foods as inferior or damaged hay and some kinds of coarse grains. Such hay may have a considerable feeding value, and barley so stained by exposure as to be greatly discounted in price in the market will make as much and as valuable meat, milk or wool, and will sustain as much labor as barley that sells for the highest price. To the third class belongs corn stover, every acre of which is about equal to the produce of an acre of hay for feeding uses, and yet millions of acres of this valuable food go back to earth ungathered every year, because the production is in excess of the needs of the live stock kept.

There are also by-products from the dairy, the orchard and the garden, which usually can only be given a money value by feeding them on the farm. Such are skim milk, fallen fruit, unmarketable potatoes and the unsalable parts of vegetables. Nearly all kinds of field root crops also, to be profitable, must be fed upon the farm. The utilization of all these products in the way indicated, may alone constitute the difference between successful and unsuccessful farming.

Bearing on transportation.—The consumption of the food grown upon the farm through the medium of live stock invariably cheapens the cost of marketing the product, whether marketed nearby or through the medium of railroad transportation. A ton of hay, for instance, is marketed more cheaply, viewed from the standpoint of transportation, in the form of meat, milk, butter, cheese or wool than it can be through the medium of wagon or railroad transportation. As previously shown, many products grown upon the farm cannot be sold profitably or sold at all in the open market. (See p. 4.)

The cost of transportation frequently makes the shipment of bulky foods prohibitory. This is particularly true of foods other than concentrates, and is more especially true of transportation where more than one road carries the product to its destination, each road making its own rate. Because of the increased charges in the absence of a through rate and also for other reasons, it is, in some instances, easily possible for the European farmer to buy American grown products and to feed them to live stock at a profit, while the American farmer who is distant from the place of production is unable to do so. The New England dairyman or feeder could turn to excellent account the cheap hay grown in the upper Mississippi basin, but the cost of transportation makes prohibitory the feeding of such food upon his farm. Notwithstanding, the New England factory employe is able to stand the cost of transporting the same hay virtually to the same market in the form of butter or cheese.

It is impossible to state with decision the saving in transportation by turning bulky foods, and even concentrates, into the still more concentrated forms of meat, milk and other products of the dairy. This will be influenced first by the relative reduction in weight effected, the relative advance in value of the finished product in a given market compared with the value of the materials used in making it, and relative freight charges on these products. The influence last mentioned will not be discussed here since it is, to so great an extent, a varying factor.

The saving in weight effected by feeding foods in the form of animal products is proportionate to the bulkiness or the opposite of the foods fed; to the relative nutrition in these in proportion to weight; to the relative proportion of bulky foods and concentrates that are fed, and to the degree of the concentration in the animal product made from these foods. It is apparent, of course, that the greater the bulk, the less the nutrition; the larger the proportion of bulky foods fed and the less concentrated the forms into which the foods are changed, the less relatively will be the saving effected in transportation. While the amount of the saving effected on the basis of reduced weight from transforming food for animals into animal products cannot be given with precision, it may be stated approximately. To make 2 pounds of meat per day from a good 1,000 pound steer that is being fattened would call for say 30 pounds of good clover hay and grain, of which, say 12 pounds would be grain. The reduction in the weight to be transported as meat, compared with the food used in making it, would be 28 pounds or 93 per cent. To secure 22 pounds of milk per day from a dairy cow of similar weight during a prolonged period of feeding would call for say 36 pounds of the same kinds of food, of which say 8 pounds would be grain. The reduction in this instance is 14 pounds or 39 per cent. Suppose that the milk is made into cheese and that 10 pounds are allowed for 1 pound of cheese. The reduction in freight would be 33.8 pounds or 94 per cent. Suppose again the milk is made into butter, and that the 22 pounds of milk make 1 pound of butter, then the reduction in freight is 35 pounds or 97 per cent. It is thus apparent that the reduction in freight from turning food into these respective products increases in the following order: Milk, beef, cheese and butter. It is further apparent that while butter, beef and cheese may be readily transported to long distances, the transporting of milk must always be circumscribed by distance, because of its relative weight in proportion to the food products from which it is made.

That the degree of the advance in value of the finished product, as compared with the value of the foods used in making it has an important bearing on transportation, may be readily shown. Suppose, for instance, that a given amount of food is turned into butter. It has been shown that the weight to be transported is reduced by 97 per cent. But suppose that in the one instance, the butter sold at the point of destination for 20 cents per pound and in the other instance for 25 cents. The butter which brought the larger return was carried at the same rate as that which was sold at the lower price, which means, virtually, less cost in relation to the return for the weight transported.

It has also been shown that but for such transformation through feeding certain products, they could not be sold at all. (See p. 4.) The home market thus created, as it were, for foods otherwise unsalable, is one of the greatest benefits from stock keeping. It not only obviates waste which would otherwise be unavoidable, but it greatly increases profits. It also encourages the growth of many products that would not otherwise be grown, thus widening diversity in crop production.

Bearing on labor.—Stocking farms partially, or to the full extent of their capacity, has an important bearing on the question of farm labor. This bearing is proportionate to the extent to which the farm is stocked. It tends to the distribution of labor throughout the year, exercises an important influence on the relations between the farmer and the farmhand, and furnishes profitable work for every member of the family, according to the capacity of each.

The growing of live stock distributes labor throughout the whole year: (1) Through the diversity in crop production, which it necessitates; (2) through the ever present necessity of providing food for the animals kept; and (3) through the labor entailed at certain seasons and with certain foods in preparing these for being fed.

Those farmers who grow but one kind of crop from year to year are only busy when growing that crop and marketing the same. Those who add to the number of crops grown and marketed directly, extend the period for labor in proportion to the increase in the number of the crops grown. Nevertheless, in the latter instance, there will be a period of idleness as well as in the former, though not so prolonged. But the keeping of live stock on arable farms compels the farmer to widen his rotation in order to provide the requisite foods for the same, and usually to the extent of making ample employment throughout the entire season of growth.

Animals, like the human family, must have sustenance, and they must have it during every day in the year.

Where they are to give the highest possible return, they must have food supplied them at certain intervals. The owner must in some way supply this food, and should do it as cheerfully and as faithfully as the uncomplaining mother prepares food from day to day for the household. Work horses need currying from day to day, cows must be milked at least twice a day and stables must be cleaned daily, thus entailing the blessed necessity of laboring more or less every day in the year.

The proper preparing of foods for winter feeding usually involves much labor. It may and does usually include such processes as grinding grain, shredding or chaffing fodders, slicing or pulping roots, soaking, steaming or boiling foods for certain classes of live stock, and blending foods so as to increase their efficiency when fed. The labor thus created gives employment, and where wisely directed, should prove remunerative.

Growing farm stock exercises a salutary influence on the frequently vexatious question of farm labor: (1) By creating employment for farmhands through all the year; (2) by adding to the permanency of such labor, and (3) by the bearing which it has upon the price of labor.

When farm hands are only employed for a portion of the year, but one of two results must follow: they must remain idle through a part of the year, or secure employment in some other line of work, and at a season when employment is hard to get, that is, in the winter. Live stock call for more attention in winter than in summer, and thus necessitate the employment of labor at that season.

Permanency of employment must be given to the farm laborer who is to remain in this line of work, and who is to excel in the same. It is unreasonable to expect any one to continue in any line of work which furnishes employment for only a portion of the year. The best farm laborers, thus treated, must drift into other lines of work. Those only will remain whose unstable habits unfit them for permanency in any line of work.

Employment throughout the year will act as a regulator of farm wages, as men who work on a farm 12 months in the year can work for lower wages per month than those who work but eight months. Men who are given but eight months wages, which represents maintenance for one year, must get more per month than men who can maintain themselves by laboring all the year.

The maintenance of live stock furnishes profitable employment to all the members of the farmer's family, by giving work to each, according to the capacity and sex. The benefits resulting are: (1) Increased efficiency in laboring with the hands; (2) the formation of industrious habits, and (3) increase in profits.

At a very early age members of the family may feed fowls, when a little more advanced, they can care for sheep and other small animals. Later, both boys and girls can aid in the milking, and still later, the boys take part in the more laborious work of preparing foods.

Each is exercised in using the hands in manual labor at an age when such labor is not only helpful to physical development, but when it is greatly helpful to future usefulness. The individual not trained to use the hands until matured can never become so expert in the use of the same as if such training had been given at an earlier period. The most skillful axemen of America are those who were exercised in swinging the axe from the time that they were first able to swing it.

The value of habits of industry will be discussed under the sub-division of the subject following. But it may be said in passing, that it is the habits of industry that are formed in early life in the members of the farmer's family that, more than anything else, aids in making them the foremost builders of the nation.

The members of the family in this way become wage-earners at a relatively early period, which adds to the profits of the farm by increasing the resources without increasing the wage bill. While thus engaged, the members of the home have the great advantage of parental oversight, and they enjoy all the privileges which home furnishes. In the absence of live stock on farms, family labor can only be remunerative through the growing season. With live stock it becomes remunerative through all the year.

Bearing on industry.—Stocking farms to their full capacity tends in a marked degree to the promotion of industry in rural communities and to the formation of industrious habits of young people who are reared on such farms. These results are brought about: (1) By the increase in labor thus necessitated; (2) through the distribution of the same over the entire year. The habits of industry thus maintained in the parents and begotten and developed in the children, are of inestimable value to rural communities, to industrial centers, and to the entire nation.

The increase in labor thus necessitated has been dealt with in part in the sub-division preceding. It has been shown that such increase in labor is necessitated through the necessity for a wider rotation, through the preparing of foods for feeding and through feeding and caring for the animals. To this may be added the statement that such labor increases the farmer's profits, as a rule, and for this reason if for no other, it is to be commended.

It increases his profits in various ways, (see p. 2) but more probably than in any other way through the added value given to farm products by converting them into more valuable forms. In this way every farm home thus managed becomes a factory in which foods in the raw form, so to speak, are manufactured into what may be termed finished form. The parents are the managers of this factory and all the members of the family are co-operative partners in it. Turning coarse fodders, field roots and screenings which may have practically no value on the farm into butter worth 20 to 25 cents per pound furnishes an illustration of such profitable transformation of food products.

The significance of distributing labor on the farm throughout the year, lies not so much in the greater profits, which in the end it usually leads to, as in the salutary moral influence which it exerts on the farmer and his household. Those who grow and sell grain only are overcrowded with work during seedtime and harvest, while at other seasons they are unduly idle. The influence on the parents is not good. It gives the husband too much time to discuss the policies of the nation in the grocery and gives his wife so much time to visit her sisters, as to militate against good housekeeping. But the children become the chief sufferers. They have a period of practically enforced idleness during much of the year, notwithstanding that they attend some school. This is most unfortunate for the reason, first, that they do not become inured to physical labor during the formative period, and second, that such enforced idleness makes labor distasteful through the inertia which it leads to. In this way encouragement is given to drifting from the farm.

The importance of thus developing habits of industry in the young people who grow up in farm homes cannot be easily overestimated. Such habits usually make the difference between success and the want of success in farming. It is the possession of these more than anything else that makes men reared on the farm leaders in industrial centers when they center their thought on industrial lines of work. They also tend to higher and more stable citizenship wherever they are possessed.

Bearing on intelligence.—The general influence which the growing and feeding of farm animals exercises on the general intelligence of those thus engaged is unquestionably beneficent. This is evidenced (1) in the nature of the work, (2) in the necessities to which it gives rise, and (3) in the equipment called for if it is to be successfully prosecuted. It is not the thought here to draw invidious distinctions between farmers engaged in different lines of work, but rather to show the greater complexity of the problems of growing live stock as compared with those in some other lines of farming, and consequently the greater skill that must be intelligently exercised where the work is to be a marked success.

The most simple style of agriculture that can be practiced is that pursued in pastoral districts where those who practice it lead the life of nomads. The skill called for in such farming relates chiefly to the selection of pastures adapted to the needs of the flock. Tilling virgin lands on the one crop system is a little more complex, as it involves the use of implements of tillage. Rotating crops calls for more thought and skill, since the habits of growth in these differ, and consequently the requisites to produce growth differ correspondingly. When fertility wanes, those who grow crops must use some kind of fertilizers. The proper use of these compels thought and so leads, of necessity, to higher intelligence. When live stock are introduced, additional factors of complication come with them, owing to the necessities of the animals themselves.

The necessities of the animals in the lines of food and shelter on arable farms compel diversity of a certain kind to provide suitable food, the erection of buildings to provide suitable shelter, preparing the foods when necessary to make them more suitable and feeding them in balance to make them more effective. The stock grower who does not understand how to do all this with a fair measure of efficiency is not properly equipped for his business.

Efficient equipment on the part of the stock raiser involves a reasonable knowledge, at least, of the principles that relate to the selection of animals for rearing, breeding or feeding, of those that govern development in its various phases and stages, of those that relate to the selection of foods, of those that govern digestion and also of those that tend to promote the comfort and well being of the animals. It also calls for a reasonable understanding of the knowledge of relative values of animals of different types and at different stages of development, of the relative value of foods and finished meat and milk products that may be made from them, and the various details of management that lead to higher achievement in breeding, feeding and producing a finished product of high relative value.

From the foregoing it will be plainly evident that the individual who attains to high success in stock keeping must be a close observer, a correct thinker, a careful business man, an untiring student of valuable live stock literature and unsparing in his attentions to the needs of the animals which he keeps. In other words, he must be possessed of intelligence and industry in no small degree.

Bearing upon development.—The growing of live stock not only tends to advance intelligence as outlined in the preceding sub-sections, but it would also appear to have inherently a favorable influence on both physical and intellectual development. This may be shown: (1) In the fact that the foremost nations, both ancient and modern were consumers of animal products in addition to vegetable products, including fruits; (2) that people who have lived entirely or mainly on flesh alone or on vegetables alone, have never stood in the front rank among the peoples of the earth, and (3) that these results are the typical outcome of supreme wisdom and design in the arrangement which results in the growth of products from the soil that may be consumed directly by man; of other products that can only be prepared for human consumption by the animals that feed upon them, and in the bestowment of animals capable of thus transforming their foods.

That the foremost nations of the earth intellectually and physically were consumers of both animal and vegetable products is shown in a marked degree in ancient times by the history of the Jews, the Greeks and the Romans. These nations produced the finest specimens of the human race in the olden times, viewed from both standpoints when taken together. In the more recent centuries the Anglo-Saxon peoples have forged away to the front as evidenced in the relative position held by Great Britain and her colonies and more recently by the United States, at one time a British Colony. These races are the greatest relative consumers of animal products in the world. In the consumption of these products per capita, the United States stands first among all the nations of the earth, and where, it may be asked, among all these nations, can the superior of the average American be found in physical and intellectual development.

The low development intellectually of the peoples who live entirely or mainly on the flesh of animals is shown in the history of the barbarous races of both ancient and modern days. Such races have never wielded an important influence in shaping the destinies of the human family. They vanish in the presence of the more aggressive races whose food blends in reasonable equilibrium, grains, vegetables, fruits and animal products, as illustrated in the present condition of the Indian tribes of North America. The showing is some better with peoples who live mainly on vegetable products, as in the case of some of the nations of southeastern Asia, but none of these now occupy or have ever occupied that high position relatively which has been accorded to the nations above referred to, whose people have fed on animal and vegetable products.

Had no provision been made by the Creator for sustaining man except through the growth of products from the soil to be consumed directly, then a very large proportion of nature's energy in production would be expended in vain, since many of earth's products would be consumed to no purpose so far as man is concerned. This would be true of the major portion of the products on which domestic animals feed. It would deprive the human family of milk, the most valuable single food product ever given to the world. It would mean that nearly all the coarser grains now grown would not be grown, from the absence of a sufficient incentive to grow them, and that the by-products of all grains grown, as bran and gluten meal, would be a waste, from the want of animals to consume them. On the other hand, should animals only be grown in any considerable numbers, then their only use would be to furnish hides. The carcasses, so valuable now, would then be naught but waste. Nor does it remove the difficulty to say that domestic animals capable of milk production were given for that purpose only, as this still leaves unexplained the great problem as to why half the entire number of the milk giving classes of animals are males, and therefore, incapable of milk giving. The evident mission, therefore, of all domestic animals is to utilize the products of the soil for man's advantage and they accomplish this by turning their products into other food forms, into materials for clothing and into energy to furnish labor.

It does not follow that some examples of unusual strength of body and mind may not be found among men who subsist wholly on flesh or wholly on vegetables. In communities which subsist mainly on a mixed diet of animal and vegetable products, much of this may be due to inheritance. But it does follow, that rulers of the world are just about certain to be consumers of such products and that, therefore, animals must be grown in ever increasing numbers as the population increases in such countries, in order to provide them with foods so intimately related to national supremacy.

Bearing on farm life.—The growing of live stock has an exceedingly important bearing on the interest taken in farm life, and the pleasure derived from it, and it certainly tends more than any other phase of agriculture to moor the young people of the farm to farm life. It adds to the pleasure of life on a farm: (1) By the closer bond that exists between the human family and animal life than is possible between men and plants, (2) by increasing the profits derived from the farm, and (3) by making it possible to multiply farms as the necessity for so doing increases.

The bond between humanity and plant life can never be so close as that between humanity and animal life. In the very nature of things it cannot be, since in plants there is no response to attentions from the human family other than the dumb response of growth. In addition, from animals there is the response of submission and more or less of friendly feeling, which is closely allied to gratitude. In fact, it would almost seem as though domestic animals were more uniformly grateful for attentions bestowed than man. "The ox knoweth his owner and the ass his master's crib, but my people do not know."

This reciprocity as it were between human and animal life is inherent in many ways, and it begets between young people and their pets what cannot otherwise be expressed so well as by the use of the term affection. This is evidenced in the disconsolate grief sometimes shown by a little maiden of the farm over the loss of a pet lamb torn by dogs. It is also evidenced in the innate bond that exists between young boys and their pet dogs. This bond would seem to be stronger in some instances than the bond between David and Jonathan. The thrill of feeling that comes to the farm girl in witnessing the rapid trooping of fowls into her presence in response to her call is such as never can come from feeding plants. The thoughts of the pets of the farm in those early days are thoughts that linger, and who can measure the influence which they have wielded in the decision reached to stay on the farm, when inclination and outside influences pulled in an opposite direction. The bond between a grown person on the farm and the members of his herd or flock is also strong in a large proportion of instances. This is evidenced in the regret which the farm matron feels when she sees a favorite cow of the herd driven away to the shambles, and in the disturbing thought that comes to the farmer when a herd or flock which he has been feeding for months is driven away for slaughter. Such thoughts never come into the mind when grains are sold or any other class of vegetable products, and they evidence the fact that the relations between the farmer and his dumb dependents were to him a source of pleasure while they lasted.

The increase in the profits of the farm through the keeping of live stock has already been discussed. (See p. 2.) When such increased profits are wisely and promptly shared with the members of the family who help to earn them, the bond becomes still stronger, which binds them to the farm.

The keeping of live stock on arable farms is of that character known as intensive. It creates labor (see p. 11). Because it does, it makes possible more of sub-division in farms than would be possible under other conditions of farming. This results in increase and greater proximity of farm homes, with all the benefits which flow from the same to the schools and churches in rural parts, to social life, to the municipality, to the adjacent villages and towns and to the nation at large.

The great relative importance of live stock has been dwelt upon at length because of its importance. The part that it is playing and the far greater part that it is going to play in building high the pillar of the nation's prosperity, are but dimly understood by farmers even in the aggregate. Hence, the justification for trying to impress this thought upon the student of agriculture, when crossing the threshold of a treatise on Feeding Farm Animals.

CHAPTER II.

PRINCIPLES THAT GOVERN THE SELECTION OF ANIMALS.

Selecting animals, in relative importance, towers away upward, head and shoulders above the other principles that govern feeding. Though each of these should be scrupulously observed, if the principle governing selection is violated, marked success will be unattainable. In proportion to the measure of such violation, will be the want of success. So broad is it that it involves nearly every consideration relating to breeding, and many considerations relating to previous management, and yet, in discussing it, the aim will be to narrow the discussion down to all possible brevity of statement not inconsistent with clearness in the same.

Prominent among the principles that govern selection are: (1) Those that relate to adaptation in the sense of requirement or use; (2) to inheritance; (3) to type or form (4) to quality; (5) to transmission; (6) to adaptation in its relation to environment; and (7) to the indications of good health. The aim has been to state those principles in the order of relative importance, except the last, which manifestly may exercise a qualifying influence on all the others, but coming light on these questions may show the necessity for rearrangement.

Adaptation to requirement.—Adaptation in the sense requirement or use has reference to the object or objects for which animals are kept. In the nature of things these objects vary greatly in the different classes of domestic animals, and they frequently differ considerably in animals of the same class, but of different breeding. Some horses, for instance, are wanted for labor only, some for driving only, and some for both uses. Some cattle are grown to provide milk only, some to provide meat only, and some to provide milk and meat. Some breeds of sheep are kept primarily for mutton production, others primarily for wool production, and yet others for both uses. Likewise some breeds of swine are maintained mainly for the purpose of producing carcasses with relatively heavy hams and shoulders, and a large amount of fat, while others are maintained primarily to produce a large percentage of high priced side meat, with lighter hams and shoulders, and a large proportion of lean distributed through the carcass. The former are now generally spoken of as lard hogs and the latter as bacon. Others again have carcasses a sort of mean between the two. The intermediate form in swine may not be quite so pronounced as in other classes of farm animals, but it exists, nevertheless. It should also be observed that the intermediate or dual types are, in the meantime, more numerously kept than the other types.

It is manifest, therefore, that should animals primarily adapted to one specific use be chosen and maintained for the other line or lines of production for which other animals of the same class have high adaptation, the end sought would not be well attained, and so far as attained it would be at an undue sacrifice of food and labor. The same will prove true when animals adapted to two lines of production are chosen in lieu of animals of the same class primarily adapted to one line of production, where that one line only is wanted. For instance, to seek the highest quality of profitable meat from a high type dairy cow, or the most abundant milk produ tion from a high type beef cow, would be a forlorn hope. Likewise to expect either of these to furnish meat and milk in well balanced equilibrium, as it is furnished by the dual types of cows, or to expect the latter to equal the single purpose cows in their own specific line of production would be an unwarranted expectation. It is exceedingly important, therefore, that animals shall be carefully chosen with reference to the specific uses for which they are kept.

By what standards shall the selections be made? First, by those that relate to inheritance; second, to form or type; third, to quality; fourth, to environment; fifth, to health, and in some instances, but not in all, to transmission. These standards are discussed below, each in its place, hence, further discussion at this time is not necessary.

Inheritance.—Inheritance in the selection of animals for feeding, and more especially for breeding, is important, because of the bearing it has on prospective results. With rare exceptions these results are assured in proportion (1) to the duration of the purity of the breeding; (2) to the degree of excellence in the near ancestry; and (3) to the correct individuality of the animals in respect to form and also in respect to function, proved or prospective. The first is ascertained through pedigree, the second, through facts bearing on the history, including the performance of the animals in the near generations, and the eye or hand or both acting in conjunction.

The importance of inheritance as a factor in selection is not always equal. It is probably never equal except when the particular individuals are chosen for the same specific purpose, as when two cows, for instance, are chosen for the same line of production in the dairy. It varies (1) with the object for which the animals are chosen; (2) with the duration of the period for which they are to be kept, and (3) with the relative value of the products which they produce.

It is very evident that selection based on inheritance, though usually important in selecting animals for feeding, is less important than when selecting them for breeding. In the former instance, individual performance until they reach the block is the only question at stake, in the latter, succeeding generations are involved.

Lambs or swine purchased for feeding are seldom retained on the farm for a longer period than four months, and steers for a similar use are seldom retained for a longer period than six months, but when young ewes, young sows or young cows are purchased for breeding, the greatly increased relative importance of care in selecting for the latter use is at once apparent, because of the years of prospective usefulness ahead of them. Young horses retain utility for a longer period and, therefore, still more care should be exercised in choosing these.

The difference in the relative value of the product resulting from different classes of animals is readily apparent if the production of the steer is compared with the labor of the horse on the farm or on the road, the latter being vastly greater viewed from the standpoint of intrinsic value and of duration; and the difference in the value of animals of the same class is readily shown by comparing the meat value of the young cow, slaughtered at three years old, with that of her full sister, retained in the dairy for years and capable of producing on an average 6,000 pounds of good milk in a year. Care in selecting the latter is vastly more important than care in selecting the former, and the same is true of the greater care and skill necessary in choosing a horse for speeding than when choosing one for ordinary driving.

Type or form.—The terms type and form are not quite synonymous, but the distinctions between them are not very wide. The latter relates more to individuality in the animals and the former to breeds, sub-breeds or families within sub-breeds. The first has ıeference to that form which is ideal for all the individuals of the breed, sub-breed or family. In this respect it is inexorable. The standard type is the correct type, whatever the performance of the individual may be. But the standard form is, or ought to be, that form which will bring the highest results in performance.

In this respect, type and form are not always in absolute agreement, though they ought to be. The standard type is that set up by the association guarding the interests of the breed, while the standard form is, or ought to be, that form in which individuality usually results in highest performance. There is the further distinction that type is fixed by the breeders' associations, while form is fixed by concurrent opinion based on practical results. For instance, type in all the breeds of cattle differs to the extent of the difference in breed peculiarities, while in form there is general agreement as to the exact individual shapes that are most likely to result in highest performance. The term type, therefore, is more correctly applied to breeds as such, while the term form is more properly applied to correct furnishings regardless of type peculiarities. To illustrate, type in Shorthorns points the horn up or down, form considers only its shape, regardless of the pointings. Type includes color markings; form does not. The first more properly belongs to breeds; the second, to individuals.

Both type and form have a very direct bearing on performance. In this respect they have the strength of law indisputable and decisive. For instance, the correct form of a draught horse is very different from the correct form for the standard bred horse, and the correct form for an ideal beef producing animal is very different from the correct form for an ideal milk producer. The performance of the draught horse on the track and of the beef type of cow in the dairy can never compare with the performance of the standard bred horse in the one instance, or of the dairy bred cow in the other. In this respect a great gulf between them is fixed.

But it is true, nevertheless, that two animals may have exactly the same form and they may be of exactly similar inheritance, and yet the performance from them may vary considerably, hence, type or form is only a general guide when selecting animals for feeding or rearing. This is owing to such influences as those exercised by the condition of the male at the time of generation, or of the female during gestation, to the character of the food fed before and after the birth period, and to habit as the outcome of use or training. But it is the best guide considered alone, when selecting animals for feeding or performance, especially in the absence of a knowledge of facts bearing on inheritance.

The relative importance of inheritance and type or form in selecting animals is a disputed question. In this respect the object sought will have an influence. In selecting animals for breeding and prolonged performance, it would seem as though correct inheritance overshadowed in importance correct form, as the results in breeding from correct form, in the absence of correct inheritence, would probably be very disappointing; whereas, correct form may usually be expected to produce fair results during the short period covered by the finishing process for the block, in the absence of any knowledge of inheritance other than that which form furnishes. Where the two are combined, the guaranty of correct selection is so far strengthened as to be a reasonably safe guide.

Quality.—Quality in domestic animals as now generally understood means capacity for well doing or capacity for good performance in the line or lines for which the animals may be kept. The indications of quality, therefore, are the indications of such capacity, hence, it is very evident that the indications of quality will not be the same in some respects with these classes of animals, since they are kept for different uses, in consequence of which the basis of interpretation is different. So important is the possession of quality in domestic animals, that in its absence marked results are unattainable either in the line of breeding or feeding.

Quality is not easily defined. In the broad sense it would mean the possession of all the essentials requisite to indicate at least average performance and these are many. It would thus include evidences of correct form for the end sought, of function as indicated in the form and of vigorous digestion and assimilation as indicated in the skin and the hair which covers it. In so far as it relates to form, it is judged chiefly by the eye, to function it is determined by both the eye and hand, and to digestion and nutrition chiefly by the hand as indicated by the sense of touch.

It would probably be correct to say that the dominant thought in the mind when the term quality is used has reference to the indications of good digestion and assimilation because of the high relative importance of these. The same animals may be possessed of the indications shown by correct form and function in a marked degree, but these will not avail when the digestion in the animal possessing them is weak or deranged.

The indications of good digestion and assimilation are more difficult to grasp than the indications of correct form and function, since a knowledge of them is obtained so largely through the sense of touch, and the difficulty is further enhanced by the fact that present condition of flesh effects the handling more or less. An animal in good flesh handles more satisfactorily than one in low flesh, since the skin and hair are better nourished through the added vigor given to the circulation of the blood from which came the good flesh. The skin will, in consequence, be more pliant and the hair more abundant and soft. Nevertheless, the difference between the handling of lean animals in the same condition is quite marked, sufficiently so to furnish a correct basis for judgment.

The handling of animals with a view to throw light on their digestive qualities is done chiefly: (1) Through gentle pressure of the finger tips on various parts of the body; (2) light pressure and lateral movement of the inside of the four fingers over the ribs; (3) gently grasping the hide also over the ribs between the thumb and forefingers or within the hand, and (4) passing more or less of locks of hair between the thumb and two forefingers. The greater the degree of electricity in the first instance, of ready vibration in the second, of softness and easy lifting up in the third, and of soft and velvety feeling in the fourth, the stronger relatively are the indications of good digestion and assimilation. These modes of judging of digestive qualities, in the very nature of things, do not apply equally to the different classes of animals because of the different physical conformation and furnishings. They apply most perfectly to cattle.

In *beef cattle* the chief indications of quality are: (1) Certain requisites of form essential to a high order of beef production (see p. 138); (2) good handling qualities, and (3) a quiet disposition.

In *dairy cattle* the chief indications of quality include: (1) Certain requisites of form essential to milk production of a high order (see p. 142); (2) good handling qualities though not so necessarily marked as in beef animals; (3) indications of sufficient nerve power (see p. 146), and (4) good development of the lacteal system (see p. 145).

In *sheep* the more important indications of quality are: (1) Certain requisites of form essential to making good mutton freely (see p. 151), and (2) good handling qualities, including a pinkish color of the skin and lustrous wool, plentiful in supply for the breed and possessed of an abundance of yolk (see p. 152). The handling is ascertained chiefly through the covering of the essential parts, the elasticity of the flesh and readiness of vibration in the skin under general lateral pressure over the ribs.

In *swine* the more important indications of quality include: (1) Certain requisites of form essential to the production of a large quantity of meat of the kind desired on the more valuable parts (see p. 153); (2) good handling qualities, and (3) a quiet disposition. Handling in swine as an indication of quality relates chiefly to the hair, but does not overlook the skin so apparent to the eye (see p. 154).

In *horses* the chief indications of quality include: (1) Those essentials of form which are requisite to enable each type or class to render in a marked degree such performance as it is mainly designed to furnish (see pp. 156 and 159); (2) that degree of cleanliness, soundness and correctness of shape in bone and limb, which indicates present and prospective prolonged usefulness (see pp. 157 and 160); (3) such action as indicates high merit in that line for the type of class (see p. 161), and (4) evidences of that degree of spirit and staying power peculiar to each class, which is the promise and also the accompaniment of high performance.

Any who may desire to follow the subject further are referred to my book, "Animal Breeding," pages 215 to 227, where it is discussed at some length.

Adaptation to environment.—Environment exercises a more potent influence on animals that are retained for breeding than on those that are selected for a temporary period of feeding. But it would not be correct to say that environment exercises no influence in the latter respect, for it does, as may be shown by the adverse influence of disturbing sights and sounds on timid lambs, previously unused to these, during the feeding period; by the disturbing and retarding influence on development of flies and excessive heat on swine that are being fattened; and by the slower fleshing of steers in a feed lot paved with mud and mire while being made ready for the block. But these influences are largely under the control of the owner, and because of the short duration of the feeding period may be so far met as to ward off in part, or wholly, the influence which they would otherwise exert in retarding the development sought, other influences, however, cannot be met without an expense that may greatly cut in upon and even absorb all profits, and in some respects they cannot be met at all. Of the first class are the foods which under the natural and artificial conditions may be furnished. Of the second class are the unalterable conditions that appertain to the contour of certain soils, to the unremovable obstructions to tillage found in them, and to the degree of their exposure, climatic influences also included.

The power of environment to produce modification, sometimes almost imperceptible and again more quickly, is so great as to be in a sense irresistible. It is one of those mighty forces that work in silence. The rapidity of the modification produced is proportionate to the intensity of the changed conditions to which the animals are subjected. Nature unassisted at length brings to that level which the natural conditions of soil and climate can maintain, the animals subjected to such environment, and man can modify the results by the extent to which he resorts to artificial conditions when caring for them.

Natural environment may exercise an influence in the direction of increase or decrease according to its nature. Illustrations of the former are found: (1) in the greater size of Southdown sheep on rich prairie lands, than of the same on their native downs in England; (2) in the wonderful hardihood of Sable island ponies and of certain sheep bred on islands off the coast of Maine and (3) in the great powers of endurance of the average horse bred for generations on the range. Illustrations of the latter are found: (1) In the decreased size of the Lincoln sheep brought to hill pastures; (2) in the decrease of bone, size, stamina and breeding qualities of swine kept for generations in the corn belt of the United States and (3) in the lessened hardihood of West Highland cattle long subjected to artificial conditions.

Selecting animals for breeding without due reference to environment is a mistake that is all too common, and it is a mistake in all instances costly in proportion to the extent to which the conditions of environment have been violated in the choice. The breeder who attempts to rear Shorthorns on pastures only fit to sustain the small Devons undertakes the task of the engine which draws a heavy train up grade. No question is more frequently put with reference to selection than that which asks, "Which is the best breed?" The best breed is that which will give the best returns for the food fed, having due regard for the objects for which it is kept, under the conditions of environment to which it is subjected.

Health indications.—No consideration in selection is more important than the indications that relate to good health whether present or prospective. Under conditions unartificial, animals usually die only from old age when they do not fall a prey to those that are stronger. If decimated by some disease, epidemic in its nature, such disease has been introduced from some outside source, and when it runs its course does not originate again within the breed.

The moment, however, that artificial conditions are introduced, the danger arises that stamina will be lowered, notwithstanding other advantages that may be gained, and that it will be lowered in proportion to the extent to which the animals are subjected to artificial conditions, as strikingly illustrated in the vigor of the wild hog as compared with the pampered hog of the corn belt. Happily, however, artificial conditions so conducive to generous production when of the right kind, are in no way necessarily inconsistent with the maintenance of good health in animals. It is when the conditions are unwise or are carried beyond a prudential limit that they unduly lower stamina, as for instance, when cattle and sheep are too closely housed in winter, or where swine are fed too continuously on corn.

Conditions of good health.—The following are prominent indications of good health in animals: (1) A full, bright eye. The moment that the general health becomes impaired the eye begins to lose its brightness, and as disease progresses, it sinks and becomes languid, the immediate cause being lack of sustenance. (2) A moist, dewy muzzle. With derangement in the circulation and a rising temperature, moistness in the muzzle, which is always abundant in a healthy animal, grows less, the immediate cause being inactivity of the excretory organs. (3) A fairly active play of the ears. Such action is the evidence of generated power seeking opportunity to expend itself. (4) An abundant, smooth and glossy coat. The same instances that produce elasticity in the hide produce glossiness in the coat. But the degree of such smoothness and glossiness is much influenced by the weather. Subjected to exposure, the animal may be in good health and yet have a much rougher coat than one not so exposed. (5) An active carriage. An active carriage bears testimony to healthful action in all the organs of the system, and especially to those concerned in digestion. No sooner do these organs lose vigor than there is a corresponding loss of freeness of movement and activity in the carriage. These indications have been taken substantially from the book "Animal Breeding," by the author. Closely allied to them are the indications of constitutional vigor discussed in the same work (p. 290).

But the germs of some diseases may exist in animals and no indications of the same be manifest to the eye. Such are tuberculosis in cattle, tape and also stomach worms in sheep. In the summer of 1905 the author saw a herd of 32 head of Scotch Shorthorn cows at Rockland, Ont., Canada, every one of which had responded to the tuberculin test. They fed in a pasture on the farm of Hon. W. C. Edwards who was experimenting in a large way as to the outcome of rearing calves from tuberculous dams, but on milk obtained from healthy animals. For some time previously Mr. Edwards had been purchasing representatives of certain Scotch families to be retained for future breeding. In every instance, when brought to the farm they had been subjected to the tuberculin test and those which responded were given a place in the tuberculous herd. In the high character of the breeding, in magnificent individual development and in satisfactory condition as to flesh and apparent thrift at the time, it is more than questionable if this herd, for the number of animals in it, could have been equaled in America, and yet, every now and then, some individual of the herd would pine away and at length succumb to the disease, nor can it be certainly told from the appearance, whether tapeworm or stomach worm is present or not in mature sheep. If indications exist, therefore, which happily they do, that are any guaranty of prospective good health in animals, their importance will be at once apparent.

The indications of prospective good health, or rather, indications that are a guaranty of these, are to be sought in the records of the ancestry in the near generations and in the health of the herd during recent years. For instance, if a cow that has suckled her own calves has produced one or more that has been found tubercular when purchased for breeding, it would be very unwise to invest in any of the progeny reared by the same. If stomach worm or tapeworm has been known to decimate a flock of sheep during recent years, it would be exceedingly unwise to purchase breeding animals from the same unless sufficient evidence has been furnished that the germs have been removed from the flock. Since the seeds of the disease may thus be introduced with animals apparently in perfect health, and which may never succumb to such parasitic diseases or show any indications of injury from them, and yet those same seed germs may prove the source of great harm to the flock in the future, even to the extent of destroying it. When swine are purchased for breeding from herds that are accustomed to run behind cattle in the feed or pasture lot, that are being fed on whole grain, the danger is present that tuberculosis may thus be introduced into the breeding herd, unless it is positively known that no individuals of the breed are affected with tuberculosis.

To purchase such animals for feeding may not incur great hazard with the animals themselves, because of the short duration of the feeding term. But it does always incur hazard to breeding animals on the same farm unless these are at all times kept from coming in contact with the feeding animals or their surroundings. To purchase swine for feeding in proximity to cholera infected areas, is always hazardous, as an outbreak of the same may not only decimate the swine in the feed lot, but in the breeding pens also. The aim should be to rear the animals for the feed lot to the greatest extent practicable on the farms on which they are finished. The barter carried on in live stock in rural communities is responsible more than anything else for the distribution of live stock diseases.

Transmission.—It is not necessary of course to consider transmitting properties when selecting animals for feeding only. In such instances, inheritance may be greatly important, but, since the animals are not to be used in breeding, transmitting properties are of no account. But when the selection pertains to animals to be retained for breeding, then it becomes all important.

Correct transmission is another name for prepotency, and prepotency means the power to transmit individual and breed properties to the progeny. The guarantees of desirable prepotency are: (1) Purity of breeding, for several generations on the side of both sire and dam; (2) high performance in the individuals of the near ancestry on the side of both sire and dam; (3) line breeding, but not carried to the point of weakened stamina; and (4) indications of marked individual stamina or bodily vigor. An animal possessed of all these requisites will assuredly be prepotent. But when selecting animals for breeding, it is not only necessary that they shall be prepotent, but it is all important that they shall be possessed of prepotency adapted to the end sought. Prepotency in transmitting flesh making properties to the dairy cow rather than milk producing properties would make high class dairy performance impossible, and prepotency in transmitting a weak type of stamina would soon result in retrogression, alarming in character. It is all important, therefore, that animals shall be chosen for breeding with the most careful reference to desirable prepotency.

Desirable prepotency, in other words desirable transmission, may be defined as prepotency in consonance with the principal objects sought by the breeder. In breeding horses it will mean transmission relating primarily to labor or speed requisites as the case may be; in breeding beef cattle to desirable form and milk elaboration; in dual cattle to desirable equilibrium in form, milk production and meat production; in sheep, to desirable form for profitable mutton production and wool production of the kind wanted; in swine, to desirable form for making heavy hams and shoulders or a large amount of bacon. Such prepotency relates to the possession of many additional requisites in each instance, but these are stated with more or less of precision in the chapter on type or form (see p. 133).

Bearing on digestion.—It will be evident from what has been said, that transmission has an important bearing on the character of the digestion, and vigorous digestion has an important bearing on the generation of the requisite force or speed wanted in horses, meat or milk elaboration or both in cattle; mutton or wool production in sheep, and fat or leaner meat in pork. It would naturally follow, therefore, that in prepotent animals, all digestion will have, so to speak, a natural bias in the direction of production for which animals of the breed or grade are primarily kept, that is to say, it will be bias in the direction of producing force, speed, flesh, milk, mutton, wool, fat or lean. It is also self evident that this bias will not be markedly interchangeable, that is to say, if acting strongly in one direction, as in meat making, its action will be proportionately lessened in the opposite direction as in milk making. It follows then that highest attainment in milk and also in beef production cannot be secured in one and the same bovine. The same is true of speed and force in the horse, mutton and wool making in the sheep, and fat and lean production in swine. But this fact is in no sense antagonistic with medium attainment in both directions when the animals have been so bred.

In the face of these irrevocable laws, it has been claimed that a cattle beast of dairy or scrub blood will make gains as cheaply and as quickly as a steer of beef blood, some tests conducted at experiment stations seem to favor this view. Other tests, but probably not so many, favor the opposite view. With reference to the former it may be said that they relate to periods of feeding of short duration, and it may be they are accounted for in part by the leaner condition in which dairy and scrub animals usually are when the period of fattening begins, and in part because of the influence of individual vigor on digestion.

This explains why, in the face of the fact, that the compact form, other things being equal, will produce gains most cheaply and quickly, a less compact form will in certain instances, excel in both respects. It also explains why, though constitutional vigor is usually most strikingly associated with good chest development, animals with less of chest development will frequently possess more vigor than the former.

Nevertheless the fact remains, that the unchangeable law of transmission that like begets like, other things being equal, should and doubtless will enable the well bred beef animal to make gains more quickly and cheaply than the well bred dairy, common or scrub animal. If this is not true, then by parity of reasoning it should follow, other things being equal, that this high class beef animal should under certain conditions produce milk as abundantly and cheaply as the high class dairy animal, which is absurd. It would also follow that it would be impossible to fix a bias in the system pronouncedly in the direction of one kind of production as meat or milk, as a reasonably certain factor in transmission.

Bearing on quality.—Transmission also has an important bearing on quality in performance and production, and also on habit. The influence which it exercises on performance is seen in the character of the action possessed by draft and standard bred horses respectively. The influence which it exerts on quality is very clearly shown in what may be termed breed characteristics in the quality of meat, milk and wool. The influence which it exercises on habit is well shown in the difference in the prolificacy of certain breeds of sheep and swine.

While easy and vigorous action is required in kind, of both draft and standard bred horses, the speed of the latter must greatly exceed that of the former, and the same is true of the ability to maintain speed prolonged in duration. On the other hand, the strength of the former must greatly exceed that of the latter.

In beef and dairy breeds of cattle the difference in the depth of the covering of loin and sirloin, and in the weight of the thigh is markedly in favor of the former. The latter also puts on relatively much more internal fat when being finished. In the beef breeds the difference between the covering of fat on the loin and the streaking and flecking of the meat in various parts of the carcass, that is the intermingling of the fat and lean, is marked. The same is true of the mutton breeds of sheep and also of the texture of the meat in these with reference to toughness or tenderness and coarseness or fineness of fiber. In swine the difference in quality is markedly seen in the contrast in the amount of streaking of the fat and lean in the side meat.

Some breeds of dairy cattle produce milk with a high percentage of fat as a breed characteristic in the milk, but only moderate in quantity. Such for instance are the Jersey and Guernsey. They produce a quality in milk which it has taken centuries of careful breeding to reach; other breeds as the Holstein, produce a large flow of milk with a relatively low per cent of butter fat, but the claim that it is richer in casein may possibly be correct. So fixed is the character of the transmission in the instances cited, that years and years of careful breeding and selection would be required to make any important modification, for the reason that modification in quality of production is far more difficult to attain than modification in form.

Contrasts in sheep.—The wide and striking contrasts in the character of the wool in sheep furnish notable instances of the potency of transmission relating to quality in production. In some breeds of sheep not more than 500 wool fibers are produced on one inch square of the body, while on others as many as 1,500 have been produced. In some breeds the normal length of fibre is not more than 2 to 3 inches, in others it is not less than 10 to 12 inches in very good specimens. To transform the one kind of wool into the exact counterpart of the other, more especially when the change is from extremely fine to extremely coarse or the opposite, would take more years than are usually allotted to an average life. Some breeds of sheep, as the Dorset, are very prolific, and the same is true of some of the breeds of bacon swine; other breeds in both classes produce less numerously and less regularly. The breeding habit also influences the season for breeding, as shown in the production of autumn lambs by the Dorsets as a normal feature of production. But modification in breeding habit is much more easily secured than modification in quality of production.

Food exercises more or less of an influence in relation to transmission in the lines mentioned, but it usually acts slowly as a factor in securing permanent modification, especially in relation to quality in production. The most potent influence in securing such modification is the proper selection of the purely bred sires used in breeding.

CHAPTER III

PRINCIPLES THAT GOVERN SELECTING FOODS

In selecting foods for feeding farm animals, for whatsoever purpose they may be kept, certain principles should be observed which have the strength of law. Prominent among these are the following: (1) The aim should be to choose foods so that they may be fed in approximate equilibrium as to their constituents; (2) the equilibrium or balance in foods varies much with the class of animals to which they are fed, with the age of the animals in the same class, and with the object sought from feeding them; (3) under some conditions it may be more profitable to feed foods out of balance than in equilibrium as to their constituents; (4) the chemical analysis of a food is not in itself a complete measure of its value for feeding; (5) when choosing foods a due regard must be had to the proportion of bulk or concentration in the same with reference to the end sought from feeding them in order to obtain the best results; (6) succulent foods are more favorable to milk production than those of similar analysis as to nutrients, but lacking in succulence; (7) variety in foods will produce returns more satisfactory than will those of similar analysis, but lacking in variety when fed for long periods; (8) the value of foods is influenced by the nutrients they contain, by the condition of the nutrients as to digestibility, by the influence which they exert on development and production, and by the fertility which they furnish.

Equilibrium in foods.—Equilibrium in foods means the possession of nutrients in such proportion as are necessary to meet the needs of the animals to which they are fed. The chief food elements in foods are known as protein, carbohydrates, ether extract and ash. They also contain more or less water according to the kind of the food and the stage of maturity at which it is fed. Each of these food elements has a distinct mission to perform in the sustenance of the body. Protein, for instance, is chiefly concerned in producing flesh and the vital fluids of the body, carbohydrates in producing fat and heat and ether extract in producing fat. These foods are fed in equilibrium when the components which they furnish are in exact proportion to the needs of the animals to which they are fed. For instance, the protein in the food is in equilibrium when it is present in sufficient quantity to meet the exact needs of the animals to which it is fed with reference to flesh production. Carbohydrates are in equilibrium when they meet exactly the needs of the animals with reference to heat and fat production. Likewise fat is in equilibrium when it properly fulfils its mission and the same is true of ash when it properly furnishes the elements for the growth and sustenance of bone. These are also in equilibrium when they bear a relation to one another resulting in the most economic use of each.

It is very apparent, therefore, that when these food elements are fed out of balance waste must result. For instance, should protein be fed in excess, the amount fed in excess of the needs of the animal would be wasted. The same would be true of the other food elements, for the system can only appropriate so much; any amount fed beyond this will not be utilized.

The danger is also present that there will be one-sided developments where protein is fed in excess, the muscular development will be in excess of the development of fat and bone in the growing animal. When carbohydrates are fed in excess muscular development will be arrested by an excess of fat production. When ash is fed in excess, bone development will be out of balance. Results the opposite will follow if these nutrients are insufficient in supply. It would be easily possible to feed foods so out of balance as to entirely defeat the objects for which animals are grown. An exclusive corn diet for instance, fed to swine grown and maintained for breeding uses, would in time, reduce size, weaken bone and destroy breeding properties, so highly carbonaceous is it.

Two factors add much to the difficulty found in feeding foods in equilibrium or balance. One of these is the variations in the needs of the animals to which the foods are fed, and the other is the variations in foods at different periods of growth. Take for instance the horse grown for work. When a colt, much protein is needed in the food to make muscle and much ash to make bone. When the animal is grown and set to work, a much larger proportion of carbohydrates are needed to sustain energy and to prevent excessive waste of tissue. These variations must be taken into account by the successful feeder and he must strive to govern his work accordingly.

Variations in the foods are to some extent caused by variations in climate and soil. These are not usually greatly significant in degree. But those variations are greatly significant that relate to the constituents of plants at different stages of development. Take for instance the corn plant. In the early stages of its growth, it is succulent, and not specially rich in carbohydrates. These increase with increasing maturity in the plant. Subsequently to harvesting, the food nutrients are decreased in the fodder by exposure and it loses in palatability. Hence the value of corn as a food plant varies continually at every stage of its growth and utilization.

Some few foods are balanced in themselves. Grass is one of these. This at least is true of some kinds of grass. Because it is so, additional food is not usually given to animals abundantly supplied with grass.

Usually, however, it is absolutely necessary to feed foods in combination, for the reason first, that one is lacking in certain food elements, and second, that another possesses these, hence, feeding the second makes it the complement of the first.

From what has been said, it will be readily apparent that the whole question of feeding animals is one that calls for the exercise of much intelligence. It is a complicated work. So complicated is it that it may be almost impossible in practical feeding to feed foods in exact balance. Usually of course it would be desirable to feed them thus. Notwithstanding, such feeding may not give results absolutely satisfactory as is shown later (see p. 48). The qualifying factors of digestibility, palatability and incidental influence on digestion must be considered. For practical purposes it will suffice to feed foods in approximate equilibrium. It is not difficult to feed them thus. From such feeding there may be some waste, but it will not be serious. Tables giving the chemical composition of feeding stuffs are easily accessible. Some of these give the constituents of digestibility as well, hence the individual who uses the foods which he may feed according to the information thus given, will not fail to feed them in approximate balance.

Changes in equilibrium.—The equilibrium or balance in foods varies much with the class of animals to which they are fed, with the age of the animals in the same class and with the objects sought from feeding them. A ration that is in exact balance to meet the needs of a horse at work, of cows giving milk and of swine that are growing is so radically different that the difference will be at once apparent to any who are at all familiar with the needs of these classes of animals. The first calls for food with concentration and but moderate bulk, the second calls for much bulk and not more than moderate concentration, and the third requires but little bulk and much concentration. It is evident, therefore, that the measure of value in the same food for the different classes of animals is very different. Oats for instance, are more valuable relatively to the horse at work than to the cow in milk, since they are unexcelled in producing energy and in sustaining muscle so much needed by the horse. The cow is not so much in need of sustenance of the kinds named. She wants foods that will produce milk freely at moderate cost. Other foods will do this which usually cost less, but oats are more valuable relatively for cows than for swine, since the large amount of hull renders them less well adapted to the digestion of swine than to that of cows.

The necessity for changing the equilibrium or balance in the foods fed with the age of the animal within the class is equally apparent. It is so whether considered with reference to digestibility, bulk or concentration, or the character of the nutrients. The young calf is sustained for a time solely on food taken in the liquid form and easily digestible. Later meal is given nearly all of which is digestible; as time goes on the young animal becomes gradually more capable of digesting food without harm which contains relatively more crude fiber. With increasing age the calf becomes more capable of digesting more and more bulky foods. In fact these are necessary to its proper development. If they are withheld unduly, the want of distention in the stomach and digestive system generally will be proportionate, and just in proportion to that want of distension will be the lack of capacity to take enough food to result in high performance.

The necessity for such variation is usually recognized. The same cannot always be said with reference to modification in the nutrients given, notwithstanding that the latter is in some respects as essential as the former. The young animal will not develop a frame equal to the average in its class unless it is given enough of ash in the food to accomplish such an end. When matured, ash is needed only to repair waste. So also it must have enough protein to supplement the ash in building the framework and in covering it with the requisite muscle. Where either or both are lacking the development will not be of the highest order. Carbohydrates are needed to furnish the requisite heat and fat which the animal requires. They are needed in less proportion when it is young than when it grows older, for the reason first, that the machinery of digestion runs more rapidly near the birth period and consequently generates more heat in proportion to the amount of food consumed, and second, that during the period of growth much muscle is wanted rather than much fat. It is very evident, therefore, that the ration suited to a mature animal at rest should contain more of carbohydrates relatively and less of protein than would be suited to a young animal

The objects for which animals are fed are equally insistent in their demand for variation in the food given to them. The calf that is being prepared for veal calls for food that is rich in fat, such as whole milk or its equivalents, that grown for being fattened at a later period or for milk production calls for food with but litle fat in it, such as skim milk furnishes. The animal grown for baby beef, must have more of carbohydrates in its food than that grown for being fattened later. Likewise the animal that is giving milk must be given more of protein and less of carbohydrates than would suffice for the same animal while being fattened. Similarly, illustrations could be multiplied of the necessity for variation in the food nutrients in feeding all classes of domestic animals kept on the farm.

Foods not in equilibrium.—In some instances it may be advantageous viewed from the standpoint of profit to feed foods out of balance, that is to feed an excess of carbohydrates in some cases and an excess of protein in others. This may happen when some food factor, rich in one class of nutrients, is relatively cheap and another class, opposite in character, is relatively high.

It has been found profitable, in some instances, to feed corn out of balance rather than to go to the expense of purchasing protein to feed it in balance. When corn is fed thus it will not be possible to secure gains so satisfactory as when it is fed in balance, but it is possible in many instances to secure gain thus, more cheaply than if it resulted from feeding balanced foods under these conditions. When corn was so abundant that it was used as fuel in running steam engines, it was in order to feed such corn out of balance to both cattle and swine up to a certain limit, rather than to purchase the protein needed in order to balance the ration.

It has also been found profitable in some instances to feed protein in excess, as for instance in the western valleys where alfalfa grows abundantly and carbohydrate foods as corn are scarce. The alfalfa thus fed out of balance is in part to some extent wasted, but allowing for this, the product resulting is more cheaply made than it would be through the purchase of corn to balance up the ration.

There are localities in which it is not so easy to grow foods in balance as out of balance, because of natural adaptation. For instance, in western mountain valleys it would be possible to grow alfalfa so as to obtain much more food per acre than could be obtained from corn. Likewise in certain areas of the western states it is easily possible to obtain food nutrients from corn, greatly in excess of those obtained from a similar area in the form of clover or alfalfa or indeed of any other protein food. In these facts and under these conditions, the feeding of foods out of balance finds much justification. Nevertheless it should be the aim where at all possible to grow foods so that they can be fed in balance. It is usually much easier to obtain a sufficiency of carbohydrates than of protein, because of their abundance, but it should be the aim, nevertheless, to grow a sufficiency of protein. The value of protein foods grown in the locality cannot usually be measured by the food which they furnish. They generally add to the fertility of the soil in the process of growth. In fact they always do if of the legume class. The fertility which they bring to the land in some instances, goes far to equal the value of the food nutrients which they furnish. It would probably be correct to say that the adaptation is such in nearly all localities, that a sufficiency of both protein and carbohydrate plants may be grown to make it possible to feed them in balance without the necessity of purchasing from an outside source On the other hand such purchase would not only be justifiable but would also be commendable, when relative values will justify the same.

Nor does it always follow that such unbalanced feeding will be the most profitable in the end though it may be the cheaper in the meantime. Suppose, when growing an animal for breeding purposes, for labor, or for milk giving of a high order, that during the growing period it is fed food in excess that is highly carbonaceous, as corn, the usefulness of the animal for either purpose would be materially lessened. Its size would be less than normal. Its bone would not be of the best and the habit in digestion of using the food materials for building and maintaining the body would be so fixed that the milk giving capacity would be lessened. In such instances it would be better to purchase some protein to help at least to balance the ration, unless the cost of the same was excessive. When, however, the question is one of finishing an animal which is to be sent to the block after a few months of feeding, there need be no hesitancy in feeding foods out of balance even for prolonged periods, where the lacking element or elements are present in such quantity as to prevent any loss further than is entailed in the waste of the food fed in excess, when values justify such a course. It may also be justifiable to feed them out of balance.

Analysis not a complete guide.—When selecting rations for feeding the fact should be borne in mind that the chemical analysis of foods is not a complete guide as to their feeding value. It is not for the reason first, that the analysis does not give the exact degree of the digestibility, second, that it says nothing about the palatability, and third, that it takes no account of the influence which the product exercises on the general digestion.

The analysis gives the various components of any food viewed from the standpoint of the nutrients which it contains, but it does not always tell what proportion of the various nutrients is digestible. Two foods may give the same chemical analysis and yet the feeding value of the one may greatly exceed that of the other, for no other reason than that a much larger proportion of the several nutrients in the one are more digestible than in the other. Of course the digestibility of foods viewed from the standpoint of averages has been worked out by the chemist and the experimenter laboring in conjunction, but the digestibility can only be taken as an approximate guide.

The importance of palatability in foods as a measure of their value is very great. Other things being equal, a food is valuable in proportion as it is palatable, that is, in proportion to the degree of the palatability which it possesses, and in proportion to the percentage of the same consumed as the result of such palatability. The analysis of the chemist can throw no light on either aspect of this question. At one time it was supposed that palatability was important only because of the influence which it exercised on the consumption of food. Now it is known that it exercises more or less influence on digestion. That has been demonstrated by experiment. It aids digestion by increasing the flow of the gastric juices and possibly in other ways. But the most important influence which it exercises is on the increased consumption which results from increased palatability. The influences that affect palatability are variety in plants, maturity, harvesting and preparation for feeding.

A food may be fed possessed of certain nutrients and while it may answer well the purpose for which it is fed, it cannot be said that it exercises any perceptible influence on the other foods fed along with it. Other foods again are fed which invariably exercise such an influence. They do so by the favorable influence which they exert on the digestive organs and digestive processes. They put the system in better tone. For instance, should the fæces indicate constipation, some food can be fed in limited quantity which corrects such a condition. Such a food is found in wheat, bran and oil cake. Other foods may produce undue laxness. The influence may be counteracted by feeding but a limited quantity of some other food. Such a food is found in dry fodder of certain kinds. The analyses of these foods cannot indicate anything as to these influences. It would not be possible to measure the additional influence thus exerted by these foods, but under some conditions it would seem safe to say that this influence is in some instances of greater value than the direct influence exerted through their food nutrients. (See page 276.)

Bulk and concentration in foods.—A due relation must be maintained between the relative bulk and concentration in the foods fed. The laws of physical conformation demand this and the demand is imperative. This relation differs first, with the different classes of animals; second, with the same class at different ages; and third, with the objects for which they are kept. It cannot be ignored by the successful breeder and feeder, because of the relation which it bears first, to relative production; second, to relative cost in relation to production; and third, to the influence which it exercises on continued production.

This relation differs greatly in different classes of animals. They differ greatly in their capacity to consume and digest bulky foods. Chauveau gives the total capacity of the stomach of the horse as 19 quarts, of the ox as 226.9 quarts, of the sheep in its various divisions 31.3 quarts, and of the hog as 8.5 quarts. With horses and swine, however, the intestinal capacity is much larger than with cattle and sheep. Notwithstanding, the superior ability of the latter to consume relatively larger quantities of bulky foods is apparent, both from the relatively larger stomach capacity and from the better mastication which they can give to these while ruminating. The pig, because of the smallness of the stomach, is the least well adapted to consume bulky food. To attempt to rear an animal thus constituted on bulky foods only would be fatal to success.

The difference in the needs of the animals of the same class at different ages is very marked with reference to the bulk and concentration in the foods fed. The stomach of a calf is relatively small. This is particularly true of the first stomach. To feed a young calf bulky food would be fatal to its well being. The stomach has not sufficient distension for such a food, nor have the organs sufficient capacity to digest it. The introduction of bulky foods must be gradual and increasingly progressive. The adaptation to modified digestive capacity gradually secures the distension necessary. By the time a cattle beast becomes grown, it may easily be maintained on bulky foods only. This change in digestive capacity is found in all domestic animals, but not in equal degree, because of the differences in digestive capacity.

The objects for which the animals are kept, influence in a marked degree the relative proportions in the bulk and concentration in the foods fed. It would seem correct to say that necessity for bulk in foods is greatest during the growing period, and that the necessity for concentration increases with production required from the living animal in the form of food and labor, and that it is greatest when the animal is being finished for the block. Under favorable conditions, horses, cattle and sheep may be grown to maturity but not to earliest maturity on bulky foods alone; especially is this true of the two latter. But the best returns in milk and labor cannot be secured without more or less concentration in the foods fed.

The digestive capacity is not sufficiently ample to give the highest returns in milk in the one case and labor in the other, notwithstanding that such foods may be fed in equilibrium as to their constituents. When animals are being finished in finest form for the block, the necessity for concentration in the foods is greatest. As in the case of animals producing milk and labor, they cannot consume enough of the bulky foods to furnish a sufficiency of nutrients to produce the milk required in the one instance and labor in the other. On the necessity for a sufficiency of concentrated food to effect the end sought is based the universal custom of feeding grain in the instances named in addition to the fodders.

That the feeder who ignores the intimate relation between bulk and concentration in foods will pay a proportionate penalty is easily shown. The breeder who grows a heifer on foods too concentrated rears an animal so lacking in stomach distension, that it cannot consume a sufficiency of bulk products. The one who grows a beast on foods too bulky for its tender age, has an animal with so much of paunch that it will have an excess of waste in the carcass for highest use on the block. Swine reared subsequent to the weaning period on pasture will not make sufficient gains. Those fed during the growing period on corn only, will not make sufficient growth. The necessity for equilibrium in bulk and concentration in the foods fed would seem to be about as important as the necessity for equilibrium in the chemical relation of foods, and yet it has been given much less attention than the former by the authorities on animal nutrition. The relative cost of bulky foods and concentrates respectively should be duly considered when feeding animals. Other things being equal, the greatest profit will be made from feeding these in equilibrium. But because of the contrast in values it may be advantageous sometimes to feed them somewhat out of equilibrium. For instance, when corn was low in price, in certain states of the corn belt years ago and clover was not plentiful, or not to be had at all, it was found profitable to feed corn out of equilibrium, both in regard to the needs of the animal viewed from the standpoint of the chemist and also that of the needs of the animal as to bulk requirement. Again, when lambs are being fattened on alfalfa and grain in the western mountain valleys where alfalfa is very cheap relatively and grain is dear, it has been found profitable in some instances to feed grain below the equilibrium of the requirement in concentration and to feed alfalfa above the same.

The influence of equilibrium in feeding bulky and concentrated foods on continued production is very marked. Feed a calf too large a proportion of concentrated food, and its power for all time to give the highest possible return for the food fed is reduced. It may be reduced first from weakened digestion, or, second, from want of development in the digestive tract. Feed a colt too large a proportion of bulky food while in process of development, and its capacity for speed will be lowered because of the excess of paunch development which it must carry. Feed a dairy cow too large a proportion of grain and her digestive powers will be permanently injured, because they have been overtaxed, and the same is true of a steer fed so much grain that he loses appetite. With a due proportion of bulk to concentrates, these results would never follow in the cases named. They never occur but they tend to curtail production, hence the great importance of feeding foods in equilibrium as to bulk and concentration.

Succulence and milk production.—That succulent foods are more favorable to milk production than those of similar analysis as to nutrients but lacking in succulence, could be premised from the season of the year when mammals in a wild state nourish their young. It is also shown in many ways in the experience of feeders, and it has been demonstrated by actual experiment.

Nature has so regulated the influences that are concerned in reproduction, that animals dependent on herbage for sustenance bring forth their young at that season when the same is succulent. The bison of the western plains brings forth her young when the spring time grasses are tender and juicy. They are more abundant in the autumn, but they lack the succulence, hence the young could not be so well sustained at that period. But the richness of the autumn grasses is favorable to breeding, hence the animals mate at that season, which brings the young into existence at a time which is most favorable for providing them with suitable sustenance.

The experience of feeders has abundantly shown the closeness of the relation between succulence and milk production. It has been found that cows in milk, during winter and spring, invariably increase in the milk flow when first turned out on succulent pasture. This result will follow, even though foods possessed of succulence in a considerable degree, as roots, form much of the ration, the other portion being dry fodder and grain. When thus grazed grass usually forms all the ration, and is therefore all succulent. It is also highly nutritious, hence as a result, the milk flow is increased. So invariably does this result follow, that many dairymen plan to have their cows produce calves in the autumn, that the milk flow may be thus increased again when it has begun to decline. If, on the other hand, the period of decline begins in the autumn, at that season when the animals are taken in from the pasture to be put on dry food, it will be almost impossible to prevent it, even though they should be ever so liberally fed on dry food. Various green foods invariably increase the milk flow when they are added to a ration consisting of dry food. This result follows, even though the nutrients in the dry food should be proportionately reduced. The list will probably include all varieties of green products grown upon the farm when fed at a certain stage, and also certain other products when fed mature. The former includes such products as soiling foods of all kinds, the tops of field roots, cabbage leaves and rape; and the latter such crops as corn ensilage, field roots of all kinds, cabbage heads and Kohl-rabi.

Danish experiments conducted with a large number of cows showed that feeding roots materially increased the milk flow, even when concentrates were fed freely, but with heavy grain feeding it was found that one pound of the concentrates was equal to 10 pounds of mangels. With lighter grain feeding the results would probably have been more favorable to the mangels. At the New Jersey experiment station, it was found that silage as compared with corn fodder increased the milk flow by 12.8 per cent. At the Maine experiment station corn silage added to a ration of good hay and concentrates also materially increased the milk yield.

Variety in foods.—That variety in foods will produce returns more satisfactory than can be obtained from foods of similar analysis but lacking in variety when fed for long periods is rendered probable in the following, and it may be in other ways: (1) In the great variety in the products which nature furnishes; (2) by analogy in the dietary of the human family; (3) by the fact that animals tire sooner of some foods than others, and (4) by the experience of practical feeders.

In nature's garden, the open prairie, many varieties of grasses will be found on the same acre and on every acre of the prairie. This provision of nature would seem to have a twofold object in view. The first is to stock the ground with plants, each one of which will draw sustenance from the storehouse in the soil adapted to its needs. The second is to furnish that variety which sustains the appetite in animals, to the extent of leading to increase in consumption which in turn results in increased production. In this way an increase in the consumption of food and resultant products from the same is secured.

The human family tire of foods that furnish no change, even though the foods are adapted in their constituents to the precise needs of the body. So universally is thus true that it needs no demonstration. Analogy, therefore, would make it probable that the same would be true of live stock which feed upon the fruits of the earth. The table which furnishes the greatest variety of suitable food products and properly prepared, is the table that is most frequented in the public house. Likewise, the manger that is best furnished with variety in suitable foods is the one that will best effect the ends sought from feeding. The necessity for variety, however, is much influenced by the character of the food, as is shown later.

That animals tire of some foods much more quickly than they do of others is certainly true. Of the grains, for instance, they tire much more quickly of rye and barley when these are fed as the exclusive grain ration than of oats and corn. Of the by-products, sheep tire more quickly of wheat bran than of wheat screenings and swine tire more quickly of bran than of middlings. Corn and oats may be fed with a relish for a longer period probably than any other grain. Legumes also, as clover, alfalfa and cowpeas may be fed for long periods without the relish for them growing materially less. Animals never lose the relish for good grass with ample succulence, but they do for corn fodder and sorghum, months after these have been harvested.

Every practical feeder of extended experience has found that suitable variety in foods is helpful to him in his work. He has found this true especially in times of feeding the same foods for prolonged periods, even when the animals were not subjected to high pressure feeding. But when fed under pressure the necessity for variety and the advantage from the same is much increased. This is especially true of animals that are being pushed for the block. The appetite gets cloyed and when such indications appear, they may be dispelled for a time at least by substituting another food factor for one of those fed, or by adding it to the ration without increasing the amount fed. Shepherds and herdsmen who grow and fit animals for exhibition resort to such methods from time to time to promote increase.

The reasons why a change in foods thus promotes increase are not all understood. It would seem correct to say that they include the following: (1) The change may meet the needs of the system more perfectly by supplying nutrients that may be lacking in some degree; (2) the change may lead to some chemical action that is beneficial to digestion, and (3) the influence on appetite frequently leads to increased consumption of food. But it should be remembered that all changes are not beneficial.

Value in foods.—That the value of foods is influenced by the nutrients which they contain is so evident that it needs no demonstration. But to take those nutrients as the true measure of their value would be a great mistake as has already been shown. It is a mistake, however, of too frequent occurrence.

That the condition of the nutrients exercises a potent influence on the value of foods is equally clear. Food that is not digestible cannot nourish the system, although in some instances it has a mission in furnishing bulk. The percentage of the nutrients that go to sustain life and maintain production, is that proportion of the same which is digestible. This varies greatly in plants of different varieties and in the same plants at different stages of growth. Only 21 per cent for instance of the protein in rye straw is digestible, whereas 62 per cent of the protein in clover hay is digestible. Relative digestibility, therefore, in the value of foods is worthy of the most careful consideration on the part of feeders.

Suitability for the purpose for which foods are fed cannot be given too much consideration. Some foods may be used with the greatest profit in feeding certain classes of animals, while they are wholly unsuited to other classes of the same. Such, for instance, is cottonseed meal. It is one of the very best concentrates that can be fed to beef or dairy cattle, and one of the worst that can be fed to swine. In fact, with the latter it seems to act like slow poison. Field roots make a grand food for growing cattle and sheep, but in large quantities they would prove too laxative for horses. Oats are unquestionably the best concentrate that can be fed to horses, but they are quite unsuited to the digestion of young swine. Coarse fodders may answer quite well for store cattle somewhat advanced in age, whereas they would be quite unsuitable for calves if fed equally coarse to them. The successful feeder must, therefore, give careful heed to the adaptation of foods for the needs of the animals to which they are fed.

The influence which foods exert on development and production must also be carefully studied by those who are to feed them in the most profitable manner. One food is suited to development during the milk period, but is not so well suited to the same at a later period, if indeed at all suited for such feeding. Flax fed as gruel furnishes such a food. While exactly adapted to the needs of the calf fed on skim milk, it would be out of all proportion costly for mature animals. Oats are admirably adapted to the needs of the young calf, and because of their excellence for such feeding and the relatively small amount required, they may in all instances virtually be thus fed with a profit. For such feeding they are much more suitable than corn. But when animals are more mature and are being made ready for the block, while oats if not too costly may form part of the ration, a much larger proportion of it should be corn. Field roots also are excellently adapted to feeding calves and young stock, because of their excellence in promoting growth of muscle and bone, but they would be too costly to feed in large quantities to cattle that are being fattened, nor would they be so suitable for producing fat as some other foods.

Feed corn only as the concentrate to horses and overmuch fat will be produced at the expense of energy. Feed bran to young pigs before and after weaning, and they will not thrive upon it, but feed the same in large proportion to a brood sow and it will help to nourish her pigs in the milk that it will furnish. Feed all bran as the concentrate to a milch cow and it will greatly stimulate the milk flow, but at the expense of flesh. Feed only corn and the cow will gain flesh at the expense of milk. Feed both bran and corn and the result will be a fair amount of milk with no loss of flesh.

The manurial value of some foods is so great, that in some instances and under some conditions, it approximates more or less the value of the same for feeding. Such are bran, oil cake and cottonseed meal. The relation of these values will depend, first, on the price of the foods; second, on the cost of commercial fertilizers; and third, on the necessity for using them. The lower the cost of the food, the dearer the cost of the commercial fertilizer and the greater the necessity for applying the added fertilizer, the more nearly will the manurial value of the food approximate the feeding value. In feeding concentrated foods and in some instances fodders, especially legumes, this question is sufficiently important to merit the most careful consideration when selecting or providing them.

CHAPTER IV.

PRINCIPLES THAT GOVERN DEVELOPMENT

The principles that govern development in animals include the following: (1) Possible development is usually less rapid as the birth period is receded from; (2) more food is called for to make development with advancing age; (3) periods of stagnation during development lessen capacity for future development; (4) when animals that are being fattened reach that stage of high finish, termed ripeness, further increase is made at a loss; (5) the relation between the character of the development and the foods used in making it is close and intimate; (6) undue energy expended or undue exposure incurred by animals when taking food results in relatively lessened increase in flesh or wool, and in a lessened production of milk; (7) relative production gradually decreases after animals have reached the meridian of vigor; (8) development inferior in character will sometimes occur, howsoever perfect the breeding and management may be and (9) development in what may be termed equilibrium is most conducive to continued well doing in the animals of a stud, herd or flock. Each of these principles has the strength of inexorable law.

Development and decrease.—That possible development is usually less rapid as the birth period is receded from arises, first, from the changing character of the digestion; second, from the changing character of the foods fed, and third, from the gradual increase called for in the food of maintenance from birth to maturity.

The digestive and assimilative processes are most active at birth, and become gradually less so, until finally these become unable longer to sustain life. It is not the amount of food consumed which sustains labor or furnishes tissue to promote growth, but rather the amount digested and more especially the amount assimilated in the processes of digestion. This is clearly evidenced in the fact that during the finishing process two animals will consume practically the same amount of food and yet one will make about twice as much increase as the other.

The foods fed usually change from the more to the less concentrated forms, as with advancing age, the capacity to digest more relative bulk continually increases. These, as a rule, if not indeed always, have more of crude fibre in them, hence the energy required to digest such foods is more than is required to digest the former in proportion to the nutriment obtained. More digestive energy is used for instance in obtaining a given amount of nutriment from timothy hay than in obtaining the same from whole milk, and more energy is used in obtaining the nutriment from ripe timothy hay than in obtaining it from timothy cut at the blossoming stage.

The food of maintenance gradually increases with advancing age. This arises first, from the increased demand on nutrition to sustain the enlarging frame, to maintain animal heat in the larger body surface exposed, and to drive properly the machinery of digestion with the increase in performance put upon it, and to repair the greater waste of tissue relatively because of increase in the fleshy domain where waste occurs. After the meridian of growth has been attained, the decrease in the activity of assimilation and the increase in the waste of tissue call for increasing quantities of food to sustain the animal, hence so much less is left for production.

This law of development is fittingly illustrated in the gains made by calves, lambs and foals at different stages of growth. There is no real difficulty in securing two pounds of gain daily during the first year of the life of a calf, not including the weight at birth. It is more difficult to secure an average daily gain in the same animal of 1¾ pounds the second year, and of 1½ pounds the third year. A lamb well nourished may be made to gain from say, 0.6

to 0.9 pounds per day the first month, exclusive of the birth weight. The second month 0.5 pounds would be a good gain and even during the fattening period at from six to nine months 0.3 pounds of increase is considered an excellent daily gain. Well nourished foals of the draft type may be made to increase 2 to 3 pounds per day during the first month, but with them also relative increase becomes slower as they grow older.

Swine furnish an exception to this rule. During the nursing period, it is scarcely possible to secure a pound of increase in the young pigs daily. Subsequently, when from three to four months old, they may be made to gain 1 pound a day and even more, but after a time with them also possible increase lessens. Just why possible gains in swine are greater subsequent to the weaning period is not absolutely clear. It is possible that it may arise from the inability of the animal to take enough food into its relatively small stomach to make such gains possible.

Development and more food.—That more food is called for to make equal increase as age advances will be readily apparent when it is called to mind first, that the food of maintenance increases relatively as age advances (see page 63), and second, that as stated above, the digestive processes grow less and less active with advancing age.

As has been stated, the food of maintenance increases with advancing age. It is self-evident that a cattle beast at the age of three years will take more food to drive the machinery of digestion than the same at three months. It is also self-evident, that if, as has been previously stated and which is certainly true (see page 62), the digestive processes grow less active and the waste of tissue becomes greater with advancing age, that more food relatively will be required to make increase as the animal grows older. A point will at length be reached in development beyond which increase cannot be made in flesh and weight, and yet a large amount of food must needs be fed daily in order to maintain weight, hence the folly of keeping such animals longer for meat production, after they have reached a maximum development. Even with immature animals, a point may be reached beyond which development may be so slow as to render further feeding unprofitable.

But it does not follow that because more food nutrients are required to make a pound of increase as the birth period is receded from, such increase necessarily entails greater cost while making it. Frequently it does not. The cost of such production is largely determined by the relative cost of the foods used in making it, hence, even though 25 per cent more increase should be obtained the first year in the life of a cattle beast than is obtained the second year, and though less food nutrients should be used in making it, the relative cost of increase the second year may be less relatively than the first year. This will certainly be true if the animal has been fed chiefly on whole milk and concentrated foods the first year, and chiefly on pasture and cheap roughage the second year.

This difference in the relative cost of the foods fed in making meat especially, exerts a far reaching influence on profits. It explains why, under intensive conditions of farming where foods are high priced, cows which only furnish milk for their calves yield little or no profit, while a substantial profit may be thus produced by them when maintained under extensive conditions. It explains why under some conditions, the quickest maturity attainable is not always the most profitable, and it explains why it may be more profitable in the end under some conditions to winter cattle and other animals on a comparatively unnutritious diet, in order to secure subsequent growth on pastures that are very cheap or entirely free.

Development and capacity.—That periods of stagnation in growth during development tend to lessen future possible development has been proved by observation and experience in unnumbered instances. This loss in capacity may arise from a deficiency in the quantity of suitable food fed, from feeding unsuitable food, from excessive feeding of foods that may or may not be suitable and in balance, or from exposure, or from unsuitable feeding combined with undue exposure.

A calf may be fed food that is just right in its proportionate constituents, but if the quantity fed is quite below the needs of the animal, there must, of course, be a corresponding deficiency in growth. A habit of digestion will thus be formed which unfits the stomach and digestive apparatus for digesting large quantities of food to the best possible advantage.

If the foods fed are unsuitable, the loss in capacity for development will be greater, and if they are deficient in quantity, the evil is intensified. Thus it is, that if a young calf is fed for a prolonged period on whole milk, but insufficient in supply, it will be lean and lack growth, but still may retain shapes that are reasonably correct. The relative proportion of bone may be unduly large and the hair may be more than normal in quantity, the outcome probably in both instances of a provision of nature thus to give strength to the ill-covered framework and to provide warmth for it. Should the food be in ill balance, development will be further arrested. Should it be unsuited to the age of the animal, as when young calves are forced to live largely on grass, unbalanced as well as insufficient development follows. There is undue distension of the stomach at too early an age, resulting in an excess of paunch, which the animal retains through life.

Should the animal be correctly fed, but unduly exposed, development will be proportionately arrested. Should it be fed food under such conditions, correct in balance, but deficient in quantity, the loss in development will be correspondingly more. But if in addition, the food is unbalanced and not adapted to the age of the animal, then development is still more arrested, and in conjunction therewith comes ill-balanced development, that is, undue development of some parts in proportion to development in other parts. A striking illustration is furnished by whey fed calves, reared under conditions of undue exposure. Relatively they have an excessive amount of bone and paunch, and hair unduly long and staring. The machinery of digestion has not only been weakened, but it has become unbalanced, and never again can it produce entire correctness of development or a complete sufficiency of the same.

This loss in capacity for correct development is proportionate not only to the intensity of the causes which produce it, but it is intensified by the proportionate nearness to or remoteness from the birth period at which it occurs. Suppose, for instance, development in one case is arrested and distorted while the animal is being fed milk, and suppose in another case that the hindrance to correct development does not occur until the animal is a yearling, the loss in capacity for future development will be much less in the second instance than in the first, for the reason that correct habit in digestion had been duly formed in the second instance, while in the first it had been given incorrect bias during the formative period.

The same thing will happen should the animals be overfed, that is, should they be given an excessive amount of concentrated foods. Development will not only be checked for the time being, but the capacity for future development will also be lessened. This law or principle of development will be operative, not only during the period of development, but even subsequently to the maturing period. But the evils resulting from such over-feeding are more disastrous relatively the nearer that they occur to the birth period.

Some foods cannot be fed to excess, in the sense that feeding them in unlimited quantities will derange digestion. Such, for instance, are grass and good clover hay. Of course it would be possible to require the animal to take so much of these as to interfere with highest possible performance in certain directions. To illustrate: An animal may be required to consume so large a proportion of grass when it is being fitted for exhibition, as to make impossible such increase for the time being as would result from feeding grass and a larger proportion of concentrated grain foods. Similarly, the production of a dairy cow will be less when fed on good clover hay alone, than when fed on clover hay and a certain allowance of suitable concentrated foods, but neither the grass sufficiently advanced in growth nor the clover hay will derange digestion in bovines howsoever liberally fed.

It is not so, however, with concentrated foods. At a comparatively early age, in fact but a few months from the birth period, a calf will partake of rye, barley or corn meal so freely if allowed to, that digestion becomes deranged. A strain is put on its machinery which it cannot bear, and it becomes impaired to the extent of the excess of the ill balance in the food nutrients given. Thus it is, that young animals being fitted for show purposes frequently break down under the heavy tax put upon their digestive capacity, and so have to be laid aside. Many an animal possessed of the requisites that would have enabled it to win champion honors with suitable feeding, has thus been forever unfitted for entering the show ring.

The hazard from feeding concentrated foods to excess with young animals varies with the kind of the concentrate and with the age at which it is fed. The proneness of animals to consume concentrated foods in excess when the opportunity is present would seem to increase with advancing age. Calves quite young are not much liable to partake of such foods greatly in excess of what will benefit them, but it is entirely different a few months later. Of all the concentrated grain foods fed, oats is the safest by far for horses, mules, cattle and sheep, when fed in unmeasured quantities. This is owing to the relatively happy balance between the nutrients and to the suitable bulk relation that exists between the hull and kernel portion of this grain. Other grain foods, such as corn, rye, and barley fed thus freely, puts a tax upon the digestive processes which they are unable to bear, gives the assimilative powers more material than they can adjust to the needs of the animals, and puts an impossible task upon the secretions. The whole system as it were becomes clogged, and in proportion as it does the machinery of digestion suffers beyond the possibility of absolute recovery.

With matured animals the same law or principle is operative, both with regard to increase and production. Feed the grown animal in the feed lot excessively on rich concentrated grain foods, and it gets "off feed." This means that the digestive functions have been overtaxed and must have rest. Nature to provide this causes the appetite to fail. Prompt withholding of the grain portion of the ration may bring about measurable restoration, but the animal will not again bear being thus fed so heavily during the finishing period. Even should recovery be almost complete, the cost of maintenance has been incurred meanwhile, with little or no advance in the weight of the animal.

Once overtax the digestion of a cow in milk, by thus overfeeding her, and similar results follow. Production lessens and in proportion to the overstrain put upon the digestive machinery, so to speak, of the cow, even though there should be no sudden break down in the machinery of digestion, there may be a weakening so gradual as to be imperceptible. This may be so gradual as to cover a period of several years. Its presence may only be discernible in lessened capacity for milk production, notwithstanding the consumption of the same quantities of food as were consumed when the production was greater. Thus it is that by high pressure feeding of concentrates, the capacity of a cow may be so reduced as to materially lessen the profit that would otherwise be obtained from her. It may also materially shorten the period of possible profitable usefulness.

It will be readily apparent that the loss thus recurring from such underfeeding or overfeeding, will be far more serious in breeding than in feeding animals, more particularly during the period of finishing. With animals, therefore, that are being reared or kept for breeding, it is doubly important that these mistakes shall be avoided.

Development and ripeness.—When animals approach the ripening period, the capacity to make gains gradually decreases, and if kept up for a period sufficiently long, will at length cease altogether. Notwithstanding, the consumption of food will be practically the same. The feeder who does not watch this point closely may thus unconsciously allow what would have resulted in substantial profit, had the animals been sold at the opportune time, to be greatly reduced if not indeed turned into positive loss.

Ripeness in meat making may be defined as that completeness of finish which puts animals in the best condition to meet the needs of the market, just as ripeness in the carcass after it is slaughtered means that condition of increase in tenderness of muscle which best meets the taste of the consumer. Fruit is ripe when it has reached the maximum of fitness for the use that is to be made of it. Usually, in meat production, ripeness means the same as completed fattening. This may be attained at almost any stage of development in some types of animals, though not in all, hence it is not necessarily synonymous with completed maturity.

Before maturity it can be most readily attained in animals of compact build and of marked meat-making tendencies through natural inheritance. Cattle of the pronounced dairy types cannot be so effectively ripened at an early age as cattle of the pronounced beef types and the same is true of bacon swine as compared with the small breeds, such as the Essex and Small Yorkshire.

The stage of development at which ripeness may be reached is dependent on the character of the foods fed, the manner of feeding them and the forced character of the feeding. Foods highly carbonaceous hasten such ripening, and those highly nitrogenous prolong and defer the ripening period. Early ripening is accelerated by so preparing foods that the least possible amount of energy is used in masticating and digesting them, as when, for instance, cereals are ground rather than fed whole. It is likewise hastened by feeding so forced, that after a time relative increase lessens materially and finally ceases altogether, it may be at a period considerably in advance of the normal period of maturity for that particular class of animals. But ripeness also applies to animals that are being fattened subsequent to the maturing period, in which case it means that stage of finish in which profitable gains cease.

Three methods may be adopted in determining ripeness: (1) It may be ascertained through the medium of the eye; (2) the hand and (3) the weigh scale. In some instances judgment must be determined by the first medium, as when range cattle are sorted out for shipment to the block. In other instances the eye and hand may both be used, as when animals are fed in the stall. In yet other instances, all three mediums may be resorted to when weigh scales are easily accessible.

The indications of ripeness apparent to the eye include: (1) That plumpness and fulness of form in cattle which covers well the ribs and angular points; (2) fulness underneath the throat in both sexes, and in the purse of steers; (3) lateral movement back and forth over the shoulder and bunching of the flesh at the hind flank when the animal walks; and (4) measured and deliberate rather than quick locomotion. These indications are never all present in the same animal unless it has been brought to a high condition of finish. With sheep the indications would be much the same, but when covered with a fleece only that last mentioned is apparent. With swine the most important indications include fulness, completeness and massiveness of covering over the body, and especially in the lard types sluggish locomotion. With bacon types so much finish would be excessive. The degree of the same can only be obtained from experience.

The indications that come through touch in cattle are found: (1) In the depth and mellowness of the fatty covering over the pin bones, and (2) in the relative firmness of the muscles, under gentle pressure of the finger tips. The pin bones do not become thus covered unless the animal has reached an advanced stage of fattening. The degree of the firmness of flesh in the muscles is influenced by maturity in the animal, being of course greater under equal degrees of finish with advancing age. This firmness is by no means the same as hardness of flesh in the poor feeding animal, and it does not mean that there shall be any want of vibrating power in the skin over the ribs under gentle lateral pressure of the open hand, such as is found in animals that feed slowly. With cattle in the less advanced stages of fattening, the muscles are soft and yield more under gentle pressure than those in the ripe animal. This increasing firmness of muscle is caused by the firming of the fatty tissue within and over the muscles, and it is best ascertained on those parts of the body most deeply covered with muscle. With sheep, these indications are ascertained in much the same way as with cattle, with the difference, that more frequently the handling is confined to the pin bones and the fatty tissue around the tail head. The fleece, when present, interferes somewhat with examination through light pressure over the muscles. Swine are seldom handled in order to judge of ripeness, but firmness of flesh may be ascertained with them also by hand pressure.

There are instances, however, in which firmness of flesh will not be present, even though the animal has practically ceased to make increase in flesh, as when it has been fattened on food possessed of an excessive amount of oil. Such, for instance, is the flesh of swine fattened on beechnuts and peanuts. It is indicated by excessive softness of the muscles. Such a condition of flesh is improved by feeding the animal for a longer period on food less rich in fat. Furthermore, it will be apparent that proficiency in judging of such indications can only be obtained through experience.

The weigh scale properly used is a sure indication of ripeness in animals that are being fattened on suitable foods. If, when weighed occasionally, as for instance every two weeks, at an advanced stage of the fattening process, they show little or no gain, the feeding at the same time being correct, it is so far an indication that they are ripe. Care should be taken, however, to weigh from time to time, under the same conditions, or the weights obtained may mislead.

The loss resulting from continuing to feed animals that are ripe is influenced by the age, and probably to a greater extent by the price of foods. The more mature the animal, the slower will be the gains subsequently to the ripening of the animal. A yearling steer may be ripe enough to meet the conditions of the market, and yet be capable of making considerable increase subsequently, whereas a mature steer thus ripened would make but little increase and under some conditions, none at all. The influence of food prices is so apparent as to need no discussion.

The importance of prompt marketing when the animals are ripe is apparent from sundry tests made by certain of the agricultural experiment stations. During 90 days in feeding swine at the Ontario station in 1891, under the direction of the author, pork was made at a cost of $4.65 per 100 pounds live weight. During the 47 days of subsequent feeding on the same kinds of food, the cost was $14.93 per 100 pounds. During five months' feeding of steers at the Nebraska station in 1905, the average daily gain made was 2 pounds. The following month it fell to 1½ pounds. It may be prudent, nevertheless, to hold over finished animals for a period of relatively short duration when the condition of the market has become unsettled, as from excess in supplies or from some other cause.

Development and food.—The character of the development secured is influenced by inheritance, environment and nutrition. The most potent of these is nutrition, which is another way of saying that the most potent influence in securing development of a certain kind, is the character of the food used in making it: The food consumed influences (1) meat production in regard to quantity and quality; (2) milk production with reference to quantity and quality; (3) the quantity and character of bone; (4) the character and abundance of the coat, and (5) the production of energy. The relation between equilibrium or balance in the development secured and equilibrium in the foods used in making it, is of the closest character, as has already been shown (see page 43).

The bearing of food upon the production of flesh with reference to quantity is so self-evident that it is scarcely necessary to discuss it. Illustrations are readily found in the contrast between the development of the calf that is suckled by its own dam and the calf fed on whey, also in the contrast between the yearling steer wintered only on straw and the same animal the following summer, when grazed upon plentiful pastures. The largest production will be obtained from foods which contain the largest amount of nutriment possessed of the most suitable digestibility and fed with due reference to balance in the food constituents and also bulk requirements or the opposite.

Quality in meat viewed from the standpoint of the table, has reference to fibre or grain, tenderness or toughness, proportion of fat to lean, and the character of the fat and the flavor. All these unless the last, are influenced by inheritance and to some extent by exercise, age and environment, but less so in all or in nearly all these respects than they are influenced by food.

The fibre, composing the muscle or lean portion in meat is sometimes large and coarse, in other instances, it is fine. The former is present to a much greater extent in large than in small breeds. The nature of the food provided, more than any other influence, accounts for the difference in size referred to. The luxuriant and somewhat coarse grasses of Lincolnshire, England, have produced the largest breed of sheep in the world. The fine, short grasses of the Downs in proximity to the English channel, have produced one of the smallest breeds, the Southdown. The fibre or grain of the meat in the Southdown is much finer than in the Lincoln. Similarly coarse fodders will produce coarser fibre than fine fodders. Thus, if a long enough time were given, the Southdown could, in the fibre of its meat, be transformed into a Lincoln and vice versa. Of course, fineness of fibre enhances the quality of meat.

The tenderness or toughness of meat is markedly influenced by age, but it is also greatly influenced by the food and the manner of feeding it. Succulence in food is one of the most potent influences in producing tenderness and also juiciness in meat. Lamb grown and finished on such foods as succulent bluegrass and rape, will furnish meat more tender and juicy than lamb grown on the less succulent grasses of the range. Beef made from feeding corn ensilage or field roots freely to cattle that are being fattened is more tender and juicy than that made from feeding dry food only. Similarly the meat of aged animals is more tender when they have been brought up quickly from a low to a high condition of flesh than when the feeding period is slower and more prolonged, owing probably to the short period given to the newly formed tissue to firm and harden as it otherwise would.

The tenderness of meat is much influenced by the proportion of the fat to the lean, and by the way in which it is distributed. There is a constant relation between leanness and toughness and high condition and tenderness and juiciness. Even the lean of a fat carcass will be more tender than the lean of a lean carcass, and it will be much more juicy. But both tenderness and juiciness in meat are more influenced by the manner in which the fat is distributed than by the amount of it present. In some instances the fat is laid on in great measure externally and internally. In other instances, it is more distributed through the lean, sometimes in the form of layers of fat and lean alternating, and sometimes in the flecking of the lean with little pockets as it were of fat. Inheritance exercises some influence over the manner in which fat is distributed in the carcass, and the same is true of exercise, but it is probably correct to say that neither influence is so potent as food in producing the results desired. Young animals so fed, that they are always in a good condition of thrift and flesh, but without excess of fatness, will have a more perfect distribution of fat and lean than if allowed to lose flesh for a period more or less prolonged and are then fleshed up quickly. The most perfect distribution of fat and lean can, of course, be obtained when the three modifying influences; viz., inheritance, exercise and balanced foods are fed in due quantity. The side of the bacon pig furnishes a good illustration of the deposition of fat and lean in layers, and the loin of an Aberdeen-Angus, an illustration of lean flecked with fat.

That the flavor of meat is influenced more or less by food is shown: (1) In the excellent flavor of mutton grown upon mountains, caused by the variety and to some extent the aromatic character of the plants from which it is produced; (2) in the peculiar flavor of the meat of wild animals and in the difference of the flavors, owing largely to the difference in the foods selected by them, and (3) in the peculiar flavor, in a sense amounting to a taint, of the flesh of the sage hen of the western plains and of domestic animals which have fed much on pastures abounding in penny cress (*Thlaspi arvense.*)

The influence of food on increase in milk production is readily apparent: (1) When a change is made from a diet dry and without succulence as from fodder corn to corn ensilage, from dry winter foods to succulent pastures, or when dry pastures abundant in the quantity of the grass furnished are supplemented by such food as green corn or rape, and (2), by changing from a ration essentially carbonaceous to one nitrogenous in character, or sufficiently so to furnish food approximately in balance, such a change may be made by substituting clover or alfalfa hay for corn stover, or meal composed largely of wheat bran or gluten meal for corn meal.

Quality in milk is also affected by the food, first, with reference to the constituents which it contains, and second, with reference to its flavor. The first influence is so slow in its action as to be virtually imperceptible under normal conditions. To illustrate: Feed, under normal conditions, a Jersey cow whose milk is very rich in butter fat, food that will test practically the same, but it will be reduced in quantity. Reverse the process of feeding and it will still test practically the same, but will increase in quantity up to a certain limit. The quality of milk, therefore, viewed from the standpoint of direct influence of food upon its essential constituents, is not perceptibly influenced thereby. The percentage of butter fat and other constituents will be just the same, except the total quantity of these will be increased or decreased with such increase or decrease in the total milk product from a cow, within a given time, as may be brought about by the character of the food fed.

The quality in milk, viewed from the standpoint of its analysis, is almost entirely a matter of transmission, and it is probably more a breed peculiarity than a matter of individual inheritance and yet the importance of individual inheritance is not to be under-estimated. The Channel island breeds are characterized by the production of milk only moderate in quantity, but rich in butter fat. The Holsteins on the other hand are characterized by the production of a large quantity of milk, and relatively low in butter fat. But these differences in the character of the milk are not due to inheritance and selection alone. They are due also to the action of food producing change so slowly as to be imperceptible, except when measured by decades or even centuries. The short, rich grasses of the Channel islands have certainly exercised an influence on the richness which characterizes cows of that breed, and the more abundant and more succulent foods grown in Holland have also exercised an influence on the abundant milk flow which characterizes Holstein cows and the relatively low amount of butter fat found in the same. Would not the task of producing a Jersey in Holland and likewise a Holstein in Jersey have been difficult?

But food may also influence the constituents of milk even perceptibly for a time under certain conditions. Experience has shown that if a cow has been grown under conditions adverse to good development, and if she has been kept upon inferior food, and low in nutrition for a considerable time, it is possible in such an instance to secure perceptible increase in the percentage of butter fat in the milk. It is brought about probably by renovating the system of the cow, through the more or less prolonged feeding of nutritious and suitable food. Such increase, however, is not marked.

Certain foods affect the flavor of milk adversely, even though eaten in limited quantity. Such are leeks (*Allium tricoccum*), sometimes found in wild pasture, penny cress (*Thlaspi arvense*), found sometimes in those that are tame, and the leaves of certain vegetables, as cabbage, fed in a state of partial decay. Other foods give the milk an undesirable odor only when fed in too large quantities and too near the usual milking period. Such include rape, rutabaga and turnip tops and also rutabagas and turnips, concentrated foods also, as brewers' grains for instance that have reached the borderland of putrefaction, will produce offensive odors in milk.

A normal amount of development of bone in domestic animals can only be secured by feeding them on food sufficiently supplied with ash and protein, particularly the former, since these are nutrients required in building bone. Where these are insufficient in the food, the development of bone will be below what is normal and likewise relative strength in the same.

The relation between strength and cleanness of bone in horses and grasses grown on soils of limestone formation has long been noticed. The same may also be said of the relation between a corn diet and deficiency of bone development both in quantity and strength, in growing and fattening swine, but more particularly during the growing period. It has been noticed that when a brood sow is fed exclusively on a corn diet during the period of gestation, the pigs are deficient in size at birth and have small bones. The corn does not furnish the dam with enough of the elements of bone making material.

It has also been proved by experiment that swine fed on corn alone during the growing period have bone development inadequate in quantity and quality. This of course is adverse to large and robust development, since a small framework of bone and similar muscular development are more or less intimately associated. It has also been observed that swine reared chiefly on corn and fattened on the same go down on their limbs much sooner than those fed on foods which supply an ample amount of bone making material. It has furthermore been observed that sheep largely reared on alfalfa and red clover develop large frames covered by a corresponding amount of muscle.

But increase in bone development beyond what is normal is not produced by feeding foods to an animal possessed of more ash than is necessary for normal development. In other words an animal may be fed bone making materials much in excess of its needs, and yet the production of bone will stop at that point of development which is normal for the breed or at least which is normal for the individual as determined by inheritance. But increase in bone development may be attained beyond what is normal for the breed by feeding food relatively rich in the materials for making bone, aided by selection. In other words the normal standard of the bony framework may in this way be increased to a certain limit.

It is also possible to exercise a far-reaching influence on the amount of bone in swine and other animals, where corn is fed to excess, simply by selection, as may be observed by the marked difference in the amount of bone possessed by herds of swine in the corn belt, and it is reasonable to suppose that the food fed to the dam during pregnancy does exert a material influence in determining the possible development of bone subsequently. When amply supplied with bone making materials in the food, it cannot be otherwise than that the whole bony framework will be larger in the young animals at birth than if there had been a deficiency of these, and that in consequence larger bone development will result at maturity than would be possible had the bony framework been opposite in character. This relation, however, is probably more general than specific, as animals small at birth do sometimes develop into large animals at maturity, but the opposite of this is more commonly true.

Development and waste energy.—Under some conditions of environment and management, acting independently or in conjunction, there is an undue drain upon the energies of the system as: (1) When searching for food; (2) in resisting the influences of exposure, and (3) in making up for the loss caused by disturbing influences from whatsoever source these may come. All such expenditure of energy will result in loss in proportion to the extent to which it exists. In some instances, it is loss of energy for producing labor; in others, it means retarded increase of flesh or actual loss of the same; and in yet others, low or even reduced production in milk yields.

Require a horse that is laboring to gather food from pastures in the one instance that are low in production or from rich pastures in the other but not allowed sufficient time to gather such food, and the capacity to furnish labor will be so far lessened. Require an animal to gather food on insufficient pastures and its development will be proportionately hindered. The same result will follow should the animal be able to secure a sufficient supply of food, but at an expenditure of energy which does not admit of ample time to rest sufficiently. The larger the animal that is subjected to such conditions, the greater will be the relative loss, owing to the correspondingly larger expenditure of energy in carrying the additional weight over the pastures. Beyond certain limits such requirement would result in an actual loss of flesh, even during the growing period. The effect upon milk production would be precisely similar.

To keep animals in comfort, the heat within the body must be maintained up to a certain degree. The food consumed is the source of bodily heat. A certain amount of heat is given off continuously through the pores of the skin. Exposure to temperatures below what is normal for the animal, increases the loss of bodily heat in proportion as it is incurred, and just in that proportion will there be a drain upon the food consumed to furnish such heat. This will mean that just to that extent will its power to produce be diverted. The influence on decreased milk production will be even greater than on flesh production, for the reason first, that the milk producer must also be possessed of a certain amount of flesh which must be maintained before effective milk production can follow; second, that milk producing animals are usually lower in flesh than other animals and, therefore, are so much less effectively equipped for resisting the influences of undue exposure; and third, the entire organization of the milk producer is more refined and, therefore, so far more delicate than that of the male animal and consequently in so far weaker is the resisting power referred to. The effect of such exposure will be similar in kind with reference to labor, though it may be less in degree.

The accompaniments of low temperatures as wind, rain, snow and sleet, are an additional drain on bodily heat when they are present, and under some conditions severely so.

Cold rain draws most severely on the bodily heat of exposed swine, because of the light hair covering and next in degree probably upon that of opened wooled sheep, since the fleece to some extent retains for a time a portion of the water within it. The influence upon cattle is still less, because of the fine character of the hair covering and the thicker hide, and on those breeds with a long covering of hair and also a dense furring underneath, as in the Galloway, it is still less. In horses and mules it is least probably among domestic quadrupeds in the country, owing to the greater natural activity of the horse and mule.

Cold wind acts powerfully in removing bodily heat. Sheep, for instance, may maintain a fine condition of thrift in one instance where protected from cold winds in winter, and in another instance completely fail to do so when much exposed to cold winds, and the same is true of other domestic animals. This difference will occur even though the temperatures judged by the thermometer should be practically the same. The drain on bodily heat from the action of snow and sleet is most readily seen in the quickness with which young lambs and pigs succumb when exposed to it, and in the sudden and large reduction in milk yields of animals so exposed. The influence of the extent of the drain upon bodily heat when these influences act in conjunction, is probably greatest in blizzards, such as occur occasionally on western ranges, when even strong animals so exposed not infrequently perish.

The different classes of animals as such, differ considerably in the degree of their resisting power to the influences of low temperatures, owing more to the differences of the coat than to any other single influence. To temperatures low and without wind, sheep have probably the greatest resisting power and swine the least. Some breeds of cattle as such have greater resisting power than others, as for instance, the West Highland compared with the Jersey or Guernsey. The same is practically true of breeds of sheep, owing to a difference in the density of the wool and to its greater adherence at the outer ends of the wool fibres, because of the abundance of the yolk or soil in the wool in conjunction with external influences such as dust. This more than anything else has given Merino sheep a foremost place in hardihood among the pure breeds of sheep, now found in America.

While natural hardihood in animals is, under some conditions, an exceedingly valuable characteristic, under other conditions it is considerably less valuable relatively. Range conditions, where climate is austere, illustrate the former, and arable farms, where domestic animals may be protected from all undue exposure, the latter. How far natural hardihood is to be sought must be left to the judgment to determine. If the highest possible hardihood were possible of attainment without sacrificing producing power, then it should be sought, but observation and experience have shown that such is not the case. If on the other hand the highest possible production can be secured from breeding animals without inducing undue delicacy, then this should be sought. But, similarly, it has been shown that such is not the case. It may, therefore, be wise to sacrifice something of hardihood for more production and vice versa. The breeder of domestic animals on the farm should guard carefully against seeking production to the extent of impairing constitutional vigor, as when dairy cows are too constantly housed in winter, brood sows are bred too young and too continuously, and males are used in service too young and excessively.

The influence of food on the temperature of the body is marked, hence this fact should not be lost sight of when regulating the temperature of buildings. Foods carbonaceous in character produce more heat than those that are nitrogenous. The amount of flesh carried at the time exerts an influence. The temperature of a stable, therefore, that would be quite suitable for a dairy cow in a somewhat low condition of flesh, because producing heavily would not be the same as for a steer laden with fat. So marked is the difference, that while the latter may lie down in comfort in an open shed, the former would shiver subjected to like conditions.

Development and decadence.—In the life of all animals there is a time when possible production reaches a maximum, after which it gradually decreases. That time is when they have reached the meridian of bodily vigor and capacity to produce, which does not always mean that period when bodily growth ceases, as is shown below. Decadènce more or less gradual at once begins, howsoever perfect the management may be. The moment that such decadence begins, the profitableness of the animal begins to grow less, as production grows less with decrease in the food of maintenance.

The immediate cause of such decadence is the changed and continuous changing character of the nutrition. Waste of tissue is more than the assimilative powers can repair and expended energy is more than the forces that generate energy make good. Later, the teeth begin to fail and when they do, digestion suffers proportionately, first from inability to take enough food, and second from inability to properly masticate what is eaten.

The age at which such decadence begins varies with breeds. Usually the longer the time occupied in maturing, the more deferred is the beginning of decadence. It is also influenced by excessive performance and insufficient nutrition. The over-worked horse, the cow whose digestive machinery has been driven at a high speed through heavy grain feeding and long continued, and the brood sow kept producing twice in the year, will all begin to decline at an earlier age than if the system in each instance had not been thus overtaxed. The meridian of vigor is reached when the animal has reached fullest maturity. This in one sense is reached when further increase in weight ceases, but in another sense it is not until the limit is reached of greatest possible producton. The latter comes later than the former. The farm horse may cease to increase in weight after the fourth year, and the same may be true of the dairy cow, and yet the labor of the former may be and usually is worth more two or three years subsequently, and the same is true of milk production in the latter. With the former, use has hardened the muscles so that they can endure more than when maturity was attained, and habit in work has increased capacity for work. With the latter, habit has increased capacity for milk giving beyond what would have been possible when increase in bodily development ceased.

The period of highest usefulness, therefore, viewed from the standpoint of production, including the results from breeding, covers a period of years beginning with maturity. With working horses this period may be said in a general way to extend from the age of four to ten years. With dairy cows it ranges from about the age of three to eight years. With sheep, it extends from say two to six years of age, and with brood sows from say one to five years. This does not mean that animals should not be retained beyond the ages named, but that the most profitable production is likely to occur between the ages named. It will usually be profitable to keep good producing animals longer than the period of highest production, especially when they are reared on the farm, as an offset to the cost of rearing up to the time when production began. It will pay to keep some animals longer than others, because of their relatively higher producing power.

Much has been written, but not too much, as to the unwisdom of breeding from animals at too early an age. It is quite as important, nevertheless, that they shall not be bred from at too advanced an age, for physical powers considerably advanced in the decadent stage can no more be expected to produce animals of highest excellence than physical powers not yet perfected. While it is proper and commendable to retain for breeding, animals of marked prepotency and high excellence as breeders for a longer period than those of average merit as breeders, a time comes when even they should not be retained for breeding. The common saying that such animals should be retained for breeding as long as they are capable of breeding, is not quite true. Can any instances be cited in which animals that became noted performers were forgotten when decadence from age had become considerably advanced? The bearing of what has been said upon profitable feeding will be at once apparent.

Development and inferiority.—Howsoever excellent the management of a stud, herd or flock may be, and howsoever skillful the breeding, some animals will be born into it with inferior development and also with capacity for development below the average of the breed. In some instances this happens in the case of animals from the same sire and dam which have previously produced specimens of great excellence. This is the outcome of the operation of that second law of breeding known as the law of variation.

All the reasons for such contrasts may never be fully known, but doubtless they are prenatal. They may be influenced by the condition of the sire or dam, or both, at the time of mating, with reference to condition as to flesh, the food which has produced it, and the degree of vigor possessed. They may also be influenced by the food given to the dam during pregnancy as to quantity and quality, by the exercise given or withheld, and by the performance required in furnishing labor or milk. That other influences are operative, however, is apparent from the fact that marked variations occur in the progeny of the same parents when all the conditions are as uniform as the breeder can make them. The assertion is safe, notwithstanding, that the number of the instances in which such inferior production appears is few relatively in approximate proportion as the breeding and management are correct.

The true destiny of such animals is the block and at an early age. If retained or sold for breeding, they are pretty certain to aid in transmitting inferiority. If grown for meat until maturity, the production will be less profitable than from animals of normal or superior excellence. But decision with reference to their disposal should not be reached too soon, as animals of but little promise at birth change quickly for the better in some instances to a remarkable degree.

In no other way can the standard of the herd be brought up to a high level, than by removing from it those inferior specimens when they appear. The breeders of pure-breds hesitate sometimes to send such specimens to the shambles, since they can ordinarily sell them above meat price, because of the pedigree which they possess. To sell them for such a use, however, is simply to take advantage of the ignorance of the purchaser.

Development in equilibrium.—Equilibrium in development may be defined as steady, even and robust growth, from birth to maturity, with a view to accomplish in the highest degree the end for which the animal is reared. At no time is it excessive, and on the other hand at no time is it wanting. To accomplish the first calls for the exercise of sound judgment. To prevent the second demands the most constant watchfulness as well as forethought. Animals thus reared will best fulfill the end for which they have been reared, and will longest remain productive under continued good management.

This does not mean that animals should not be grown for a single and specific purpose, but it does mean that in growing them, the effort to accomplish that purpose shall not be carried so far as to reduce vigor in the animal beyond what is necessary to accomplish that end in the highest degree. It is easily possible to secure form for free and easy action in the running horse so extreme that his staying powers will be reduced. Dairy form in the milk producer may become so extreme that stamina is so reduced that it hinders high performance, and the meat making form in the cow may be pushed to the extent of lowering breeding qualities. These results are the outcome of the law of correllation which makes increase in a marked degree in one direction to be followed by suppression in another. The more extreme the increase, the more marked the depression. The individual who seeks extreme increase in one direction cannot afford to ignore the ever-present influence of this law or his efforts will ultimately end in failure.

The most profitable animal is the one that produces best for the longest period in proportion to the food fed, and that has the power of transmitting like production to the progeny. Such a combination of qualities is never found in the animal that has not been developed in equilibrium. Grow a meat-making animal for showing at an early age and its breeding powers are lowered. Require excessive service in a young male and his possible development is lowered. Feed a meat-making animal a low diet in early life and its meat-making powers are lowered.

Equilibrium in development has a far higher significance in relation to animals grown for breeding and production that will cover a term of years, than when grown simply for the block. With the latter, the feeding term is short, with the former it covers years. No great loss may occur from over-developing a calf at the age of one year, but it would be entirely different if a breeding animal were so over-developed at that age, that its prospective usefulness was permanently lowered.

Equilibrium in development is the highest attainment of the breeder's art. The man in whose herd are a score of really good animals and no culls, stands on a higher plane than the man who has some prize winners and a number of only ordinary animals in the same. The man whose animals are all good performers has accomplished more than the man who has some great performers and some inferior, notwithstanding that the latter may shine before the public while the former may be unknown to the same.

CHAPTER V.

PRINCIPLES THAT GOVERN HABIT IN DIGESTION AND ASSIMILATION.

Digestion means the preparing of foods for being resorbed into the system. Assimilation is the process of resorbing them when thus prepared. The two processes though closely related are distinct and yet both are frequently included in the term digestion. Certain principles govern both processes which have the strength of law. Consequently they cannot be ignored by the stockman without paying a proportionate penalty. In its essence, habit in digestion and assimilation is the outcome of repetition continued long in one direction in a certain line. When the repetition continues through a number of generations, it becomes a habit of the system so fixed that it is transmitted from generation to generation. The relation of habit to these is evidenced: (1) In the fact of its existence; (2) in the influences which flow from it; (3) in the modifications through food, and treatment of which it is susceptible, and (4) in the greater ease or difficulty found in modifying digestive and assimilative habits that have a bias in one or more directions.

Habit, digestion and assimilation.—That habit exercises a powerful influence on digestion and food assimilation is abundantly evident. It is witnessed in the very different results that come from feeding substantially the same foods to animals of the same species and also to animals of different species. Take, for instance, good hay and oats and feed them to beef and dairy cows, to mutton and wool-producing sheep, and to draft and standard-bred horses. Note the difference in the product. The meat-making animals in milk will turn the larger share of the food fed into muscle and fatty tissue, while the dairy breeds will turn the major portion into milk. The mutton breeds of sheep will turn the larger portion of the food into meat, but it is meat much unlike that made by beef cattle from the same feed. The wool breeds of sheep will turn a much larger percentage of the food into wool production and it will differ in many respects from the wool of other breeds of sheep. The same food fed to draft horses will be used largely in making or sustaining strong bone and muscle, and if fed to standard-bred horses in making or sustaining finer bone of high quality, and in generating energy or staying power. Thus it is that results so different, are produced from the same foods in that dark laboratory of the digestive and assimilative organs. The same is true of the lard and bacon types of swine. Both may be fed on the same kinds of food for a time at least, and the character of the pork will be very different indeed.

It is very surprising that materials the same in kind should be thus transformed into products so different. The laboratory in which the transformation takes place is so filled with mystery that the search light of science has not been able to look into it very far. The diverse results from feeding foods essentially the same in kind have a parallel more or less close in the different character of the fruits of the earth, especially those of the same species which grow side by side in the same soil.

But it must not be concluded that the strength of those habits is such that many of them at least may not be greatly modified. Nor would it be correct to conclude that food alone would not be able to make marked change if given time enough. In this way the bacon hog could be transformed into one of the lard type and vice versa through the agency of food alone. But changes thus brought about by natural causes may be hastened or retarded by selection and in other ways.

Influence of habit on digestion.—The influence of habit on the digestion of food, its assimilation and the deposition of its nutrients finds illustration: (1) In the character of the flesh produced by animals of the various breeds devoted to the making of meat; (2) in the quantity and quality of the milk yield; (3) in the degree to which muscle and energy respectively are produced in horses; and (4) in the degree to which flesh and wool respectively are produced in sheep. The difference in the extent to which these characteristics are held in breeds is marked and what is more surprising in individuals of the same breed. The beef breeds of cattle while being fattened intermix fat and lean in a considerable degree. They do not possess this quality in equal degree, nor do the animals of the same breed possess it equal in degree. But they do possess it in sufficient degree to furnish the breeder a reasonably sure guide when determining the breed that he shall grow to furnish meat of a specific character. While all meat-making breeds of cattle have this characteristic, it would seem to be more marked in the Aberdeen-Angus breed than in some other meat-making breeds. Such deposition of fat and lean adds to the juiciness and tenderness of meat. The dairy breeds on the other hand are much prone to deposit the fat internally and otherwise less intermixed than in the beef breeds. Somewhat akin to this in principle but not exactly in kind, is the depositon of fat and lean in the bacon and other portions of the carcass in the lard and bacon types of swine. The differences in the texture of meat are also considerable, more especially when there is much difference in the size of the respective breeds which furnish the meat. The muscle in large breeds is more coarse in texture than in those that are small.

The difference in the quality and quantity of milk produced by the average of the respective breeds is very marked. The Channel island breeds are proverbial for the richness of their milk, the Holland breeds for the quantity produced, and it would seem correct to say that the milking

Shorthorns and Ayrshires are characterized by producing milk in a sort of equilibrium in regard to quantity and quality.

Equally marked is the difference in the degree of muscle produced in the different breeds of horses and in the difference in the degree of energy generated as manifested in a difference in speed and staying power. The only limit to the possible development of muscle on the one hand and the generation of energy on the other is that set by normal inheritance. It would not be correct to say that this limit may not be changed, but it cannot be changed suddenly.

That one breed of sheep should possess wool on an average 10 inches long and that another breed should possess the same but 3 inches long, though similarly fed, is surprising. Nor is it any less surprising that the sheep with the short wool, as for instance the American Merino, should center the energies of digestion on the production of wool, whereas the sheep with the long wool, as, for instance Lincoln, centers its energies rather on the production of mutton.

It is not meant that these various habits are not influenced to some extent or at least some of them and very directly by the character of the food fed. It would be easy to feed freely to a draft horse food, as corn for instance, that would aid him in winning at a fair, whereas, if the same food were fed equally to a standard-bred it would cause him to lose in a speed contest. Likewise, food that is best for beef production is not that which is best for milk producion. Nor is it meant that these habits in digestion may not be so changed in time as to lose their distinctive character, but the fact is emphasized that these changes can only be effected gradually, hence the breeder when commencing his work should give due recognition to the influence which established habit in the animals which he breeds is likely to exert on his work.

Modifications of habit in digestion.—That habit in digestion may be so modified as to produce certain results is sustained by the entire history of evolution in live stock. At one time the Aberdeen poll was not the peerless beef producer that it is today. There are also good reasons for believing that centuries ago the Channel island breeds gave milk less rich than the average of the milk obtained from there now. Such modification finds further illustration in the outcome from the way in which the heifer is grown intended for the dairy, in the modifications made by corn feeding in the bacon types of swine and in the improvement of the milking qualities of the beef types of cattle.

It has been noticed that when the female of a dairy breed has been fed foods from calfhood onward that are rich in elements of fat and muscle production, the tendency in the system to produce flesh and fat is strengthened to a degree that appreciably lessens the value of the same as a producer of dairy products. Because of this, the most successful growers of dairy stock are careful to rear females intended for the dairy on foods that make growth of frame and muscle rather than fatty tissue. It will be observed that this tendency in food appropriation in the system is brought about by the influence of food only.

The same is true of modification in the character of bacon grown almost entirely on corn. In one generation it will so modify the bacon produced that it will not be assigned first place in the market, although it would have been assigned first rank had it been properly grown. Let such feeding be continued for a few generations and the bacon form will be greatly modified. It will bear a much closer resemblance to the form of the lard breeds.

The milk production of any class of beef cattle may also be modified through food fed so as to considerably increase the milk flow. It is a fact the beef breeds are not equal in milk production, though fed similarly, a result owing doubtless in part to inheritance, and in part to nutrients contained in the foods which furnished the major portion of their diet. Modifications in this direction, however, are quite slow unless aided by selection and facilitated by the influence of hand milking.

Habit in digestion also modifies the breeding season. Animals well and suitably fed, breed more freely than those not fed so well. Through the influence of food alone, the breeding season may be greatly modified if not indeed entirely changed. But such modification is greatly influenced by selection as is the case with all modification. The domestic cow as now kept breeds at all seasons. Her sister running wild on the plains breeds only when the spring grasses are suitable and abundant. They then provide ample food to enable her to nourish her young. The relation, therefore, between food and management and modification of habit in digestion is abundantly clear.

Modifications not equally easy.—The modifications in habit in digestion which are possible are by no means equally easy. To illustrate: It does not take long to transform the wool growing sheep into one that produces mutton that may be considered high class. But it takes a long time to make equally pronounced changes in the character of wool, and marked modification in the constituents of milk call for long generations, if not indeed centuries, to make them in a marked degree.

Modifications in meat production may be quickly made. The author purchased ewes from the range very common in character. They were mated with a high-class Southdown ram. The female progeny of the next generation and also of the next were similarly mated. The lambs of the third generation were then exhibited at the International Fat Stock show at Chicago in 1901 and won first honors, both alive and dead, competing against the world. The range females originally purchased were possessed of very indifferent mutton form and they were of diverse blood elements, Merino characteristics being in the ascendant.

Modification in the character of wool is made much more slowly, notwithstanding that considerable modification is possible with each succeeding generation. It would seem correct to say that modification in the length of staple in wool is much more quickly made than modification in the fineness of the same. Beginning with sheep producing coarse wool, it would probably require more than a score of generations of careful breeding and selection to produce wool as fine in fibre as that of high class Merino wool, whereas in less than half a dozen generations the form of distinctively wool bearing sheep can be transformed into high-class mutton form.

That modification in the essential elements of milk is a work that is slow and tedious, is sustained by many experiments conducted to throw light on this question. It is so slow and so tedious that it seems as though centuries would be required to effect marked change through food alone. Of course careful and rigid selections would facilitate the process. Contrary to the almost universally prevailing belief, the food fed does not influence materially the per cent of the fat in milk. A cow which furnishes milk low in the per cent of butter fat will continue to furnish milk essentially of the same character, though fed food ever so rich in carbohydrates and fat. The quantity of the milk furnished will of course be increased, and along with such increase will come increase in the amount of butter fat produced, but only, or at least mainly, because there has been increase in the quantity of the milk produced. To increase the per cent of butter fat in milk would require the most persistent selection through long years of careful breeding.

CHAPTER VI.

PRINCIPLES THAT RELATE TO RESTFULNESS.

When animals are not kept perfectly at rest there is waste in the food fed to them proportioned to the degree of the disturbing influence, from whatsoever source it may arise or of whatsoever character it may be. It is seen in less development in growing animals than would otherwise have resulted, in reduced milk flow in the case of milk giving animals, in diminished increase in animals that are being fattened, and in reduced capacity for labor in animals kept for such a use. This suppression or withholding as it were, or reduction of capacity in performance, means in every instance that more food will be utilized in attaining a given end than would otherwise be necessary, since it adds just so much to the food of maintenance that would otherwise be required. Since domestic animals have not the power to proclaim their wrongs in speech, nature has thus furnished them with this mute way of compelling attention that might not otherwise be given.

Among the many ways in which these disturbing influences manifest themselves are the following: (1) Discomfort arising from inclement weather or from protection that is excessive; (2) unrest, caused by insufficient or excessive feeding or by an unsuitable bed on which to lie; (3) deprivation resulting from irregularity in feeding or working; (4) suffering, caused by insufficient or irregular water supplies; (5) irritation, caused by the presence of insect life in various forms; (6) injury resulting from labor violent, excessive, unduly prolonged, or performed under adverse conditions; (7) harmful results from injury inflicted by vicious animals in the herd or flock, or by those of some other species, and (8) unrest growing out of sexual desire. All of these have the strength of law. No one of them can be present without exacting its proportionate penalty.

Unrest and undue exposure.—The injury resulting from undue exposure has already been discussed with some degree of fulness (see page 97), but not that arising from excessive protection. Protection is excessive when it produces undue delicacy, permanently lowers stamina or lessens production. Delicacy is to some extent a question of degree, and varies much with animals of the same species. An animal becomes unduly delicate when it is no longer able to fulfill the end for which it is kept without excessive care on the part of the owner. A steer is too delicate for range conditions if he cannot endure without hazard the conditions to which all the animals of the herd are subjected. A dairy cow is too delicate when she cannot successfully endure any reasonable exposure required of the average of the herd. Such delicacy may arise from various causes, but more frequently from close housing in stables that are too warm than from any other cause.

Protection that lowers stamina as it were by insensible degrees is excessive, even though it should not reach that point which produces delicacy that is apparent. The cow is overprotected that is kept standing in the stable all winter without the opportunity for exercise, even though the conditions for ventilation should be perfect. The ewe is overprotected when kept even a portion of the time in a shed in which the heat of the body becomes excessive under the fleece which she carries. The colt is overprotected when its environment is such that it is not encouraged to take all the exercise it ought to have in the open air to produce high development in frame, muscle, wind and limb. The loss of stamina from such protection may be so gradual that it can only be certainly measured by comparing one generation with the previous, and yet it may be going on all the while. Overprotection combined with unwise protection is doubtless one of the leading factors in the delicacy that characterizes to some extent the Jerseys and some families of Shorthorns and Aberdeen Polls, in the marked tendency which they have shown to fall an easy prey to tuberculous diseases and also in other ways.

Increased delicacy and lowered stamina will assuredly be followed by lower average production, and the degree of the decrease, other things being equal, will be proportionate to the degree of the increase in delicacy and decrease in stamina. The proviso that other things shall be equal is made because decreased production may arise from various other causes for which increased delicacy and lowered stamina may be in no way responsible. Decrease in production, the outcome of one or both of these causes, is sometimes witnessed in the lack of staying power in the running or trotting horse, of endurance in labor in the draft horse, of milk yields in the dairy cow, of vigor in new born lambs and of decrease in the producing power of some of the lard breeds of swine.

The fact, however, should be carefully noted, that the degree of the protection called for varies with the species. The necessity for this arises from a difference in inherent constitutional endowment, modified by the object or objects for which the animals are maintained. The highest degree of protection is called for by swine, next come dairy cows, then beef cattle, after beef cattle sheep and after sheep horses and mules. In furnishing protection these constitutional variations must be recognized. The degree of protection just right for swine would soon prove fatal to sheep, and that exactly suited to the dairy cow would be destructively enervating to the horse.

Unrest and improper feeding.—When feeding is insufficient or excessive, the unrest that follows is proportionate, and the same is true when the supply of litter is inadequate. Food supplies are insufficient when they do not satisfy the cravings of the appetite, when they satisfy the former but do not afford sufficient nutriment, or when they are sought at a loss of energy that hinders growth or performance. They are excessive when they are taken to the extent of producing digestive derangement or even temporary discomfort.

The sense of deprivation caused by hunger in animals cannot be described by language, but it can be understood in a way by every human being who knows what it is to be hungry. It begets unrest. It is not when the lion's appetite is satisfied that he ranges through the forest, but when he is hungry, even in the stall the animal will not be content under such conditions. There is hindrance, therefore, to growth or performance arising from the unrest growing out of short supplies in addition to the hindrance to these arising from insufficient nutrition.

Food given in excess produces discomfort for the time being and if continued for any considerable length of time will eventually derange digestion. There are some foods which animals will not usually take in excess under normal conditions. Grass is one of these and hay is another. Wheat bran among meals stands almost alone in not producing digestive disturbance under ordinary conditions, though the animal should eat of it to the extent of satisfying the appetite, and oats among cereals comes the nearest to accomplishing the same without injury. Notwithstanding, grass under some conditions will lead to purging, hay in some instances will hinder rather than help labor, as when eaten by horses to excess, and the same is true of bran and even of oats if eaten in excess by the running horse just before a race.

Other foods are only dangerous when eaten under improper conditions, as for instance clover and rape pasture, and yet are always harmful when eaten under such conditions. Nearly all kinds of cereals and the by-products made from them are harmful but by no means equally so when eaten in excess. Prolonged feeding of these in excess is certain to produce derangement of the digestive organs. As soon as this occurs these become unable to fulfill their functions. Nutrition is not taken in sufficient quantities from the food, hence the case becomes one of starving in degree in the presence of waste. If such feeding continues, the consequence will be more harmful, owing to the tax put upon the digestive organs through feeding to it excessive supplies of food.

But should the animal have to labor unduly in getting its food, and notwithstanding, the supply secured is short, the injury resulting will be correspondingly greater. An illustration is furnished by animals on short supplies of food when pasturing. Under these conditions every step taken by the animal in excess of what is necessary to maintain health is taken at a loss to development or performance. The same is true of work horses who are made to expend too much energy in masticating food not properly prepared for them when taking their noonday meal in the short space usually allotted to it.

Discomfort frequently arises from requiring animals to lie down on a bed which does not furnish the requisite conditions of comfort. Any bed harder than earth which is not furnished with bedding is too hard. The same is true of any bed that does not furnish the resting animal with conditions that will maintain the necessary bodily heat. These questions call for consideration from those who use cement or concrete floors, notwithstanding their excellences in various ways. Yards in which steers are compelled to lie down amid numerous clods formed from congealed excrement furnish sleeping conditions adverse to well doing. Damp beds for swine in cold weather will soon produce physical wreckage, and these are even more fatal to sheep. The degree of the loss from discomfort arising from allowing cattle that are being fattened to wade in miry yards has been made the subject of experiment by some of the stations, and as was to be expected, it has proved to be considerable. Under some conditions ample supplies of litter may be difficult to obtain, but because of their absorbing powers they are useful as well as because of the comfort which they bring.

Unrest and irregularity.—Domestic animals come to look for food at a definite time when they are fed with reasonable regularity. Although they cannot of course consult a timepiece, they come to know almost to a minute when the time for feeding arrives. That they are in the expectant mood is shown by cattle in the stalls usually rising to their feet when the hour for feeding draws near, and by those in the field being at the feeding troughs when they are accustomed to get their food. "The ox knoweth his owner and the ass his master's crib." Sheep will frequently proclaim this expectancy by bleating if there is any delay, and swine above all animals will proclaim their sense of neglect by the unanimity which they show in making hideous noises. Delay in feeding in such instances means unrest, a condition which can be well understood by the individual who goes beyond the accustomed hour in taking food.

The same is true of furnishing water. Where water is accessible at all times, of course animals will help themselves when they want it, but when supplied only at intervals they come to look for it at such times. The system craves it because of the habit begotten, and experiences disquietude when it is not supplied on time.

It is equally advantageous to milk cows with unfailing regularity. When the usual hour arrives they expect to be relieved of the milk which they have been making, otherwise its retention interferes more or less with milk elaboration for the next milking. Experience has shown that maximum production in milk cannot be realized from any cow from which the milk is not regularly withdrawn. It has been noticed that even the unhallowed rest which on Sabbath morning sometimes leads to delay in milking the cows of a herd, sensibly decreases the milk flow from two or three milkings immediately following.

It is equally important to work horses with regularity where the circumstances are such as will admit of it. Habit in work is much the same in horses as in men. Ask a man to perform the work that he is accustomed to do between the hours of seven and twelve in the morning at any period of equal duration prior to that hour or subsequently, and he will not perform it with the same ease, though sufficiently supplied with nutriment that may be exactly suitable. Habit has prepared the muscles for working under certain conditions, and at certain times, and any disturbance in those conditions means lessened capacity for work. This is seen no less in the domain of mind than in that of matter. In one instance, a man does his best work intellectually in the early morning hours. In another instance, another will do his best work in the late evening, and this may sometimes happen with members of the same family. Ask either to do the same work at any other hour or hours of the day and the effort would end in failure. The same law governs the effective use of muscles in men that governs the same in horses.

The farmer who is his own feeder, and who makes the time or times of feeding subservient to the demands of other work greatly errs. Other work is with things inanimate, or at least with things that do not feel, and consequently are not conscious of deprivation. The feeding of a herd or flock, therefore, should never be made to give place to the plowing of a field.

Unrest and insect pests.—As is known to all, certain forms of insect and parasitical life prey upon domestic animals to an extent that seriously hinders growth during the period of growth and production at a later period. These may, speaking in a general way, be divided into three classes; viz., those which irritate temporarily by their bite or sting; those which produce prolonged irritation by the intolerable itching which they give rise to, and those which affect a lodgment within the tissues or within certain organs of the body. To the first class belong flies, to the second the mite which produces sheep scab, and to the third the stomach worm.

Each class of domestic animals has its own peculiar insect and parasitical foes. The horse is annoyed by many kinds of flies and also by certain skin diseases which produce unrest, although every form of irritation from the itching of the skin does not arise from the presence of insect life. The condition of the blood may produce much irritation. The Bot fly (*Gasterophilus equi*) is peculiarly the enemy of the horse.

Prominent among the fly enemies of cattle are the House fly (*Musca domestica*), and the Horn fly (*Passalus cornutus*). They are also annoyed by warbles or grubs which are developed in the fleshy tissues immediately underneath the skin. They suffer from the presence of lice which irritate by biting. They are also liable to attack from such skin diseases as ringworm and mange, the latter of which is peculiarly harmful, because of the ease with which it is communicated, the extent to which it annoys and the prolonged treatment oftentimes called for in removing it.

Sheep are peculiarly liable to attack from a species of the Gad fly (*Tabanus ruficornis*), which at a certain time of the year sometimes succeeds in depositing eggs in the nostril, which give rise to the trouble known as "grub in the head." The Sheep tick (*Melophagus ovinus*) and the mite (*Psoroptes equi*), which produces scab, are peculiarly enemies of sheep. The same is also true of certain parasitical troubles, such as Tape worm (*Bothriocephalus latus*), Stomach worm, (*Ascaris lumbricoides*,) and nodule disease.

Swine are much subject to attack from lice, which, unless dislodged, go down from one generation to another. They are also subject to mange, and there is no animal probably which suffers so much from the house fly. This arises in part, at least, from the extent to which they are so frequently fed and housed in proximity to surroundings favorable to the breeding of the flies.

The methods by which those varied forms of insect life are to be combated will not be discussed here. They have been mentioned for the purpose, first, of pointing them out as prominent among the sources of annoyance and harm to domestic animals, emanating from insect and parasitical sources, and second, of emphasizing the fact that their presence is always adverse to well doing in farm animals. The injury resulting ranges all the way from temporary annoyance of short duration to weeks and sometimes months of suffering. In other instances death results. Watchfulness may entirely prevent the presence of many of those sources of irritation and in other instances prompt action may remove them when they appear. But, whenever present, they exact a proportionate penalty which the owner of the stock has to pay.

Unrest and labor.—All labor is harmful when it is carried to the extent of hindering growth before maturity, production before or after maturity, or when it shortens the period for producing. Illustrations are furnished in the grazing of animals on short pastures, overtaxing digestion at any time and in working horses beyond their capacity.

Up to a certain limit, grazing is not labor. It is exercise which tends to invigorate the whole being of the animal. It becomes labor when it disturbs the equilibrium that should exist between exercise and rest. Under some conditions, it may not be possible to maintain such equilibrium, as when animals graze on mountain pastures or on those of the range. But under farm conditions the proper relation between these can usually be controlled by the exercise of sufficient forethought. The amount of exercise thus taken without injuring differs in species and in individuals. Horses and sheep can take more than cattle and swine, and light-bodied animals more than those that are heavy. But in all instances when the amount of time called for in securing food does not allow time enough for rest and recuperation, the penalty is hindered growth or production.

When an animal is given an undue proportion of unnutritious elements in the food fed to it, the labor put upon it is excessive in digesting such food. Suppose it could take enough to supply its needs, energy is thus expended to no purpose, hence flesh-making, milk-giving or return in physical work is so far hindered. Again an animal is being fattened. It is given more concentrated foods than it can properly digest. Energy is unduly drawn upon in the effort of digestion to reduce and assimilate the excess, and again in the effort of the secretions to carry off the waste. There is thus a waste of energy, even though the power to digest should not become impaired. Again, when food is given not in the best condition of preparation for being easily digested, the digestive powers are taxed unnecessarily. Potatoes fed in the raw rather than in the cooked form to swine that are being fattened, furnish an illustration of such feeding. Happily, however, many foods as furnished by nature are in the best condition for easy digestion as nature has furnished them.

The requirements of labor from the horse are excessive, first, when more labor is required of him than his natural physical endowment can endure, that is, when he is worked beyond his strength; second, when more labor is exacted than the food nutrients though digested can sustain; third, when the labor though not excessive in kind is excessive in degree, either through being too violent in character as when a horse is overdriven, or too long continued as when he is worked too many hours. The law of equilibrium between labor and rest demands that sufficient time must be given from day to day to rest as well as to work, and when this is not given the penalty of a lessened return is exacted with unfailing certainty.

Overwork in all these instances reduces the period for profitable production and in proportion to the degree of such overwork. The earlier in the life of the animal that the overwork occurs, of course the more harmful it is, because of the longer period that is affected by it. Animals are also more susceptible to injury from this source while in process of development.

Unrest and vicious animals.—In some instances, the stronger animals of the stud or herd so injure and domineer as it were over those that are weaker, as to hinder development or production, and in some instances both. This tendency is more strongly developed in horses and cattle than in sheep and swine, and probably for the reason that they are more effectively armed with weapons of offence. Sheep are almost entirely free from viciousness, hence they have come to be the emblem of innocence and passive suffering.

In some instances the tendency is inherited, in others it is begotten and strengthened by short supplies of food. In the latter instances horses, cattle and swine will play the dog in the manger over food that may be given, with the difference that they consume the best of the food, whereas, the dog does not consume any. Under such conditions horses sometimes strike and kick viciously, cattle gore mercilessly, and swine will move back and forth wantonly along the trough, punishing every animal as they go and eating all the time with gluttonous haste. Even sheep, when rack room is not abundant, will, through crowding, force the weaker animals to stand back and watch for their opportunity. Unless some remedy is brought to bear, the return from the weaker animals will be seriously lessened.

In some instances the only remedy is removing either the strong or the weak to separate quarters. This remedy is about the only one that can be applied in the case of horses and swine. With cattle, dehorning is effective. The removal of the horns after they have grown a while, say until the animals are one year old, is more potent in its influence on docility than preventing the horns from growing in early calfhood. If the horns are not allowed to grow, the animals learn to strike with the head more or less. If they are allowed to remain long enough to enable the animals to realize their use, and yet not long enough to permit them to do serious harm to their fellow animals by using them, the spirit of viciousness is almost completely broken. Dehorned animals are more completely docile than animals naturally polled.

Animals chased or injured by wild animals, as wolves, or by wanton dogs, sustain injury far beyond that resulting from the actual physical harm at the time. Chase and worry swine by dogs occasionally, and they become restless. They will in time rush away when a dog is called within their hearing, whereas, other swine will give no heed to such calls, indicating that apprehension, which means unrest, is present in their conceptions. Sheep that have been chased by dogs once or oftener, become so apprehensive that in some instances they never produce profitably again. The injury done by dogs to sheep and the apprehension of loss from this source, has probably retarded sheep husbandry more than all other causes combined. The supineness that has been shown in dealing with this question by legislatures is nothing short of a stigma on an intelligent people.

In some instances animals suffer greater injury at the hands of man than from each other. Some attendants are simply brutal in their treatment of animals, and the same is true occasionally of owners. The basis of their treatment rests on passions uncontrolled. Angry words and angry blows are of frequent occurrence. Their unoffending dependents instinctively shun their presence when they can. The unrest thus occasioned results in decreased production. The penalty thus paid is always proportioned to the degree of the unrest occasioned by such treatment, and it is meet that it should be so. It would not seem fitting that such offenders should reach final judgment before they receive the first instalment of the retributive punishment due to their indefensibly harsh treatment.

Unrest and sexual desire.—With breeding animals, unrest is occasioned at certain seasons by sexual desire.

With females such unrest occurs at certain regular intervals. Those intervals are known as seasons when in heat, and they occur with unfailing regularity, when conditions are normal, from the time that females are capable of conception until they reach an age when they are no longer able to conceive. Of course the period of pregnancy and for some time subsequently to parturition are exceptions. It is in a sense surprising, that with domestic quadrupeds the interval between those periods is practically the same, notwithstanding the marked difference in the natural longevity of the different species. They occur at intervals of 21 days, and last for about three days. During those periods the animals are in a condition of unrest, and one of its worst features is that it tends to disturb other animals of the herd. Because of this, where it is practicable, such animals should be confined until the season of heat is passed. During their continuance production in the form of either milk or meat is greatly hindered.

When animals are reared for meat only, unrest from sexual desire is prevented by castration or spaying operations, which may be performed with greater safety when the animals are young than when considerably advanced in age. These operations have a beneficial influence on development with reference to increase in certain parts of the carcass that are more valuable for meat and decrease with reference to parts that are less valuable. This is more especially true of males. The influence thus exerted is far reaching and has an important bearing on the relative price that shall be paid for the finished carcass.

When males are kept mainly or solely for breeding purposes, as a rule they should be kept separate from the females, because of the unrest from sexual desire caused by unrestrained access to the presence of the latter. This unrest is of course greatest when some of the females are in heat, and in such instances it results in needless waste of energy on the part of the male. Even when kept apart but in adjoining fields, the unrest thus occasioned may lead to results that are greatly harmful. In some instances with swine, males have been rendered impotent by such proximity to pastures in which females have grazed in large numbers.

Nor is the plan to be commended of allowing males and females to herd together during seasons when the females are pregnant, or when they do not come in heat. The latter are much liable to be disturbed by the former, and to the extent of more or less of harm resulting to both.

CHAPTER VII.

PRINCIPLES THAT RELATE TO PROLONGED USEFULNESS.

Years ago domestic animals matured much more slowly than they do today. Those intended for labor were not pushed so rapidly nor were they required to work so early as is customary with such animals today. Those intended for the block were given at least 50 per cent more time in which to reach maturity than is accorded to them today. Nor were cows reared for the dairy bred so young as now. The bearing of this upon prolonged usefulness with reference to labor, continuity in profitable breeding and abundant milk giving was very direct and far-reaching. Unquestionably, the relation between the time required for maturity and the continuity of usefulness is very direct and close. There is not the shadow of a doubt in the mind of the author that quick maturity secured under high pressure feeding tends to shorten this period of usefulness in the life of the animal, notwithstanding that the demonstration of this fact may in a sense be an impossibility at the present time, from the absence of the necessary data.

The benefits from prolonged usefulness are many and important. These include the following: (1) The animal must be grown for a time before it begins to give any return, hence, the shorter the period of usefulness in animals, the larger the number that must be grown in order to produce a given result. From want of sufficient data, it may not be possible to show that there is more profit in maturing animals for labor and milk giving, also for breeding with only moderate haste than under high pressure feeding, but in view of the fact, first, that fewer animals are to be reared and maintained to produce a given result; second, that the results from breeding are more satisfactory;

and third, that high selection is more easily possible the fewer the number of animals required, it would seem reasonable to conclude that highest profit would result from not rushing maturity. The additional cost also of securing the larger number of animals prior to the birth period, tends to further strengthen this conclusion; (2) the feeding is not of the high pressure order, and therefore, it is not so costly. Too much must not be made of this fact, however, as it is to some extent offset by increased cost of food of maintenance in the slower maturing animals; (3) the productive return is more certain than from animals young and unproved, hence the risk of introducing animals that are inferior for work as breeders, and also as performers at the pail, is reduced to a minimum. Fewer animals are required to produce a given result, for the reason that they produce for a longer period. The smaller the number of the animals to be chosen, the less the hazard of introducing individuals that are mediocre or low performers. Nor is the fact to be overlooked, that the early years of production are not so valuable as those that come later. The young horse is not at his best for two or three years after he begins to labor and the same is true of milk giving in the cow. The fewer the number of animals, therefore, that are required to produce a given result, the fewer relatively will be the number of those years of performance below what is maximum. It is different, however, with animals that are being grown for the block. The more quickly they are grown without excessive feeding, the more profitably are they grown.

Deferred production and usefulness.—The period of usefulness may be prolonged in various ways. Among these are the following: (1) By not seeking production at too early a period in the life of the animal; (2) by practicing moderation in feeding while the animal is in process of development and subsequently; (3) by intelligently adapting the degree of exercise given to the needs of the animal. Of course, inheritance also has a qualifying influence, but that phase of the question has already been discussed. (See page 37.)

Production is sought at too early a period when the animals are bred too near the birth period, when the milk giving begins at too young an age, or when labor is required at a period too early in the process of development.

The age at which animals should be bred depends somewhat on the class of the animal and also the object for which it is kept. There should be a proper relation between the period of the first breeding and the period of average usefulness in the life of the animal. The longer the time covered by this period, the longer should the first mating be deferred. It is evident, therefore, that deferred breeding would stand in the following order with domestic animals: Standard-bred horses, draft horses, beef cattle, dairy cattle, sheep kept mainly for wool, sheep kept mainly for mutton, swine grown primarily for bacon and swine of the lard types. The longest period of the deferred breeding would apply to standard-bred horses, and would decrease with the other classes in the order named. It would seem at least approximately correct to say that the relation between the time of the first mating and the period of usefulness covered in the life of the animal, would be as one is to six; that is, if the period of usefulness covered by the average animal were 12 years, it may be bred at the age of two years. This would make the minimum age for breeding the various classes of animals named approximately as follows: Swine of the lard types one year, mutton sheep one and one-half years, dairy cows one and three-fourths years, cows of the beef breeds two years, draft mares two and one-half years, and the standard-bred three years. In practice the two classes of sheep and swine named are bred at the same age, in order to have the young produced at the most favorable season of the year for such production, and in order to accomplish this, the time for the first breeding may come a little earlier or later than the age named. Sheep, for instance, are sufficiently matured for being bred at a younger age than 18 months, but for the reason just given are not usually bred until 19 months old.

The objection to immature breeding is found in the undue tax which it puts upon the system. While development is yet uncompleted, the system is taxed by reproduction. When the energies of the system are thus divided at too early an age, the development of the animal is hindered, so that it is less perfect than it would otherwise be. The same is true of the animal produced. It has not been developed in the highest sense while in embryo, and, therefore, begins the race in life at a disadvantage. Stamina is lowered and size lessened in both the animal producing and that produced. The argument is not tenable that animals may be bred as soon as they are capable of breeding. To practice this generally would be followed by decadence, that would result in great deterioration with domestic animals and with the human family as well. Should it be objected that wild animals breed at the earliest age possible, and yet do not deteriorate, the answer is found in the precarious character of the food supplies which insures relatively slow development.

A second objection to immature breeding is found in the fact that no sooner has the animal produced than the drain on the system in order to feed it becomes intensified. The influence of such a drain is best seen in the quick tendency in the sow, and especially the immature sow, to lose flesh while nursing her young. Beyond question, reproduction unduly early, though it may hasten returns at the first, is obtained at the cost of less perfect development and also at that of a curtailed period of production. Should the animal thus required to give milk while yet immature be soon bred again, the evil is intensified. The threefold burden is laid upon the animal of completing maturity, of furnishing milk and of again nourishing the fœtus from a second impregnation.

Should the question be raised as to whether animals should be allowed to mature fully before being bred, theoretically the answer given must be yes, but practically it is no. It has been noticed that there is some danger that the organs of reproduction may become less active if breeding is long deferred, hence the number of non-breeders is increased by such breeding. Food overabundant and lacking in succulence intensifies such a condition. It is also thought, that a habit of the system to nourish the frame, at the expense of lessened capacity for milk production, is thus unduly intensified. It would seem probable, however, that many dairymen have overestimated this danger, and have in consequence been led to breed the young females of the herd at too early an age. Where influences thus antagonistic meet the breeder in his operations, the only wise course is compromise, that is to have animals bred while maturity is yet uncompleted but at a more advanced age than that at which they are now generally bred.

The third objection to immature production applies to labor, such as is now generally performed by the horse and mule. If labor, and especially labor unduly severe, is required of these animals while short of maturity, capacity for labor will undoubtedly be lessened and also the period of effective labor. Notice, it is not labor that is thus criticised, but labor that is unduly severe, which means driving the standard-bred horse too rapidly at too young an age and setting the draft horse and the mule drawing burdens beyond their strength. In both instances, such labor continued until the energies are fagged intensifies the resultant injury. But light labor, even at an early age, should not be in any sense harmful, since it is in line with the natural tendency in the young horse to take abundant exercise. Without doubt the muscular capacity of the draft horse could thus be increased by judicious labor while young, and also the staying capacity of the standard-bred by judicious driving at an early age. It is more important with the horse and mule that the period of production shall be prolonged than with animals whose flesh is used for meat since labor is the only return which these animals furnish.

Moderate feeding and usefulness.—The influence of excessive feeding at any time during the life of the animal is adverse to prolonged usefulness, and the earlier that it occurs, the more harmful is it. The harmful influences are clearly seen in the results from fitting young animals for the fair, in the decline of breeding power in the milch cow fed for any prolonged season under high pressure, and in the curtailed period of production in the same.

The opinion is current among experienced breeders that fitting a herd or flock for the fair is in a manner sacrificing the breeding qualities of the same. The advice is freely tendered to those who are about to lay the foundation of herds or flocks not to invest in prize winning animals. The opinion in the one instance and the advice in the other, is grounded on experience and observation, if not indeed on both. When breeders claim, as sometimes they do, that a certain animal in the herd is too valuable to sacrifice by fitting it for the fair, there is great significance in the statement. It is not to be understood, however, that the breeding powers of all animals are destroyed or even greatly lowered by such fitting, but it is to be understood that such hazard is always or nearly always present, and that it is the result of forced feeding. The larger the proportion of succulent foods fed, the more advanced the age of the animal and the greater the skill of the feeder, the less is the hazard from such fitting, and in fitting dairy animals it is largely eliminated, since the basis of judgment rests largely on the evidences of milk capacity which does not involve the question of capacity to lay on flesh.

That breeding power in milch cows wanes under high pressure feeding of long duration has been shown in numerous instances by the results from such feeding with many of the most famous performers at the pail. The statement cannot be gainsaid that the progeny from them which have been equally famous at the pail have been relatively few. Such feeding apparently disturbs that equilibrium of the system which is equally favorable to milk-giving and to breeding capacity. The energies of the system become so centered on the former, that transmitting power is apparently weakened. It has also been noticed that the duration of the period of such production has been short, seldom covering a period of more than two or three years. It then materially declines, and no amount of skill can again restore the equilibrium. The digestive machinery has been driven at a pressure so high that it has become impaired, and the period of profitable production in the cow has been proportionately curtailed.

Steady, prolonged and high production that does not in any way impair or destroy equilibrium in the system, is to be sought by the breeder rather than phenomenally high production, spasmodic and short lived. The temperate zone is to be preferred to either the frigid or the torrid zone. Likewise the medium high production that does not call for forced feeding to produce it, and that does not impair transmitting power or in any way curtail capacity for prolonged usefulness, is to be preferred to high pressure production, transient in duration. Ten years of milk production in a cow aggregating 60,000 pounds of milk, the outcome of moderately high feeding, and a numerous progeny of good performers is much more profitable than six years of milk production aggregating the same, the outcome of immoderate feeding, and a progeny not numerous nor capable.

Exercise and usefulness.—The bearing of exercise on prolonged usefulness is both direct and far reaching. It qualifies with a certainty that is unerring the degree of the present good health that the animal shall possess, the extent to which it shall possess stamina, the powers of reproduction and also the various functions concerned in production, whether in the form of milk or labor. The degree of exercise called for, however, differs with animals of the different species. Horses require the most and swine will do with the least among domestic animals. Sheep must be given more exercise than would be suitable for cattle. Young animals also call for more than aged. Such exercise is a necessary accompaniment of muscle development, and in the firming of muscles during the growing period. That nature has made provision for it is witnessed in the gambols of young animals which grow less and less with decrease in the necessity for them, as age advances. The adverse influence of want of exercise is readily seen in the case of swine, even when confined in close pens and especially when fed a carbonaceous diet. Soon they become unable to use the limbs and general disaster follows if such treatment is continued. So is it with all animals. It is only a question of time when deprived of exercise as to when the inevitable premature breakdown shall come. The influence of want of exercise on stamina is probably most readily seen in the horse. Deprive the colt of exercise and the muscles are so soft as to become incapable of enduring properly taxing labor at a later period. There will also be a deficiency in lung expansion and hence a deficiency in staying power.

Nowhere is the baneful influence of insufficient exercise more apparent than in the extent to which it impairs the powers of reproduction. That probably more than any single influence is responsible for barrenness in domestic animals. The adverse influence which it exercises on the character of the production in breeding is even more marked, as is witnessed in the enfeebled condition in which young animals so frequently come into life. Exercise may even be withheld to the extent of rendering the animal unable to bring forth when the birth period is reached.

The adverse influence of insufficient exercise on production has already been touched upon when speaking of its influence on muscle development and staying power in the colt. The dairy cow in milk will probably do with less of it than any other animal on the farm. But, unquestionably in time, the want of exercise will tell adversely on production in the dairy cow, if in no other way than through the enfeebling influence which such want of exercise would exert on her entire system. The limit of the restriction that may be put upon the exercise given to a dairy cow has not yet been fully determined, and probably it never can be to the extent of formulating any rule that will prove generally applicable since it is a factor that will be influenced by conditions which relate to breed and general management. That the results referred to above will tend to curtail the period of possible usefulness in an animal is so patent that it does not need demonstration.

Of course the period of usefulness may be curtailed by over exercise, but such exercise will seldom be taken voluntarily. If taken it is under the constraint of labor that compels, as in the case of the horse, or under the necessity for exercise in searching for food, as in the case of animals kept much of the time on pastures quite inadequate to their needs.

Extent of prolonged usefulness.—There is, of course, a limit to the period covered by the profitable production of all animals. That period differs in the classes of domestic animals and in the breeds of the same. Since it is influenced by feeding, management and inheritance, it is evident that the duration of this period is in a sense flexible. It may be prolonged or shortened. The tendency during recent years has been to shorten it through shortening the period of maturity. It would seem to be easily possible to carry change in this direction too far, especially for the best interests of breeding, of milk production and of labor. With meat-making animals it is different. The end for which they are grown is the block and the age at which they will bring greatest profit for this purpose, all things considered, is the age when life should terminate with them.

It is entirely different, however, with breeding animals. The successive acts of breeding involve repetition, and the greater the number of the instances of successful repetition in breeding proper in character, the greater will be the degree of the profit from keeping such animals for breeding. The same is true of milk giving. There is succession in its periods, and the longer the succession of those periods, that is, the greater their number without much diminution in the maximum of milk furnished by each, the greater will be the return. With reference to labor there is also succession, and more constant in character than is possible from either breeding or milk production. It is in some instances daily repetition from year to year. Its daily occurrence without the necessity for periods of temporary cessation other than those necessary for rest from day to day, make its prolongation still more important. The importance of such prolongation is further emphasized by the fact that usually animals used for labor, that is horses and mules, are not used for meat after the labor term is ended.

From what has been said, it will be very evident the age limit of usefulness cannot be definitely fixed. With animals grown primarily for meat, the shorter the life period which duly considers the cost up to the time of birth, and which does not involve too costly feeding, the better. With animals maintained primarily for breeding and in a secondary sense for meat production at the close of the breeding period, the aim should be to prolong the period of such breeding. The limit of such prolongation would be the limit of capacity for breeding without any diminution in the individual prospective excellence in the progeny, and without too much reducing the value of the carcass when finally disposed of. With animals kept primarily for milk production and in a still more secondary sense for meat making, at the end of the milk-giving period, it is still more important that the period of usefulness shall be prolonged, since animals may be profitable for milk giving for a longer period than it would be profitable to retain progeny which they may bear for breeding uses.

In other words, animals may be profitable for milking when so far past the meridian of vigor that they may not be able to produce animals possessed of the highest essentials for successful breeding. The limit of the period of usefulness with these would seem to be the limit of markedly profitable milk production. The resultant meat production from them is of so little account that it is scarcely worthy of serious consideration as a factor in influencing duration in the milking period. It is quite different, however, with dual types of cows. With them the carcass is a factor of no little importance, hence its value should be considered. The limit of the duration of milk giving in the dual cow would probably be the same as the limit of the duration of her capacity for successful breeding. But most of all is it important that the period for useful labor shall be prolonged in horses and mules, for reasons already given. The limit of the duration of such usefulness is not easily fixed. It ought to cease when the relative cost of maintenance and of driving become too great relatively for the resultant profit. Then it is that such animals should be sent to the shades of non-existence by some form of easy death. To sell them to those who are liable to abuse them subsequently would be in a sense criminal.

CHAPTER VIII.

PRINCIPLES THAT RELATE TO PREGNANCY

The discussion of this question will consider only such phases of pregnancy as will show the relation between food and exercise and development during the period of pregnancy and the nursing period that immediately follows it. The whole question in the wider sense is discussed by the author in the book, "Animal Breeding," Chapters IX to XVI.

Among the principles that relate to food and exercise in their relation to pregnancy and that have the strength of law, are the following: (1) The time of mating is much influenced by the food fed; (2) the degree of the impregnation is influenced by bodily condition at the time of mating; (3) the relation between the food fed and the character of the development *in utero* is intimate and close; (4) sufficient exercise for pregnant animals is absolutely essential to successful breeding; (5) a reasonably high condition of flesh during pregnancy is in no way antagonistic to successful breeding; (6) dams in good flesh at the time of parturition can nourish their young better than those in low flesh.

Pregnancy and time of mating.—The chief influences that determine the breeding season are food, habit and inheritance. The first of these only will be discussed here. Food affects the time of mating through the influence which it exercises on the system as a whole, and more particularly on the organs concerned in generation. It would seem correct to say that whatever aids digestion will also prove an aid to prompt and regular breeding. The breeding impulse is influenced by the character of the food fed as to its constituents, the degree of its succulence and the nutrition which it contains.

Some foods are less favorable than others to reproduction, because they are ill-balanced. An exclusive corn diet is too highly carbonaceous. A diet consisting entirely of sorghum is even more harmful. Other foods are in sufficient balance, but their condition is too dry. Such is grass of certain kinds, matured and dead. Others again are too watery. Grass young and watery may have reasonable balance in its constituents, and yet be too watery, as when it induces a condition of the bowels so lax as to be unfavorable to development for the time being. Foods in reasonable balance as to their constituents, possessed of ample nutrients in proportion to their bulk and withal succulent, but not watery, are the most favorable to breeding. Thus it is that cows wintered on a low and dry diet come in heat after having fed for a long enough season on grasses succulent and nutritious. It also explains why ewes act similarly which have reared lambs after they have grazed for a short season on well-grown rape. This explains also why wild animals that breed once a year, breed only at a particular season

Any food that is possessed of the desirable nutrients and that has a reasonable amount of succulence when fed with sufficient liberality to improve the condition of the animal will have the effect of hastening the breeding impulse. This arises from the fact that food that tends to build up the system stimulates activity in all the functions of the same, including the organs of reproduction. The knowledge of this fact has been turned to practical account by the stockman. It has enabled him to hasten the mating season with ewes after their lambs have been weaned, and likewise the breeding of sows from which two litters are sought each year. It enables the stockman also to modify the season for breeding. This has proved of great practical service in connection with the breeding of cows.

Pregnancy and impregnation.—The character of the food fed not only influences the season for mating, but it also influences what may be termed the degree of the impregnation. This means that the character of the development *in utero* is influenced more or less by the physical condition of the parents at the time of mating. It means also that with animals which produce more than one at a birth, the relative number of the progeny will be influenced by the same condition.

That the first influence referred to is operative has been determined by observation. Similarly it has been ascertained that this influence extends to the male, howsoever the female impregnated may be fed subsequently. It is fair to infer, therefore, that the same is true of the influence of the female at the time of mating.

But it would seem reasonable to suppose that the sum of the influence exerted by the female prior to the birth period, would be greater than that from the male, not in determining form and other inherited qualities, but in influencing the size of the young animal or animals when born, the relative degree of bone and muscle possessed, and also the vigor of the young animal at that time since these are of necessity influenced by the food fed to the dam while the fœtus is in process of development.

That the condition of both parents at the time of mating does influence the numbers of the progeny where more than one is very commonly produced at a birth has also been ascertained by observation. If either parent is reduced in physical vigor, whether from want of sufficient nourishment or from excess of the same, the influence is adverse to relatively numerous progeny. The influence of a diet lacking in succulence acts in the same direction, though sufficiently nourishing. These, of course, are not the only influences that affect prolificacy, but they are among the most potent, though not so potent as inheritance.

The influence thus exerted has been turned to good account, more especially by flockmasters as those of Great Britain. As the breeding season approaches they exercise special care in the feeding of the ram. The aim is to give him food sufficiently nourishing and succulent to keep him in a vigorous and "sappy" condition. Likewise the ewes are put upon fresh and nourishing pastures two or three weeks or more before the breeding season. Usually the pastures are supplemented with a small allowance of grain. In some instances the pastures are sufficiently nourishing without grain, as for instance when they consist of rape well advanced in growth. Similarly by feeding brood sows nourishing food subsequently to the weaning period, and for a longer or shorter period before weaning, it has been noticed that the numbers in the litters are increased. The duration of the building-up period, so to speak, is dependent on the degree of the flesh carried.

Pregnancy and food.—That the relation between the food fed and the character of the development *in utero* is both intimate and close is witnessed in the varied results from feeding different foods to pregnant dams of the same species. When the carbohydrates are in excess in the food, the development of muscle is so far less than it would otherwise be. When the protein is in excess, the muscular tissue will be in excess at the time of birth, hence the progeny though large when born are much liable to be flabby and weak. When the ash is deficient, the relative proportion of bone will be too little and the quality of the same will be lacking.

Feed corn for instance as the exclusive diet to a pregnant sow and the young when born will be less in size, and possessed of less bone than is normal. Corn is not a balanced food. It is rich in carbohydrates and deficient in ash. Feed clover hay to pregnant ewes and along with it large quantities of rutabagas, and the lambs will be large at birth but flabby and weak. In such food there is an excess of protein.

The importance of feeding foods in balance and suitable in kind to pregnant animals is too frequently underrated. When it is not thus fed, the young are at a disadvantage at the very outset, from the lack of equilibrium in development. Such disadvantage can never be entirely overcome.

The danger is also present that malformations will be more numerous when ill-balanced food is fed, and that

TYPICAL CHESTER WHITE SOW

the proportion of still-born will be increased, and that troubles will multiply at the time of parturition, and also that the newly born animals will call for more careful attention than would otherwise be necessary.

Pregnancy and exercise.—That ample exercise for pregnant animals is essential to the well being of the progeny has been abundantly proved in the realm of experience. The relation between the amount of exercise taken by the dam when not excessive, and vigor in the progeny when born, other things being equal, is constant. This accounts for the much greater vigor of the lambs of the Cheviot and Black-faced Highland breeds of sheep dropped on their native pastures, as compared with those of some of the large breeds when kept in small paddocks during the larger portion of the period of pregnancy. The former are not easily caught when but a few hours old, the latter frequently call for special attention to get them on their feet.

The amount of exercise required by the different classes of domestic animals when pregnant varies. The mare calls for even more than the ewe, and the ewe needs more than the cow and the brood sow. The cow will bring forth her young with reasonable safety under conditions of confinement that would prove fatal to the progeny of the breeding mare. Likewise the sow will produce with reasonable success under conditions of confinement that would prove fatal to the progeny of the ewe. The importance of this question is such as to encourage the efforts of stock growers to increase the exercise taken by pregnant dams under confined conditions in winter. This may be done by enforcing labor in the case of mares and by compelling other dams to take some exercise by changing the conditions of feeding.

Milch cows will breed with reasonable success under conditions of close confinement in winter providing they have access to the pastures in summer. The confinement may be as close as restriction to the stall and its stanchion or tie chain. Notwithstanding, the stamina of the progeny at birth is less than that of calves from cows which have some daily yard exercise, and the stamina of calves from the latter at birth is less than that of calves born on pastures months subsequently to the commencement of the grazing season.

Pregnancy and good flesh.—That a reasonably high condition of flesh rightly put on previous to or during pregnancy is in no way detrimental to successful breeding, but rather the opposite, is capable of easy demonstration. It is sustained by theoretical principles, the soundness of which cannot be shaken, and by the results of practical experience, notwithstanding that the opposite view is still held by some breeders.

The dam of course must nourish the fœtus from the time of impregnation. The nourishment comes through the circulatory system. The circulation is sustained from the food digested. It stands to reason that as soon as conception has taken place, a part of the nutriment from the food eaten is diverted from the dam, who would otherwise profit by it, to the fœtus which she carries. If she is in a condition of reasonably high flesh at the time of conception, she will not suffer by such diversion, but if in low flesh at such a time then the opportunity to build up the system and thus to fortify it against the drain which the milk-giving period entails is so far taken away. It is true of course, that a dam in low condition at the time of conception may be so built up as to be in good flesh at the time of parturition.

Of course, it is easily possible to have the dam in so high a condition of flesh at the time of mating as to be unfavorable to conception. It would also be possible to sustain her in a condition of flesh so high as to be unfavorable to the development of the fœtus. Such difficulty is met with in the management of females shown at fairs which are grown chiefly for producing meat. The progeny of such females are in many instances less than average in size at birth. It should be remembered, however, that for one animal too high in flesh at the time of conception and during pregnancy for the best results, there are many animals too low in flesh for the same.

When pregnant animals carry flesh, to the extent of proving adverse to successful breeding, it will usually be found that the adverse results are owing more to the unsuitable character of the food which made the flesh than to the high condition of flesh. The influence of high flesh made by feeding carbonaceous foods, such as corn and fodders lacking in succulence though rich in nutrients, is very different from that exerted by the same resulting from feeding foods in balance and withal succulent. The same is true of course of the influence exerted by foods on development *in utero*. If a dam in low flesh at conception is brought into high flesh before the time of parturition by feeding foods highly carbonaceous, such foods will be adverse to development in the fœtus. The same condition of flesh can be attained by feeding succulent foods in balance without injury to the fœtus, but a longer time is required to produce such a result.

The extent to which nutriment in the food will be diverted from the dam to the fœtus is not governed alone by the character of the food. Two dams of the same breed may be fed the same kind of food when pregnant and one will nourish the fœtus much better than the other, though all the conditions are the same. One female with suitable food will increase in flesh but at the expense of the progeny, as evidenced in small size at birth. Another female under like conditions will not increase in flesh, but will produce a robust progeny of large size at birth. The reasons for such variations are not well understood, but it is probable that habit in digestion, the result of inheritance and also the character of the feeding previous to the first conception, exert an important influence.

Pregnancy and nursing.—That dams in good flesh at the time of parturition can nourish their young better than if in low flesh is proved by observation and by general experience. So constantly do such results follow that they cannot be gainsaid, even by those who are opposed to the idea of much flesh in the dam when her young are born.

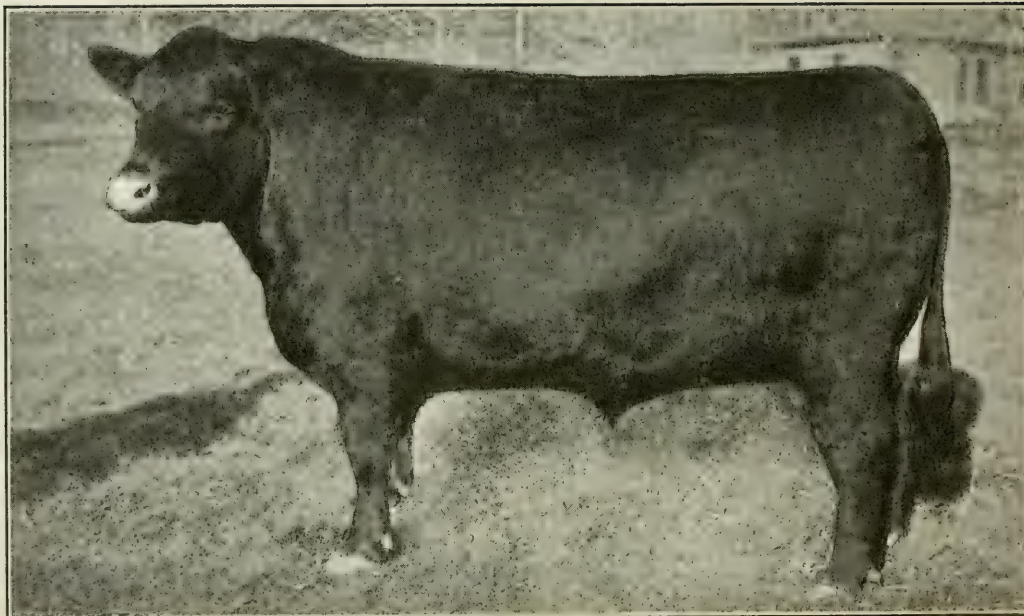
When a dam produces progeny while she is low in flesh, the drain upon the system is such in nourishing her young, that howsoever she may be fed, she will scarcely be able to maintain her weight. It is more than probable that she will lose rather than gain. The more freely that she produces milk, the more probable is it that she will lose rather than increase her flesh. The food that she furnishes to her young must come almost entirely from the food which she eats. Suppose the same dam had been in good flesh at the time of parturition, and that the extra flesh she carried had been made from suitable foods, she would then have been possessed of a reserve supply as it were from which to nourish her young in addition to the milk produced from the food fed. As in the former instance she would lose flesh but not to anything like the same degree, owing to the extent of the reserve in flesh. Her young, therefore, would be nourished not only by milk, but by the reserve food in her system transformed into milk. In the second instance, therefore, she would certainly nourish her young much better than in the first instance. While doing so, she would be possessed of greater vigor than in the first instance, and this would have a favorable bearing on the processes of digestion.

The advantages from maintaining a good condition of flesh in pregnant animals, therefore, include the following: (1) They have a reserve fund stored in the system which is drawn upon for the advantage of the young after they are born; (2) they are possessed of more vigor which is turned to good account in the processes of digesting and assimilating the large amounts of food fed; (3) they are much less liable to reach that low condition of flesh which is not favorable to high production or profitable breeding.

Abundant flesh, however, produced by food highly carbonaceous in character, would be unfavorable to impregnation, and if maintained subsequently by feeding similar food, would also be unfavorable to the development of the fœtus and to the proper feeding of the young animal when born. Such foods fed freely to dams in low condition when their young are born, will aid in maintaining flesh in them, but at the expense of the progeny, as such food is not favorable to milk-giving.

PART II.

Having discussed the leading principles that govern feeding in Part I, it is now in order to discuss in Part II the value of type in the animals to be fed, and the principles that govern the actual feeding of the foods with reference to adaptation to age and class. The principles that govern feeding will not avail unless the foods are fed to animals of at least measurably correct form to answer the purpose for which they are fed. Nor will these avail unless the rations used are given in at least approximate accord with the principles that govern the actual feeding of the foods. Chapter IX, therefore, will discuss the value of type in domestic animals and Chapter X, the principles that govern the feeding of foods.



CLEAR LAKE JUTE II. GRAND CHAMPION OVER ALL BREEDS AT THE WORLD'S FAIR, CHICAGO, 1905.

By courtesy of the owner, Minnesota Experiment Station.]

CHAPTER IX.

THE VALUE OF TYPE IN DOMESTIC ANIMALS.

Type may be defined as another name for form or conformation. But it differs from these in that, when used, it has reference to form or conformation, bearing upon adaptation to a certain end, whereas these terms apply to conformation in the abstract. In the strict sense it applies: (1) To conformation within the breed rather than to conformation within the class to which the breed belongs. For instance, the class cattle embraces many breeds. These differ from one another in form, hence they differ from one another in type. But within some of the breeds are certain strains or families possessed in common of peculiarities of form. In Shorthorn cattle, there are the Bates, Booth and Cruikshank strains. Each of these constitutes a type which differs from the others in certain points of conformation, hence these differ from one another in type; (2) to conformation within the class as determined by classification, or, to be more exact, as making classification possible. For instance, within the species cattle are known as the beef, dairy and dual purpose classes. Each of these embraces several breeds, and also many animals of mixed breeding, possessed of certain peculiarities in form in common, with reference to a certain end, notwithstanding other peculiarities of form in which they differ. Hence, they are also spoken of as beef, dairy and dual purpose types; (3) to animals possessed of certain peculiarities of form which stand out more prominently than other peculiarities but without reference to breed or grade, as when cattle are referred to as being of the low-down, blocky, or of the longer limbed and more rangy form. They are then commonly referred to as possessed of the blocky and rangy types respectively.

Type is valuable as an indicator of utility or adaptation for a certain end. Peculiarities of form in horses indicate capacity for speed or labor respectively, or for a combination of the two. In cattle these indicate capacity for meat or milk, or for a combination of the two. In sheep they indicate capacity for mutton or wool production, and in swine for producing meat of a certain quality. In a sense less pronounced, it is an indicator of breeding qualities, of general ruggedness or weakness, and of feeding capacity. But its chief value lies in what it indicates with reference to capacity for production, as of meat, milk, wool, speed or labor.

Type, however, as an indicator of utility or adaptation is to be taken as a general, rather than as an absolute guide. In a general sense, it is an infallible guide. For instance, when a cow is possessed of pronounced dairy form, it is also known that she is possessed of far higher adaptation for producing milk than for producing meat. But this exact degree of her capacity for milk production cannot be known in the absence of actual proof, the result of performance. Hence, it is, that no judge living can go into an exhibit of dairy cattle, all the individuals of which are high performers, and tell to a certainty which stand highest in actual milk production. So it is with performance in all lines and with all classes of live stock. This is owing to the bearing which other qualifying influences have on production; such as habit, use, training, and also to the wisdom previously exercised in the application of the various known influences that have a bearing on development in performance or production.

Type should be sought in the highest degree obtainable in the line of what it indicates, providing it is not carried to that point where it begins to react prejudicially upon properties co-related and essential to highest performance or production in the direction sought. For instance, should ranginess in the running horse be sought to the extent of weakening staying power, the type thus sought is extreme. The same is true of dairy type that carries lightness and spareness of form to the extent of undue narrowness in the chest and hind quarters, of mutton type that carries blockiness to the extreme, which is prejudicial to breeding, and of bacon type which carries length of body so far as to produce unprofitable feeders.

Type is the basis on which rests the classification of breeds with reference to production or performance. To be more precise, it is the interpreter of the indications of that utility on which classification rests. It divides cattle into the beef, dairy and dual purpose classes; sheep, in a general way, into mutton and wool-producing classes; swine, into producers of lard and bacon, that is, fat and lean pork; and horses into draught, light and general purpose classes. Each of the individual breeds within the class is also characterized by its own distinguishing type features.

It is very evident, therefore, that if food is to be utilized to the greatest extent possible, this can only result when it is fed to animals possessed of the correct type for the end sought. To feed food to animals possessed of pronounced beef type in the hope of securing a high return in milk would be in vain, and *vice versa*. To feed food in harmony with correct type for the ends sought is positively fundamental, or these ends will not be obtained. This necessity has the strength of law as shown in Chapter III.

To aid the student and indeed any who may desire to get a correct knowledge of form or type, what are termed "standards of excellence" have been drawn up for the various breeds, as such, and also for the various types, grouped with reference to adaptation to a certain end. In some instances, these standards are known by the designation "scale of points" and in others by the term "score cards." The scale of points is so designated because a certain value is affixed to each expressed requisite relating to form, singly or taken in groups, and stated in figures. The sum of these for each standard is 100, which indicates perfection. The score card is simply a scale of points, usually condensed in the terms in which it is expressed. It is intended to show the student the relative value of each particular factor or requisite of form, but it is not adapted for use in the show ring, because of the time consumed in using it thus. When judging by the score card blank spaces for the numerals are filled in by the student, according to his judgment of the merits of the various points of the animal which he is judging, and the sum of these indicates his judgment of the standing of the animal in relation to perfection.

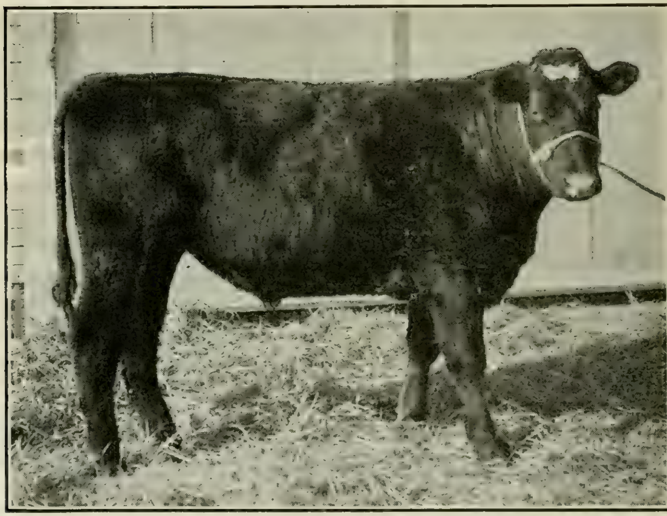
These standards, as usually drawn up, are intended and very properly so, to indicate the perfect animal of its kind or class. In some instances, indications of function are also given as well as those of form. It is very evident, however, that correct form in the same animal will apply very differently, at least in some phases thereof, according as the animal is in high flesh, moderately high flesh, or lean. This means that the standard of perfection for meat-making animals in good flesh as given in the standards, will not furnish a sufficient guide for the person who is selecting animals for feeding. For instance, the standard for the beef cattle beast in good flesh calls for full crops. Should the animal be lower in flesh, the crops will not be full, and so of various other points of conformation. But the measure of fulness in the crops of lean animals varies greatly, and the ability to distinguish between these, so as to know whether future good feeding will fill the crops or not, and how far it will fill them, is of great moment to those engaged in producing meat. The ability to judge animals prospectively with reference to future development is much more rare than ability to judge the standing of the finished animal. Cattle, sheep and swine, purchased with a view to growing or fattening them, or for both uses, are usually purchased while in moderate, or even in a low condition of flesh. To purchase these on the basis of standards drawn up to represent the animal in perfect condition as to flesh, would be misleading.

In the hope of furnishing more exact guides to those who single out animals for future feeding, or who purchase them for the same, feeding standards will be submitted, which are intended to show the leading essentials of form which such animals should possess. This, however, will not be necessary in the case of animals not kept primarily for growing meat, as dairy cattle and horses. As these are supposed to be maintained simply in that moderate condition of flesh most favorable to production of milk in the one instance and of labor in the other, the necessity for two classes of standards for these does not exist as in the case of animals grown for the block. Type will now be considered in its relation to cattle, sheep, swine and horses respectively.

Type in its relation to cattle.—Type with reference to production, as already intimated, divides cattle into the beef, dairy and dual purpose breeds. The recognized beef breeds in America are, the Shorthorn, Hereford, Aberdeen Angus and Galloway breeds. The vast majority of high class animals suitable for the best productions of meat are grades of these, which means that they are the progeny of sires of one of these pure breeds, and of females of common or mixed breeding. The dairy breeds are the Holstein, Dutch Belted, Ayrshire, Guernsey, Jersey, French Canadian and Kerry. Likewise, the great majority of good dairy cows in the country are grades of these, more especially of the Holstein, Ayrshire, Guernsey and Jersey breeds. The higher the grade, both in the case of beef and dairy cattle, that is, the greater the number of the successive generations of straight breeding from sires of one breed, the more valuable are the animals likely to be, up to a certain limit, for the ends for which they are kept. The dual purpose breeds are, the milking Shorthorn, the Brown Swiss, the Red Poll and the Devon. The bulk of dual purpose animals are not confined to the high grades of these breeds, but as found at present are composed of various blood elements, in many instances, blended without much system.

But they are produced with much more certainty and satisfaction as the direct progeny within dual purpose breeds or high grades of these.

Type in cattle for feeding.—The standards of perfection not only for beef cattle but for each of the recognized pure breeds in America, and also for each of the pure breeds of sheep, swine and horses, are intended to represent what these should be in the perfected form. A correct



SELECTED STEER FOR FEEDING
[By courtesy of the owner, Ill. Exper. Sta.]

knowledge of the standard for any breed is invaluable to the person engaged in breeding the same. These standards are given in the "Study of Breeds" written by the author. But the standard for the guidance of the breeder, as already intimated, in the case of animals designed for the block, is not the same as that for the feeder. For the guidance of the latter, therefore, when selecting cattle, sheep and swine, standards for these respective classes of animals will be submitted, each in its proper place. That for cattle is as follows:—

Principal points in cattle for feeding.

1. *Uniformity.*—They should be selected with a view to uniformity in breeding, size and quality.

2. *Size.*—At least medium for the age and breed.

3. *General Outline.*—The body should be moderate in length, with good depth and width, and not high from the ground.

4. *Head.*—Of medium size, short, broad and clean cut.

(a), Forehead, broad,

(b), Muzzle, large, broad and moist,

(c), Nostrils, large and expansive,

(d), Eyes, large, full, clear, calm,

(e), Horns, of medium size and good texture and oval in shape,

(f), Ears, of medium size, short and broad for the breed, carried firmly and not unduly active.

5. *Neck.*—Moderately short, with indications of good muscling as shown in depth and thickness.

6. *Back.*—Straight from base of neck to tail-head, width and levelness depending somewhat on condition as to flesh, and having large loin area.

7. *Fore quarters.*—Wide and deep, fulness in front, also width and levelness at withers, depending largely on the flesh carried.

(a), Shoulders(broad, front and top shoulder points not too prominent, smoothness of shoulder being largely dependent on the amount of flesh present,

(b), Chest, capacious,

(c), Breast, broad and deep, fulness depending on flesh carried,

(d), Brisket, broad but breadth is dependent largely on condition,

(e), Arm, broad at elbow, well muscled, and tapering markedly toward the knee.

8. *Barrel or coupling*—Large, wide and deep.
   (a), Ribs, good outward spring and good length, well spread apart and well muscled,
   (b), Crops, full preferably, but fulness is dependent largely on condition,
   (c), Foreflank, deep and moderately full,
   (d), Hindflank, deep,
   (e), Barrel depression, but moderate in size,
   (f), Underline, straight or nearly so,
   (g), Girth, good around flank and heart and about equal.
9. *Hind quarters.*—Long, deep and wide.
   (a), Hips, broad and well muscled,
   (b), Rump area, large and broad from loin to tail-head and the more level the better,
   (c), Pin bones, wide apart and placed on a level or nearly so with the loin,
   (d), Thigh, broad and well muscled.
   (e), Twist, low.
10. *Legs.*—Both before and behind, short, straight, and set well apart with bone of fairly good size and quality.
11. *Handling qualities.*—
   (a), Skin of moderate thickness and covered with a fair amount of hair,
   (b), Pliability of skin and softness of coat are dependent chiefly on conditions relating to food and flesh.

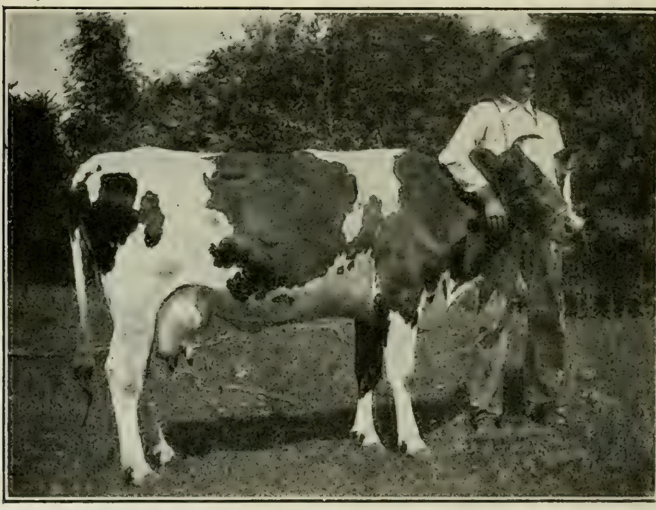
Points especially objectionable.—These include, probably in the order named, a narrow chest, a long, slim head and neck, flat ribs, a small loin and rump area, and a rough shoulder and hook points.

Reasons may be given in minute detail why these indications of form and function should be present. But to give them in connection with each of the standards submitted would unduly swell the contents of the book. For the fuller study of these, the reader is referred to "Animal

Breeding," more especially the chapter therein on "Animal Form an Index of Qualities." However, as standards in previous works by the author have not been submitted relating to the proper furnishings of animals selected for feeding, the following brief explanations will be in order:—*Uniformity* is important because of its bearing upon evenness in quality and attractiveness and through these on price. *Size* has an important bearing upon future possible increase. The *head* and *neck* indicate in various ways capacity for development and the character and quality of the same. The *back* has an important bearing upon the character and hence upon the value of high-priced meat. The development of the *fore quarters* influences weight, and indicates measurably the degree of the stamina. The *barrel* development indicates capacity for food consumption, in its relation to possible production. The *hind quarters* have an important bearing upon weight of relatively high-priced meat. *Legs* short, straight and wide apart, usually sustain compact and wide bodies. *Handling* qualities indicate the character of the digestion and more especially of the assimilation of food. The *carriage* is an indication of health, vigor and disposition.

Development in the framework of all immature animals must continue until maturity, hence, the fattening of young animals carries on development of the frame but in a less degree relatively than of the flesh. In animals more mature, the development relates mainly to the clothing of the framework with flesh and fat and in those mature entirely so. In the latter, therefore, fattening affects only in a slight degree the head in all its essentials, the chest capacity and the size of the limbs. With reference to the head, chest and limbs, therefore, the standards for the unfinished and finished animals are virtually the same. But in various other respects, the difference is marked.

Prominent among those differences are the following:—(1) In the finished animal the entire body becomes more massive and the carriage more labored; (2) the neck vein is more filled, the back is wider and more level, the breast is fuller, the brisket is wider, the fore flank becomes fuller and the hind flank thicker, the crops become fuller and the thighs increase within and without; (3) the covering of the parts usually bare, or nearly so, in the lean animal, as the shoulder blade and loin is increased; (4) the points prominent in the lean animal, as the shoulder points, hooks,



AAGGIE CORNUCOPIA PAULINE

World's Champion Holstein seven-day butter cow with her owner and breeder, H. D. Roe. Record 34 lbs. 5.2 ozs.
[Photo by Prof. W. G. Johnson.]

and pin bones, become less so, in some instances, to the extent of being hidden and (5) the skin often somewhat harsh and adherent over the ribs in the lean animal, becomes much more pliant and loose, and the hair increases in mossiness an brightness.

Type in dairy cattle.—With dairy cattle the leading indications of form and function are essentially the same in all breeds and grades, from the time that the cow first comes in milk until she is sent to the shambles. Even before lactation begins, the indications are virtually the same, except that in the heifer not yet in milk, the inclination to paunchiness in barrel is not so pronounced, and the milk veins are not so large, as they develop with age and use, and the udder is not sufficiently developed to furnish the opportunity for properly judging of the character of its glandular development. The one standard, therefore, will suffice for dairy cows, viewed from the standpoint of capacity for production. The variations arising from breed peculiarities may be found from the standards for the respective dairy breeds given in the "Study of Breeds."

Indications of correct form and function in dairy cows.

1. *Size.*—Medium to large for the breed or grade.

2. *General outline.*—What is known as the triple wedge-shaped formation, which means,

   (a), Increasing width from the withers downward,
   (b), Increasing width toward the rear parts,
   (c), Some increase in distance between the top and bottom lines as they go backward.

3. *Head.*—Medium to fine, clean cut, and relatively longer, lighter and more dished than in the beef breeds.

   (a), Forehead, broad and dishing,
   (b), Nose, fine,
   (c), Muzzle, medium to broad and moist,
   (d), Nostrils, large and open,
   (e), Cheeks, clean and spare,
   (f), Eyes, prominent and lively,
   (g), Poll, medium to wide, according to breed,
   (h), Horns, fine,
   (i), Ears, medium with ample secretions, thinner than in the beef breeds and somewhat livelier.

4. *Neck.*—Inclining to long and light, almost slim.

   (a), It should be fine at the junction of the head and should widen and deepen only gradually, (b), The junction with the body should be well defined, almost abrupt in character.

5. *Back.*—Narrow at the withers, wide at the loin, and at least moderately so at the pin bones, and straight or swayed according to individuality.

(a), A straight back is to be preferred, other things being equal,

(b), The spinal column should be large, well defined and open spaced,

(c), There should be more or less downward slope from the crupper to the outer edge of the hip.

6. *Fore quarters.*—Lighter than the hind quarters and spare.

(a), Withers, narrow,

(b), Shoulders, not heavy, pronounced in their upward slope toward one another, and more or less abrupt in front,

(c), Chest, wide through the heart and capacious,

(d), Breast, wide below, but not prominent,

(e), Brisket, wedge-shaped,

(f), Arm, inclining to light.

7. *Barrel.*—Long, deep, capacious, in a sense paunchy.

(a), Ribs, broad, wide-spaced, with a deep, downward and outward spring, and much space between the last rib and hook point,

(b), Crops, steep, but not necessarily depressed,

(c), Fore flanks, fairly well filled,

(d), Hind flanks, thin but not sunken,

(e), Underline, more or less sagged,

(f), Girth, at least fairly good around the heart, and increasingly so at the hind flank.

8. *Hind quarters.*—Long, but varying somewhat in the breeds, wide at top of the hips and coming well down, but without fulness.

(a), Hips, not heavy, but more heavy in some breeds,

(b), Thighs, inclining to light, thin and more or less incurved, (c), Buttock, upright or receding somewhat toward the thigh,

(d), Pin bones, prominent and wide-spaced,

(e), Twist, open, placed high, and roomy,

(f), Tail, not coarse, tapering, of good length, and hanging at right angles to the back.

9. *Escutcheon.*—Well defined and well developed from the perineum to the udder and extending well outward on the thighs.

(a), Breadth below the perineum is said to denote prolonged milking qualities,

(b), Width at the thighs is said to indicate deep milking qualites.

10. *Udder.*—Long, broad and deep, extending well forward and well up behind, and evenly quartered.

(a), It should be well let down, but not pendulous, and the skin should hang in loose folds behind when the udder is empty,

(b), In quality it should be fine and elastic, glandular, not fleshy,

(c), The hair on the udder should be soft and not plentiful,

(d), The veins on the same well defined,

(e), The teats of medium size and squarely placed or pointing slightly outward.

11. *Milk veins.*—Large, tortuous, preferably branched and entering the abdominal wall, well forward and through large orifices, usually called milk wells.

(a), More commonly there are but two milk wells, but more are much prized,

(b), The veins increase in size with advancing age in the animal.

12. *Legs.*—Medium in length, fine in bone and straight, at least fairly wide apart and yet well under the body.

13. *Skin.*—Medium to fine, finer than in the beef breeds, easily movable, and covered plentifully with fine, soft hair.

14. *General appearance.*—The carriage should be active, the prominences at the angles and also the ribs distinctly apparent, and there should be evidences of a tendency to spareness in form when in milk.

Given in summary the more important indications in a good dairy cow and important perhaps in the order given are the following:—

(1) Much length and depth in the barrel or coupling, indicating a large consumption and utilization of food; (2) refinement of form, as evidenced more particularly in the head, neck, withers, thighs and limbs; (3) good development of udder and milk veins; (4) constitution, as indicated by a capacious chest, much width through the heart, a broad loin, a full, clear eye, and an active carriage; (5) downward and yet outward sprung and open spaced ribs, covered with a soft, pliable and elastic skin. Details relating to nerve power, or temperament, constitution and vitality, also quantity and quality in milk are given in the "Study of the Breeds," page 16. (See also XVIII.)

The males differ from the females in the following essentials, as outlined in Extension Bulletin No. 9 of the Michigan Agricultural college:—

1. *The general outline* should be stronger, including more bone and should possess marked indications of masculinity, as shown in head, neck and fore quarters.

2. *The head* should be strong and full of character and vigor, as expressed in its poise, clean cut outline, width at forehead and full active eye.

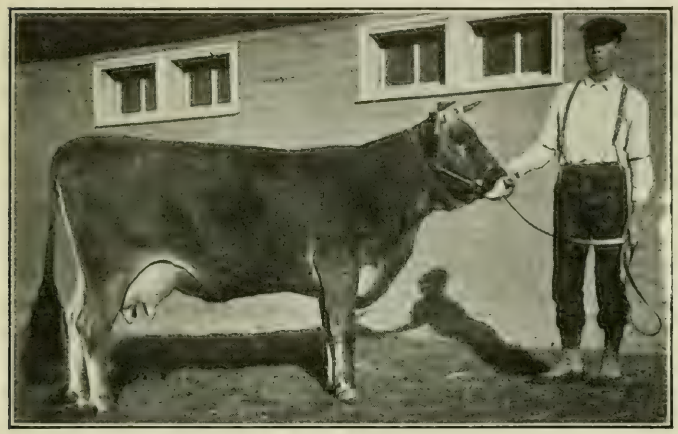
3. *The neck* should have less of length, more of muscling, and should be somewhat arched.

4. *The fore quarters* should be more strongly developed and should have good width and depth of breast and chest as a strong guaranty of good constitution.

5. *The back* should be straighter, stronger and wider.

6. *The barrel* should be relatively shorter and more compact.

7. *The hind quarters* should be relatively longer and broader, the width being carried well back from loin to tail-head, and the hip bones set well apart.



CHAMPION BROWN SWISS COW

[Typical Dual Purpose Cow.]
[By courtesy of the owner, E. M. Barton, Hinsdale, Ill.]

8. *The rudimentary teats* should be well developed and the milk veins should be easily traceable.

9. *The skin* should be thicker and heavier and yet it should be loose, soft, pliable, mellow and elastic and covered with a good coat of soft, silky hair.

10. *The general appearance* should indicate what may be termed irrepressible action, but without any tendency to viciousness.

As the indications of milk inheritance are not so easily traced in the dairy male as in the female, it is more important relatively that he shall come from ancestry distinguished for abundant dairy production in the near generations thereof. It is also more important because of the more numerous progeny which comes from the male.

Type in dual purpose cattle.—The essentials in form and function in dual purpose cattle are virtually the same in all the breeds and grades of this class. The chief differences are such as relate to breed and grade peculiarities. The differences pertaining to breed may be ascertained by consulting the standards given in "The Study of Breeds." Those pertaining to grades of those breeds are virtually the same, but may be less in degree.

Indications of correct form and function in dual purpose cows.

1. *Size.*—Large in form and capacious in body, not massive like the high type beef animal, neither coarse nor unduly refined and possessed of what may be termed a happy equilibrium in development.

2. *General outline.*—The form should be parallelogrammic rather than wedge-shaped, and nearly evenly developed in front and rear.

3. *Head.*—Only moderately large and inclining to long, clean cut and free from throatiness.

    (a), Forehead, wide,
    (b), Nose, inclining to long and fine,
    (c), Muzzle, medium to strong and moist,
    (d), Nostrils, large and open,
    (e), Cheeks, lean,
    (f), Eyes, large, prominent and neither restless nor sleepy,
    (g), Poll, varying with the breed or grade,
    (h), Horns, inclining to fine when present,
    (i), Ears, of medium size, thickness and action, but varying with the breed or grade.

4. *Neck.*—Inclining to long and fine, but not slim.

    (a), Not coarse at the junction with the head.

(b), Of medium increasing width and depth toward the shoulder, and joining the latter neither abruptly nor so smoothly as in the beef breeds.

5. *Back.*—Moderately wide at the withers, wide at the loin and pin bones, and straight.

6. *Fore quarters.*—Nearly equal in development with the hind quarters.

(a), Withers moderately wide,

(b), Shoulders large but not prominent, and possessed of medium upward and forward slope,

(c), Chest, wide through the heart, capacious,

(d), Breast, wide, moderately deep and full,

(e), Brisket, wide and but moderately full,

(f), Forearm, broad and but moderately full,

7. *Barrel.*—Long, deep, roomy, capacious.

(a), Ribs, at least fairly well sprung and deep, well spaced, easily discernible when the animal is giving milk, and possessed of good space between the last rib and hook point,

(b), Crops, filled up nearly level with the shoulder, when in fair flesh,

(c), Fore flanks, low and full,

(d), Hind flanks, low, moderately full and of less than medium thickness,

(e), Girth, good at the heart and at least good at the hind flank,

(f), Underline straight, or slightly rounded downward.

8. *Hind quarters.*—Long, wide, deep and but slightly drooping away from the sacrum and crupper.

(a), Hips straight on the sides,

(b), Thighs, broad and in a line externally with the hips, and possessed of but little or no incurvature behind,

(c), Buttocks, straight, or nearly so,

(d), Pin bones, wide, but not prominent,

(e), Twist, open and placed moderately low, (f), Tail, inclining to fine and long, smoothly set on and hanging at right angles with the body.

9. *Udder.*—Capacious, evenly quartered, coming well forward and backward and not too high or too low.

(a), When empty it should be pliant, not fleshy, and with much loose skin hanging in folds at the rear,

(b), The teats should be of good size and pointing slightly outward.

10. *Milk veins.*—Large, long, tortuous, all the better if branched, and they should enter the body through large orifices or milk wells.

11. *Legs.*—Medium in length and bone, straight and widely placed.

12. *Skin.*—Medium, inclining to fine, easily movable particularly on the ribs, and plentifully covered with soft hair devoid of coarseness or harshness.

13. *General appearance.*—The large, refined and fairly smooth form of the dual purpose animal carries with it evidences of producing capacity.

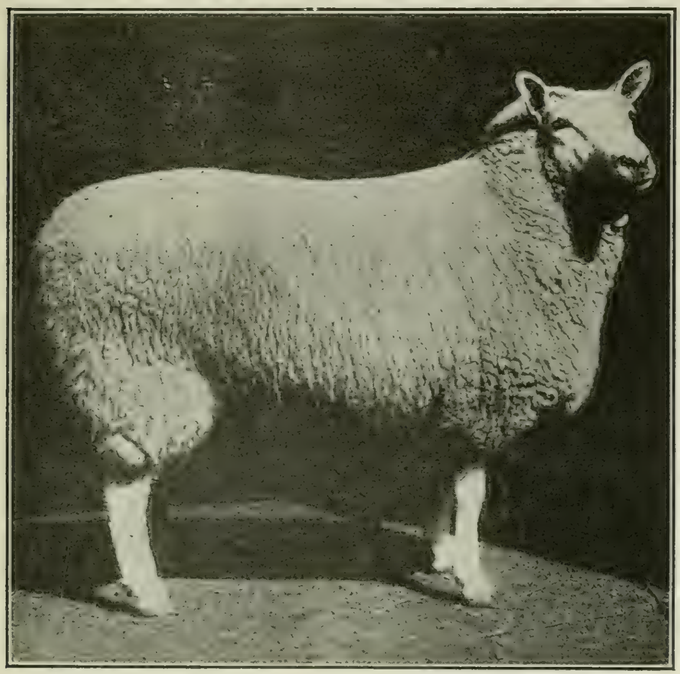
(a), In movement, it is neither sprightly nor sluggish, but easy,

(b), When in milk, it is not high fleshed, but puts on flesh quickly when dry.

Given in summary the more important indications in dual purpose cows and important, perhaps in the order named, are the following:—

(1) Medium to large size for the breed or grade; (2) good length and depth in the barrel; (3) good development of udder and milk veins; (4) good constitution as indicated by good width through the heart; (5) head and neck inclining to long and fine and (6) ribs of medium spring, deep, open-spaced and covered with a good handling skin.

The points of contrast between dual purpose cattle, dairy and beef cattle respectively are given in "The Study of Breeds," page 21. What has been said with reference to the points of contrast between the male and female in dairy cattle (see p. 146) will apply also to the dual purpose breeds, except that the indications of nervous energy are not so marked in the latter. In choosing males, much attention should be given to the dual qualities of the immediate ancestry.



GRAND CHAMPION CHEVIOT EWE AT STATE FAIR
[By courtesy of American Agriculturist]

Type in sheep for feeding.—As previously intimated, the standard for sheep selected for fattening is not the same as for sheep of the pure breeds. For the guidance of the feeder, the following standard is submitted:

Principal points of sheep for feeding.

1. *Uniformity.*—This should relate to breeding, size and quality.

2. *Size.*—The size should be sufficient for the breed and the age, and linked with it should be bone, medium to strong but not coarse.

3. *General outline.*—Smooth, compact, cylindrical in shape and square at the ends.

4. *Head.*—Of medium size, the shape varying with the breed, but a tendency to short, broad and tapering is preferred.

5. *Neck.*—Short, round rather than flat, well muscled, and increasing in size toward the shoulders.

6. *Body.*—Long, wide, deep, round and equally balanced before and behind.

(a), Back, strong, straight and broad, with large loin area,

(b), Breast, broad and deep and the fuller the better,

(c), Brisket, broad and rounded,

(d), Shoulder, wide, deep and smooth,

(e), Forearm, strong and well-muscled,

(f), Girth, at fore and hind flank large and about equally good,

(g), Ribs, well-sprung from spinal column, well arched and deep.

7. *Hind quarters.*—Long, broad and deep.

(a), Rump area, long, wide and level as possible,

(b), Twist, low,

(c), Hind flank, low,

(d), Thigh, well-muscled.

8. *Skin.*—Of bright color and the more pliable, the better.

9. *Legs.*—Short, straight and strong, wide apart and well under the body, and standing firmly on hoofs of good shape and quality.

10. The whole body should be covered with bright lustrous wool and characteristic of the breed or grade.

Points especially objectionable.—These include and probably objectionable in the order named:—(1) Indications of lack of constitution as shown in long, slim head and neck, narrow chest and small heart girth; (2) lack of vigor, as shown in low carriage of head, dull eye, drooping ears, crooked legs with weak bone, short dry lusterless wool and sluggish movement and (3) lack of good fleshing qualities, as shown in weak back, small loin and rump area and small thighs.

Except in animals not mature, fattening does not increase the size of head or limbs but it does influence materially the covering on all parts of the body. The neck vein is filled, the breast rounded out, the crops and flanks are filled much fuller, the spinal column is covered or nearly so in all parts, flesh is increased on the loin and the thighs increase within and without. The yoke is increased in the wool and with such increase comes increase in luster. Thus marked are the contrasts in the furnishings of the finished sheep, as compared with the one not yet fattened.

Type in swine for feeding.—While the standard for swine chosen for being fattened is not the same as for the various breeds in perfected form, the difference is not so marked usually as with cattle and sheep, since swine are more commonly kept in a relatively better condition of flesh during the growing period. The standards for the different breeds are given in "The Study of Breeds." The standard now submitted applies more to the lard and intermediate types than to the bacon types. The essential differences will be given by way of contrast.

Principal points of swine for feeding.

1. *Uniformity.*—This should relate to breeding, size, color and quality.

2. *Size.*—The size should be sufficient for the breed and the age of the animal.

3. *General outline.*—Moderately compact rather than rangy, having the appearance of strength and vigor.

4. *Head.*—Medium size, short, broad, tapering and not coarse.

5. *Neck.*—Short rather than long, moderately wide and deep at the junction with the head and increasingly so at the junction with the shoulders.

6. *Body.*—Long, deep and broad, with fore and hind quarters evenly balanced.

(a), Back, straight, or slightly arched in the longer bodied breeds and even in width,

(b), Shoulders, large, broad and deep,

(c), Chest, wide and deep,

(d), Brisket, broad,

(e), Forearm, moderately short, broad, tapering and well-muscled,

(f), Side, moderately long, deep, straight and even,

(g), Ribs, springing out well from the spinal column, descending with a sharp curve and extending well down,

(h), Heart and flank girth, large and about equal.

7. *Hind quarters.*—Long, deep and wide.

(a), Hams, large and at least moderately full,

(b), Rump area, broad, level, retaining width from loin backward, and not much drooping toward the tail-head,

(c), Thigh, moderately short, broad, tapering and well-muscled within and without,

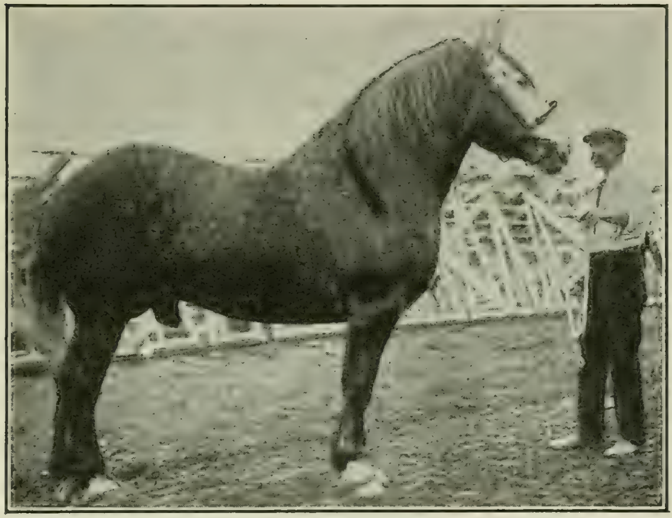
(d), Twist, low.

3. *Legs.*—Short, straight, set well apart, with strong bone and short, straight pasterns.

9. *Skin.*—Smooth, free from scurf, and covered with a moderate coat of soft hair of good quality.

Points especially objectionable.—These include and probably objectionable in the order named:—(1) A long narrow, shallow body; (2) long fine legs with weak pasterns; (3) a long, narrow head, neck and chest and (4) scurfiness of skin, indicating mal-nutrition.

The bacon breeds differ from the lard and intermediate types in the following particulars:—(1) They are less compact in form and are longer in head, neck, body



QUALITY, CHAMPION PERCHERON STALLION AT SPRINGFIELD, ILL., 1906,

[A Typical Draught Horse]

[By courtesy of the owners, Taylor & Jones, Williamsville, Ill.]

and limbs; (2) they are fully as deep in body but not so wide; (3) they have relatively lighter shoulders and hams; (4) they are more active in movement.

Except with swine not mature, fattening does not increase the size of head except in the jowl, or of the limbs, but it does increase the covering on all other parts of the frame. It affects the width more than the depth.

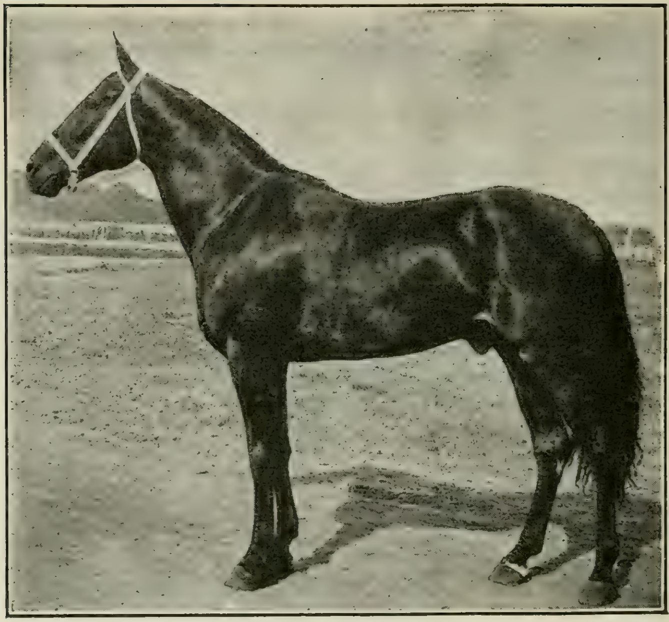
Type in its relation to horses.—As previously mentioned, type divides horses into the draught, light and general purpose classes. This classification is general rather than specific, as the intermediate types between draught and light horses are many and various, and in some instances these are not distinctly pronounced. The minute discussion of these differences cannot be entered upon in this work. Draught horses are maintained primarily for drawing heavy loads in the cities and towns and for doing heavy work on the farm or elsewhere. For doing such work strength and endurance are the first considerations. Light horses are maintained primarily for driving or riding. While thus employed, speed and endurance are the first consideration. General purpose horses are maintained primarily for driving and also for performing work. But such strength is not to be looked for as from draught horses, nor such speed as from light horses.

Type in draught horses.—The four distinct breeds of draught horses in America are the Percheron, the Clydesdale, the Shire and the Belgian. Each of these has its own distinct peculiarities. These can only be ascertained by the careful study of the literature pertaining to each. Notwithstanding these differences, there are certain essential points of form and function which they possess in common, to the extent of making it feasible to draw up a scale of points that will apply to each of these breeds. This has been done by Prof. John A. Craig in his excellent book "Judging Live Stock," and is reproduced here.

Scale of points for gelding draught horses.

	Perfect Score
General appearance.—	
Weight, over 1500 pounds. Score according to age,	4
Form, broad, massive, low set, proportioned,	4
Quality, bone clean, yet indicating sufficient substance; tendons distinct; skin and hair fine,	4
Temperament energetic, good disposition,	4
Head and neck.—	
Head, lean, medium size,	1

	Perfect Score
Muzzle, fine, nostrils large, lips thin, even,	1
Eyes, full, bright, clear, large,	1
Forehead, broad, full,	1
Ears, medium size, well carried,	1
Neck, muscled, crest high, throatlatch fine, windpipe large,	1
Fore quarters.—	
Shoulders, sloping, smooth, snug, extending into back,	2
Arm, short, thrown forward,	1
Forearm, heavily muscled, long, wide,	2
Knees, wide, clean cut, straight, deep, strongly supported,	2
Cannons, short, lean, wide, tendons large set back,	2
Fetlocks, wide, straight, strong,	1
Pasterns, sloping, strong, lengthy,	3
Feet, large, even size, straight, horn dense; dark color; sole concave, bars strong, frog large, elastic, heel wide, high, one half length of toe,	8
Legs, viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern and foot. From the side a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and back of hoof,	4
Body.—	
Chest, deep, wide, large girth,	2
Ribs, long, close, sprung,	2
Back, straight, short, broad,	2
Loin, wide, short, thick, straight,	2
Underline, flank low,	1
Hind quarters.—	
Hips, smooth, wide,	2
Croup, long, wide, muscular,	2



DAN PATCH 1.55 AT HOME

[By courtesy of the owner, M. W. Savage, Minneapolis, Minn.]

	Perfect Score
Tail, attached high, well carried,	1
Thighs, muscular,	2
Quarters, deep, heavily muscled,	2
Gaskins, or lower thighs, wide, muscled,	2
Hocks, clean-cut, wide, straight,	8
Cannons, short, wide, tendons large, set back	2
Fetlocks, wide, straight, strong,	1
Pasterns, sloping, strong, lengthy,	2
Feet, large, even size, straight, horn dense, dark color, sole concave, bars strong, frog large, elastic, heel wide, high, one half length of toe,	6

	Perfect Score
Legs, viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern and foot. From the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle and a perpendicular line from the point of the buttock should run parallel with the line of the cannon.	4
Action.—	
Walk, smooth, quick, long, balanced,	6
Trot, rapid, straight, regular,	4
Total,	100

Type in light horses.—Light horses are commonly divided into three classes. These are the roadster, saddle and carriage types. In the pure form they are represented in the standard trotter or pacer, in the standard saddle horse and in the various breeds of coach horses. Because of variations in type more or less pronounced, it will not be possible to present a scale of points that will furnish an absolute guide for the selection of the various classes of light horses. Nevertheless they have in common certain essential characteristics which may thus be given. These have been well summarized by Prof. John A. Craig, and are now submitted:—

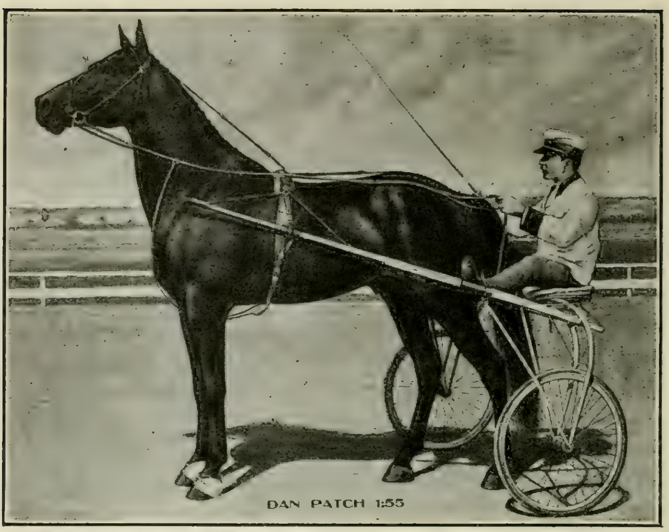
Scale of points for gelding light horses.

	Perfect Score
General appearance.—	
Form, symmetrical, smooth, stylish,	4
Quality, bone clean, firm, and indicating sufficient substance, tendons defined, hair and skin fine,	4
Temperament, active, kind disposition,	4
Head and neck.—	
Head, lean, straight,	1

	Perfect Score
Muzzle, fine, nostrils large, lips thin, even, teeth sound,	1
Eyes, full, bright, clear, large,	1
Forehead, broad, full,	1
Ears, medium size, pointed, well carried, and not far apart,	1
Neck, muscled, crest high, throatlatch fine, windpipe large,	1
Fore quarters.—	
Shoulders, long, smooth, with muscle oblique, extending into back,	2
Arms, short, thrown forward,	1
Forearms, muscled, long, wide,	2
Knees, clean, wide, straight, deep, strongly supported,	2
Cannons, short, wide, sinews large, set back	2
Fetlocks, wide, straight,	1
Pasterns, strong, angle with ground 45 degrees,	3
Feet, medium, even size, straight, horn dense, frog large, elastic, bars strong, sole concave, heel wide,	6
Legs, viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern and foot. From the side a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and back of hoof,	4
Body.—	
Withers, muscled and well finished at top,	1
Chest, deep, low, large girth,	2
Ribs, long, sprung, close,	2
Back, straight, short, broad, muscled,	2
Loin, wide, short, thick,	2
Underline, long, flank let down,	1

	Perfect Score
Hind quarters.—	
Hips, smooth, wide, level,	2
Croup, long, wide, muscula.,	2
Tail, attached high, well carried,	1
Thighs, long, muscular, spread, open angled,	2
Quarters, heavily muscled, deep,	2
Gaskin or lower thighs, long, wide, muscular,	2
Hocks, clearly defined, wide, straight,	5
Cannons, short, wide; sinews, large, set back,	2
Fetlocks, wide, straight,	1
Pasterns, strong, sloping,	2
Feet, medium, even size, straight, horn dense, frog large, elastic, bars strong, sole concave, heel wide, high,	4
Legs, viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern and foot. From the side a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle and a perpendicular line from the point of the buttock should run parallel with the line of the cannon,	4
Iction.—	
Walk, elastic, quick, balanced,	5
Trot, rapid, straight, regular, high,	15
Total	100

Type in general purpose horses.—Since general purpose horses have been variously bred and usually in a sort of aimless way, that is without any very distinctly defined purpose in view, it could not be otherwise than that the horses of this class should vary greatly. Some will be so heavy as to constitute what may be termed light draught horses and some so light as to carry no more weight than



DAN PATCH, THE WORLD'S RECORD PACER

[By courtesy of the owner, M. W. Savage, Minneapolis Minn.]

the carriage classes. They will also vary much in conformation, according to the character of the grade or cross used in obtaining them. Because of these differences, it is scarcely possible to present a scale of points at the present time that would be of much service in describing horses of this class.

CHAPTER X.

PRINCIPLES THAT GOVERN FEEDING.

The discussion in Chapter X relates to the principles that govern the feeding of animals with reference to the chemical constituents which feeds possess, as adapted to the class and age of animals to which they are to be fed and the precise objects for which they are maintained. It differs from the discussion in Part I in that it is specific while the former is general. The principles in this chapter relate to furnishing feeds that will contain the nutrients which they must have in due proportion if the end sought is to be reached.

In theory, these principles have all the strength of law, but in practice it is very frequently not possible to apply them so that the results sought or that should be expected from such feeding, will follow, owing to the subtle influences that frequently result from environment, from internal causes that cannot always be discerned, and from variations resulting from the physiological influence of feeds apart from the nutrients they contain as given by chemical analysis.

The elementary substances necessary to the growth of plants are essentially the same as the chemical elements of the animal body. These are carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, calcium, magnesium and iron. In addition to these are chlorine and sodium, the elements of common salt. These elements do not exist simply but are united into numberless compounds, both organic and inorganic. For convenience of reference, they are classified as nitrogenous or non-nitrogenous, according as the chemical compounds of which they are composed contain nitrogen or do not contain nitrogen. The water in foods must also be considered, but this is not so important, since water can be supplied. These elements exist in varying degrees in plants and in the same plant at different stages of development, and similarly they differ in the degree of the digestibility which they possess. The degree in which they are present and also the degree of the digestibility which they possess, can only be determined by chemical analysis, hence the necessity for tables of feeding stuffs, which the feeder may consult when preparing or feeding foods. The proportions in which these elements should be supplied to animals also varies with the class of the animal, the age, the performance and the object for which it is kept. The adaptation of food to the needs of the animals to which it is to be fed virtually constitutes the great art of feeding.

For convenience in reference, certain definitions pertaining first to the feeds themselves and second to the methods of blending or compounding them for feeding, have come into common use. These are all considered in Chapter X. The definitions which pertain to feeds include the terms: (1) Food nutrient; (2) food factor or feeding stuff; (3) food or feeding ration and (4) table of feeding stuffs. Those which pertain to the blending or compounding of feeds, include the terms: (1) Nutritive ratio; (2) feeding standard and (3) table of feeding standards. Familiarity with these terms and the ability to reduce to practice what is implied in them, should prove helpful to all persons engaged in growing stock.

Food nutrient.—A food nutrient is any single chemical compound capable of being assimilated by the body, for the purpose of producing new tissue, either for new growth or to replace that which is worn out. The body is composed of: (1) Nitrogenous organic substance; (2) non-nitrogenous organic substance and (3) mineral substance. Since a food nutrient in order to permit of easy assimilation, must in its composition be identical with the substances normally found in the body, the nutrients may be classified very similarly to the classification of the substances of the body as given above. They are, therefore: (1) Nitrogenous organic substances; (2) non-nitrogenous organic substances and (3) mineral or inorganic substances. Albumen, the essential constituent of the white of egg, is an example of a nitrogenous nutrient, starch of a non-nitrogenous nutrient, and common salt of a mineral or inorganic nutrient. Nutrients are seldom found in an unmixed state, but are generally combined in one fodder.

Food factor or feeding stuff.—The term food factor or feeding stuff is any natural or artificial product used as food for animals. Food factors usually contain two or more nutrients intimately blended but in varying proportions and also more or less substance that is indigestible and which, therefore, cannot be appropriated by the animal to which the food is fed. Feeding stuffs may be roughly classified as nitrogenous or non-nitrogenous according as the organic nutrients are more largely of one kind or the other. In nearly all instances they contain a sufficiency of mineral nutrients, the exceptions being common salt and in some instances ash and phosphate of lime.

The principal nitrogenous constituents of feeding stuffs are the albuminoids, as legumin, the nitrogenous constituent of peas, beans and clover, and gluten, the nitrogenous constituent of wheat. Likewise the nitrogenous substances of the body consist largely of albuminoids. So intrinsically important are they, that all the manifestations of animal life are dependent on them and on the organs which are composed of them. They also furnish the materials out of which the other important groups of nitrogenous substances are formed; viz., the gelatinoids and the horny matters.

The albuminoids are found under various manifestations in all the organs and fluids of the healthy body except the urine and they form the chief constituents of their composition. Nearly all the vital processes of the body have for their object the effecting of changes upon the form, location or function of the albuminoid material. The principal albuminoids of the body are albumen, found in nearly all its fluids, flesh fibrin, the chief constituents of muscular fibre, blood fibrin, the essential element of the clotting part of blood, and casein, the constituent of milk which forms the basis of cheese. The gelatinoids form the nitrogenous substance of the bones and cartilages and also make up the larger part of the tendons, ligaments, connective tissue and the skin. The horny matters, which differ but little in chemical composition from the albuminoids or gelatinoids, are found chiefly on the outer surfaces of the body, that is, in the epidermis or scarf skin, the hair, the wool, the horns and the hoofs. The chemical composition of these three groups of nitrogenous substances is practically the same, and what is exceedingly important in this connection, the same chemical composition will hold good with respect to the nitrogenous substances found in foods. The further discussion of the many and exceedingly important functions of the nitrogenous substance in the animal body cannot be carried further in this work.

The principal non-nitrogenous constituents of feeding stuffs are cellulose, starch, sugar, gum, fat, oil and the various vegetable acids. These are classified as carbohydrates and fat. The carbohydrates, composed principally of carbon, hydrogen and oxygen, include cellulose, starch, sugar, gum and the vegetable acids. The fat and oil are generally considered together as fat. The non-nitrogenous constituents of plants may, therefore, be considered as being carbohydrates or fats. But a part of the cellulose of plants often becomes hardened into a more or less indigestible fibrous condition. This is commonly separated from the remaining carbohydrates in the table of feeding stuffs (see p. 175) and placed in a class by itself as crude fibre. The non-nitrogenous substance also includes the ash, that is, the inorganic or mineral part which remains after the plant has been consumed by fire. These all play a more or less important part in the economy of animal growth and production.

Fat is the most abundant by far of the non-nitrogenous organic substances of the animal body. It is found in various parts of the same, in some places as minute particles and in others as special deposits of considerable quantity. The sources of fat in the body are, first, the fat in the food; second, the albuminoids or nitrogenous substance in the food, and third, the carbohydrates in the same. Whether the carbohydrates are direct sources of body fat is uncertain, but indirectly they certainly are. The presence of animal fat in the animal body has the effect of decreasing the protein consumption and of retarding the tendency to nitrogen equilibrium.

Protein consumption means the removal of that portion of the nitrogenous substance, that is protein, taken into the body and digested through oxidation and the excretion of worn out nitrogenous tissue.

Nitrogen equilibrium is that principle which inheres in the animal body through which it eventually puts itself into equilibrium with the nitrogenous constituents which it receives in its food above what is necessary to maintain it in an average condition. This question, significant in its bearing on practical feeding, cannot be elaborated further in this work.

The following are chief among the influences which fat in the food exerts: (1) It decreases protein consumption and thereby increases protein deposition. Protein deposition means the retention and use of that portion of the nitrogenous food consumed and digested which remains in the body for a longer or shorter time. It is assimilated as new nitrogenous tissue or as tissue which has replaced old worn out or waste nitrogenous tissue. (2) It decreases the protein consumption in the body and it does so independently of the protein supply. The protein consumption increases and diminishes with the protein supply in the food, and all that the fat does is to diminish it by a certain quantity, which will be the same no matter how large the protein supply in the food may be. (3) Like fat in the body it retards the tendency to nitrogen equilibrium. Its presence in the food favors the formation out of the protein supply of stable tissue, in place of part of the circulatory protein, which means to some extent increase in flesh. Circulatory protein is that portion of the nitrogenous substance taken from the food which remains for a time in the blood, awaiting either conversion into stable flesh tissue, or oxidation and decomposition into the fluids of the excretory organs. In well-fed animals, it causes what is called the juiciness of the flesh.

It should also be remembered that while the presence of fat in small quantities is favorable to the formation of flesh, in large quantities it is injurious, since it disturbs the digestion and thus impairs the appetite. Therefore, the ordinary feeding stuffs fed to farm animals should contain but little fat.

The influence of carbohydrates in the food on the formation of flesh is very similar to that of fat in the same. Prominent among these influences are the following: (1) Carbohydrates in the food decrease the protein consumption and thereby increase the protein deposition (see p. 167) the protein consumption depending as regards quantity solely on the protein supply. (2) They retard the tendency toward nitrogen equilibrium and therefore cause a longer continued gain of flesh than would be affected by nitrogenous foods alone.

The carbohydrates are helpful in promoting growth, in producing fat, and in generating heat so necessary to the maintenance in healthy action of all the functions of the body. Experience has shown that the greatest gain of flesh is made when the proportion of carbohydrates in the food fed is large. In regard to flesh formation they produce about the same results as fat and are much cheaper, hence they should be fed to the greatest extent possible instead of fat, except in such instances as when it is necessary to feed fat in the food because of its greater power to produce heat (see p. 177). They are much more abundant than protein in foods and, therefore, cheaper than this element also, hence their free use in feeding stuffs tends to cheapen the ration. Moreover, they are readily eaten and digested by all the animals of the farm. And yet a sufficiency of protein must be fed since the nitrogenous substances constitute so large a proportion of the animal body, since many of the vital processes are dependent on them, and since they are so necessary to performance as in the production of flesh, milk and muscular exertion.

Crude fibre is that tough woody portion of the plant which constitutes its framework. It is the portion that remains after the softer parts have been dissolved and washed out. Young plants contain considerably less of crude fibre than those which have produced seeds, and the seeds of plants also contain much less than the stems and leaves. It is not easily digested, especially by animals which do not ruminate. The portion digested is thought to have practically the same function as the other digestible carbohydrates, and is supposed to equal them in value. The indigestible portion, oftentimes a tax upon the digestion, may sometimes serve a useful purpose in the bulk which it furnishes.

Ash, the inorganic portion of plants and of animal bodies, is that part which remains after either has been consumed by flame. In plants it is most abundant in the leaves. These mineral matters are usually amply present in all foods to meet the needs of animals, with the exception of salt, which must be supplied. In the form of lime and phosphate they go to make bone, as soda and chlorine they aid the digestive juices, and as iron they probably help in the formation of the red corpuscles in the blood. For reasons that will be manifest young and growing animals need them in largest supply.

Importance of nitrogenous substances.—From what has been said, it will be apparent that the nitrogenous substances of the body are by far the most important since they include nearly all the solid parts except the fat and the mineral constituents of the bones. Therefore, for the sake of brevity, it is usual to speak of all the nitrogenous substance of the body as flesh, as distinguished from fat and bone. For a similar reason the word fat is used to denote all the non-nitrogenous substance of the body, both the real fat and the other substance. Likewise the word bone is frequently used to denote only the mineral constituents of bone, although much of the substance of bone is nitrogenous organic matter. The flesh of the animal body is also referred to as protein substance and the fat as non-protein substance. It should be remembered that these various terms are only close approximations to the truth.

The discussion of the various food factors in feeding stuffs should not close without some reference to their functions in producing heat and in sustaining muscular exertion. The influence which they exert on milk production is touched upon elsewhere (see p. 413).

Heat in the animal body results from the constant process of oxidation or burning of waste tissue and of food substance which is going on everywhere in every part of the body to which the blood reaches. The heat supply is dependent on the food supply, for the tissues that are oxidized or burned come orignially from the food. This oxidation is maintained with no gain of substance but of loss, as the products of the combustion, carbonic acid gas, water and urea must be gotten rid of by the excretory organs. It is estimated that of the whole quantity of food eaten by an animal for maintenance about four-fifths are required to sustain the demand occasioned by the production of heat.

Since the nitrogenous substance, the fats, and the carbohydrates of the food are all oxidizable, they may be all used as sources of heat. But the fats and the carbohydrates are the most suitable since their oxidation in the blood is much more readily effected than that of the nitrogenous substance. They are also on the whole much cheaper, as previously intimated (see p. 168).

Regulation of animal heat.—How the heat of the animal body is regulated cannot be discussed here. But in passing it may be said that the following are chief among the influences concerned in such regulation: (1) The kind and amounts of the food fed; (2) the temperature to which animals are exposed; (3) the warming of food and drink taken into the stomach; (4) the amount of the muscular exertion allowed or demanded; (5) the conduction and radiation of heat from the skin; and (6) the evaporation of water from the skin and lungs.

Muscular exertion may be classed as external and internal. The former is the muscular exertion called for in effecting the movements concerned in the various vital processes within the body. The latter is the muscular exertion called for by animals when exercising or performing physical work. The relation between these is very close. Of whatever kind it may be, it calls for a constant supply of heat to maintain it, and the greater the exertion, of course the greater the supply of heat demanded. Of course this heat must all come directly or indirectly from the food. Beyond this, the relation between food supply and muscular exertion is not well understood. It is certain, however, that the food given to the animal to support muscular exertion must be something more than fuel, that is, it must be partly nitrogenous and it must be liberal in supply. Stated in summary: (1) Muscular exertion is dependent on the food supply; (2) the greater the exertion to be made, the greater must the food supply be; (3) the greater the exertion, the greater also must be the proportion of the nitrogenous substance in the food.

Food or feeding ration.—The term food or feeding ration more commonly means a combination of the food factors used in feeding animals in any given instance, but sometimes it may mean but one food factor. When the proportion of the nitrogenous and non-nitrogenous nutrients are present in a food ration in that degree that will best effect the ends sought when fed, it is said to be in balance (see p. 172). When not fed in balance waste in some of the nutrients will follow since they cannot be all resorbed into the system, and energy is taxed in removing the excess from the same. Nor can that happy equilibrium in the process of digestion, assimilation and excretion be attained, which is necessary to the best utilization of all the food fed unless it is in balance, not only in its nutrients but in the proportion of the bulk that accompanies the nutrients. The definition of a balanced ration usually considers only the balance of digestible nutrients, while the balance in bulk and concentration may be of but little less importance. Certain foods have also a physiological influence in addition to the nutrients they contain. The comprehensive definition, therefore, of a balanced ration may be made to read thus: A balanced ration is one in which the bulk and concentrates, the nitrogenous and non-nitrogenous nutrients, and the physiological influence which these exert in addition to their food value, are present in that degree which will best produce the results sought from feeding them. The great importance, therefore, of feeding foods in at least approximate balance is very evident.

Information regarding the balancing of rations is obtained from two sources; viz., from the experience of feeders and from a table of feeding standards (see p. 184). The first of these sources is by no means to be despised, as an old and experienced feeder, without any knowledge of feeding standards, will frequently take foodstuffs and, guided only by his own judgment, will obtain superior results from feeding them to those obtained by the inexperienced feeder who blends them in exact accord with what is called for in the feeding standards. This result may not follow from any error in the standards, but from the presence or absence of the physiological influences referred to above, or because of lack of equilibrium between the bulk and nutrition, or from both causes combined. Notwithstanding, a knowledge of feeding standards and of the way in which they may be utilized in feeding will always be of great service to those engaged in this work, because of the wide range of its general practical application. The feeder who gains his knowledge only through experience and from tradition, is long in gathering it, and his knowledge of compounding rations is usually confined to the productions of but limited areas.

The definition of a feeding ration does not necessarily call for a balanced food. Nor does it imply that more than one kind of food shall be used. Grass pasture, though it may embrace but one variety of grass, is none the less a food ration than one formed by blending any number of foods. In some instances a single food may make a balanced ration quite as effectively as a combination of foods, since it may contain within it, not only the requisite proportions of both nitrogenous and non-nitrogenous constituents to effect a given end, but it may also contain the requisite bulk that should accompany the feeding of the nutrients.

Table of feeding stuffs.—Feeding stuffs vary greatly in their nutritive constituents, that is, they vary in the total dry matter which they contain and in the proportion of the nitrogenous and non-nitrogenous factors, as carbohydrates, fat and crude fibre, and in the proportions of these that are digestible. They also vary in the relative proportions of mineral matter which they contain, and in the proportion of the nitrogenous and non-nitrogenous factors, as protein, carbohydrates, fat and crude fibre, and in the proportions of these that are digestible. They further vary in the relative proportions of mineral matter which they contain. Information regarding the relative amounts of each of these factors have been obtained through analyses made by the chemist of the various foodstuffs, and of the proportions of the nitrogenous and non-nitrogenous factors digestible in each instance. The proportion of these that are digestible have been obtained from chemical analyses based upon actual experience in feeding the respective foods. The great value of such information to the practical feeder will be at once apparent. These proportions are stated in percentages, and for convenience of reference are collected and given in tables in orderly sequence. Such a collection is known as a table of feeding stuffs. Briefly then, a table of feeding stuffs is a table giving the chemical constituents of food expressed in percentages. In some instances these tables only give the relative proportions of the various factors that are digestible. In others the total percentages of each factor is also given.

It should be remembered, however, that these tables are only to be taken as general guides. The chemist and the scientist can ascertain the proportionate percentages of nitrogenous and non-nitrogenous constituents in a feeding stuff or in the feeding stuffs fed in a given instance. But the following influences among others that may be named lead to variation: (1) Plants of the same variety differ in the nutrients which they contain at different stages of growth and of maturity. (2) These percentages vary with the inherent character of the soils on which the plants have been grown, with the manures applied or withheld, and with the cultivation given. (3) They further vary with the time and method of harvesting, with the degree and nature of the exposure while curing and in some instances in the way in which they are prepared for feeding. Moreover, (4) the various classes of animals differ in their ability to digest and assimilate foods, more especially the crude fibre, and the same is true of individual animals of the same class. These tables, therefore, are only to be taken as approximate estimates of the nutrients which the foods contain. But they are reasonably close approximations since with the more important at least of the foods the constituents submitted are the averages of a number of analyses and their digestibility as stated represents as a rule the average of a number of feeding trials.

Table of feeding stuffs.—Feeding stuffs vary greatly in the more important feeding stuffs mentioned in this work is now submitted and also their digestibility as far as both could be obtained from American sources. This table is based on the composition of feeding stuffs as given in the revised edition of Farmer's Bulletin No. 22 issued by the U. S. Department of Agriculture. Those who desire to follow the subject further are referred to this bulletin. The figures giving the digestibility of the various feeding stuffs submitted are based chiefly upon the digestion trials conducted by the experiment stations and compiled by Lindsay in the report of the Massachusetts (Hatch) Experiment Station for 1896.

TABLE I.

GIVING THE CONSTITUENTS OF THE ORDINARY FEEDING STUFFS AND OF THEIR AVERAGE DIGESTIBILITY.

Note 1. The figures printed in ordinary type show the percentage of composition of each constituent.

Note 2. The figures below in each instance show the percentage of these quantities that are digestible.

Cured fodders	Total dry matter	Nitrogenous substance (protein)	Fats (ether extract)	Carbohydrates other than fibre (nitrogen free extract)	Crude fibre	Ash
Red clover hay	78.2	12.4	4.5	33.8	21.9	6.6
	61	62	62	69	49	
Alsike clover hay	90.3	12.8	2.9	40.7	25.6	8.3
	62	66	50	71	53	
Crimson clover hay	90.4	15.2	2.8	36.6	27.2	8.6
	62	69	44	62	45	
White clover hay	90.3	15.7	2.9	39.3	24.1	8.3
	66	73	51	70	61	
Alfalfa hay	91.6	14.3	2.2	42.7	25.0	7.4
	60	74	39	66	43	
Cowpea hay	89.3	16.6	2.2	42.2	20.1	7.5
	59	65	50	71	43	
Vetch hay	88.7	17.0	2.3	36.1	25.4	7.9
	65	76	65	66	54	
Soy bean hay	88.7	15.4	5.2	38.6	22.3	7.2
	62	71	29	69	61	
Timothy hay	86.8	5.9	2.5	45.0	29.0	4.4
	57	48	57	63	52	
Orchard grass hay	90.1	8.1	2.6	41.0	32.4	6.0
	56	60	55	55	61	
Red top hay	91.3	8.9	2.7	46.4	29.9	4.9
	60	61	51	62	61	
Millet hay	92.3	7.5	2.1	49.0	27.7	6.0
	65	60	64	67	68	
Corn fodder	57.8	4.5	1.6	34.7	14.3	2.7
	66	53	76	74	52	
Corn stover	59.5	3.8	1.1	31.5	19.7	3.4
	60	45	62	61	67	
Sorghum fodder	20.6	1.3	0.5	11.6	6.1	1.1
	67	46	74	74	59	
Rye straw	92.9	3.0	1.2	46.6	38.9	3.2
	46	21	32	37	60	
Wheat straw	90.4	3.4	1.3	43.4	38.1	4.2
	43	11	31	38	52	
Barley straw	85.8	3.5	1.5	39.0	36.0	5.7
	53	20	42	54	56	
Oat straw	90.8	4.0	2.3	42.4	37.0	5.1
	48	30	33	44	54	

TABLE I—*Continued*

Food from cereals and other seeds	Total dry matter	Nitrogenous substance (protein)	Fats (ether extract)	Carbohydrates other than fibre (nitrogen free extract)	Crude fibre	Ash
Wheat	89.5	11.9	2.1	71.9	1.8	1.8
	72	70	60	74	30	
Oats	89.0	11.8	5.0	59.7	9.5	3.0
	70	78	83	76	20	
Barley	89.1	12.4	1.8	69.8	2.7	2.4
	86	70	89	92	50	
Rye	88.4	10.6	1.7	72.5	1.7	1.9
	87	84	64	92	—	
Peas	89.5	20.2	1.2	51.1	14.4	2.6
	87	83	55	94	26	
Cottonseed	90.9	19.6	20.1	28.3	18.9	4.0
	66	68	87	50	76	
Flax	90.8	22.6	33.7	23.2	7.1	4.3
	77	91	86	55	61	
Dent corn	89.4	10.3	5.0	70.4	2.2	1.5
	91	76	86	93	58	

By Products	Total dry Matter	Nitrogenous substance (protein)	Fats (ether extract)	Carbohydrates other than fibre (nitrogen free extract)	Crude fibre	Ash
Wheat bran	88.5	16.1	4.5	54.5	8.0	5.4
	61	79	68	69	22	
Wheat middlings	87.9	15.6	4.0	60.4	4.6	3.3
	79	82	85	85	36	
Brewers' grains, wet	24.3	5.4	1.6	12.5	3.8	1.0
	63	73	86	62	40	
Brewers' grains, dry	92.0	24.1	6.7	44.8	13.0	3.4
	62	79	91	59	53	
Malt sprouts	89.8	23.2	1.7	48.5	10.7	5.7
	67	80	100	69	34	
Corn and cob meal	84.9	8.5	3.5	64.8	6.6	1.5
	79	52	84	88	45	
Gluten meal	91.4	30.0	8.8	49.2	2.6	0.8
	87	88	93	88	—	
Gluten feed	92.2	23.4	8.3	53.2	6.2	1.1
	84	85	83	87	72	
Oil cake, old process	90.8	32.9	7.9	35.4	8.9	5.7
	79	89	89	78	57	
Oil c'ke, new pr'cess	90.1	35.9	3.0	36.8	8.8	5 6
	80	85	93	84	74	
Cottonseed meal	91.8	42.3	13.1	23.6	5.6	7.2
	76	88	93	64	32	
Cottonseed hulls	88.9	4.2	2.2	33.4	46.3	2.8
	41	6	79	34	47	
Whole cow's milk	12.8	3.6	3.7	4.9	—	0.7
	98	94	100	98	—	

TABLE I—*Continued*

Field roots and tubers	Total dry matter	Nitrogenous substance (protein)	Fats (ether extract)	Carbohydrates other than fibre (nitrogen free extract)	Crude fibre	Ash
Sugar beet pulp	10.1	1.0	0.2	6.3	2.2	0.4
	82	63	—	84	83	
Mangels	8.8	1.4	0.2	5.4	0.8	1.0
	79	75	—	91	43	
Sugar beets	13.3	1.5	0.1	9.9	0.9	0.8
	95	91	50	100	100	
Rutabagas	11.4	1.2	0.2	7.5	1.3	1.2
	87	80	84	95	74	
Turnips	9.4	1.3	0.2	5.9	1.2	0.8
	93	90	98	97	100	
Potatoes	21.3	2.1	0.1	17.3	0.6	1.0
	77	44	—	91	—	

Nutritive ratio.—By the term nutritive ratio is meant a statement of the proportion of the digestible nitrogenous substance in a feeding ration to the digestible proportion of the non-nitrogenous substance. It is obtained by dividing the total digestible non-nitrogenous substance in the same by the total digestible nitrogenous substance. The total digestible nitrogenous substance is simply the digestible protein. The total digestible non-nitrogenous substance is the sum of the digestible carbohydrates other than fibre, of the digestible crude fibre, and of 2¼ times the digestible fat. The digestible fat is multiplied by 2¼ to place it on the same basis as the carbohydrates in heat production. It has been found that although the carbohydrates and fat are about equal for producing flesh, if one pound of digestible fat is burned under water, all the heat being conserved, it will raise it to the same temperature as would 2¼ pounds of digestible carbohydrates burned under similar conditions. Therefore, the power to produce heat is 2¼ times greater in the former than in the latter, and this is true of these food factors in the production of heat in the animal body.

It will be apparent, therefore, that with a table of feeding stuffs at hand giving the relative amounts of the organic substances in any food stuffs that are digestible, the nutritive ratio of the same may be easily computed. Take clover hay for instance, in the table on page 175, the total digestible nitrogenous substance given in this food is 0.07688 per cent, the total digestible carbohydrates other than fibre as 0.23322 per cent, crude fibre as 0.10731 per cent and fat as 0.02790 per cent. When the fat is multiplied by 2¼ and added to the carbohydrates the sum of these is 0.40330 per cent. When this is divided by 0.07688, the total digestible protein, the quotient is 5.2. Therefore, the nutritive ratio in clover hay is 1 :5.2. When more than one food is combined in the ration, the digestible nitrogenous constituents of each must of course be taken together and also all the digestible non-nitrogenous constituents when ascertaining the nutritive ratio.

Nutritive ratios are regarded as wide and narrow in proportion to relative amounts of the digestible nitrogenous and non-nitrogenous nutrients which they contain. One comparatively rich in nitrogenous substance is spoken of as narrow, and in non-nitrogenous substance as wide. For instance, skim milk has a nutritive ratio of 1 :1.63 and mangels of 1 :9.2. The former represents an unusually narrow ratio and the latter a more than ordinarily wide one. Whether the ratio should be wide, narrow or intermediate to effect a given end is shown in the table of feeding standards on page 184.

The great value of the nutritive ratio to the practical feeder lies in the fact that it enables him to understand the value of the food stuffs which he may have on hand to effect a given end. The nutritive ratio in itself would not tell him this, but when taken in conjunction with the facts given in correct feeding standards it does, as is shown on page 182. Similarly it serves as a guide to him in compounding food stuffs for feeding, that is, in determining the approximate proportions in which they shall be fed.

Table II, given below, states in pounds the dry matter, the digestible food ingredients and the fuel value contained in 100 pounds of the feeding stuff submitted. The fuel value, that is the value of the food to produce heat for the body and energy for work is stated in calories. It is taken from Farmer's Bulletin No 22, U. S. Department of Agriculture:—

Table II.

GIVES THE DRY MATTER AND DIGESTIBLE FOOD INGREDIENTS IN 100 POUNDS OF FEEDING STUFFS.

Feeding stuff	Total dry matter lbs	Protein lbs	Carbohydrates lbs	Fat lbs	Fuel value cal'ies
Green fodder:					
Corn fodder (average of all varieties)	20.7	1.10	12.08	0.37	26,076
Kafir corn fodder	27.0	0.87	13.80	0.43	29,101
Rye fodder	23.4	2.05	14.11	0.44	31,914
Oat fodder	37.8	2.44	17.99	0.97	42,093
Redtop, in bloom	34.7	2.06	21.24	0.58	45,785
Orchard grass, in bloom	27.0	1.91	15.91	0.58	35,593
Meadow fescue, in bloom	30.1	1.49	16.78	0.42	35,755
Timothy, at different stages	38.4	2.01	21.22	0.64	45,909
Kentucky blue grass	34.9	2.66	17.78	0.69	40,930
Hungarian grass	28.9	1.92	15.63	0.36	34,162
Red clover, at different stages	29.2	3.07	14.82	0.69	36,187
Crimson clover	19.3	2.16	9.31	0.44	23,191
Alfalfa, at different stages	28.2	3.89	11.20	0.41	29,798
Cowpea	16.4	1.68	8.08	0.25	19.209
Soy bean	28.5	2.79	11.82	0.63	29,833
Rape	14.3	2.16	8.65	0.32	21,457
Corn silage (recent analyses)	25.6	1.21	14.56	0.88	33,046
Corn fodder, field cured	57.8	2.34	32.34	1.15	69.358
Corn stover, field cured	59.5	1.98	33.16	0.57	67,766
Kafir corn stover, field cured	80.8	1.82	41.42	0.98	84,562
Hay from—					
Barley	89.4	5.11	35.94	1.55	82,894
Oats	84.0	4.07	33.35	1.67	76,649
Orchard grass	90.1	4.78	41.99	1.40	92,900
Redtop	91.1	4.82	46.83	0.95	100,078
Timothy (all analyses)	86.8	2.89	43.72	1.43	92,729
Kentucky blue grass	78.8	4.76	37.46	1.99	86,927
Hungarian grass	92.3	4.50	51.67	1.34	110,131
Meadow fescue	80.0	4.20	43.34	1.73	95,725
Mixed grasses	87.1	4.22	43.26	1.33	93,925
Rowen (mixed)	83.4	7.19	41.20	1.43	96,040
Mixed grasses and clover	87.1	6.16	42.71	1.46	97,059
Red clover	84.7	7.38	38.15	1.81	92,324
Alsike clover	90.3	8.15	41.70	1.36	98,460
White clover	90.3	11.46	41.82	1.48	105,346
Crimson clover	91.4	10.49	38.13	1.29	95.877
Alfalfa	91.6	10.58	37.33	1.38	94.936
Cowpea	89.3	10.79	38.40	1.51	97,865
Soy bean	88.7	10.78	38.72	1.54	98,569
Wheat straw	90.4	0.37	36.30	0.40	69,894
Rye straw	92.9	0.63	40.58	0.38	78,254
Oat straw	90.8	1.20	38.64	0.76	77.310
Soy bean straw	89.9	2.30	39.98	1.03	82,987
Roots and tubers:					
Potatoes	21.1	1.36	16.43	—	33,089
Beets	13.0	1.21	8.84	0.05	18,904
Mangel-wurzels	9.1	1.03	5.65	0.11	12,889
Turnips	9.5	0.81	6.46	0.11	13,986
Rutabagas	11.4	0.88	7.74	0.11	16,497
Carrots	11.4	0.81	7.83	0.22	16,999

TABLE II—*Continued*

Feeding stuf	Total dry matter lbs	Pro-tein lbs	Carbo-hydrates lbs	Fat lbs	Fuel value cal'ies
Grains and other seeds:					
Corn (average of dent and flint)	81.1	7.14	66.12	4.97	157,237
Kafir corn	87.5	5.78	53.58	1.33	116,022
Barley	89.1	8.69	64.83	1.60	143,499
Oats	89.0	9.25	48.34	4.18	124,757
Rye	88.4	9.12	69.73	1.36	152,400
Wheat (all varieties)	89.5	10.23	69.21	1.68	154,848
Cotton seed (whole)	89.7	11.08	33.13	18.44	160,047
Mill products:					
Corn meal	85.0	6.26	65.26	3.50	147,797
Corn-and-cob meal	84.9	4.76	60.06	2.94	132,972
Oatmeal	92.1	11.53	52.06	5.93	143,302
Barley meal	88.1	7.36	62.88	1.96	138,918
Ground corn and oats, equal parts	88.1	7.01	61.20	3.87	143,202
Pea meal	89.5	16.77	51.78	0.65	130,246
Waste products:					
Gluten meal—					
Buffalo	91.8	21.56	43.02	11.87	170,210
Chicago	90.5	33.09	39.96	4.75	155,918
Hammond	91.9	24.90	45.72	10.16	174,228
King	92.8	30.10	35.10	15.67	187,399
Cream gluten (recent analyses)	90.4	30.45	45.36	2.47	151,429
Gluten feed (recent analyses)	91.9	19.95	54.22	5.35	160,533
Buffalo (recent analyses)	91.0	22.88	51.71	2.89	150,933
Rockford (Diamond)	91.3	20.38	54.71	3.82	155,788
Hominy chops	88.9	8.43	61.01	7.06	158,952
Malt sprouts	89.8	18.72	43.50	1.16	120,624
Brewers' grains (wet)	24.3	4.00	9.37	1.38	30,692
Brewers' grains (dried)	92.0	19.04	31.79	6.03	119,990
Distillery grains (dried), principally corn	93.0	21.93	38.09	10.83	157,340
Distillery grains (dried), principally rye	93.2	10.38	42.48	6.38	125,243
Atlas gluten feed (distillery by-product).	92.6	23.33	35.64	11.88	159,818
Rye bran	88.2	11.47	52.40	1.79	126,352
Wheat bran, all analyses	88.5	12.01	41.23	2.87	111,138
Wheat bran, (all analyses)	88.5	12.01	41.23	2.87	111,138
Wheat middlings	84.0	12.79	53.15	3.40	136,996
Wheat shorts	88.2	12.22	49.98	3.83	131,855
Buckwheat bran	88.5	19.29	31.65	4.56	113,992
Buckwheat middlings	88.2	22.34	36.14	6.21	134,979
Cottonseed feed	92.0	9.65	38.57	3.37	103,911
Cottonseed meal	91.8	37.01	16.52	12.58	152,653
Cottonseed hulls	88.9	1.05	32.21	1.89	69,839
Linseed meal (old process)	90.8	28.76	32.81	7.06	144,313
Linseed meal (new process)	90.1	30.59	38.72	2.90	141,155
Sugar beet pulp (fresh)	10.1	0.63	7.12	—	14,415
Sugar beet pulp (dry)	93.6	6.80	65.40	—	134,459
Milk and its by-products:					
Whole milk	12.8	3.38	4.80	3.70	30,829
Skim milk, cream raised by setting	9.6	3.10	4.61	0.90	18,139
Skim milk, cream raised by separator.	9.4	3.01	5.10	0.30	16,351
Buttermilk	9.0	2.82	4.70	0.50	16,097
Whey	6.2	0.56	5.00	0.10	10,764

Feeding standard.—A feeding standard is a statement of the proportionate amounts of digestible nitrogenous and non-nitrogenous substance which experience has shown to be best suited to effect a given purpose in feeding. The purposes sought are such as maintenance or the production of flesh, of fat, of milk or of work. For the sake of precision it is usual to state these amounts as proportions or ratios, and when so expressed they are spoken of as the nutritive ratio resulting from the foods used in the feeding standards. A feeding standard differs from a nutritive ratio in giving the proportionate amounts of the digestible food factors found in the foods selected from which to form the ration, which experience has shown to be best suited to the purpose, whereas the nutritive ratio is simply a statement of the relation which these bear to one another. The first relates to foods and their chemical constituents, whereas the latter relates to the quantitative relation which these bear to one another.

The following is an example of a feeding standard that has been found suitable for the sufficient maintenance of cattle at rest, that is, cattle neither doing work nor laying on flesh or fat. The amounts are calculated per day and per 1000 pounds live weight.

Digestible nitrogenous substance,	0.7	pounds
" carbohydrates,	8.25	"
" fat,	0.15	"
Total nutritive substance,	9.10	"
" " carbohydrates and fat	8.4	"
Nutritive ratio,	1:12	
Total organic dry matter required,	17.5	"

In regard to the above it will be noticed: (1) That the ratio is a wide one and for the reason that the animal is at rest. Had the same animal been producing, the ratio would have to be narrowed, that is, it would have to contain a much larger proportion of nitrogenous substance, and the total amount of nutritive dry substance required would have to be greater. (2) That the standard supposes a moderately warm stable. Exposure to cold would call for the use of more carbohydrates as fuel food. (3) That the total amount of dry matter required by the standard should be bulky, which means that it may contain a considerable proportion of crude fibre. (4) That the quantities of the food factors fed are calculated for an animal of 1000 pounds weight, which implies that with variation in the weight of the animals, the quantities fed would vary, but not necessarily in exact proportion to the variations in weight, since smaller animals require in proportion more food than large ones owing to the greater proportionate loss of heat in them. (5) That if the animals were being fattened, the proportion of digestible fat in the food should be increased, but not to the extent of disturbing digestion.

The explanation now follows of how such a ration may be compounded. Being a wide one it will be low in protein and must also be bulky. Such a ration is likely to result from straw alone or from straw and some hay. Since it is to be fed to animals at rest, it is important that it shall be inexpensive and, therefore, that the proportion of straw fed shall not be large. Suppose that the feeder has both. He knows that he requires about 17.5 pounds of total dry organic matter (see p. 181). By consulting the table of feeding stuffs on page 175 a little calculation will show him that about 21 or 22 pounds of these feeding stuffs will give him approximately that amount if he uses about twice as much straw as hay. This he ought to do to make the ration inexpensive.

He tries, say 15 pounds of oat straw and 7 pounds of clover hay and the problem works out as follows:

15 pounds of oat straw would yield
15x90.8-100 pounds of dry matter or 13.620 pounds
7 pounds of clover hay would yield
7x78.2-100 pounds of dry matter or, 5.474 "

Total dry matter in the ration,	19.094	"
Again:		
15 pounds of oat straw would yield 15x4-100x30-100 of digestible nitrogenous substances or,	0.1800	"
7 pounds of clover hay would yield 7x12.4-100x62-100 of digestible nitrogenous substance or,	0.53816	"
Total amount of digestible nitrogenous substance,	0.71816	"
Similarly, the 15 pounds of oat straw will yield:		
Digestible fat .11385x2¼	0.25616	"
Digestible carbohydrates other than fibre,	2.79840	"
Digestible fibre,	2.99700	"
Total amount of digestible non-nitrogenous substance in the straw,	6.05156	"
And the 7 pounds of clover hay will yield:		
Digestible fat, .19530x2¼,	0.43942	"
Digestible carbohydrates other than fibre,	1.63254	"
Digestible fibre,	0.75117	"
Total amount of digestible non-nitrogenous substance in the hay.	2.82313	"

Therefore, the total amount of the digestible non-nitrogenous substance in the ration is 8.87469 pounds and the ratio of digestible nitrogenous substance to digestible non-nitrogenous substance in the ration is as 0.71816 to 8.87469 or 1 : 12.3. The ratio thus obtained is a little too wide and may be narrowed by reducing somewhat the amount of straw fed which would also make it conform more nearly to the total amount of dry matter required in such a ration.

Feeding standards.—A table of feeding standards is simply a collection of feeding standards stated in a regular and concise order. It usually relates to the feeding of various classes of animals at different ages and from which different kinds of performance are required. Although the form of expression in those standards varies, they usually contain the following:

1. The total dry organic substance,

2. The total digestible nitrogenous substance,

3. The total digestible non-nitrogenous substance which includes,

(a) The total digestible carbohydrates including fibre; and,

(b) The total digestible fat.

4. The total nutritive substance, and,

5. The nutritive ratio resulting.

The following table of feeding standards is taken from that portion of "First Principles of Agriculture" credited to the author and published in 1891. It is virtually identical with the standard given by Armsby in his book "Cattle Feeding."

Table III.

GIVING FEEDING STANDARDS.

(Calculated per day and per 1000 pounds live weight.)

			Non-nitrogenous substance			
	Total dry substance (organic)	Total digestible nitrogenous substance (albuminoids)	Total digestible carbohydrates including fibre	Digestible fat	Total nutritive substance	Nutritive ratio
	lbs	lbs	lbs	lbs	lbs	
1, Cattle, at rest in stall	17.5	0.7	8.25	0.15	9.1	1:12
2, Sheep, producing wool (coarse wool breeds)	20.0	1.2	10.6	0.2	12.0	1: 9
Sheep, producing wool (fine wool breeds)	22.5	1.5	11.75	0.25	13.5	1: 8
3, Oxen, moderately worked	24.0	1.6	11.7	0.3	13.6	1: 7.5
Oxen, heavily worked	26.0	2.4	13.9	0.5	16.8	1: 6
4, Horses, moderately worked	22.5	1.8	12.0	0.6	14.4	1: 7
Horses heavily worked	25.5	2.8	14.6	0.8	18.2	1: 5.5
5, Milch cows	24.0	2.5	13.1	0.4	16.0	1: 5 4
6, Cattle, fattening (1st period)	27.0	2.5	15.75	0.5	18.75	1: 6.5
Cattle, fattening, (2d period)	26.0	3.0	15.8	0.7	19.5	1: 5.5
Cattle, fattening (3d period)	25.0	2.7	15.6	0.6	18.9	1: 6
7, Sheep, fattening (1st period)	26	3.0	16.0	0.5	19.5	1: 5.5
Sheep, fattening (2d period)	25	3.5	15.15	0.6	19.25	1: 4.5

TABLE III—*Continued*

	Total dry substance (organic)	Total digestible nitrogenous substance (albuminoids)	Non-nitrogenous substance: Total digestible carbohydrates including fibre	Non-nitrogenous substance: Digestible fat	Total nutritive substance	Nutritive ratio
	lbs	lbs	lbs	lbs	lbs	
8, Swine, fattening (1st period)....	36.0	5.0	27.5		32.5	1: 5.5
Swine, fattening (2d period)....	31.0	4.0	24.0		28.0	1: 6
Swine, fattening (3d period)....	23.5	2.7	17.55		20.25	1: 6.5
9, Cattle growing:						
Age in months — Average live wt per head						
2- 3 — 165 lbs	23.0	4.0	16.8	2.0	22.8	1: 4.7
3- 6 — 325 lbs	23.4	3.2	15.0	1.0	19.2	1: 5
6-12 — 550 lbs	24.0	2.5	14.4	0.6	17.5	1: 6
12-18 — 750 lbs	24.0	2.0	13.6	0.4	16.0	1: 7
18-24 — 925 lbs	24.0	1.6	12.5	0.3	14.4	1: 8
10, Sheep growing:						
Age in months — Average live wt per head						
5- 6 — 62 lbs	28.0	3.2	16.8	0.8	20.8	1: 5.5
6- 8 — 74 lbs	25.0	2.7	14.52	0.6	17.82	1: 5.6
8-11 — 83 lbs	23.0	2.1	12.1	0.5	14.7	1: 6
11-15 — 91 lbs	22.5	1.7	11.5	0.4	13.6	1: 7
15-20 — 95 lbs	22.0	1.4	10.9	0.3	12.6	1: 8
11, Swine, growing and fattening:						
Age in months — Average live wt per head						
2- 3 — 50 lbs	42.0	7.5	30.0		37.5	1: 4
3- 5 — 110 lbs	34.0	5.0	25.0		30.0	1: 5
5- 6 — 137 lbs	31.5	4.3	23.65		27.95	1: 5.5
6- 8 — 187 lbs	27.0	3.4	20.4		23.8	1: 6
8-12 — 275 lbs	21.0	2.5	16.2		18.75	1: 6.5

Note—The weights given above represent German pounds, each of which is equal to 1 1-10 pounds avoirdupois. Practically this fact is of but little importance since the weights of the animals and of the foods given are relative.

A careful study of the table of feeding standards will abundantly repay the labor thus expended. The truths which it teaches with reference to practical feeding are many and far-reaching. Prominent among them are the following:

1. That for the maintenance of animals at rest, the nutritive ratios are the widest. For any kind of production, animals need more food and of a more nitrogenous character. The additional quantity of food required is principally

for the production of heat, and the additional nitrogenous food for the production of muscular tissue or of muscular exertion.

2. From an examination of 9, 10, and 11 in the table, it will be noticed that for all growing animals the nutritive ratios are narrow and that the younger the animal is, the narrower is the ratio, for the reason that for the development of all the important parts of the animal, nitrogenous food is absolutely essential and in sufficient supply to secure the necessary development needed above what will be oxidized and excreted.

3. While for animals at rest but a small amount of fat is required, it must be increased very considerably for animals working or fattening, for the reason in the one case that heat is required which the fat readily supplies and in the other that fat in the food conduces both directly and indirectly to the formation of body fat.

4. An examination of the total nutritive substance as given in the table which appertains to the growing of cattle, sheep and swine respectively, will show that the total nutritive substance set down as being required for each age given per 1000 pounds live weight, decreases relatively more or less rapidly with advancing age in the animal. But with it the relative increase made decreases even more rapidly (see p. 371). This indicates the great importance of securing, during the whole time of the animal's development, the largest increase consistent with economy.

5. Cattle that are reduced in flesh and fat cannot at once be quickly fattened as before quick fattening can follow, the animals to be fattened must possess a certain proportion of both organized and circulatory protein before they are capable of rapidly storing up the protein and fat of the food as new fat (see p. 377).

6. The proportion of fat and also the proportion of the same in the standard ration for milch cows is less than in the rations for fattening. Since the fat of the ration does not increase the percentage of fat in the milk, but it does

slightly increase the quantity of milk by protecting some of the nitrogenous substance of the food from oxidation and increasing the amount available for the formation of cells in the milk glands.

7. The nutritive ratio for the food of milch cows is comparatively narrow. The explanation is first, that protein is necessary for the production of dry substance in the milk; and second, that within certain limits the percentage of the dry substance will be increased with an increase of the nitrogenous substance in the food.

8. Sheep require relatively more fodder than larger animals and fodder with a relatively narrower nutritive ratio, both for maintenance at rest and in fattening. They can bear a more concentrated food than cattle and the food should be less watery. For the production of wool only, it is only necessary to keep the animals in good condition, hence an excess of nitrogenous food would be waste when wool is the sole or even principal object sought.

9. Swine eat much more food relatively than other animals, especially during the early stages of growth and fattening, and they increase in weight correspondingly. But in both respects their ability to increase in relative weight diminishes with advancing age and with advancement in the fattening period.

10. Horses that work severely call for not only a proportionate increase in the amount of the food, but they also require food with a greater proportion of nitrogenous constituents.

Notwithstanding the valuable assistance which these tables render to the feeder in choosing and balancing rations suitable to the needs of the animals fed, the fact remains, that rations balanced from the standpoint of chemical analysis are only to be considered as approximate rather than as absolute guides. The following influences among others may lead to variations in the results from feeding rations so balanced: (1) The inherent and cultivated appetites of animals to take the same food vary greatly and these variations produce corresponding variations in the results from feeding the same foods. (2) The inherent power of animals of the same age and class to digest certain foods also varies greatly, and with these variations the results obtained will correspondingly vary. (3) Foods vary in their digestibility with variations in the soils on which they grew, and with the mechanical and chemical condition of the same, also with the degree of the development and maturity, hence the constituents of these will not be in strict accord with the chemical analyses given in feeding standards. (4) Some foods have a physiological influence which is favorable or adverse to digestion, and this influence will lead to even important variations from feeding rations in equal chemical balance. (5) Adaptation or the want of this in the relative proportion of bulky food and concentrates fed, will have an important bearing on the results obtained from feeding them. And (6) the degree of succulence in the ration has also a modifying influence.

ART III.

The more important of the foods grown in the United States and Canada are discussed in Part III; also their preparation for feeding. The discussion of the various subjects is in the following order: Chapter XI discusses food from cured fodders; Chapter XII, food from cereals and other seeds; Chapter XIII, food from by-products; Chapter XIV, food from pastures; and Chapter XV, food from field roots and tubers. Chapter XVI dwells briefly on preparing foods for feeding.

CRESCEUS, THE KING OF TROTTERS, RECORD 2:02¼

[By courtesy of the owner, M. W. Savage, Minneapolis, Minn.]

CHAPTER XI.

FOOD FROM CURED FODDERS.

The term fodders, as used in this chapter, means bulky foods such as hay, corn and sorghum stalks, also straw of the various small cereals. The necessity for feeding cured fodders is usually proportionate to the length of the winter, but under no conditions can their use be entirely dispensed with. Cured fodders only are discussed in Chapter XI. Fodders are also frequently fed in the green form. Those who desire further information in regard to feeding them thus are referred to the book "Soiling Crops and the Silo," by the author. The leguminous fodders discussed are: (1) Clover hay; (2) alfalfa hay; (3) cowpea hay; (4) hay from vetches, and (5) bean hay. Those derived from the grasses proper are: (1) Timothy hay and (2) hay from grasses other than timothy. Those derived from small grain bearing plants are: (1) Hay from the small cereals, (2) hay from cereals mixed and (3) millet hay. Those derived from corn and the sorghums are: (1) Corn fodder; (2) sorghum fodder and (3) non-saccharine sorghum fodder. Lastly, the discussion of straw as fodder includes straw furnished by all the small cereals.

Clover hay.—In one or another of its varieties, clover may be grown with more or less success in nearly all the arable areas of the United States and Canada, but it has higher adaptation relatively to conditions North, rather than South. Its distribution is wider and much more general than that of alfalfa since it may be grown on a greater variety of soils. It may be designated the standard fodder crop of the farms of the United States, and also of much of Canada, but it is not probable that it will ever become greatly popular when fed away from the farm. This is owing first, to the extent to which the leaves are lost while it is being handled in transportation; second, to the dust it frequently contains, the outcome of curing too little or too much before it is stored, and third, to the fact that it is less satisfactory than timothy on the whole as a fodder for horses.

The varieties of clover chiefly grown differ from each other in feeding value, but the elements of difference are physical rather than chemical. The common red, the standard clover grown, is of medium fineness in both the cuttings, which are commonly obtained the same season. The mammoth variety has stems so coarse that the waste in feeding may be considerable. The alsike, of fine growth, is usually fed with little waste. White clover with its small stems and leaves adds comparatively little to the bulk of the ordinary meadow. Crimson clover has a relatively large proportion of stem and the stems soon become woody, hence, as a hay, it is not so popular as the medium red or the alsike. Moreover, the stems are covered with hairs, and in these, on hay made from clover well advanced toward maturity before cutting, the danger is present, that when fed to horses, the hairs will gather into balls in the digestive tract and so lead to impaction. Japan clover, used for hay to some extent in the South, has proved about equal to Bermuda hay as food for cows. It would probably be correct to say, that clover provides more hay for live stock, and especially for cattle and sheep, than all other legumes taken together. Its preeminence in this respect is owing to the wide range in its distribution, its high palatability, and the richness of its nutrients.

For cattle, clover hay is excellently adapted to their needs owing to the relish with which it is eaten and to the equilibrium in its nutrients. It is virtually in itself a balanced food for them, especially for making growth and producing milk, but, owing to its bulkiness, concentrates are frequently fed along with it for making quick growth and are commonly always fed along with it when seeking abundant milk production or rapid fattening. No better fodder can be given to calves, when the clover has been cut while young and tender. So excellent is it for such feeding that, where practicable, a supply of it should be specially stored for such feeding by those who need it. Like alfalfa it has high adaptation for being fed along with corn in fattening cattle. Since clover, however, is not quite so rich in protein as alfalfa, some concentrate rich in protein should be added, though in limited quantity. Oil cake, gluten meal or cottonseed meal are very suitable. When it forms the sole fodder ration for cows in milk, as much as half the concentrate fed may be corn, but in proportion as corn fodder or corn stover is substituted for clover, the proportion of the corn fed should be decreased.

For sheep, clover of fine growth and well harvested is particularly excellent. Its value for such feeding is lessened in proportion as it is coarse, over ripe when cut or over dried when cured. For breeding ewes, good clover hay alone may furnish a sufficient ration in itself until the lambing season. When it forms the sole fodder part of the ration, it is not necessary to add much protein to corn when fed as the concentrate, but 5 to 10 per cent of such food as oil cake will prove helpful.

In feeding swine, especially in winter, clover nay may be made to serve a useful purpose; first, as a source of protein and second, to give distension to the digestive organs. It is particularly valuable in feeding brood sows to which such carbonaceous foods as corn and rye are being fed. It is frequently fed simply as hay, but the ration is improved by chaffing the hay, adding the meal and steaming the mixture. Such food, however, should not be fed to swine being fattened.

For horses, clover has been assigned a lower place than is meet for such a fodder. This is owing chiefly to the dust so frequently found in it, as the result of over or of under-curing at the time of storing. This dust, penetrating the lungs of horses to which such hay is fed for a prolonged period, is much liable to produce heaves. It is also claimed and probably with truth, that working horses fed on it are liable to sweat more than horses fed timothy or native hay. Nevertheless, it furnishes fodder quite suitable for foals and brood mares when it is of good quality. The prejudice to feeding well made hay composed of timothy with a goodly sprinkling of clover in it, is not well founded, as the clover really adds to the feeding value of the hay.

Alfalfa hay is the principal reliance for hay in all the mountain states of the West. In the states of the Central West, between the Mississippi and the semi-arid region, it is also extensively grown for fodder, and in sections of various other states, its growth is extending more or less rapidly. As hay it is usually fed in the uncut form, but when run through a cutting box and mixed with cut straw, it insures a much larger consumption of the latter. Recently a preparation has been made from it known as alfalmo which consists of alfalfa hay, fine in character, cut early, cured in good form and ground more or less finely. It is sometimes fed to young calves when started on fodder. The value of alfalfa hay is largely dependent on the stage of growth at which it is cut, and on the nature of the curing. Alfalfa cut, when, say one-fifth of the blossoms have appeared and cured without loss of leaves or exposure to rain, may be fully 50 per cent more valuable than alfalfa cured under opposite conditions. When the conditions of growing and curing are correct, alfalfa is somewhat more valuable as a fodder than the clovers but if the stems have become woody before it is cut, and if in addition many of the leaves are lost in the curing, its feeding value may be much less than that of well made clover hay.

For cattle, alfalfa hay properly made is unexcelled. Cattle are very fond of this fodder. It is easily masticated and digested, is fed with but little waste, and is very rich in protein. Hay made from it, of thick growth and cut early, makes unexcelled fodder for calves. Young cattle will come through the winter in good form on alfalfa alone, and will also make a good growth. It has special adaptation for being fed to cattle that are being fattened along with carbonaceous food such as corn. When corn is virtually the exclusive grain ration fed, alfalfa is so far superior as roughage to corn or sorghum, that feeding it should effect a saving of not less than 33 per cent in the grain fed. Its large protein content makes it highly suitable for pregnant cows or cows in milk. When fed to the latter as the sole fodder, fully 50 per cent of the grain fed may be corn.

For sheep, it is quite as valuable as for cattle. Sheep grown chiefly upon it like cattle similarly grown, attain to a relatively large size. Breeding ewes may be successfully wintered on alfalfa of good quality without grain, up to the season for lambing. As when fattening cattle, it should effect a saving of fully 33 per cent in the grain ration when fed to sheep.

As swine fodder, when of good quality, alfalfa hay is frequently fed to brood sows in the winter and also to other swine, but is relatively more suitable for the former because of its bulkiness. In some instances it is fed as hay, in others in the cut form and in admixture with meal, steamed or not steamed, but preferably steamed where the cost involved is not excessive. The leaves are much prized for such feeding when they accumulate sufficiently for such a use. In corn and alfalfa growing areas, alfalfa hay may be made to furnish a very considerable proportion of the ration for swine in winter.

For horses.—In some sections, as in areas where alfalfa grows very abundantly and the grasses grow less abundantly, alfalfa furnishes the chief fodder fed to horses. It has been found very suitable for colts, horses that are idle and also for brood mares both when carrying and nursing their foals. As it is more or less laxative when fed to horses driven faster than a walk, it produces too much looseness in the bowels, especially at first. Alfalfa hay and corn furnish a more suitable food for horses than timothy and corn, viewed from the standpoint of nutrients, since it is in better balance. Tests have shown that horses will maintain flesh better on alfalfa hay than on timothy hay. Like clover, unless due care is taken in curing it, the hay is much liable to be dusty; this lowers its value much as a food for horses which soon become very fond of it and may eat it to excess.

Cowpea hay, not required in the North because of the large number of other hay plants that may be grown, is very commonly made in nearly all parts of the South. No other plant in the South of equal value for hay is grown over so wide an area. In many of its varieties it may be grown for hay after the removal of a crop grown previously the same season. It furnishes hay of high quality viewed from the standpoints of palatability and nutrition. When well cured, live stock relish it quite as much as, or even more than alfalfa, and in nutrients it is very similar. The yields average about two tons an acre and run all the way from one-half ton to five tons. It has been claimed that two tons of cowpea hay an acre will furnish in total digestible nutrients more than a similar area yielding 40 bushels of oats or 30 bushels of corn. But the curing of cowpea hay is somewhat difficult, and in some varieties it is not easily handled because of the running character of the vines.

By cattle, cowpea hay is not only relished, but for growing cattle, no fodder in the South is superior to it. In fattening cattle it feeds well along with corn stover or corn fodder, but its highest use in the South as food for stock, is found in producing milk. For this purpose it has proved fully equal to alfalfa and somewhat superior to clover hay and has been claimed to be even superior to corn silage. The value of the hay for such feeding is much influenced by the stage of maturity at which the crop is cut. Hay with grain well advanced toward maturity is more valuable for fattening cattle than hay cut during the period even of medium bloom and it is much more easily cured, but it may lose something in palatability. For the silo, they should be reasonably well advanced before being harvested.

In feeding sheep and lambs, cowpea hay, though not much used because of the relatively small amount of such feeding done in the South, has high adaptation. Of course, hay produced by the finer growing varieties is more valuable than what is bulky. What is said about the value of vetch hay for fattening sheep (see p. 198) will apply about equally to cowpea hay. If additional grain were added, corn, barley, rye and even oats would prove very suitable. For milk production, cowpea hay cut, say when the plants are in the late stages of bloom, should answer well for ewes nursing lambs.

For swine, cowpea hay is not well adapted, owing to the relatively small amount of the vine consumed, except when the crop has been cut at an early stage of growth. But when it has been harvested at maturity and the fodder much injured by rain, it may be in order to feed the loose sheaves or bundles to swine that will search out and consume the peas.

For horses.—This hay is considerably prized in the South, not only for feeding brood mares, weanling foals and indeed all young horses of the draught types and also of the standard bred classes. Such food adds to the size. For working horses and mules it serves about the same purposes as alfalfa (see p. 195) and answers well for being fed with a grain ration consisting of corn and oats. As with vetch hay, more or less dust is likely to be present. This, of course, is so far objectionable.

Hay from vetches.—Vetches are frequently grown for hay, but more commonly in conjunction with one of the small cereals in order to furnish them the support necessary to prevent them from falling on the ground during the later stages of growth. For this purpose rye is sometimes sown, but more commonly the cereal of support is wheat or oats. Hay from these is more relished than hay from rye. Vetch hay is thus grown from the winter and spring varieties of the common vetch and also from the sand or hairy vetch. Such hay is grown to a considerable extent in the Pacific states, and to a less extent in the South. In the former large yields of hay are obtained especially from the common vetch which is highly nutritious and is much relished by stock. The feeding value is much influenced by the stage of maturity at which it is cut. The more grain the hay possesses and the more mature it is up to the limit of not lessening the palatability of the plant, the more valuable is it for fodder.

By cattle, vetch hay is much relished. Grown thickly and cut when the first pods have formed, it makes a most excellent fodder for young calves. It is probably more valuable for older cattle when more mature. When fed to beef cattle and also to dairy cattle, the most suitable vetch hay is obtained when the grain is a little short of maturity. Such hay is especially valuable for producing milk. Vetch hay made from vetches and oats grown together is also almost equally good for producing milk.

For sheep, it is admirably adapted. The growth is finer than that of the pea, hence there is even less waste in feeding vetch hay to sheep than in feeding pea hay. Vetch hay cut at any stage between that of full bloom and the filling of the pods makes admirable hay for sheep being carried through the winter and especially for ewes nursing lambs. Such hay will virtually suffice for nursing ewes without other food, and when the hay is almost mature before it is cut, sheep may be fattened by feeding vetch hay alone when it can be spared for such a use. As with peas, exposure to rain while being cured speedily reduces the feeding value.

For swine, vetch hay pure and simple is virtually of little value, except when cut not later than the stage of early bloom. But when fed in the mature form, swine will, of course, find food in the grain to the extent even of fattening upon it, as when they are allowed to glean amid the mature though unharvested crop. But this makes no use of the vines for food, which would be a waste that in ordinary feeding could not be defended. However, should the harvested crop be greatly injured by rain, it would be justifiable to feed vetches to swine in the loose sheaves or bundles in which they are usually harvested, except when the straw is wanted for bedding.

For horses, vetch hay stands much on a par with clover hay as a food. It is richer in nutrients than clover and horses are fond of it, but like clover it is not easily cured so as to be free from dust. When grown in admixture, as with wheat or oats, the combination makes excellent fodder for horses when cut somewhat short of maturity.

Bean hay.—Hay is seldom or never made from the common field bean (*Faba vulgaris*), but it is sometimes made from the soy bean (*Glycine hispida*), the velvet bean (*Mucuna utilis*), and the horse bean, a variety probably of the species *Taba vulgaris*. It is more frequently made from the soy bean than from the other plants of the bean family, but soy beans also are more commonly grown to provide grain rather than hay. Soy bean hay which yields on an average about two tons an acre is much relished by stock when cut and cured so as to retain the bulk of the leaves. Owing to the intertwining nature of the vines, the harvesting of velvet beans is not easy nor is the crop easily cured, hence it does not stand as high, relatively, in the popular estimate as it otherwise would. But its hay is said to be much relished by stock and in some instances the cutting may be so regulated as to give two of these crops a year.

Horse beans are seldom harvested for hay. They are usually grown primarily for the grain and incidentally for the straw. They are slow in curing but may be made into hay should occasion require this. As curing them thus usually calls for considerable work, it is oftentimes considered preferable when the facilities are present, to cure them in the silo along with other feed such as corn.

By cattle, hay made from the crops named is much relished, but it is not commonly fed to them in any considerable quantity nor in prolonged feeding, since in nearly all instances such fodder may be obtained with less labor from other plants that may be grown in the same locality. It is more commonly fed to dairy cows, as the high protein content in each is conducive to free milk production. It is claimed that soy bean hay should be made before the plants approach the maturing period or much of the grain will escape mastication and will not be properly digested.

In sheep feeding, hay from these plants is not much used for the reason just given as to why it is not much used in feeding cattle. But when cut early and well cured, sheep eagerly consume it, especially after they have become accustomed to it. It is particularly useful in feeding ewes nursing lambs and which have not yet been turned out to pasture. When largely made up of coarse stems from which many of the leaves have been lost, the value of the hay for feeding sheep is proportionately lessened.

In feeding swine, bean hay is of but little value, owing to the small quantities of it the animals consume. But, of course, hogs may glean profitably in soy bean and velvet bean fields, when the crops are not to be otherwise harvested. Common field beans and horse beans are too valuable for such feeding. Swine are not so fond of beans in the raw state as they usually are of peas, corn and the small cereal grains.

Horses and mules may be fed bean hay when available. To young horses and brood mares it may be fed with much freedom, when the proportion of grain in the hay is not too large. The horse bean, when fed as hay in the nearly matured form, may be made to furnish a large proportion of the fodder and grain required. The additional grain should be corn when available. What has been said of the horse bean will probably apply also to the soy bean.

Timothy hay.—This crop now grown most extensively in the northern part of the United States, and in nearly all of the arable areas of Canada, stands higher as a fodder for horses than any other plant grown. In states farther south, it is also grown more or less, but in these it is not relied upon to anything like so great an extent in providing fodder for horses. No other kind of hay is so suitable for shipping and none brings so high a price in the average market.

For cattle, timothy does not rank high when fed alone. It is but little ahead of corn or sorghum in its protein content. Usually the market value for timothy unmixed and of good quality, makes it too dear for such feeding. The yield of timothy is also relatively low compared with the fodders just named. Timothy of fine growth, cut early and well cured, may be fed to calves with suitable adjuncts, but when coarse and woody, the results from such feeding will not prove satisfactory. If fed as the exclusive fodder portion to cattle that are being fattened, the concentrate fed along with it should be rich in such protein foods as oil meal, gluten meal, pea meal, cottonseed meal and wheat bran. When fed to cows in milk, even larger proportions of these foods should be fed. When grown on farms for such feeding, it is usually sown in conjunction with clover. The two grow admirably together and furnish a mixed hay well suited to the needs of cattle. The larger the proportion of the clover in such hay, the more valuable it is relatively for cattle and sheep, but the reverse of this is true though with some limitations with reference to horses. (See p. 193).

For sheep, timothy when fed alone, is even more unsuitable than for cattle. This is especially true of timothy that is coarse and overripe, as sheep will not readily eat such hay. Should they be compelled to eat it as the sole fodder ration, they will not maintain good form, unless concentrates rich in protein are fed to them. It is quite admissible, however, to feed mixed timothy and clover to sheep when the crop has been cut at an early stage in the maturity of the timothy.

For swine, timothy hay is quite unsuited. The swine do not care to eat it and it is also ill suited to their digestion. It is questionable if it will pay to feed it to them, even though chaffed and steamed.

For horses, timothy is par excellence the fodder. No fodder grown on the continent will at all compare with it in popularity for this purpose. It occupies the place among horse fodders that oats does among grains. Timothy and oats are the standard and favorite foods for horses wherever they can be grown.

The high estimate thus put upon timothy arises: First, from its freedom from dust; second, from the little loss resulting from handling it; and third, from the fondness which horses show for it. It does not, like clover and alfalfa, produce too much of laxness in the bowels, and it seems to impart and sustain both nerve and staying power akin to the results that come from feeding oats. It has, moreover, peculiar adaptation for being fed to horses that are driven much and fast or worked hard. But mixed timothy and clover has higher adaptation for being fed to foals, young horses, brood mares and horses that are idle because of its higher protein content.

Hay from grasses other than timothy.—Prominent among the grasses other than timothy that are grown in the United States for feeding as hay, are Redtop (*Agrostis vulgaris*), Russian brome (*Bromus inermis*), Orchard grass (*Dactylus glomerata*), Meadow fescue (*Festuca pratensis*), Tall oat grass (*Arrhenatherum avenaceum*), Western rye grass (*Agropyrum tenerum*), Kentucky blue grass (*Poa pratensis*), Canadian blue grass (*Poa compressa*) and in the South Bermuda grass (*Cynodon dactylon*). The wild grasses of the prairie are also an important source of hay in western and northwestern areas. Other grasses, as for instance, Perennial rye grass (*Lolium perenne*), Italian rye grass (*Lolium Italicum*), Texas blue grass (*Poa arichnifera*), Rough stalked meadow grass (*Poa trivialis*), Fowl meadow grass (*Poa serotina*), Rescue grass (*Bromus unioloides*) and Velvet grass (*Holcus lanatus*) are grown more or less largely for fodder, but because of the comparatively limited areas to which their growth is restricted, they will not be discussed here further than to say that being carbonaceous, they should be fed in conjunction with legumes.

Redtop, probably more extensively distributed than any other grass, ranks high as a fodder. It is seldom grown alone to provide fodder in northern areas, save in land that is naturally slough-like in character. It is much grown along with timothy on congenial soils, to increase the total yield. The feeding qualities are much like those of timothy, and alone or in conjunction with timothy, it may be fed in much the same way (see p. 200).

Russian brome grass is popular as a dry fodder in large areas of the northwestern states and in nearly all of the cultivated areas of northwestern Canada. The yields are generally in excess of those obtained from timothy, and the feeding value is by many considered higher, owing to the greater leafiness and superior palatability of Russian brome. It is adapted to about the same uses as timothy (see p. 200), but is not so readily cured, nor is it so good a fodder for shipping, nor in all respects for feeding horses.

Orchard grass has never become nearly so popular as timothy or redtop as a hay crop. This is owing to its coarse growth, to the greater woodiness of the stems, to the short period during which it may be harvested in season, to the greater degree of the injury it takes from rain, and to the less relish which animals have for it. It must not be understood, however, that it will not make good hay if cut and cured properly. It may be fed in substantially the same way as timothy.

Meadow fescue is not grown alone to provide dry fodder over large areas, as it takes longer to form a thick and strong growth than timothy. Nor can it be said that on average soils it produces more abundantly than the standard hay fodder mentioned, although in some of the central western states it has produced more abundantly than timothy. Its feeding value is much the same.

Tall oat grass, more extensively grown in the South and in the central and far western states than elsewhere on this continent, has the merit of growing quickly and vigorously into hay. Its palatability is not so high relatively as that of timothy, owing to a somewhat bitter principle found in the hay, and to a greater extent in the pasture and to the coarseness of stem and leaf. Nor is it so easily cured as timothy, while it takes greater injury from rain. In feeding value it is scarcely equal to timothy, especially for horses, but like timothy it should be fed in conjunction with leguminous foods.

Western rye grass, frequently called slender wheat grass, has special adaptation for the prairies of the West and the Northwest, and more particularly for areas too dry for growing other grasses at their best. It is native to much of the prairie region, and under cultivation will produce large yields of hay. The hay is very easily cured, but it is not so much relished as timothy or Russian brome, owing in part at least to its woody character, but it will furnish hay under cultivation on soils too dry for the growth of other cultivated grasses. Its uses are almost identical with those of timothy (see p. 200).

Kentucky blue grass is not a good grass to furnish fodder. Because of the fine and dwarfish habit of growth, the yields are relatively small and unless cut with much promptness at the proper stage of growth, it becomes so dry and woody as to be little relished. Its habitat will ultimately embrace nearly all the tillable areas of the United States. It is very easily cured and may be fed in about the same way as timothy (see p. 200). It is seldom cut for hay except when it forms a part of another hay crop.

Canadian blue grass, like the Kentucky variety, does not give large yields, but it produces more valuable hay, especially for horses. It has so much of body to it, as it were, that it weighs heavily. When the conditions for growth are not really favorable, this grass may frequently be grown with profit for hay. Like all the grasses, when cured it has highest adaptation for feeding horses, especially when at work.

Bermuda grass is by far the most valuable grass grown in the South. It is, strickly speaking, a summer grass, and one for mild latitudes, as it turns brown with the first frosts of autumn. It will not live in a soil that is penetrated deeply by frost. It will also grow, though by no means equally well, on nearly all the soils of the South. Strickly speaking, it is a pasture grass, but it also makes palatable and nutritious hay, although the yields are not large relatively. The aim should be to feed it in conjunction with such fodder as alfalfa or cowpea hay, or with such a concentrate as cottonseed meal.

Wild prairie hay is largely fed in both the American and Canadian Northwest. Of course it is a gradually diminishing quantity, but for many years it will still continue to be an important source of hay in the areas named. It varies greatly in quality with the grasses which compose it, the soils on which it grows, the stage at which it is cut, and the character of the curing. It usually embraces a number of grasses and other plants, some of which partake of the character of the weeds. On the upland the general character of the growth is fine, but in the sloughs it is usually rank and dense. Harvesting prairie grass is very frequently so long deferred that the value of the hay is lessened although it will bear such treatment better than most grasses. It is also very frequently injured by over exposure in the swath. It is very evident that such hay will vary so much in character that its feeding value cannot be given in any other than a general way. In tests made, upland prairie hay has been found to possess feeding properties about equal to timothy and to be adapted to the same kinds of feeding (see p. 200). The presence of foreign substances will of course reduce the value of such hay in proportion as they are present.

Hay from the small grains.—Hay is sometimes made from the various kinds of small grains grown singly, or in various combinations. When grown singly the hay takes its name from the grain which furnishes it. There is, therefore, rye hay, speltz hay, wheat hay, barley hay, oat hay, pea hay and vetch hay. The oat is more commonly made to furnish hay than any of the small grains . The necessity for growing hay from these sources is based on the needs of the localities where they are thus grown, and on the attendant conditions of soil and climate. Hay from these crops is made in the same way as hay from the grasses. The time of cutting varies with the use that is to be made of it. The aim, however, in cutting it seeks to retain the green color in the hay without sacrificing entirely the grain product. In other words it seeks to cut the crop as soon as the plants are possessed of a maximum of nutrition and before the crop has matured.

Rye hay is probably the least valuable of the kinds of hay made from any of the small cereals. At a very early stage of growth it becomes woody in character and so unprofitable that live stock do not eat it readily unless when chaffed and mixed with other fodders. The matured grain of rye is usually more valuable than the grain and fodder together when harvested short of maturity. Rye hay is less relished by sheep than by other live stock unless it has been cut at or before the early earing stage.

Speltz hay is sometimes made in semi-arid regions where hay from other sources is not easily obtained. That it does not produce high yields of fodder is so far an objection to its use. Care must be taken not to allow it to become so mature that it will get over-woody.

Wheat hay is grown to a considerable extent in certain of the Pacific states and in some of the semi-arid country to provide hay chiefly for horses and more particularly for horses at work. On the bench lands of these states it may usually be harvested and cured in the absence of rain. When cut a little short of maturity it makes excellent hay for horses at work, but for other classes of animals on the farm it is usually too costly for such feeding. In other words, other plants may usually be grown that will furnish hay more cheaply.

Barley hay is frequently grown in the western mountain and Pacific states, and as with wheat, chiefly for the purpose of providing food for horses. For such a use it stands high in favor, especially for horses that are being driven. In regions where alfalfa grows, such hay would be too costly for feeding cattle, sheep or swine. If allowed to become mature before it is cut, the beards will make trouble.

Oat hay is probably grown more than hay from all the other grains combined. In all parts of the United States where oats can be grown, more or less oat hay is also grown. This hay may be fed with profit under certain conditions to all classes of farm animals except swine. It is chiefly grown to provide food for dairy cows and the aim in growing it thus is to furnish fodder and a part of the grain in the same plant, without the necessity for threshing or grinding the grain. Such hay usually ranks next to clover hay as fodder for dairy cows. The crop is usually cut with the binder when the grain is in or nearing the dough stage, tied in small sheaves and cured in the shock. When fed to sheep it should be cut not far beyond the heading out stage.

Pea and vetch hays are not usually grown alone, but rather in combination with some other cereal. For the discussion of growing peas thus see p. 208. For the discussion relating to vetches see p. 208.

Hay from cereals mixed.—Hay is sometimes grown from a mixture of the seed of certain of the cereals. Such fodders are usually more valuable relatively, at least for certain uses, than they would be if grown singly. This arises first, from the finer growth that usually characterizes the hay because of the thicker stand of the plants; second, from the larger yields that result from the thick stand; third, from the variety in the hay which whets the appetite, and fourth, from the better balance given to the fodder when legumes are grown with non-legumes.

These mixtures may be varied indefinitely; the most popular by far are mixtures of oats and peas, oats and vetches, or of the three combined. In other instances wheat, oats, barley and flax are grown together. When legumes are grown with non-legumes, the aim usually is to have not more of the latter in the mixture than will sustain the legumes, but this of course may be varied at the will of the grower. In order to obtain the desired proportions of each plant, the seed must be sown with that end in view, and it may take some time to ascertain how much of each will furnish the best fodder.

Peas and oats grown together furnish excellent fodder when the crop has been kept from lodging. If cut a little underripe the hay is excellent for all kinds of growing stock. But when fed to growing animals it may be necessary to add other fodder as the peas and oats may contain too large a proportion of grain for the needs of the stock. For dairy cows, such food is excellent. It also meets in fine form the needs of sheep. When breeding ewes are fed such fodder usually they do not require any additional grain. This fodder when properly grown may be cut with the binder and fed from the sheaf or it may be cured like hay.

Oats and vetches are grown similarly to oats and peas. The proportions of each that ought to be sown can only be determined by experiment, but the vetch is the more valuable fodder of the two, and should, therefore, furnish the bulk of the fodder. The relatively high cost of the seed is the most serious objection in the way of growing such hay in the meantime. It furnishes a grand fodder for milch cows and ranks even higher as a fodder for sheep. Such hay can be obtained from the common vetch and also from the sand or hairy vetch. The latter cannot be harvested satisfactorily for hay, unless grown with some grain crop owing to the intertwining nature of the vines.

Oat, pea and vetch hay is much relished and when properly grown is of fine growth. Usually the seed of the vetch must be used freely in the mixture or the vetches will be overshadowed by the growth of the other plants. Some variety of oats, short and stiff in the straw, is to be preferred to oats tall and coarse. It is important that the crop shall be prevented from lodging, otherwise its quality will be proportionately lowered.

In wheat, oat, barley and flax hay, the flax is sown to furnish what is the equivalent of oil meal to the fodder. The amount to sow must be determined by the conditions of each locality. The more rank the growth of the other plants in the mixture, the more the amount of the flax required and *vice versa.* Usually from 2 to 4 quarts an acre will suffice. Hay properly made from these grains, much relished by cattle and useful in feeding sheep, is of highest value relatively for horses.

Millet hay.—Millet in all its varieties is more commonly grown as a catch crop in the United States and Canada than as the principal crop of the season. It is peculiarly adapted for being grown thus, owing to the short period it occupies the land. It will usually mature a hay crop in from 60 to 75 days from the date of sowing. It grows best during the warm weather of summer, and it may be successfully grown on any land that will grow good corn. Its value for hay depends much on the season of cutting and also on the method adopted in curing the crop. If cut too early, the hay is lacking in body and yield, and when fed freely tends more or less to induce scouring. If cut too late, it becomes so woody that more or less of the coarser parts will be left uneaten by the stock to which it is fed. Much of the seed will also shatter, and that which does not is so hard that it may cause more or less irritation in the digestive organs. To make hay suitable for feeding to live stock generally, it should be cut when a golden tint begins to show in the heads on looking over the field. The curing should be about the same as would be suitable for curing first class quality of clover hay. When properly cured the hay should be green rather than brown. No class of hay varies more in value because of variations in the modes of making it. When made as outlined, it is an excellent fodder adjunct for cattle, horses and sheep. But, usually, it should form not more than 50 per cent of the fodder fed, for the reason first, that its protein content is not high; and second, that it has not proved entirely satisfactory or safe when fed continuously as the sole fodder ration.

Fed to cattle, the aim should be to alternate the feeding with clover or some other legume. Though not equal to clover or alfalfa as a food for calves, when finely grown and well cured, it may, with much propriety form at least one half the fodder ration. It may also be fed thus to beef cattle, the other fodder in all such instances being leguminous. Cut and cured in good form, it is superior to timothy as a milk producer, but when overripe it is of little value for such feeding and may do harm.

Fed to sheep, it is highly important that it shall be of fine growth. When thus grown and well cured, sheep eat it with avidity, but when coarse, overripe or overcured, it is less valuable than straw of some of the small cereals. Fed to lambs at the Michigan experiment station, it proved less valuable than clover hay and oat straw fed together, the grain fed being corn.

For swine, it has low feeding value. Unless when it contains seed, it has practically no feeding value as the animals will not eat enough of it to make it in any considerable degree even a food of support. But in some instances, they have been carried through the winter by allowing them to eat the heads of matured millet, when other food was not obtainable.

For horses, millet, if well cured, may usually be made to form half the fodder ration, but if fed continuously for any considerable period, serious complications may follow. In the prairie sections of the Northwest where considerable millet is grown for hay, it is claimed that horses have died from the exclusive feeding ot millet hay. Experiments conducted at the North Dakota experiment station apparently justify the following conclusions: (1) That feeding millet increases unduly the action of the kidneys; (2) that it causes a swelling of the joints that leads to lameness, which may, however, disappear when the feeding of millet is discontinued; and (3) that it injures the texture of the bone by rendering it softer and less tenacious.

Corn fodder.—This is an elastic term which may be applied to corn cut at any stage of growth and fed in the green or cured form, with or without the removal of the ears. It thus applies to the crop grown so thickly or cut so early that it has no ears, to the mature crop fed along with the ears which it has borne and also to the crop from which the ears have been removed, but the stalks from which the ears have been taken are usually spoken of as stover. Shock corn means the cured product as fed from the shock or stack and without husking. Snapped corn is a term applied to ears which are pulled from the standing stalks and fed without being husked.

In estimating the value of corn fodder for feeding, the following considerations should be taken into account; viz., (1) The proportion of ear to stalk; (2) the object sought from feeding the corn; (3) the stage of maturity at which the crop is harvested and (4) the time that has elapsed since harvesting the corn. Of well matured corn grown for the ears, it would probably be correct to say that more than half the entire weight of the crop and considerably more than half of the nutrients is in the ear. Consequently when cattle and sheep are being fattened, the greater the proportion of ears to the fodder fed the more suitable is it for such fattening. But, as usually fed, the proportion of the stalks rejected will be greater than from corn grown rather to produce fodder than ears, because of the coarse and harsh character of the former.

When corn is fed simply for maintenance, to promote growth without fattening, or for milk production, the consumption of the entire product will be greater when the fodder has been grown so thickly as to reduce the size of ear and stalk. When thus grown, the total yield to the acre of nutrients will also be greater than if grown to produce the largest amount of ears. Consequently the food value of an acre of corn of the former class, should be greater for such feeding than of the latter class. There is a limit, however, to the extent to which corn should be crowded in growth in order to increase fineness and leafiness with a view to increase palatability in the fodder. Ordinarily that limit is the point at which the yield of total digestible nutrients per acre would be decreased, if thick growth were carried further. Where this point is, cannot be definitely stated, since it will vary with variations in varieties of corn, soils and temperatures. It is possible, however, to grow corn fodder so fine and leafy as to insure its entire consumption when fed.

The stage at which corn should be cut for feeding when cured is greatly important. The increase in weight from the time the corn is fully silked until mature is very great, and the increase in nutrients is much greater. Corn should never be cut to be made into cured fodder or for the silo, until the grain has reached the glazing stage, except when such cutting is necessary to protect the crop from impending frosts. It is even better when the crop passes the glazing stage. Nevertheless, corn that has not passed the milk stage of the grain when it must needs be cut for the reason given, is by no means to be despised for fodder, notwithstanding that pound for pound well matured corn fodder has a higher feeding value.

The maximum of nutrition is in the corn crop when it has matured. When shocked in the field in well put up shocks, the loss from deterioration in feeding value is not great for a time. Soon, however, there is loss though the fodder should not be injured by rain, and this loss increases in an acclerated ratio and with increase in duration subsequently to the time of harvesting. The losses in dry matter and in such substances as protein, sugar and starch are heavy, especially after the winter months, nor will stacking or storing under cover prevent such losses. They are thought to result from chemical changes brought about by fermentations. Add to such loss the incidental losses from fodder exposed and from decrease in palatability, and the feeding value of the crop in time becomes greatly lessened, hence the advisability of feeding the fodder when practicable in the autumn and early winter, reserving the fodder for later feeding.

For feeding calves, corn fodder is suitable when of fine growth, but not so suitable as clover hay or alfalfa. When not too coarse, it furnishes excellent food for young cattle of any age, but it is too low in protein to produce results entirely satisfactory when fed alone. Stover is less suitable for such feeding, being lower in nutrients, but may be so used when shredded.

For cattle that are being fattened, corn fodder is increasingly suitable as the grain which it contains increases. Feeding corn from the shock is regarded as more economical than feeding from the crib, as the labor of husking is saved, more or less of the fodder is consumed, and the tendency to scouring often resulting from the heavy feeding of ear corn is lessened if not entirely prevented. The benefits resulting from feeding snapped corn are somewhat similar though less in degree, as when feeding it the consumption of coarse material is not so great. Fodder corn is fed by strewing it over grass pastures daily, or by feeding in slatted racks in yards or sheds. The distance between the slats should be enough to permit the cattle to insert their heads when feeding. The aim should be when feeding such fodder to have two pastures or two feeding lots, and to allow other cattle to glean after those that are being fattened. When fodder with but few ears or stover is being fed to such cattle, the aim should be to feed it in the shredded form, and to make not less than half the ration clover hay.

For dairy cows in milk, corn fodder furnishes excellent roughage when not too coarse on the stalk. With much advantage it may form 50 per cent or even more of the entire roughage fed, according to the nature of the other fodder used. When possessed of a fair amount of nubbins, it is not necessary to add any more shelled corn. Even mature corn, grown so thickly as to furnish virtually no nubbins has been found excellent for milk production, and also one of the most economical of foods, owing to the ease with which it may usually be grown and to the relatively large yields obtained. Good corn fodder is fully as valuable ton for ton, if not more so, than good timothy. In trials at the Wisconsin station, one ton of corn stover fed to dairy cows was found to be equal in feeding value to three tons of mixed clover and timothy hay. Fully one-third of the stover was left unconsumed. Cows in milk may be fed about 12 pounds of corn fodder per day, and mature cattle that are being wintered a much larger amount.

For sheep, the value of corn fodder depends largely on the character of the growth. For ordinary feeding the fodder should be of fine growth, but some feeders prefer corn with full sized ears when sheep are being fattened. In such instances, a large proportion of the fodder is left unconsumed. Corn stover is less valuable relatively for feeding sheep than for feeding horses and cattle, and largely because of its coarse character. In the shredded form it has not always proved entirely satisfactory as a food for sheep, as they do not consume it with the same relish as the larger animals.

For swine, particularly in some of the sweet varieties, corn fodder apart from the grain and in the cured form, is comparatively valueless. The stalks of the sweet sorts may be made to furnish some food, but not nearly so much as sorghum (see p. 216). Green corn fodder will of course be partially consumed by swine. They will also find succulence in corn ensilage, but no large amount of food apart from the grain.

For horses, fodder corn has a high feeding value. When it is grown so thickly that the ears are half the size or less, it makes excellent fodder for young horses in the growing stage, idle horses and brood mares. It may even form half the fodder ration for horses that are worked moderately. Even the stover, quite suitable for growing colts and idle horses, may sometimes form a part of the ration of working horses. Pound for pound, good stover has been found to have a feeding value about equal to timothy. Shredding stover will usually insure a larger consumption of the fodder by cattle and horses, and the same is true of running it through a cutting box. Feeding tests have shown that an average acre of corn stover well preserved is fully equal in feeding value to an average acre of timothy hay.

Sorghum fodder.—Sorghum has proved valuable as a fodder in regions too dry for the successful growth of corn. But where corn may be profitably grown, it is not probable that it will supplant the former as a fodder plant since it is more delicate than corn when young and it also involves more labor to keep it clean in the early stages of growth. In certain areas of the dry West, it is much used as a fodder plant, but in states further east it is not prized so highly. The feeding value of sorghum, judged from the standpoint of nutrients, is much the same as that of corn with the difference that sorghum has more sugar and less starch. Contrasted with corn fodder, sorghum will in many instances, produce a larger tonnage per acre, is not so easily harmed by exposure when harvested, and is more palatable because of the high sugar content that it contains. But it heats in the stack much more readily than corn, and after the stalks have frozen and thawed out again, the juices still remaining in them become more or less acid to its detriment as a fodder. Its highest feeding value occurs in the period between the maturing of the crop and the advent of hard freezing weather. It may be also made into good ensilage if allowed to become practically mature before putting it into the silo.

By cattle, young and old, sorghum, especially when of fine growth, is much relished, when fed from early maturity until the ground freezes solid. To obtain fine growth, it must be grown thickly in rows not distant, or on the plan followed in growing grain. It is usually fed to cattle by drawing it from the shocks or cocks in the field where it grew and strewing it on a grass pasture. But it may also be fed in mangers or feed boxes in the stables or yards. The aim should be to feed it in conjunction with leguminous hay, because of its highly carbonaceous character. Sorghum bagasse, the substance which remains after the juices have been removed for the production of syrup, has considerable value as a fodder for cattle, should facilities for feeding it be present.

For sheep, sorghum fodder of fine quality, frequently spoken of as sorghum hay, is quite as valuable as in feeding cattle, and it may be fed to them also on the pastures or by strewing it in clean paddocks. But there would be much waste in feeding coarsely grown sorghum to sheep. When the stalks are not too coarse, both sheep and cattle will consume sorghum with but little waste. The waste is usually less than in the case of corn fodder. As with cattle, the aim should be to feed hay of some legume once a day when feeding sorghum hay.

In feeding swine, sorghum fodder has been made to render good service. For such a use, coarse stalks are better than fine. They usually contain more juice relatively and more sugar. When feeding upon them, swine simply extract the juices, leaving the stalks a mass of shreds. When stalks are fed to sheep or cattle so coarse in character that much of the coarser portions are left uneaten, if swine can be given access to the feed yards at suitable seasons, they turn to good account the food thus rejected. Some concentrate rich in protein, as shorts or bran, should accompany such feeding.

For feeding horses, in some areas as in the semi-arid region, sorghum is much used as hay. If in such areas sorghum hay may be made to alternate with alfalfa, the combination is a good one. Where this cannot be done, some such concentrate as wheat bran fed along with the grain would improve the ration. Horses are quite as fond of sorghum as other classes of live stock and because of this, it may be turned to good account in feeding them.

Non-saccharine sorghum fodders.—The chief of the non-saccharine sorghums grown for fodder in the United States are: Kafir corn, Jerusalem corn, durra and Milo maize. Of these, Kafir corn in one or the other of its varieties is by far the most extensively grown. Broom corn, much akin to these plants, may also be grown for fodder, and also pearl millet, although it is not strictly speaking a non-saccharine sorghum. Teosinte also bears some resemblance to them in its growth, but it also is not really a non-saccharine sorghum. The growth of these plants, unless it be broom corn, is confined chiefly to areas that are considered too dry for the safe and abundant production of corn and sweet sorghum. All these plants are less highly relished than sweet sorghum, and are so far less valuable for feeding.

For cattle, Kafir corn is extensively used as a fodder in areas where it is much grown. Its value for such feeding is much influenced by the way in which it has been grown and in which it is fed. When grown thickly and fed from the sheaf or cock, it contains more or less seed, which, of course, adds to its palatability and feeding value. When the fodder only is fed after the heads have been removed from a crop grown primarily for the grain, not a little of the coarser portion will be rejected. The palatability of such fodder will be so far improved by shredding, that its consumption will be much increased, thus reducing the waste, and because of the dry conditions amid which it grows, Kafir corn does not usually spoil readily in the shredded form. Because of the relatively small amount of protein which this fodder contains, it is important when practicable that it shall be fed in conjunction with alfalfa, as the latter can usually be grown on areas favorable to the growth of Kafir corn.

To sheep, when fed as fodder after the grain has been removed, much of it will be rejected unless when shredded, because of the stocky character of the growth. When grown like grain it makes more suitable fodder for sheep.

When fed to cattle, it ought to be fed in conjunction or alternating with leguminous fodder, as for instance, alfalfa or cowpea hay.

In feeding swine, Kafir corn fodder is of but little use. In this respect it would be about on a par with corn stalks (see p. 214). But when the crop contains more or less seed, swine may consume some of the stalk, especially if fed while still possessed of succulence in considerable degree.

For horses, Kafir corn fodder in certain areas serves a useful purpose. As when feeding cattle, it is more valuable when the stalks are not coarse. With horses as with cattle and sheep, it may form fully half the fodder fed when fed in conjunction with leguminous fodders.

What has been said about Kafir corn will apply in the main to Jerusalem corn and durra. These are quite stocky in growth, even more so than Kafir corn. As they are grown chiefly for the grain, fodder from them is a very secondary consideration. Milo maize, except in the dwarf varieties, is of much taller growth and has more abundant leaves around the portion of the stalk from which the seed head emerges. In the experiments conducted by the author, it was found that Milo maize was eaten by cattle even with as much avidity as sweet sorghum. When fed as fodder, these plants are more commonly grown thickly and are fed from the cock.

Broom corn, which grows up very quickly, may be used for fodder, but when thus fed should be grown for the purpose. When grown for the brush to be used in making brooms, the stalks are usually ploughed under where they grew. Other plants of this class are considered more valuable than broom corn in furnishing fodder, hence it is scarcely ever grown for such a use.

Pearl millet may be made to produce enormous crops of fodder in the milder portions of the continent. In experiments conducted by the author, however, the live stock did not take kindly to the fodder. They did not relish it nearly so well as corn, sorghum, Kafir corn or Milo maize. Its growth for fodder, therefore, where any of these plants can be grown in good form is not to be commended.

Teosinte produces an enormous amount of long, slender leaves. A large tonnage of fodder may be obtained per acre from one or more cuttings in the season, but, owing to the character of the growth, it is not easily handled nor readily cured, nor does it seem to be more highly relished than pearl millet. However useful, therefore, it may prove for regions far south, its growth is not to be recommended for fodder in the northern or central states.

Straw as fodder.—Straw from the small cereal grains, so generally used for bedding, is also frequently used for fodder. When used as fodder, it should usually be as a part of the fodder ration only, owing to the large bulk which it possesses in proportion to the nutrition and also to the large amount of the crude fibre which it contains. Although the feeding value of nearly all kinds of straw is low relatively, it may frequently be fed with profit to mature or store animals that are being simply carried through the winter, or along with concentrates to cheapen the ration, when hay is dear. The necessity for and the advantage from feeding straw, is largely dependent on the relative value of other fodders. Straw has considerable value for feeding on the farms of New England and on those of the eastern provinces of Canada, while in wheat growing areas of the American and Canadian Northwest, it is usually burned to get rid of it. Rye, wheat, barley, speltz, oats, peas, beans and flax are the principal sources from which straw is obtained in America.

The feeding value of straw is much influenced by what may be termed its physical condition, by the way in which it is cured and by the extent to which it has been injured by such diseases as rust. The physical condition of straw has reference among other things to the stage of maturity at which it was cut, the fineness of stem and abundance of leaves, and the extent to which beards are present or absent. Straw cut at early maturity is much better relished than when cut late and has less crude fibre. The finer the stems and the more abundant the leaves, the more highly is straw relished. Beards in it are more or less objectionable as they sometimes influence mastication adversely, especially when the crop is fully matured, as harshness, so to speak, in the beards, is enhanced by increasing maturity. The methods of curing straw affect it similarly to the way in which methods affect the curing of hay. When straw is overcured and bleached by exposure, live stock do not care to eat it and heavy rains wash out of it soluble nutrients. The feeding value of pea and bean straw may be almost destroyed by such exposure, and to a less degree that of oat straw. Such parasitical diseases as rust may greatly lessen the value of straw. Smut acts similarly and also mildew, which frequently attacks some kinds of leguminous plants. It may not be safe to say that straw thus affected will produce positive troubles in digestion, but it is safe to say that such visitations affect its palatability adversely in proportion as they are present.

The composition of straw, as may be expected, differs much with the class, the variety, the soil in which it is grown, the nature of the stand, whether grown alone or in combination, and whether leguminous or otherwise. Rye straw stands lowest in feeding value because of its unpalatable and woody character, unless in the case of speltz. Next in feeding value is wheat straw, based on palatability and nutrients. Then follow oat straw, flax straw, pea straw and bean straw in the order named. Varieties of the same kind of grain, naturally of fine growth and leafy, furnish straw more valuable than those opposite. Soils well supplied with nitrogen furnish straw more rich in protein than those ill supplied with the same. A thick fine stand of grain furnishes more palatable fodder than a stand thin and coarse. Straw from grains grown together furnishes a variety, and hence larger quantities will be eaten of some of them at least, than if grown alone. The straw of legumes, as peas for instance, differs from the straw of other cereals much as clover hay differs from that made from the grasses, that is, it is richer in protein and is more palatable.

For stock—Straw is by no means equally well adapted to the feeding of the various classes of farm animals. It is better adapted relatively to the feeding of ruminants than to feeding horses or mules, owing to the relatively larger stomach of the former and to the greater length and complexity of their digestive canal, which gives them more time and greater power to digest bulky products of low relative nutrition. Notwithstanding, straw may furnish a considerable proportion of the fodder ration of work horses when occasion calls for it, providing the amount of the concentrates is increased so as to furnish the requisite nutrition. Horses that are idle may be entirely, or almost entirely, wintered on good straw of certain of the cereals. Cattle that are being fattened and cows in milk may also utilize considerable quantities, providing concentrates are used to maintain equilibrium in nutrients. The free and judicious use of straw may frequently effect a considerable saving in the wintering of young cattle beyond calfhood without apparently checking growth, and, as with idle horses, straw alone, or almost alone, may be made to sustain cattle at rest, for considerable periods. Sheep utilize straw to better advantage even than cattle. They can more readily pick out the finer portions. Straw fodder is quite unsuited to the needs of swine.

Rye straw is so unpalatable and woody, that it ranks low in feeding value. In nutrients it is fully equal to wheat straw, but is not equal to it in palatability. The economy of forcing animals to eat rye straw unless in instances when fodder is scarce and dear is at least open to question

Speltz straw is somewhat more valuable than rye straw for feeding, but the hard, stiff character of the straw and beards present discounts its feeding value not a little.

Wheat straw when bright and good may, under certain conditions, form a very considerable proportion of the diet of cattle, sheep and horses in winter, but cattle and sheep that are being fattened, cows in milk and working horses should not be required to consume it in large quantities, owing to its low protein content, its relatively low digestibility and its want of palatability.

Barley straw is somewhat more valuable than wheat straw. It is eaten with more relish than the former. Nevertheless, what has been said of wheat straw will apply in a considerable degree to barley straw. Both barley and wheat straw may be made to form a considerable part of the fodder fed along with heavy grain feeding.

Oat straw is in nearly all respects more valuable than wheat and barley straw. In fattening cattle and sheep, and in feeding milch cows, also working horses, it may frequently furnish half the fodder ration, and in wintering store stock it may furnish the sole fodder ration. When bright and clean it is eaten with a relish, and when available may be fed so as to economize in the feeding of more expensive hay.

Flax straw has considerable feeding value as the analysis shows. Live stock are fond of it and will eat it in considerable quantities when well cured. The small grains which are blown out into the chaff increase its feeding value. Flax straw like the grain, though to a much less extent, tends to relax the bowels. The objection has been raised to flax straw that because of the toughness of its fibre, it tends to disturb digestion by forming indigestible masses of the nature of impact substances, but the facts do not sustain the objection. The feeding of flax straw does away with the objection to burying it in the soil because of its slow decay in climates with insufficient rainfall.

Pea straw, when of fine growth and properly harvested and cured, ranks almost as high for feeding as clover hay, but in moist climates it is frequently injured in the curing, as it is easily damaged by rain. Exposure to two or three showers in succession but with an interval between them, will so lower the palatability of the straw that it becomes of little account for feeding. The nutrients, as with clover hay thus exposed, are also measurably lost. Pea straw has special adaptation for being fed to sheep which are so fond of it that previous to the lambing season good pea straw may be the only fodder required. It may also form the bulk of the fodder fed to cattle that are being carried through the winter, and a part of that fed to milch cows. Horses also are fond of it, but the dust which frequently accumulates on the plants while growing and sometimes in curing renders it more or less unsuitable for the prolonged feeding of horses. Machine threshing also lowers the feeding value since it breaks up the straw and removes many of the leaves.

Bean straw is possessed of high relative feeding value, but the yield of straw to the acre is proportionately small. As much of this product consists of leaves and pods, the proportion rejected when fed is not usually large. The straw is also more commonly well saved as in order to insure good quality in the grain, it is necessary to harvest promptly when mature and to protect the crop as far as possible from injury by rain. When available, bean straw stands high in favor as a fodder for sheep, and it may also be fed with decided benefit to cattle. The earth that sometimes adheres to the product is an objection to feeding it to horses. The straw of the horse bean is considerably used in feeding live stock in Scotland and some other countries, but in England it is not so commonly fed.

Straw of good quality and well cured is more valuable for feeding than hay, coarse and ill cured. When fodders are scarce and dear, the harvesting of straw fodders with a view to conserve their good feeding properties is well worthy of attention. It is frequently admissible to use certain varieties of straw as principal portion of the fodder fed in order that hay may be sold when the price is dear. But when straw is made to supplement hay, more grain must be fed when grain is required.

When grasses are sown with a cereal nurse crop, it sometimes happens as in seasons of good growth that grass is abundantly present in the grain, and when it is, the straw thereof is nearly as valuable as hay. But when grass is thus abundantly present, the yield of grain may be lowered. Timothy sown in a grain crop in the autumn, in some instances furnishes a large proportion of the reaped crop and especially when the grain crop partially fails.

Chaff from wheat and oats is more valuable than an equal weight of straw, not only in food constituents but also in palatability. Wheat and oat chaff are usually eaten with avidity by farm animals, but rye and barley chaff, especially the latter, are less valuable because of the presence of the beards. Some feeders of barley straw aim to separate the chaff from the straw as far as this may be practicable. Even where the straw is used solely for bedding, the plan which saves the chaff for feeding when practicable is to be commended.

When straw is fed in the uncut form and especially when the supply is plentiful, the amount fed should be so liberal that the unconsumed portion may be used for litter. This method of providing litter is to be commended, as much of the straw thus fed is turned to higher account than if the whole were used as litter. This method of using straw is especially to be recommended in feeding sheep, as they are sure to pick out and consume the finer portions. The uneaten portion is thus used to furnish fresh litter every day.

When straw furnishes a large or principal portion of the ration for live stock, it frequently tends to produce more or less a dry condition of the fæces indicative of constipation. When a limited amount of field roots can be fed daily along with the straw, this condition will be corrected. Ten to 12 pounds of roots fed daily will suffice for a mature cattle beast. Where roots are not available, oil cake will answer the same end. It also adds protein, so much lacking in nearly all kinds of straw.

CHAPTER XII.

FOOD FROM CEREALS AND OTHER SEEDS.

The seeds of plants are primarily the source of all the concentrates fed to farm animals. These are discussed in Chapter XII from the standpoint of their feeding value, and uses. The small cereals discussed include: (1) Wheat; (2) oats; (3) barley; (4) rye; (5) peas; (6) buckwheat and (7) speltz.

The seeds distinctly leguminous considered are: (1) The common field bean; (2) soy beans; (3) the horse bean; (4) cowpeas and (5) vetches.

Those usually primarily grown for oil production and included are: (1) Flax; (2) cottonseed and (3) sunflower seed.

Seeds discussed as derived from the sorghums are: (1) Sweet sorghum seed; (2) Kafir corn seed and (3) other non-saccharine sorghum seeds.

Those discussed as miscellaneous are: (1) Corn or maize; (2) broom corn seed and (3) millet seed. Rice is not discussed because of the small extent to which it is fed to stock save in the by-products obtained from it.

Wheat.—Wheat in its many varieties is more commonly grown primarily to provide food for man. So important is the place which it fills in this respect that it has been called the "staff of life." The increase in its growth, therefore, will probably keep pace with increase in population in all civilized communities where the conditions are favorable to growing it. Although it furnishes an excellent food for all kinds of domestic animals on the farm, it is generally considered too valuable for being thus fed unless when of low grade. But its by-products, especially bran and middlings, comprising nearly one-third by weight of the cereal, are of great value in feeding live stock, and are always likely to be much sought after for such a use.

Wheat, though a hardy grain, is not so hardy as rye, nor can it be grown in so short a season as barley. The macaroni varieties are among the largest yielding sorts and have more of adaptation for being grown under hard and dry conditions than other varieties. Vigorous and productive varieties may frequently be grown with profit along with oats or barley, or both, to provide food for stock. The chief advantage from growing these grains thus consists in the larger yields that are usually obtained. Wheat is of two classes, winter and spring, and each has its own sphere for most successful growth. Usually it ought to be fed in the ground form except to sheep, otherwise a considerable proportion of it will not be digested. Because of the sticky and pasty character of the meal, the outcome of its high gluten content, the aim should be to mix it with some coarse substance as bran, when it constitutes the sole grain fed.

For calves and growing cattle, wheat furnishes an excellent food, when the price will admit of its being so fed. To the former it may be fed alone. The addition of oats, however, to the extent of one-half the grain part of the ration, will improve it except in the case of calves during the first two or three weeks after they begin to take meal.

For beef cattle, ground wheat has been found about equal pound for pound, to ground corn. When the two are fed in conjunction, however, they make a better food than either fed alone, especially when the wheat element preponderates during the first part of the fattening period and the corn element during the last. The bran present in ground wheat exerts an influence more or less helpful in keeping the bowels in tone. Some bran added, also oil meal, makes it less sticky in character.

For cows giving milk, wheat meal fed with suitable adjuncts has been found fully equal to corn meal. Mixed grains, however, of which wheat meal is a part, will doubtless prove superior to wheat meal fed alone for prolonged feeding. But for milk production, the by-products of wheat are more suitable than wheat, as they contain a higher relative protein content, and usually they are considerably cheaper. It is in order to feed a higher proportion of wheat meal to cows giving milk than would be admissible of corn meal, the fodder adjuncts being the same.

For sheep, wheat is superior to corn when fed to young lambs and breeding ewes. Wheat and oats in any desired proportions make an excellent grain food for them. It is also superior to corn when fed alone or as a factor during the early stages of fattening, but corn will result in somewhat quicker gains in the later stages of the same. It is excellent as a food for preparing sheep for show purposes, as it produces flesh, plentiful and firm.

For young and growing swine, wheat is much superior to corn. For swine that are being fattened, they are about equal, pound for pound, in production, but the quality of the meat made from wheat is superior. Tests have shown that greater gains have been secured from feeding ground wheat and corn or barley to swine that are being fattened, than from feeding either alone. Such swine should produce one pound of increase from rather less than five pounds of wheat, and greater relative increase should result from feeding it to pigs previous to the fattening season. It should be fed ground and soaked in milk or water for six to 12 hours, according to the season. Skim milk and ground wheat make an excellent food for young pigs. If wheat is fed unground to swine it should be soaked 18 to 24 hours. Thus prepared, it had been found nearly if not quite equal to ground wheat when the cost of the grinding is also considered. If fed in the natural state, a large per cent will appear in the voidings. Although swine will make a good growth while gleaning amid wheat stubbles where they consume the fallen heads, they do not fatten readily on unthreshed wheat, though it should be plentifully supplied to them in the sheaf.

For feeding horses, wheat has not been much tested. The tests made have tended to show that when wheat has been fed as the sole grain ration to working horses, a considerable proportion of the grain was voided undigested, and in time there was a decided tendency to digestive derangement. It would seem probable, however, that wheat ground and fed with oats ground or unground, up to the extent of one-half the ration, would make an excellent grain food for horses.

Contrasted with corn, it may be said that wheat is superior: (1) As a food for young animals and for cows in milk, since it is richer in protein and ash; (2) as being a safer grain food during the early stages of fattening, because it is relatively lower in its fat content, and, therefore, does not tend so much to put animals off feed; (3) it is equal or about equal to corn in making increase with cattle, sheep and swine while being fattened, and it furnishes meat somewhat superior to that furnished by corn, having more muscle in it.

Corn is superior to wheat: (1) In its fattening qualities; (2) in that it may usually be fed without grinding and (3) in that it may usually be obtained more cheaply. They are about equal in palatability. Wheat is grown over a wider area than corn and can be grown in a drier and cooler climate. While it is probable that it will seldom be found advisable in the future to feed wheat of good quality to stock, because of the price, it will always be in order to feed damaged wheat as when shrunken by rust or by frost. Such wheat has a higher muscle-producing content than good wheat. In some localities, it may be found that growing wheat with other grain for food for stock will be the cheapest method of obtaining bran or its equivalent.

Oats.—Viewed from the standpoint of general adaptation for feeding live stock, no cereal grown in this country will compare with the oat. It is preeminently the grain food for horses. In milk production, it is almost equally valuable. It may be made to constitute a large proportion of the ration in fattening cattle and sheep, and it is useful as a factor in feeding swine, but not so useful relatively as in feeding other classes of stock because of the relatively large amount of hull which it possesses, ill adapted to the digestion of swine. In suitability for young stock, it is without a rival among concentrated foods. No other cereal can be fed to stock with entire safety or in quantities so large for an equally prolonged period. It is also a valuable breakfast food for man.

The high relative value of the oat for general feeding is the outcome of the high palatability which it possesses, the equilibrium in the nutrients which give it balance as a food, and the relation between the hull and kernel which gives it a proper amount of concentration and not too much for safe feeding. The chief obstacle in the way of its more extensive use on the farm is the high relative value which it usually commands on the market.

While the oat grows reasonably well in some parts of all the states of the union, it grows much better relatively in the northern states. All the provinces of Canada have high adaptation for growing oats. The weight of a measured bushel varies from 20 pounds in some varieties in the south to 50 pounds in others in the northwestern states and provinces of Canada. As the adaptation for corn production decreases because of low temperature, that for oat production increases. To provide food for stock, the crop may be grown alone, with wheat or barley or with both.

For calves and growing cattle, oats are a grand food. In the ground form, they are excellent for young calves and for calves more advanced in age, they are equally good. For such feeding they may be fed alone with wheat bran, ground barley or ground corn, according to the degree of the flesh sought and in proportions to suit the needs of the animals. When fed alone or with bran, the calves may be allowed to partake of them at will, when the cost is not too great. To young cattle that are older, about the only limitation that may be put on the feeding of oats is that which is usually present, resulting from the relatively high value of this cereal.

For beef cattle, they make an excellent adjunct to corn, barley or rye, rather than a substitute for these, when ground and mixed with one or more of the foods named. The hulls as in the case of bran add so much to the bulk that the juices of the stomach more readily penetrate the meal thus fed. When oats are not too high, they may constitute from one-half to one-fourth of the entire grain fed, more being given during the early stages of fattening and less later.

For cows in milk, oats are at least as valuable as bran, pound for pound. If there is a difference, ground oats is probably the superior. The extent to which they may be fed to cows in milk depends in a considerable degree on market values. They may be made to constitute the whole of the grain fed or any part of it. Even when oats are somewhat more expensive than corn, it will be found profitable to combine them with corn in the ration. With such fodders as clover hay and corn stover fed in conjunction, wheat bran, ground oats and ground corn, barley, or rye, fed in about equal parts by weight, make an excellent grain ration.

For sheep, oats make a most excellent grain food. There is probably no better grain food on which to start young lambs than ground oats with the hulls sifted out. Even unsifted, they serve the purpose reasonably well, and later it is not necessary even to grind them. For milk-lambs that are being fattened, oats, cracked corn and oil cake in the nut form or as meal, in the proportions of 2, 2 and 1 parts by weight, make a suitable grain ration. To lambs that are being fattened, oats, cracked corn and oil cake in food, in quantity from one-fourth of a pound upward daily, or they may furnish the bulk of the grain given, the other part consisting of wheat, rye, barley, corn or peas, or of a mixture of these. To breeding ewes, they may be similarly fed up to the amount of one pound per day, before the lambing season, and practically without stint, subsequently, as long as the ewes are on dry feed. To sheep that are being fattened, they may constitute the sole grain ration, under some conditions, but gains considerably higher will result if corn is fed along with them. From the standpoint of increase, it would probably be within bounds to say that the proportion should vary from two-thirds oats and one-third corn at the commencement of the fattening season to two-thirds corn and one-third oats at its close. No grain food has higher adaptation for sheep, while they are being led up to full feed than oats. Other grain, as wheat, barley, rye or peas may be substituted for corn, but except in the case of wheat, the results will not usually be quite so good.

For swine, and especially for young swine, the adaptation is not high, unless the hulls are sifted out. When so sifted, the reverse is true. For swine subsequent to weaning, the adaptation of unsifted oats is not more than medium, and for swine that are being fattened, ground oats are considerably inferior to corn. When the price will admit of so feeding them, they make a good food for brood sows that are nursing pigs. They should be ground and soaked when fed to swine.

For horses, no substitute has been found that will equal them, none has been found so healthful or that will give and maintain the same degree of mettle and staying power. Oats, therefore, usually fed unground except to young foals or to horses whose teeth have failed, may make the sole grain food for all animals of this class, or they may make a part, preferably a principal part, usually not less than two-thirds of the same. For American feeding, when the prices will admit of it, the other third may be corn, barley, rye or wheat. In some countries of northwestern Europe, horse beans are freely fed with oats. More corn may be fed in winter, particularly to horses and mules at work, than would be advisable in summer. The opinion that newly matured oats should not be fed in very large quantities to horses is held by many, but all authorities are not agreed as to whether there is hazard in so feeding them.

Barley.—Barley, at one time a principal source of food for the human family, is grown almost exclusively in the United States for brewing and as food for live stock. It has been grown successfully as far north as Alaska and as far south as the tablelands of New Mexico. In altitudes where the grain fails to fully mature, it is sometimes grown and fed as hay. Westward from the eastern Rockies and southward from Montana where corn and oats do not flourish equally well, it is more largely fed to live stock than elsewhere in the United States. The relatively high price paid for bright barley for brewing tends greatly to restrict its use for feeding. When stained by unpropitious weather at the harvest season, and thus injured for malting, it is not injured, at least to any appreciable extent, for feeding. For the latter purpose, it is an excellent substitute for corn where corn cannot be successfully grown.

For calves and growing cattle, barley should seldom or never form the sole grain ration, unless when fed sparingly with adjuncts rich in protein. It seldom constitutes more than one-fourth to one-third of the entire meal ration fed, the other portion being bran alone, oats alone or both with a trace of oil cake when profitably obtainable. Other nitrogenous foods, as gluten meal or cotton seed, may sometimes be substituted for bran and oats.

For beef cattle, ground barley furnishes an excellent meal adjunct. With luguminous fodders as clover and alfalfa, it may be fed when the season is short rather than long, so as to furnish up to three-fourths of the entire meal ration, the other portion being preferably ground oats or wheat bran. For prolonged feeding, corn added to the barley in any proportion desired, somewhat improves the ration in palatability and also for fattening.

For cows in milk, ground barley has been found about equal to corn. It is somewhat richer in protein than corn, but has more crude fibre and is not quite so palatable. It is too concentrated to furnish the exclusive grain food for milch cows, but gives excellent results when fed with ground oats or wheat bran, the barley furnishing about one-third of the grain by weight or even a larger proportion. The mixture of oats and barley may be obtained in many instances with greater profit by growing the two together; when fed freely with large quantities of field roots, it tends to counteract undue laxity of the bowels.

For sheep, unground barley is valuable when fed in suitable combinations. Fed as part of the grain ration to lambs while nursing or subsequently, especially in conjunction with oats, the results are satisfactory. It may suitably form from one-third to one-half the grain ration for breeding ewes, the other portion being preferably unground oats and a small proportion of wheat bran or oil cake. To sheep that are being fattened, the fodder being rich in protein, it may furnish the sole grain ration, but when not less than one-third of the grain ration is oats or corn, according to the advancement of the feeding, better results may be looked for.

For swine, barley stands at the head of all cereals in producing high quality pork, because of the firmness and flavor which it imparts. Experiments carefully conducted have shown that ground barley when fed to swine produced 8 per cent less increase than corn. Ground and soaked, it has special adaptation for being fed along with skim milk and clover, alfalfa or vetch pasture up to the fattening period. During the fattening period, it may furnish the sole grain food, but corn in such proportion as will suit the end sought will add to the palatability of the food, and consequently will improve the gains. Barley will probably be much more used in the United States for feeding swine as it is now in Canada, when the bacon idea in pork production becomes more pronounced. The bald varieties, pound for pound, should also be more valuable than the other varieties, because of the less amount of hull in the former.

For horses, barley stands next to oats in suitability as a grain food. Where the prices will admit of so doing, it may be used as the principal or even sole grain ration, as has been shown in the practice of Bedouin Arabs, of certain peoples of northwestern Europe and now in California, and other mountain states. It has been claimed that barley, pound for pound, is more valuable as a food for horses than oats, because of the much larger percentage of hull in oats, a claim that has not been sustained by evidence based on experiment. It is not equal to oats for colts, being somewhat lower in protein and ash, nor is it so palatable as oats for long continued feeding. It may, however, be profitably fed with oats to working horses, either whole or in the crushed form in any proportions that the attendant circumstances will justify. Steamed until the grain has swollen to maximum possible distension, and fed with a little bran or oil cake added to it as frequently as may be found necessary, tends to make flesh quickly and to improve the coat, as when preparing horses for exhibition.

Rye.—Rye is probably the hardiest of the cereals, produces the best crops on poor land and grows over the widest area. It is much grown on lands too low in fertility to yield good crops of wheat, oats or barley. It is grown not only to furnish grain but also pasture and green manure. Of the two classes, winter and spring rye, the former is grown to a far greater extent than the latter. In Europe, especially central Europe, it is much grown as food for man and also for live stock, including horses. In the United States, it is grown almost entirely to furnish food for stock. It may be grown successfully in almost every state in the Union. While its constituents are much the same as those of wheat in practical feeding, it has been found from 5 to 10 per cent less valuable, owing, it is thought, to the less degree of the palatability. It is fed to horses and sheep in the unground form but is ground when fed to cattle and also to swine, except when swine are allowed to harvest it in the field.

To calves and growing cattle, the aim should be to feed rye in conjunction with some other grain product. What has been said about feeding barley to these classes of animals will apply about equally to rye (see p. 232). It should seldom form more than one-third of the meal fed in prolonged feeding.

To beef cattle, rye may be fed with much freedom, where the necessity exists for so feeding it. This necessity is, however, seldom present, as corn is usually cheaper, hence the larger the proportion of the corn fed, the more economical is the ration. It is also better relished. Wheat bran in the proportions of say one part by weight to three or four parts rye meal tends much to improve the ration. It renders the meal less adhesive and adds to the protein content. The same is measurably true of ground oats which, however, are usually too valuable to be much used in such feeding. Other nitrogeneous by-products as oil cake may sometimes be fed in the place of bran, but the necessity of adding these to the rye meal and the advantage from the same are much dependent on the extent to which protein is present in the fodder.

To cows giving milk, rye meal may be fed in reasonable quantities, but if more than 3 pounds are fed per cow daily, hazard may be present that the quality of the butter product will be affected adversely, hence when fed, it is common to give a less quantity than that named. Equal parts by weight of ground rye, ground oats and wheat bran with ordinary fodders make a very suitable grain ration, also equal parts of rye, oat and corn meal and wheat bran with clover or alfalfa hay. If fed with wheat bran only, the bran should furnish not less than one-third of the meal ration.

To lambs, rye is not commonly fed, but may be so fed with oats even with benefit, where the latter furnish the larger portion of the grain ration. Similarly it may be thus fed to breeding ewes and in larger proportions, when the roughage is rich in protein elements. To sheep that are being fattened, it is not usual, nor would it probably be wise, to feed rye, making it more than half the ration for prolonged feeding, since sheep, in common with all other domestic animals, are less fond and tire of it sooner than of some other kinds of grain. Rye, corn and oats in the proportion of one, two and one parts respectively make an excellent grain ration for sheep on full feed along with clover or alfalfa.

To swine, rye may be fed about the same as barley (see p. 233), except that for prolonged feeding, it should not furnish the sole grain portion, since thus fed, swine tire of it more quickly even than of barley. Corn, fed along with it in such proportion as will furnish the quality of pork desired, will add to the palatability of the food and also in some degree to the gains. Experiments conducted in Denmark have shown that rye and barley are almost equal in value in making pork, when fed with dairy by-products, both with reference to gains and to the quality of the pork. In the tests made in that country, it was found that corn made pork less firm as a rule, in proportion as it was fed, and therefore less suitable for high class bacon. In ordinary fattening, however, the aim should be to add corn freely to the rye.

To horses, rye is seldom fed in the United States and largely for the reason probably, that it is seldom sufficiently plentiful and cheap to admit of feeding it thus. But it is quite suitable for being so fed, especially to horses at work in conjunction with oats. A mixture of one-third rye and two-thirds oats is suitable for even prolonged feeding.

Peas.—The peas in the United States, usually designated the Canada field pea, should be far more widely grown than it is at the present time, because of its excellent feeding qualities, and also for the reason that it is a legume, and, therefore, leaves the land on which it grew rich in nitrogen. Its protein content is high, hence it has peculiar adaptation as food for animals in process of development. Being adapted to climates with only moderate summer temperatures, the pea grows best in this country in the northern states and on reasonably high plateaus of the mountain states. Nearly all the provinces of Canada have high adaptation for the growing of peas. One chief obstacle to the extension of their growth in the United States is the labor involved in harvesting them, which is more relatively than with other cereals, except corn. This may be met by growing peas and oats together in proportions that will not preclude the harvesting of the mixed crop with the binder. The mixture thus grown furnishes an excellent grain food for many kinds of feeding. The relatively high price of peas in this country also stands in the way of their more general use in feeding stock.

To calves and young cattle, peas furnish an excellent grain food when fed as a meal adjunct. The meal is heavy and lies compactly, hence, when fed to cattle and other animals, it should be along with bran, ground oats, corn, barley, rye or a mixture of these according to the nature of the feeding. Ground peas and oats in equal parts by weight, make an excellent meal ration for calves. Later the proportion of oats or bran, if bran is fed, should be increased, chiefly on the score of economy in feeding.

To beef cattle, peas may be fed in proportions varying from 25 to 75 per cent of the meal fed, the proportion of peas being increased with the advance of the feeding period when fed with oats. From the standpoint of increase, ground peas, oats and corn, barley or rye, in equal proportions by weight, furnish an excellent grain food. Bran may be substituted for oats if cheaper.

For cows in milk, a mixture of ground peas and oats grown together, so that about two-thirds of the mixture will be oats, furnishes an ideal grain food. Here also bran may be substituted for oats. In northern areas, this mixture may be readily grown on many farms and it has the further value of furnishing fodder that is much relished when well saved.

For sheep that are being fattened, a grain mixture fed unground, and consisting of peas and oats, the peas making from 25 to 75 per cent of the grain ration according to the stage of the fattening, will give excellent results. For breeding ewes on dry feed as much as 50 per cent of the grain fed may be peas, whether fed before or after the lambing season. The same mixture is also good for feeding lambs, and if the lambs are being forced for the early market, the addition of cracked corn will improve the grain ration. On certain plateaus of the Rocky mountain states, the fattening of sheep and lambs on mature peas grazed down by the sheep, is becoming an industry of no little importance. Enough oats are sown with the peas to sustain them. The dry autumns in the areas named, make such feeding entirely feasible and with but little waste.

For swine, peas have special adaptation. A mixture of peas and oats ground, or peas and bran soaked from six to 12 hours according to the weather, furnish a grand food for brood sows nursing their young. Unground or ground they may be fed with much freedom to brood sows that are pregnant, the other portion of the diet consisting largely of field roots or pasture. For swine, during the growing period, they may be made to furnish the sole grain supplement or a part of it. When swine are grazed on alfalfa or clover pasture, equal parts of peas and corn, both fed unground, will furnish excellent supplemental grain food. Swine may be fattened in the pens or in the fields where they harvest the crop, on peas alone. The peas may be fed dry or soaked. Peas may also be fed during the fattening period along with corn, barley, wheat or rye, so as to form any part of the fattening ration that may be desired. The barley and rye, however, must be ground. The few experiments conducted tend to show that peas make more increase than corn, pound for pound, when fed to swine and they make a somewhat superior quality of pork.

When swine are fattened on peas harvested by them, they may be admitted to the peas, when they have neared the maturing stage. They may glean at will after the first few days and only require a plentiful supply of water in addition.

In wet climates, peas cannot be profitably gleaned thus, as the swine shell out many of the peas and these will sprout in moist weather, which soon renders them useless for feeding. In some localities, however, this method is eminently practical. Swine not being fattened should finish the gleaning.

In some of the western mountain valleys, it is claimed that swine can be made to gather their own food all the year by growing peas, alfalfa, bald barley and artichokes. Some peas, stacked so that they are accessible to the swine on alfalfa, during the early summer months, furnish the needed grain food at that season.

To horses, peas are not usually fed to any considerable extent. But there is no reason why they should not be fed in certain proportions to horses young and old, when sufficiently plentiful. Peas and oats go well together, the preponderating factor being oats. For foals, and even for horses, the results will be more satisfactory if the grain has been ground.

Buckwheat.—Buckwheat may be grown in nearly all the various states and provinces of Canada. It is not grown to any considerable extent, however, in the southern, southwestern and western states, or in the western provinces of Canada. More is grown in the New England states and those adjacent to them elsewhere. Maine leads the states in the yields obtained, the average for the last ten years being 30 bushels an acre, whereas for the United States it has been less than 20 bushels in the same period. It is a strong point in favor of buckwheat that it may be grown as a catch crop in the early summer on land that might otherwise be idle. It may also be grown successfully on land that has been neglected or low in fertility. It matures in about 75 days from the date of sowing. It is usually fed to live stock in the ground form, save when fed to sheep, horses and poultry. Its highest adaptation is found in feeding poultry. Owing to the demand for it to make flour to be used in making cakes for the table, its use as a food for live stock is much circumscribed.

To cattle of any kind, buckwheat has not been much fed, but may be so fed when it can be spared for such a use. Being low in protein and rich in starch, it is better adapted relatively for fattening than for milk production. When fed for the latter use, it should be with grain or meal rich in nitrogen, as for instance, bran. For fattening uses, it is preferably fed with some coarse meal, as ground oats, since as meal it is dense in character and inclined to be clammy when moistened. It is seldom that it may be profitably fed so as to make more than half the ration.

For sheep.—Although not much used for the purpose, buckwheat may be satisfactorily used in feeding sheep kept for breeding or that are being fattened. For a breeding flock, the aim should be to feed the buckwheat with such grain as oats, the oats preponderating in the ration, but in fattening sheep the buckwheat should rather preponderate, especially as the fattening period is advanced.

For swine, buckwheat is more used than in feeding cattle, sheep and horses. To swine also it ought to be fed as a grain factor rather than as the sole grain food. In experiments conducted at Ottawa, Canada, more rapid growth and gains were made from feeding buckwheat as half the ration than when wheat was similarly fed, but to make 100 pounds of gain, called for feeding 6 per cent more buckwheat. The other half of the ration was meal mixed in character. The result shows a relatively high feeding value in buckwheat for swine, but it should be remembered that it is rather adapted to feeding for fat than for growth. The meal should be well soaked before feeding it to swine.

For horses, it has been fed as a conditioner rather than for sustenance and growth. It has proved fairly satisfactory for such a use, as it not only improves the flesh when it makes any considerable proportion of the grain ration, but it also exercises a marked influence on the glossiness of the coat.

The opinion prevails that when the feeding of buckwheat is prolonged, and especially when it forms any considerable proportion of the ration, that it tends to induce more or less of irritation in the skin and to the extent of being a disturbing factor. This opinion would seem to rest upon a real basis. It is also claimed that the hulls have made trouble when buckwheat meal has been fed very freely to swine. The hulls are not readily digested.

Speltz.—This grain is really Emmer, *Triticum dicoccum*, rather than *Triticum spelta*, but it is better known by the name speltz or spelt. It has special adaptation for areas where the short season for growth and the lack of moisture is such as to make the production of the common cereals more or less precarious. It is, therefore, grown chiefly in the semi-arid belt of the West and in the country adjacent thereto. It is more drought resistant than either corn or wheat, is not easily injured by rust and does not lodge readily. Notwithstanding these good qualities, it is not likely that it will ever supplant the more common cereals where these can be grown at their best, as it is not fully equal to these in all round feeding value and, under the conditions named, will not prove relatively more productive. It is fed in the unground form to sheep and poultry and may be so fed to horses, but when fed to other live stock it should first be ground. In composition it is somewhat similar to barley, but the hull which constitutes about 25 per cent of the grain is somewhat more pronounced and it has more crude fibre than barley. The trend of experiments shows that it is not fully equal to barley in feeding value.

For calves and cattle, during the growing period, its adaptation is much the same as barley only a little below it. For continued feeding to the former, a mixture of oats and barley in the proportions of two and one respectively, by weight, should prove satisfactory. For the latter, the proportion of speltz may be larger. Along with say 33 per cent bran by weight and 5 per cent oil meal or cake, it will also prove very suitable.

For cattle that are being fattened it has not been much tested in this country but should be nearly equal to barley. It may constitute at least half the grain fed, the other half being corn, or wheat when the prices will admit of feeding the latter. Five to 20 per cent of wheat bran especially during the early feeding will improve the ration.

For cows in milk, speltz has proved a useful food, but not quite equal to barley. It would not be excessive to make one-half the grain ration speltz, the other half being ground oats or bran or a mixture of the two. Even better than the above, especially for cows in low flesh, is a mixture consisting of equal parts by weight of ground speltz and corn.

For sheep, speltz has been found a valuable adjunct, whether fed to lambs at the weaning season, to breeding flocks or for fattening purposes. For breeding ewes, the mixture is improved by adding oats in any proportion desired or by adding a small percentage of bran. The tests in fattening sheep with speltz as the sole grain food, have given results differing materially. It will doubtless be found that much better results will follow when corn, wheat or rye is added to the ration, especially the former. The proportion of the corn should increase as fattening progresses.

For swine, the same objection applies as when feeding oats. Because of the large proportion of the hull, ground speltz, unsifted, is too coarse a food for young pigs before or shortly after the weaning season. It answers better for swine that are growing and still better for brood sows nursing their young. As a fattening food for swine, it is about 20 per cent less valuable than corn. The aim should to add corn or wheat to the ration, especially the former.

For horses, young or old, like barley, speltz may be fed with propriety, but as in the case of barley, the aim should be to make oats constitute at least two parts of the ration. But for foals, the speltz should be ground. In the semi-arid belt, speltz may prove a cheaper feed than oats.

It has been recommended in some instances to feed speltz with oats. The mixture may frequently be obtained by growing the two together. The advantage in so doing may prove very decided. Usually by growing them thus, the yield will be increased and on lands where oats are much liable to lodge, the speltz will aid in sustaining them.

Field beans.—The common field bean is somewhat extensively grown in certain sections of the northern states and in various provinces of Canada. It is grown primarily as food for man, hence, unless the beans have taken injury during the harvesting from adverse weather or subsequently from heating in storage, they are too valuable to permit of their being fed to live stock. However, since they stain readily from rain during the harvesting and curing process, and since the injury thus sustained greatly depreciates the market value, the most profitable use that can be made of such beans usually is to feed them to live stock. To sheep and horses they are more commonly fed unground but are ground for cattle and are usually cooked for swine and poultry.

To cattle of any kind in this country they have been so little fed that testimony based on experience in feeding them is almost entirely wanting. The nutrients which they contain give them a high feeding value for producing growth and also milk. But bean meal like pea meal, will be improved for feeding by adding bran to lessen its density when moistened by saliva. It may also be necessary sometimes to introduce the meal gradually to make cattle take kindly to it. With corn meal and ground oats or bran in the proportions of two, one and two parts respectively, it should make a good concentrated food for calves. For beef cattle the mixture may be bran or ground oats and corn in the proportions of one, one and three parts by weight. For cows in milk, with ordinary fodders, bran meal may form as much as 33 to 50 per cent of the ration. Equal parts of ground beans, ground oats and ground corn, by weight, should make a very suitable grain ration.

Sheep are fond of beans in the unground form and when fed with suitable grain adjuncts, they make an excellent food for them. Beans and oats go well together as grain food for breeding ewes, but when the fodder is leguminous, the proportion of beans fed should be small or the protein in the ration will be excessive. To sheep that are being fattened, corn or barley and beans make quick and large gains. The beans may form from 25 to 50 per cent of the grain ration according to the conditions.

For growing swine, beans make an excellent ration, cooked or ground and soaked, but some other grain as corn or barley added, improves the ration. To swine that are being fattened, beans and corn in equal parts make an excellent food. The claim that beans alone will fatten swine as quickly and satisfactorily as beans and corn, has been disposed of at the Michigan experiment station. At the said station, beans and corn fed in equal proportions by weight, gave an increase of 50 per cent higher than beans alone.

To horses, beans have been but little fed. For such a use, along with oats, corn or barley, and especially along with the latter, they should furnish an excellent food for horses. What is said with reference to the value of horse beans as a food for horses, should apply about equally to common beans (see p. 24). Beans that have heated to the extent of inducing mould, are very hurtful not only to horses but to all kinds of stock.

Soy beans.—The soy bean is now grown as a source of protein in several of the central and southern states, especially the former. The states highest in adaptation include Nebraska, Kansas, Missouri, Iowa, Illinois, Indiana and Kentucky. This warm weather plant is not much grown in the North, but even in New England it has been grown with considerable success as a source of protein for the silo, in the unthreshed form. In the northern states, the Canada field pea will usually furnish protein more cheaply and surely, and the same is true of clover and alfalfa in many sections, but the amount of the bulk in these in relation to the protein may render them insufficient of itself as a source of protein. Soy beans yield from, say 12 to 20 bushels an acre under average conditions in states suited to their growth, hence it is quite feasible in these to grow them as a source of protein. The mature grain is only fed to cattle in the ground form, except when fed as ensilage. It is also ground when fed to swine except when harvested by the swine in the field, which is sometimes done, but it is not usual to grind them for sheep or horses.

For fattening cattle, soy bean meal though not much used, may be so used as a part of the grain ration, but only as a moderate portion, owing to the high percentage of the oil which it contains. For this reason it should be fed with a prudent caution to milch cows. But it has been found quite satisfactory as a source of protein in feeding both beef cattle and dairy cows. When from 20 to 33 per cent of the silage is composed of soy beans reasonably well matured, the balance being corn also well grown, the protein in the ration will probably be found ample for cows in milk, providing the fodder is alfalfa or clover. It would furnish an excellent meal adjunct, at least as good as linseed meal for calves during the milk period, whether fed in the milk or along with other meal. Much of what is said about the feeding of ground flax will also apply to the feeding of soy bean meal (see p. 249).

For sheep that are being fattened, the grain should only form a small part of the ration, but how much would depend, first, on the relative value of the beans and, second, on the protein in the fodder. In the absence of experiment, it would seem safe to say that soy bean meal should not be fed to sheep in larger quantity than oil meal (see p. 277).

For swine the meal is expensive, too expensive in the meantime to be fed in competition with some of the other sources of protein. But the beans may, under some conditions, be profitably harvested by swine. Before turning in the swine, the beans should be practically mature. When thus gleaned, corn or some other carbonaceous food should be fed along with the beans.

To horses, soy beans have only been fed in a limited way. But when corn is the principal grain fed, a considerable proportion of soy bean seed may be added. Some localities favor the growing of soy beans so much more than others, that the wisdom of growing these as a source of protein for any kind of feeding will be largely dependent upon the cost of the same.

The horse bean.—The horse bean (*Vicia faba*), though much grown in Great Britain and also in the more moist and temperate areas of continental Europe, has not succeeded well when tried in the United States and Canada, except in comparatively limited areas. These include certain areas in proximity to the Great lakes, especially in the more northerly sections where the summers are reasonably moist and cool, and also on the Pacific coast from Oregon to Alaska. This plant is a great yielder of protein, hence it is to be regretted that it does not succeed better where the summer temperatures are warm. It furnishes food that is highly prized for stock when fed in proper combinations. It is always fed in the form of meal to cattle except when fed as ensilage, usually in the unground form to sheep, as meal or cooked to swine, and unground, ground or boiled or steamed to horses.

For cattle this crop when ground furnishes excellent food for young cattle when fed along with such ground food as barley, rye or corn, the beans preponderating in the ration. For beef cattle, 33 per cent or even less will usually prove ample in the grain ration, but for dairy cows with ordinary fodders fully 50 per cent of the meal ration may consist of bean meal. The best method by far, however, of feeding it to dairy cows is in the form of silage which consists of say one part by weight of the entire bean crop to two parts of the entire corn crop. For sheep, what was said of the common bean will also apply to the horse bean (see p. 244). When fed to swine that are being fattened, 50 per cent or more of the ration should be corn, barley or rye meal. As the name would indicate, it stands high in favor as a food for horses. It has been claimed that as a part of the ration it puts spirit into horses subjected to violent exertion, as for instance, horses used in the chase. It has also been used as a grain adjunct and even as the principal grain fed in fattening horses. It has peculiar adaptation for being fed along with corn to horses when the latter is freely fed. For fattening horses, the combination is probably unrivaled. Wolfe places the comparative feeding value of corn, horse beans, also oats as 4, 4.5 and 5.

Cowpeas.—The cowpea is the great soil restorer of the southern states. It may be grown with entire success south of parallel 40 degrees and in many localities with measurable success much further north. While it is likely that it will be much grown to furnish pasture for live stock, and also hay for the same, it would seem probable that the amount of grain fed will continue to be more or less limited, owing first, to the tendency in the crop to ripen unevenly, and second, to the considerable labor in handling it because of peculiarities of growth after it has matured. Nevertheless, it will furnish excellent food for live stock where it can be devoted to such a use. Generally the grain in the threshed form is too dear to admit of its being fed thus with profit. It is usually ground when fed to cattle, but is fed in the unground form to sheep. To swine and horses it is fed ground or unground. Owing to the high protein content possessed by cowpeas, they furnish a suitable concentrate for young stock.

For cattle, when ground and fed along with suitable adjuncts, they furnish excellent food. The meal, like that of Canada field pea, is usually somewhat heavy for being fed alone, hence, for nearly all kinds of feeding and especially for cattle, it is improved by mixing with it ground oats or wheat bran. Such a mixture, containing say 50 per cent of cowpea meal is excellent for calves and dairy cows, but a percentage much less than that named will prove very helpful. For cattle that are being fattened, cowpeas and corn in almost any proportions will answer as the concentrate fed, but when corn forms 50 per cent of the grain ration, more rapid increase may usually be looked for than if it should form a less proportion of the same.

Sheep, doubtless, may be fattened on this grain alone, just as they may be fattened on the Canada field pea alone. The peas may also be fed thus to breeding ewes. Nevertheless, for the latter use, the addition of oats will improve the ration materially. But for fattening sheep, corn and cowpeas, during the later stages of fattening, are superior to cowpeas and oats. These three fed together in equal proportions by weight, should furnish an excellent food for fattening sheep.

To swine, cowpeas are more commonly fed than to other kinds of live stock. At the Alabama experiment station, located at Auburn, it was found that cowpeas alone called for 481 pounds to make 100 pounds of increase, corn alone, 487 pounds, and equal parts of each, 433 pounds. The peas and corn may be fed unground. Rye or barley could be substituted for corn, but not quite so satisfactorily. The peas ground and soaked and fed with skim milk, a limited proportion of corn meal being in the ration, make quick growth. Cowpeas and sweet potatoes also feed well together, especially when fattening swine.

To horses, although cowpeas are not usually fed because of relative cost, they may be so fed. As in the case of soy beans, they go well with corn. When fed as meal, pea meal and ground oats in equal proportions go well together. The oats lighten up the meal in the sense that they render it more porous.

Vetches.—The leading varieties of vetches grown in the United States are known as common winter or spring vetches, also the sand vetch, which, properly speaking, is a winter vetch. The distinction between winter and spring vetches is not very sharply defined. The highest adaptation for the common vetch is found west of the Cascade mountains and northward from California to Alaska, in areas with cool summer temperatures, especially northward from the Great lakes, and in the maritime provinces of Canada and some portions of the New England states. The sand vetch is more commonly grown on light soils south of say 40 degrees.

Vetches are chiefly grown to produce pasture, soiling food or hay, but in some instances the grain is the chief consideration. In such instances they are chiefly harvested by sheep or swine where they grew, but more especially by the former, as then much of the vine is consumed as well as the grain. When sown for such harvesting by sheep, enough oats should be sown with them to sustain the crop. Such grazing is only adapted to conditions where dry weather prevails during the harvest season, as for instance, where irrigation is practised. The seed separate from the grain has usually too high a market value for being fed in that form. The grain has much the same feeding value as peas (see p. 236), and may be fed in much the same way. It is particularly valuable as a concentrate for young stock, owing to its high protein content.

Flax.—In limited quantities, flax may be grown with a reasonable measure of success in almost every state in the Union, but in the northwestern states and provinces of Canada the relative adaptation is higher for it than elsewhere, and in these areas the greater portion of the American crop is grown. Because of the abundance of the oil which it produces, and the high commercial value of the same, flax is more commonly fed as cake or meal after the oil has been extracted, and for the further reason that the high content of the oil makes it too rich a food for prolonged feeding in large quantities. Nevertheless, there are conditions in which the grain may be fed with advantage and profit, in limited quantities, whether fed directly or indirectly, as by grinding it with other foods.

By sowing the flax with the grain or grains with which it is to be fed, it may be obtained virtually without cost other than the seed sown. More than 5 to 10 per cent of flax in the grain fed would usually be unnecessary, and to ascertain how much seed to sow to furnish this amount, can only be found through actual experience in any given locality. When flax seed is thus grown, it precludes the necessity for purchasing oil cake. The favorable influence on digestion of a small quantity of flax seed in the ration, is the strong argument in favor of feeding it thus. But it can only be fed in limited quantities, otherwise the appetite will be gradually lessened

To cattle, when thus grown, the grain, with the flax in it, is ground and fed for fattening. When present only in limited quantities, the presence of the flax in the grain does not seriously interfere with successful grinding in home farm mills as would be the case with flax alone because of its oily character.

Meal similarly prepared may also be fed to milch cows. When thus fed, the flax adds protein to the ration and aids digestion, and is not present in sufficient quantities to affect adversely the quality of the butter.

Flax seed in the unground form has been used more for feeding young calves during the milk period when fed skim milk than for any other class of cattle. It is prepared by making it into a gruel by soaking and boiling and adding to the skim milk while hot. The object of heating is to raise the temperature of the milk. Though excellent for such a use, it is not so necessary to add heat to the milk, now that newly separated milk is coming to be much used for feeding calves. The seed in the ground form, usually spoken of as linseed and fed with the milk or otherwise, serves the purpose equally well except in instances in which the temperature of the milk will be improved by raising it. The quantity fed, a very small amount at first, may be gauged by the condition of the voidings. Fed in excess, the bowels become too lax.

For sheep, flax when grown with oats in suitable quantity, makes an excellent food for breeding ewes, in the unground form, the amount of grain fed being not more than one pound daily until after lambing. Grown with oats and barley, or oats, barley and wheat, an excellent mixture is furnished for fattening sheep, without adding any other grain. The gruel mixture and the linseed also are particularly excellent for lambs that are hand-fed as they can probably utilize much fat in the ration.

For swine, a small amount ground with a suitable grain mixture, will improve the ration but the amount should be very small or the appetite will be lessened.

For horses, a small quantity of the ground flax may be added to the food to prevent constipation but wheat bran is usually preferred for such a purpose. In limited quantity, it may also be thus used in feeding young horses and brood mares but oil cake is more suitable.

Cotton seed.—Nearly all the cotton grown in the United States is produced in the Gulf states and in the states adjacent to them. It is by far the most valuable crop grown in the South. Subsequently to its introduction into the United States, cotton was grown for several decades for the sole purpose of producing fibre to be used in making cloth. Previously to 1860, it is said that nearly all the seed was wasted. It was an enormous waste, as the cotton plant produces about two pounds of seed for each pound of fibre. Since the great value of the seed in furnishing food for live stock and for fertilization have come to be known and appreciated, virtually all the seed grown is fed to live stock, chiefly in the form of meal or cake after the oil has been extracted, but it is also fed to some extent while yet unground, in the natural condition or steamed, boiled roasted.

For cattle, cotton seed furnishes an excellent concentrate. In the production of beef, no grain grown in the United States is equal to cotton seed, pound for pound, in producing value. When fed in the raw or natural form to cattle that are being fattened along with Bermuda hay, it has produced meat even more cheaply than when fed as meal, but larger gains have been obtained from feeding it steamed, and also from feeding in some combinations along with other concentrates. The comparative profit, however, from feeding cotton seed as compared with cottonseed meal, will depend on the relative prices of the two. Being an exceedingly concentrated food, ordinarily not more than four to five pounds of the daily ration are composed of cotton seed, the other portion of the grain or meal being made up from some other concentrate, but in some instances, in the cotton states, more than 10 pounds of the seed are fed daily. Cattle have been successfully fattened on cotton seed and cotton seed hulls without hay. Excellent results follow the feeding of raw cotton seed, a moderate amount of corn, corn silage and Bermuda hay.

For cows in milk, cotton seed has been found even more profitable than when fed for meat, owing, doubtless to its high protein content. It is more commonly fed to dairy cows in the form of meal, but in instances not a few, is fed raw or steamed. At the Mississippi experiment station, butter made by feeding boiled cotton seed, Bermuda hay and silage stood first in cheapness of production, that from raw cotton seed and the same adjuncts came second and that made from cottonseed meal and these adjuncts was third. Here also, relative profit from feeding the seed and meal will depend upon relative values. The claim has been made, and it is probably correct, that no cheaper feed for producing milk can be fed in the southern states. For milk production as much as 10 pounds per day per cow have in some instances been fed, but the aim should be rather to feed not more than half the quantity named in prolonged feeding and to add some other concentrate, preferably one grown in the South. It would seem probable that in the future, cotton seed will be more and more fed as meal rather than as seed, as the value of the oil pressed from seed is greater for some other uses than as food for stock.

For calves, cotton seed is usually fed in the form of meal. As they become more advanced in age, however, it may be fed to them raw or steamed, and thus also it may be used with advantage as a source of protein in growing young cattle, more especially when the fodder is made up largely of corn stalks and the non-saccharine sorghums.

To sheep, cotton seed in the raw form is fed freely when fattening them in proximity to the mills, and is a good fattening food fed along with Bermuda or other hay, or even along with the hulls in lieu of roughage feeding three to four pounds of hulls to one pound of the seed. It has not been much fed to breeding ewes, but doubtless it would be perfectly legitimate to feed it to them in moderate quantities.

To swine, it is not common to feed cotton seed in any form, but when so fed it is usually in the form of meal. In the unground form it is not well suited to the digestion of swine, even though it should not injure them, as the meal does in prolonged feeding (see p. 278). At the Texas experiment station, even when fed boiled, the mortality of the animals eating it was 25 per cent.

To horses, neither cotton seed nor cottonseed meal have been much fed. The meal has been fed with safety to working horses to the extent of one to two pounds a day, and it would seem reasonable to suppose that at least as large amounts of the raw seed could be fed without hazard.

Sunflower seed.—The sunflower calls for a climate somewhat similar to that required by corn. This means that it can be grown successfully in nearly all parts of the United States that are tillable, and also in several of the provinces of Canada. The yields from reasonably good crops are about 2,000 pounds per acre. The growing of the plant calls for about the same amount of labor as the growing of a crop of corn, and the yield of the grain is not far different. The seed is also possessed of high feeding value. Notwithstanding, the growing of sunflowers as food for farm animals, unless it be for poultry, is not likely to become popular in the near future, owing, first, to the hand labor required in harvesting the crop, and second, to the little food value possessed by the stalks.

Sunflower seed may be fed in the unground form to sheep, swine, horses and poultry. When fed to cattle they are commonly ground, except when fed as ensilage. This is probably the most popular way of feeding them to cattle. When so fed, it is common to ensile only the heads and a small portion of the stalk which supports them. When thus ensiled with corn and horse beans, an excellent ration is obtained for feeding milch cows. When fed to cattle, sheep, swine and horses, only a limited percentage of the grain ration should be sunflower seed, because of the high content of oil which they contain. Even when fed to fowls, it should be along with other grain. Cake made from sunflowers is about as valuable as oil cake.

Sweet sorghum seed.—Sorghum may be grown for pasture, soiling food, fodder, or for making syrup, in nearly all localities where corn will mature paying crops of the grain. Sorghum syrup has been made in considerable quantities as far north as southern Minnesota. This crop is seldom grown primarily for the seed obtained from it, but when grown to furnish syrup, the seed also is an important consideration. Yields approximating 30 bushels per acre are frequently obtained and in some instances considerably more than the quantity named. As with Kafir corn and indeed with all the seeds of the sorghum family, much care is necessary to prevent them from heating to their injury as food when stored.

Nearly all of what is said with reference to the feeding of Kafir corn seed will also apply to the feeding of sorghum seed (see p. 255). The composition of the two is very similar. This means that sorghum seed may, under certain conditions, be fed with advantage to beef and dairy cattle, to sheep, swine, horses and poultry. For cattle and swine it is decidedly preferable to feed the seed as meal, but to sheep and horses there is probably no better way of feeding it than by simply chopping off the heads from the sheaves and feeding them unthreshed. In this form, under proper conditions of storage, this seed is but little liable to ferment. Well preserved seed when threshed, will usually command so high a price for planting that it cannot be profitably used for feeding in a large way to live stock.

Kafir corn seed.—Kafir corn will successfully withstand much more drought than corn and considerably more than sorghum, but it cannot withstand temperatures so low as some varieties of these plants. It has special adaptation, therefore, for certain areas of the semi-arid belt from say parallel 40 degrees southward. In these it produces more grain and fodder per acre than either corn or sorghum. At the Kansas experiment station located at Manhattan, it has produced about 25 per cent more grain than corn. Where, however, the yields of corn are equal to or greater than those of Kafir corn seed, the former should be grown in preference, as it is not only somewhat better relished but has a higher feeding value. Except when fed to sheep and fowls, Kafir corn is usually ground before feeding it.

For cattle, Kafir corn has not been found quite equal to corn. For fattening cattle, the feeding of corn is about 6 per cent greater. The difference in favor of corn for milk production is probably even more. Cattle tire more quickly of Kafir corn than of corn.

Twenty to 30 per cent of soy bean meal greatly improves the Kafir corn for making beef and a still larger percentage further improves it for milk production when the fodder is carbonaceous in character. Wheat bran also is well suited for being fed to cattle with this meal, as it not only increases the protein content, but adds to the bulk. It should be fed somewhat sparingly to calves except when they are being fattened, and to young cattle in process of development.

For fattening sheep, Kafir corn has proved at least fairly satisfactory It is fed to them in the unground form and very frequently without separating the seed from the heads. These are removed from the stems and run through a cutting box which prepares them for being fed in a very suitable form. In other instances the seed is fed directly and unmixed, but a small percentage of oats added improves the grain ration. When fed to breeding ewes, the percentage of oats should be large, even when the fodder consists of alfalfa.

For swine, Kafir corn, finely ground and soaked, has proved fairly satisfactory when fed to swine that were being fattened. It was not equal to corn, however. Swine tire of it more quickly and it has more of a tendency to produce constipation. When from 20 to 33 per cent of the grain mixture is soy bean meal, Kafir corn is not much behind corn similarly fed in fattening swine. When fed to sows suckling their young, from 30 to 50 per cent of soy bean meal will furnish a suitable ration. The same is true when not less than 50 per cent of the meal is composed of shorts. When fed along with skim milk to young swine before or after the weaning period, the development should be satisfactory, but it will be even more so if wheat middlings are added.

To horses, the few trials made in feeding Kafir corn have shown that it may be so fed with safety and profit under certain conditions, especially to horses at work. It is frequently fed while yet unthreshed, by simply cutting off the heads of the sheaves and feeding the heads. It is believed, however, that better results will be obtained from first grinding the seed. What has been said about feeding corn in conjunction with other grains, will also apply in the main to Kafir corn seed. It is relished at least fairly well by horses.

Other non-saccharine sorghum seeds.—Besides Kafir corn (see p. 255), the non-saccharine sorghums known as Jerusalem corn, Milo maize and Durra, are grown to some extent and in some instances largely if not chiefly for the grain obtained from them. They are grown sectionally as it were, and mainly in limited areas and in states more or less centrally located west of the Mississippi river. As a rule these have not proved equal to Kafir corn in yields of seed, but to this there are some exceptions. Nor has the fodder as a rule proved equal to that obtained from Kafir corn or sorghum. Where corn grows in fine form, it would seem safe to say that it can be more profitably grown to furnish food for live stock than any of these.

The seed of each of the non-saccharine sorghums has about the same feeding value as that of Kafir corn. This means that none of them are quite equal to corn for general feeding, although they may exceed it in some special line or lines of the same. It means also that they are better adapted relatively for fattening than for promoting growth in young animals. As in the case of Kafir corn, these should ordinarily be ground when fed to cattle and swine, but may usually be fed with more advantage to sheep, horses and fowls by feeding them while yet on the unthreshed heads, or at least in the unground form.

Corn or maize.—Indian corn or maize is unquestionably the most important single food plant grown in the United States to provide sustenance for domestic animals. In localities where it can be successfully grown, it usually furnishes more nutrients per acre than can be obtained from any other plant for the labor involved, and this holds true of it even in many instances where it is not considered profitable to grow it primarily to produce grain. It is not so exhaustive to the soil as many other plants and no other crop can be used to better purpose as an aid in cleaning the land, when the labor involved is considered.

While corn can be grown with more or less profit in every state in the Union, the greatest corn growing states are those embraced in the Mississippi basin. Although in some of its varieties it may be matured in 90 days from the date of planting, it is not usually grown to a very large extent primarily for the grain, unless in areas that are free from frost for 120 days. As a fodder crop, its growth has been pushed far northward during recent years.

Corn fed as grain is preeminently a fattening food for all kinds of domestic animals. In this respect, it is without a rival. As shown in the table, it is essentially a carbonaceous food, its leading characteristic being the large amount of starchy matter which it contains. It is low in protein and quite low in ash. It is a heat-producing food and quite low in those materials that furnish muscle and bone. It should always be fed, therefore, with a prudent moderation to young animals, to animals at work and to those producing milk, and in conjunction with foods rich in protein. It is nearly all digestible, is much relished by animals, and is one of the most healthful of cereals, even for prolonged feeding, providing it is fed with judgment.

The number of varieties of corn is in a sense without limit. These are divided into the two classes known as common and sweet. The sweet varieties are richer in albuminoids and fat, but they do not usually yield as much, as a rule, as the common varieties. The latter are subdivided into what are termed flint and dent varieties. The flint varieties are characterized by the flinty hardness of the grain and the dent varieties by an indentation on the outer end of the kernels. The flint varieties are smaller and hardier, and are, therefore, better adapted relatively to conditions with seasons too short for producing the dent varieties with equal profit. There is no marked difference in the chemical analysis of the common sorts of corn based on the terms flint and dent. The nutrients do not seem to be materially influenced by color nor by latitude and longitude.

Corn is fed as grain in various ways. More commonly it is fed after removal from the cob when it is spoken of as "shelled" corn or simply corn, but frequently it is fed on the cob after the husk has been removed when it is known as "ear" corn. Sometimes the whole crop is put into the silo and fed as "silage," at other times it is fed unhusked from the shock when it is known as "shock" or "fodder" corn.

In some instances the ears are broken off and fed without husking when it is designated "snapped" corn. The stalks, with the ears removed, are known as "stover." When these are torn into strips by a suitable machine, the product is called "shredded" corn. The discussion at this time relates primarily to the grain.

To young animals, corn is usually fed cracked or ground. By "cracked" is meant broken up into coarse particles that they may masticate it more easily. In some instances, the corn and cob are ground together before being fed, the product being spoken of as corn and cob meal. When prepared thus, it should be finely ground, as when the particles are coarse, they are not easily digested. When properly prepared, corn and cob meal has about the same feeding value as corn meal, notwithstanding the small amount of nutrients in the cob. The result is owing probably to the more easily penetrable character of the mass in the stomach when fed directly. When fed to cattle that are being fattened, corn is given ground or unground, soaked or unsoaked, as snapped corn and also as shock corn. It is usually given to cows in the form of meal. It is more commonly fed to sheep shelled and unground, but may be fed, in part at least, as ear corn or as shock corn. It is usually fed to swine in the shelled or ear form and unground. In some instances it is first soaked. For young swine and sows that are nursing their young, it is made into meal and the meal is soaked. To horses it is more commonly fed in the shelled form.

The degree of the moisture in corn has a material influence on its feeding value. In new corn the moisture content varies from 20 to 25 per cent. In old corn, thoroughly air dried, it is about 12 per cent. It loses moisture slowly, hence the necessity for great care in storing, or it will mould. In such a condition its value as food is greatly impaired. If fed in large or even in moderate quantities it is positively dangerous.

To calves and young cattle, corn must be fed with some reserve, owing to its carbonaceous character, unless when they are to be fattened. It may then be made the principal, almost the sole grain food fed, otherwise it should not as a rule form more than one-third to one-half the grain fed, the balance being preferably oats and bran. The latter quantity is only admissible when fed along with legumes or what is better, with these and field roots.

For cattle that are being fattened, corn is *par excellence* the food. It is not only much relished but it is much laden with starch, well calculated to fill the tissues of the body with fat. It may be used as the sole grain food or as any part of it, according to the nature of the other food factors. In the corn belt, it has been much used as the sole ration, the stalks supplying the roughage, but this method is only admissible when the prices of grain rule low, as it is not a balanced food. It is fed to such cattle as corn meal, corn and cob meal, the ears snapped, as shock corn and sometimes soaked. When fed with clover or alfalfa, corn may legitimately form 75 to 90 per cent of the concentrated food, the balance being some food rich in protein, as cottonseed meal, oil cake, bran or gluten meal. When the grain is fed whole, swine are made to glean amid the droppings to consume the corn that has escaped being digested.

For cows in milk, corn will easily maintain its position as the basic ration, in localities where it grows readily. It can be produced cheaply, and in the form of silage furnishes the necessary succulence. More commonly the grain is fed to cows in the form of corn meal or corn and cob meal, but sometimes it is fed as shock corn, more especially when the fodder is not coarse. When thus fed, it is usually necessary to add more grain, as in the case of feeding silage. It is seldom wise to make corn comprise more than 50 per cent of the grain fed, even when a legume is used as fodder.

For sheep that are being fattened, corn is equally as good as for fattening cattle. For winter lambs, fed as meal or cracked, along with 20 per cent of oil meal, the gains should be satisfactory when the milk supply from the dams is also liberal. For weaned lambs and mature sheep that are being fattened, it may be fed unground as the sole grain ration for short periods of feeding, the fodder being leguminous, but when from 10 to 25 per cent of the grain is a protein food, the results are usually more satisfactory. For breeding ewes, the corn should not be more than 50 per cent of the concentrate fed, and usually not more than 25 per cent.

For swine that are being fattened, corn alone answers well. It is about as profitable fed as shelled or in the cob, as in the form of meal. If so hard as to injure the mouths of the animals, it should be soaked for 18 to 24 hours. For brood sows, it may profitably form 33 to 50 per cent of the grain fed, the other meal having more of protein in it. In such instances, it is fed as meal, after having been soaked, and is thus prepared also for unweaned pigs. To these it should seldom form more than 33 per cent of the meal, the other portion being preferably wheat middlings. To growing pigs on clover or alfalfa pasture, it may furnish 50 to 100 per cent of the grain fed.

For horses, corn is not so good a food as oats, when fed as the sole food. It is not so good for building muscular tissue or in making bone in young horses, or in sustaining muscular energy in horses at work. It fattens the animals more than oats, as one result of which they sweat more readily, and yet corn may be fed as a considerable proportion of the grain ration, especially to horses at work, with both economy and profit. To these it may be fed so as to form from 25 to 50 per cent of the grain, according to the season and to the protein in the other food. Oats go well with corn. A little wheat bran added to corn meal is a material aid to the digesting of corn. Corn and cob meal is better than corn meal fed without admixture. Corn should seldom form more than 33 per cent of the grain food fed to foals, young horses or brood mares that are pregnant or while nursing their foals, because of its low protein and ash content.

Broom corn seed.—The seed of broom corn has frequently been wasted under the impression that it was not possessed of any considerable feeding value. This view may rest upon the fact that broom corn may be most profitably harvested when a little short of maturity. Nevertheless, under such conditions, the value of the seed is considerable, since it is usually allowed to reach the dough stage before it is harvested, and in some instances to go beyond it. Its feeding value is, of course, much affected by the degree of the maturity when harvested, but under almost any conditions, the value of the seed for feeding is much more than the cost involved in it. Where the seed is allowed to mature before the brush is cut, as much as a ton is frequently obtained per acre. As the feeding value is much the same as that of Kafir corn, food from such a source should not be underrated.

In some instances it has been reported that the seed not fully matured has been drawn into a pasture as soon as obtained, where horses, cattle, sheep and swine were allowed to eat of it at will, except that for a few days at the first, they were accustomed to it gradually by allowing them to take increasing quantities from day to day. The wisdom of feeding it thus is to be questioned, as under such conditions, unnecessarily large quantities will be consumed. It may be fed much the same as Kafir corn (see p. 255), remembering that, as the immaturity in the seed is increased, the relative quantity fed should also be increased. There is probably no way in which immature seed may be fed more profitably than by feeding it to sheep or fowls in the unground form. Much broom corn seed is lost by throwing it in heaps and allowing it to ferment, a result that will quickly follow when it is treated thus.

Millet seed.—Millet may be grown in many states and provinces of Canada, but the prairie states of the northwest in this country, and of the west in Canada, have highest adaptation for it. In these areas, it may frequently be grown with much appropriateness to furnish not only hay but also grain for live stock in the seed which it matures. Since it grows best in warm weather and will mature in about 75 days, according to the variety, it may furnish a crop of seed on land where crops sown earlier may have failed, or where early spring sowing was not practicable because of excessive moisture. Yields of not less than 30 bushels of seed per acre and weighing 48 to 56 pounds per bushel are easily obtainable from such lands. As the composition of millet is much like that of oats, and as it has but little hull, its feeding value for live stock, especially where corn is not successfully grown for the grain, will be at once apparent. Owing to the hardness of the grain, it is fed only in the ground form, except when fed to sheep and fowls.

For calves and young cattle, ground millet furnishes a suitable concentrate. More especially when fed in conjunction with oats, millet meal should be quite suitable for young calves, since the proportion of hull is small. Along with oats, say in equal parts by weight, calves may be given about all of the mixture that they will take during the milk

For cattle being fattened, ground millet is a useful food when it forms from 33 to 50 per cent, according to the stage of the fattening, less being fed as the season advances. The other factor is preferably corn, but may be barley. Millet and wheat may also be similarly fed.

For cows in milk, ground millet may profitably form any portion of the grain ration up to 50 per cent of the grain fed, should occasion require it. Ground oats and wheat, barley, rye or corn, in equal parts by weight, may appropriately furnish the other portion.

To sheep, millet seed furnishes suitable food. More commonly it is fed to them unground. It may be fed alone, but oats mixed with it, add to the bulk and porosity of the mass, and so far as they do, improve it for ordinary fattening. For fattening sheep, it blends well with corn, about equal parts being used, but may also be fed with other cereals, as wheat, barley or rye.

For swine, ground millet is a better food than ground oats, especially for young swine, a large proportion being digestible. Alone it furnishes good food for sows nursing their young, but is, of course, improved by feeding with various other grains. In tests made at the South Dakota station, millet alone did not prove equal to wheat or barley, pound for pound. In fattening swine, ground millet may be fed with corn, in any proportions desired, but the aim should be to have more than 50 per cent of corn in the ration.

To horses, ground millet may be fed with appropriateness. Fed to foals and young horses, as when oats are fed, it produces muscular development, and fed to horses at work, it promotes muscular strength. The ration is improved by adding oats, but in the absence of oats, it may be made to take their place in a mixed ration. For exclusive feeding, it is not equal to oats, being a somewhat heavier feed.

CHAPTER XIII.

FOOD FROM BY-PRODUCTS.

By-products are residues from the manufacture of products primarily grown for some more important use. The by-products of food stuffs are the residues left from the manufacture of these various products for which they are more commonly grown. Thus bran is a by-product of wheat manufactured into flour. Cottonseed meal is a by-product of cotton seed from which the oil has been extracted. Skim milk is a by-product of whole milk from which the cream has been removed for being made into butter. These by-products are usually fed to live stock, and in the aggregate they are of immense value. The three most valuable by-products in furnishing food for animals are, wheat bran, oil meal, and cottonseed meal, but many others are also highly valuable.

The more important of the by-products discussed in Chapter XIII, obtained from the cereals, are the by-products from: (1) Wheat, (2) barley, (3) flax and (4) corn. The discussion of the by-products of other cereals follows. These are of minor importance and include the by-products: (1) Of rye, (2) of oats, (3) of peas, (4) of buckwheat and (5) of rice. The by-products obtained from certain food products other than cereals are then discussed, and they include residues from: (1) Cotton seed, (2) sugar beets, (3) milk and (4) the by-product molasses obtained in the manufacture of sugar. Lastly, miscellaneous by-products are discussed. They include the following: (1) Tankage, (2) dried blood, (3) dried flesh meal and meat scrap and (4) fish scrap, also various kinds of cake other than oil cake and cottonseed cake.

Several of these by-products are exceedingly rich in the elements of plant growth, as well as in food nutrients.

Prominent among these are cottonseed meal, oil meal and wheat bran, rich in the order named. As but a small portion of these elements are appropriated by the animals to which they are fed, when the voidings are carefully saved and promptly applied, they furnish fertilizer of much value. So important is the value of this residue, that it should never be lost sight of in determining the foods that shall be fed. The wholesale exportation of these food products, therefore, from this country, is to be deplored. It means that these resources of production are fast being sent away to other lands.

Wheat by-products.—Wheat furnishes by-products of great value in feeding live stock. The chief of these are bran, shorts and middlings, but in some instances a low grade of flour is also fed. It would also seem correct to speak of frosted wheat, much shrunken wheat and screenings, as by-products. Bran consists of the three outer membranous coats of the kernel and also the rich protein layer just underneath them. Shorts is simply reground bran. Middlings contain the finer bran particles and more flour than shorts. The distinction between these is not clearly drawn in all instances either in the composition of the two products or in the more or less interchangeable way of referring to them. The low grade of flour fed is commonly referred to as "red dog" and in some instances as "dark feeding flour." Frozen or frosted wheat is wheat that has been injured by frost before maturity. It may be perfectly pure but lacks in plumpness and hardness, according to the stage of the growth at which it was frozen. Shrunken wheat is that which is small and shrivelled, though hard in the berry, owing to some injury sustained by the stalk and leaves, before the completion of the ripening of the grain, as when stricken by the black rust. Such grain may make good flour though low in quantity, hence it is heavily discounted by buyers. Screenings consist of small and light or broken kernels and the seeds of weeds that may have ripened in the grain, also in some instances minute pieces of broken straw. From 25 to 33 per cent of wheat is made into by-products, of course not including the frosted or shrunken grain or the screenings.

Wheat bran is probably more extensively used in feeding live stock than any single by-product of any kind of grain. There are but few instances in which it may not be fed to live stock with decided benefit. It is richer in protein than the whole grain which gives it high adaptation to the needs of growing animals and to milk production. It contains a large proportion of the mineral matter and a considerable proportion of the gluten which makes it good bone making food. It has the requisite bulkiness necessary to make it feed well with highly concentrated foods such as corn.

The germ remnants in it to some extent promote digestion. It is also a mild laxative. The feeding value of bran, except perhaps for young swine, is higher than chemical analyses would indicate. Moreover, the fertilizer from feeding it is rich in plant food. The best interests of agriculture, therefore, demand that this by-product shall be retained and fed in the country to the greatest extent possible.

For calves, bran is excellent from the time that they begin to take food other than milk. It is specially helpful when feeding some concentrated food as corn or rye meal, but is not so necessary when feeding ground oats. For growing calves, the bran should usually form not less than two-thirds of the meal when fed along with corn, rye or barley meal, but for calves that are being fattened, it should not form a large proportion of the meal ration and in some instances none at all. For young cattle that are being wintered on dry fodder other than clover hay, two or three pounds of bran fed daily, or even a less quantity with other meal, will produce excellent results. There is perhaps no kind of meal that will not be improved as food by its presence, and the more dense and concentrated the meal, the more beneficial it is to mix bran with it and the larger is the quantity of bran that may be mixed into it.

For cattle being fattened, bran may be fed with much benefit as a part of the ration from the beginning to the end of the feeding period when it is not too costly, but it should be used in very gradually decreasing proportions. When sufficiently cheap, it may form as much as one-half the grain ration by weight, in the first stages of fattening. By the middle of the period, it should seldom form more than one-third of the ration and even a less proportion is preferable. By the end of the fattening period, only a small amount is needed, and when oil meal is fed, none at all. In forced feeding with strong concentrates as corn, bran so lightens the mass in the stomach that digestive disturbances are warded off, but when oats form a considerable proportion of the food fed, it is not needed except in so far as it exerts a wholesome influence on the digestive tract. Bran has been used with considerable success in fattening animals along with good prairie hay when the bran was low in price.

For cows in milk, wheat bran is specially well adapted since it furnishes abundantly protein and ash and also a fair amount of starchy matter. Moreover, its bulky character, as in fattening cattle, tends to make more porous the mass of the heavy concentrates when mixed with them. Even cottonseed meal is improved by such admixture, although the nutritive constituents are approximately the same. Bran may form any part of the meal ration or the whole of it, according to the relative cost. When fed alone, from eight to ten pounds may be given to a cow daily. Fed along with such concentrates as corn, rye and barley, the fodder being carbonaceous in character, as corn, sorghum or any of the grasses, one-half the meal fed by weight may consist of bran, but should the fodder be leguminous, as clover hay, it will suffice if bran forms say one-third of the mixture. Usually not more than nine pounds of such a mixture are needed daily. Bran, ground oats and ground corn, in equal parts by weight, furnish a grand concentrate for dairy cows. No other by-product is so much used in feeding for milk in this country as bran.

For sheep, bran serves a good purpose and for breeding ewes when fed as a part of the grain ration, but it is rather coarse for being fed to very young lambs. It is particularly helpful to breeding ewes when the fodder consists largely of corn or the grasses. With such roughage, as much as one-half the grain ration may be composed of bran, when such grain as corn, barley, or rye are being fed, but usually a less proportion will suffice. A mixture which is two parts oats and one bran by weight is very valuable for such feeding. When fed along with leguminous fodders, but little bran is needed. Subsequently to the lambing period, the free feeding of bran will be found highly conducive to milk production. The feeding value of bran is not so high relatively for sheep that are being fattened. Sheep are not so fond of bran as of some other kinds of meal or grain, hence care should be taken not to feed it to them in excess while fattening or the gains will not be entirely satisfactory. And yet, in the absence of oil cake or field roots, a small proportion of bran will be found beneficial. Along with heavy corn feeding it is really essential.

For swine, bran has not so high adaptation as for feeding cattle, horses or sheep and yet may frequently be used with profit in the judicious feeding of swine. For young swine it is too coarse and bulky and has in it too large a proportion of crude fibre. Nor is it the best food that can be given to swine during the growing period, but with advance in age it becomes increasingly suitable for them. It is seldom fed, even as a part of a ration, to swine that are being fattened. It may, however, be fed as a factor of the meal ration along with concentrated grains to brood sows before or after farrowing and to the extent of forming when necessary at least 50 per cent of the meal fed.

For horses, bran is frequently given a place in the diet of animals, young and old, but the amount fed daily is usually quite small. In other instances it is fed not more frequently than once or twice a week, when it is scalded and fed as a mash with a view probably to render it more laxative. In other instances it is not fed at all. A small quantity fed daily exercises a salutary influence on the digestion of horses of all classes when on dry feed and not worked severely, including weanling foals, yard horses, brood mares, stallions and horses at moderate work. It is too laxative and not sufficiently nutritive for horses that are worked severely, but in some instances they have been worked somewhat severely for a considerable period on bran as the sole concentrate.

Bran is rather preferred to middlings when feeding animals that are being fattened, whether cattle or sheep, as it makes a more desirable blend with fine meals as corn and cottonseed meal and is less pasty when being masticated. Bran and shorts have been found about equal for milk production when fed to cows, but as a food for swine, bran is far below middlings. Bran is not quite equal to oats pound for pound for producing milk, or to a mixture of ground oats and barley, but the difference is slight. Swine fed chiefly on bran will not thrive so well nor keep healthy so long as swine fed chiefly on ground barley or rye. It should not be much used in fattening cattle when the relative value per pound is more than one-half that of oil meal and kindred feeds. Bran, when fed daily to horses, is commonly fed dry, but when fed occasionally, as mash. It is also fed in the dry form to cattle and sheep but is soaked before being fed to swine.

Middlings and shorts are so nearly alike in their composition and feeding qualities, notwithstanding some differences, that it will be in order to discuss them together. They have more starchy matter and less crude fibre than bran and are therefore better adapted relatively to animals whose digestive capacity unfits them for taking large quantities of bulky food. Although it is considerably more concentrated than bran, it is no richer in protein and is even less rich in mineral matter. Middlings have never stood so high relatively for feeding cattle and sheep as bran, but they may be so fed in due admixture with considerable benefit. They are less satisfactory as a diluent of the heavier kinds of meal and when fed, the quantity given is less than in the case of bran. The results from feeding middlings and corn to cows has proved quite satisfactory, the quantity required being about 25 per cent less than when feeding bran. Middlings are preeminently adapted for feeding to swine. No kind of meal is better for swine of all ages when due regard is had to the quantity fed. When the prices admit of such feeding, they may be made the sole meal ration for pigs before weaning; a large proportion of the same during the growing period, and 50 to 75 per cent of the ration of brood sows suckling their young. Even when pigs are being fattened they are sometimes fed so as to form from 25 to 50 per cent of the ration. Shorts and corn have been found to make increase about 25 per cent greater than corn alone and considerably greater than shorts alone. When fed alone during the finishing period, they produce pork somewhat soft. Middlings and skim milk are two of the standard foods in areas where bacon pork of prime quality is produced. Because of the high adaptation of middlings to pork production, under some conditions, it is in order to purchase them in large quantities for feeding swine. When fed to horses, unless duly admixed with other concentrates, it is said that they tend to induce colic.

Red dog flour is rich in protein and fat. It contains much of the germs of the wheat and because of its composition and fineness is preeminently adapted for feeding to growing swine. In limited quantities it has also been found quite useful for feeding to horses that are worked hard and to milch cows.

Frosted wheat has much the same feeding qualities as matured wheat, unless the freezing takes place several days before the wheat is matured, and is probably quite as useful pound for pound for feeding purposes. The same is true of shrunken wheat. It is even richer in protein than wheat not shrunken, and because of this and of the higher bran element it contains, it is more valuable relatively for some kinds of feeding than plump wheat. These facts are important to the grower of wheat since frosted and shrunken wheat are much discounted in the market. These may be fed in the same way as matured wheat (see p. 225).

Wheat screenings is a sort of indeterminable quantity, owing to the great difference in the composition of the various grades. Screenings that consist largely of broken kernels and small and shrivelled grains, are usually as valuable for feeding as pure wheat, whereas screenings that are light and chaffy in character may prove of but little use for any kind of feeding. Sceenings in the unground form are usually fed to sheep that are being fattened alone or in conjunction with other kinds of grain. They have been found eminently suited to such feeding, as they are a safe and healthful food. Moreover, they usually contain a variety of weed seeds that are rich in fattening properties, and that are much relished by sheep. They may be fed in restricted quantities or in self feeders, and in some instances but little fodder is fed along with them. They may be fed in conjunction with any of the cereals and in any quantity desired. Sometimes they are fed along with wheat shorts. They are also fed with good results to cattle and swine in the ground form and soaked when fed to the latter.

Barley by-products.—Barley is extensively used in the manufacture of beer and other spirituous liquors. Consequently the by-products obtained from it are large in volume. Chief among these are brewers' grains, distillers' grains and malt sprouts. Brewers' grains are the residue left after the soluble dextrin and sugar have been extracted from the malt. Barley is valuable for malting in proportion as it is rich in starch and bright in color, hence barley, rich in protein, and, therefore, of high value for feeding, may grade low for malting, as the starch is the valuable element for making beer. Nearly all the protein is left in the grain. The residue, therefore, is richer relatively in nitrogen than the original barley, although in the wet form it is very much more bulky. Lawes and Gilbert have shown, however, that barley is worth more for feeding uses than the malt and malt sprouts obtained from it. Brewers' grains are fed in the wet form when fed within a reasonable distance of the brewery, otherwise they are dried before feeding them. If not soon fed in the wet form, they will spoil, but in the dried form they may be kept indefinitely. Distillers' grains are the residue left after the alcohol has been separated from the grain by distillation, following the fermentive processes. They have much the same composition as brewers' grains, but are more watery. They contain only eight or nine per cent of dry matter, whereas brewers' grains contain about 24 per cent. Malt sprouts are essentially very young barley sprouts, about two-thirds as long as the grain. They are obtained by sprouting barley when preparing malt. Further sprouting is stopped by drying the malt when the sprouts fall off or are separated by a winnowing process. As shown in the table they are very rich in protein.

For cattle of all ages, brewers' grains are much relished and as a source of protein they rank high. They are generally fed to cows with a view to milk production, but may also be fed to other cattle when the price will admit of so feeding them. In the dry form they rank along with such foods as bran and oil meal for dairy cows and are no more perishable than either. They are most extensively used in New England dairies and much is also exported to Germany. Four to five pounds may be fed daily to a mature cow, and in the wet form five to six times these amounts. They should be fed along with, say two to four pounds of such concentrates as corn or corn meal per day, dependent somewhat on the fodder. When fed in the wet form every care should be taken to keep the mangers and feed boxes in a clean condition, especially in warm weather, or offensive odors may arise which will affect adversely the quality of the milk.

Inattention to these particulars has in some instances led to the prohibition of the sale of such milk by boards of health. Brewers' grains may sometimes be fed with decided profit to calves and young cattle, but usually other foods may be obtained more cheaply for fattening, unless in the immediate vicinity of the brewery.

For feeding sheep, brewers' grains are not considered so suitable as for feeding cattle, especially in the wet form. Sheep do not take so kindly to sloppy food as swine or even cows. But where the cost will admit of such feeding, dry brewers' grains should answer well as a part of the ration for breeding ewes.

To swine, brewers' grains are not much fed at any considerable distance from the place of their production, but feeding them to young swine will tend much to promote growth, and for sows nursing their young, they should be quite as good as for cows nursing theirs. But, as a source of protein, they will probably be found too costly for feeding swine.

To horses, trials made on brewers grains, even when at work, have proved satisfactory. The general condition and also the energy were pronounced as good as when oats were fed. At the New Jersey station it was found economical to feed them to street car horses, but the outcome from such feeding is largely dependent on relative values. As a food for foals, young horses and brood mares, the results should be satisfactory from the judicious feeding of brewers' grains.

Distillers' grains, being a very watery food when fed in the wet form, are best adapted for being fed to cattle for milk or for beef. The stables in which the animals are fattened are usually not far distant from the place of distillation. For both uses these grains have high adaptation when fed with suitable adjuncts. They are not so well adapted for being fed to sheep, swine and horses, but under certain conditions may answer well for swine.

Malt sprouts are commonly fed to cows for milk production. They are highly adapted for such a use, since they contain about 20 per cent of digestible protein. Moreover, when properly prepared for feeding, they are a succulent food. But they may also be used in feeding various other domestic animals by adding them to the ration in moderate quantities, to increase the protein in the same. Live stock are not usually so fond of malt sprouts as of brewers' grains, hence they must needs be fed with more moderation. From two to three pounds will usually answer daily in the ration for milch cows. As they absorb much water, they are usually soaked several hours before feeding them.

Flax by-products.—The principal by-product of flax seed is oil cake, more commonly spoken of as oil meal. It is used as food for live stock. Oil cake is the residue left after the oil has been removed. When removed by hydraulic pressure only, it is known as old process oil cake. When chemicals are used in extracting the oil, it is known as new process. It is sold as oil cake or as oil meal, both terms being applied to it in a somewhat loose sense. Oil cake, properly speaking, is the residue pressed into large flat cakes after the oil has been removed from the seed and the moisture from the residue. Oil meal is the cake finely ground. Adulterants are sometimes mixed with the meal. The cake cannot be thus readily adulterated, hence the preference for it in foreign markets. For a similar reason, many feeders prefer to feed it in the "nut" form, that is, in the form that is broken up into small pieces about the size of mixed nuts as ordinarily found in the market. The meal is usually fed to animals that are quite young. It is not well suited to outdoor feeding as it may be lifted by the wind. The old process meal contains a little more oil than the new and a little less relatively of total protein. But it has a higher per cent of digestible protein, as cooking the meal in the new process reduces somewhat the digestibility of the protein. The two kinds of meal may be distinguished by placing a small quantity of each in separate glasses and pouring on a small quantity of hot water. The old process meal thus treated will form a jelly-like mass, and, since the new process meal has been already cooked, it does not jelly again. In feeding value, the old and new process meals do not differ greatly. The former has probably a higher feeding value for young calves and lambs, owing to its higher content of oil or fat.

Oil cake is one of the most valuable and useful, if not the most generally valuable and useful of all the by-products of the farm. It is not only rich in protein, but it is preeminently a safe food. When fed judiciously, there is no class of animals kept upon the farm to which it may not be fed with profit for a longer or shorter period. It is much relished by all classes of domestic animals, and it is to some extent an appetizer as well as a food. It is mildly laxative and exercises a salutary influence on the digestive tract. There is no kind of meal with which it may not be fed satisfactorily should occasion call for such feeding. As stated elsewhere, its real feeding value is considerably higher than chemical analysis would assign to it. It also gives to the hair a glossy appearance indicative of thrift on the part of the animal possessing it.

For cattle of all ages and of all classes, oil cake furnishes an admirable food. Its value for feeding calves during the milk period has already been referred to (see p. 250). To all classes of growing animals, it may be fed with much benefit in the winter season along with grain or meal, when not too dear for such feeding. It may form as much as 10 per cent of the concentrate fed. Its use is equally helpful in the winter grain ration for cattle that are to be finished on pasture. But it is not so necessary to feed it, nor will the benefits be so great relatively, when field roots are being fed at the same time. In fattening cattle, it is a favorite food, but rather as an adjunct to the meal ration than as a principal portion of the same. In other words the benefits are relatively greater when the oil cake is fed in moderate quantities of say one to three pounds rather than as a principal factor in the same. But should the cost justify it, oil cake may be fed to the extent of forming half the meal ration, the other portion being some carbonaceous food as corn. From such feeding, rapid gains are secured. It is more common to feed oil cake in small quantities and toward the close of the fattening season, as then the soothing effects of this food are more needed than at other times. When feeding for show purposes, it is almost considered in a sense a necessity, because of the favorable influence which it exerts on digestion under forced feeding, and also because of the fine, glossy coat which results from feeding it. As a food for cows in milk, oil cake up to a certain limit is most satisfactory. Beyond that limit it is thought to affect the quality of butter adversely, both in regard to firmness and keeping properties. The limit may be fixed at, say three pounds per animal per day. Carefully conducted tests have shown that the increase in milk production did not keep pace with increase in amount of oil cake fed, when fed in large quantities. In tests at the Pennsylvania experiment station, it was found that rather more milk resulted from feeding cotton seed meal, but that a little more butter resulted from feeding oil meal, pound for pound. As a regulator of digestion, oil meal is, of course, as helpful with dairy cows as with animals that are being fattened. The necessity for feeding it decreases with decrease in the amount of carbohydrates fed, and also in the forcing character of the ration, and with increase in the amount of bran, field roots or other succulent food fed

For sheep, oil cake is quite as satisfactory as for feeding cattle. It furnishes an excellent food for feeding to lambs, even at an early age or as a part of the grain ration subsequently to the weaning season. A limited amount is excellent for sheep that are being wintered on dry food and for breeding ewes. When fattening lambs and mature sheep on dry food, it is equally beneficial, and may be fed to them in larger quantities, proportionate to the forced character of the feeding. More commonly it is not fed to form more than 10 per cent of the meal ration, but may be in a much larger proportion when the price will justify such feeding.

For swine, oil cake is probably not so valuable relatively as for feeding cattle and sheep, especially when fed in relatively large quantities, as when thus fed it seems to affect adversely the appetite. But when fed to form not more than 5 per cent of the meal portion, the results will be beneficial. Small amounts may be fed with profit to swine under all conditions, except when they are being given an abundance of succulent food.

In feeding horses, oil cake is quite as helpful as in feeding cattle and swine. Under all conditions, moderate quantities may be fed with benefit to horses of all classes and of all ages, except when they are on pasture or are being given other succulent food as field roots. The grain ration given to foals, to horses not yet mature and to brood mares, will be improved by adding to it say 5 per cent of oil meal. Work horses may be fed say one-fourth of a pound per day under average conditions. Quantities considerably larger should be given to horses that are being prepared for spring work. Under almost all conditions this food tends to give a gloss to the coat which materially improves the appearance.

Corn by-products.—Chief among the products of corn are starch, sugar, glucose, alcohol and beer. These are not used as food for live stock. In their manufacture, however, certain residues are left which are of much value in feeding certain classes of live stock. Prominent among them are gluten meal and gluten feed. The minor by-products fed to stock include corn bran, corn germ and corn oil meal. Gluten meal is a residue from the manufacture of starch and glucose. It is what remains after the hull, starch and germ have been removed. It is separated from the starch by the action of water. As the analysis indicates, it is rich in protein and has a feeding value equal to that of oil cake. Gluten feed is virtually what is left of the corn germ after the starch has been removed. It, therefore, contains both the hull and the germ and as a result is lower in protein and higher in crude fibre than gluten meal. Gluten meal and gluten feed, because of their concentration, are usually fed in conjunction with foods less concentrated, as wheat bran. Corn bran is composed of hulls removed from the kernels. From 5 to 6 per cent of the grain consists of hull or bran. Corn bran contains practically all the crude fibre found in the grain. Its feeding value is low, but it may be used with advantage in diluting concentrated foods by mixing it with them. Corn germs are very rich in protein, ether extract and in mineral matters, hence their adaptation for being fed with caution to young animals. They comprise about 10 per cent of the kernel. Corn oil meal is the residue of the germ that is left after the oil has been extracted from it. It may be fed in considerable quantities to young animals. For such feeding it is valuable. When the products of the factories are disposed of in a wet condition, they are known as wet starch or wet glucose feeds.

To cattle of all classes and ages, gluten meal has been found not only a safe food, but also one that is relatively economical. It is palatable also as well as safe. It may be fed with much freedom to calves during the milk period and subsequently, and also to growing animals to which concentrates are fed. The other foods to be fed with it will depend on the object sought in feeding. When growth only is sought, the complement of the gluten should be such food as oats. When fattening also is sought it should be such food as corn. As a food adjunct in fattening cattle at the Ohio experiment station, it was found fully equal to oil meal in making increase on the basis of relative cost when the price paid for oil meal pound for pound was twice that of gluten meal. For feeding cows it has been found fully equal to cottonseed meal when fed so that the nutrients are equal. When feeding gluten meal to cattle the aim should be to feed it with some more bulky concentrate unless when it is being fed to young calves.

For sheep, gluten meal has not been much used as concentrate. It should, however, because of its reasonably fine character and high protein content, make an excellent food for young milk lambs. It should also feed well with such foods as corn in fattening sheep when a little bran also is fed to increase the bulk and to prevent constipation.

For young swine, gluten meal furnishes an excellent food. When thus fed, its concentration and fineness are beneficial rather than otherwise. For such feeding it may take the place of wheat middlings when the cost is not too much For growing swine of all ages it is also excellent. In trials made at the Vermont experiment station, gluten meal fed along with corn was found to be 7 per cent more valuable than wheat.

To horses, gluten meal is not much fed for the reason probably that it is thought to be more valuable relatively for growing animals and for milk production. Nevertheless, it may be fed with much propriety as a part of the ration for foals, when the price will admit of it. It will also go well along with corn when the latter furnishes the bulk of the ration for work horses.

To young animals, when gluten meal is fed, a small amount of oil meal should improve the ration, as the former does not contain the mildly laxative principle found in the latter. For a similar reason, a small proportion of wheat bran will be found helpful when gluten meal is fed to animals going on toward maturity or matured. If field roots are being fed, the advantages from feeding oil cake or wheat bran will be less apparent if at all in evidence.

Much that has been said about gluten meal will apply nearly as well to gluten feed, the proportion of protein being less and of crude fibre more than in gluten meal. Gluten feed is not quite so suitable for young animals. On the other hand, its somewhat greater bulk makes the addition of some such food as bran less necessary when it is fed to animals well grown. The use of gluten meal and gluten feed will certainly increase much in the future since much increase in the manufacture of by-products from corn is assured.

Other cereal by-products.—The by-products of rye, oats, peas, buckwheat and rice, are possessed of some feeding value, but they are not so valuable relatively as the by-products of wheat, barley, corn and flax.

Rye.—Rye by-products; viz., rye bran and rye shorts, are chemically not far different from those of wheat. In some of the countries of northwestern Europe, they are used to a considerable degree in feeding stock. In America, rye is not extensively manufactured into bread, consequently its by-products are not to be had in large amounts for feeding. Rye, bran and shorts are sometimes fed for milk production, but they are not so highly prized for such a use as the by-products of wheat. It is said that when these products are thus fed in large quantities, they affect adversely the flavor of both milk and butter. Rye shorts have not proved equal to rye or barley for making pork, viewed from the standpoint of production. The pork also made from rye shorts has been pronounced inferior in quality, being softer and also shrinking more than pork made from ground rye or barley.

Oats.—The principal by-products of oats are known as oat feed and oat dust. These are variable in their composition, but not infrequently the former is composed of oat chaff and the latter of minute hairs found at one end of the kernel. Broken grains add to the value of such food. When composed entirely of hulls, it is not worth much more than an equal weight of oat chaff. It is not infrequently used to adulterate mill feed, the presence of the hulls being intended to show that the mixture contains ground oats. Oat meal, such as is used for porridge, is an excellent food on which to start young animals when beginning to take food other than milk.

Peas.—The chief by-product of peas comes from establishments where they are commercially prepared as human food. It is frequently referred to as split peas. It consists of broken and defective kernels and any foreign food substances found in the grain as it comes to the factories. Such food in the unground form is excellent for feeding sheep and in the ground form for feeding cattle and sheep.

Buckwheat.—The principal by-product of buckwheat is the hulls. They are of low feeding value, so low as to be of questionable utility for ordinary feeding. Unscrupulous dealers sometimes use them in a finely ground form for adulterating mill feed. When used thus in considerable quantities, they give a brownish or dark tint to the food.

Rice.—The chief by-products of rice are known as rice hulls, rice grain, rice polish and rice meal. Rice hulls are very woody and are possessed of but little feeding value when used alone, but they may serve a useful purpose by mixing them with certain kinds of meal to increase their porosity. Rice grain is composed of the outer portions of the kernel and a part of the germ. As a food for cows and pigs it is possessed of considerable value. Rice polish, which is a dust-like powder, is rich in the elements of nutrition, and has proved valuable in feeding cows and pigs. Rice meal is said to be excellent for milk production, and for such a use may be freely fed with safety.

Cotton seed by-products.—Cotton seed as it comes from the gin consists of hull, kernel and fibre. The hull is the hard, tough, leathery covering. The kernel is the soft part of the seed within, of a yellowish color and of oily consistency. The lint, more commonly known as "linters," consists of short fibres not removed by the gin. The by-products of cotton seed are meal, hulls, oil and lint. According to the tenth census of the United States, 35 per cent of the seed consists of meal, 48.9 per cent of hull, 12.5 per cent of oil and 1.1 per cent of lint. Other authorities give the percentage of oil as being somewhat greater. The meal and hulls only of these by-products are used for feeding live stock. Until within a comparatively recent period the hulls were used as fuel by the oil mills.

Cottonseed meal is the finely ground residue of the kernel after the oil has been removed from it. In color it should be a light yellow. A dark color in the meal indicates the presence of ground hulls. This may be definitely ascertained by putting a small quantity of the meal in a glass, pouring over it hot water accompanied or followed by stirring, allowing it to settle for but a few seconds and then pouring off the unsettled portion. If the residue is darker in color than the untreated meal, ground hulls are present, and if successive treatments intensify the dark color of the sediment, the adulteration is proportionate. Cottonseed meal is probably the richest protein food in the market. It contains about 37 per cent of digestible protein. When fed in reasonable quantities and in proper combination with other food stuffs, it furnishes a satisfactory food for all classes of farm animals except swine, and in some instances calves. When damaged by mould or wet, or by undue heating, it should not be fed.

For cattle, cottonseed meal has been found of great value except in feeding calves. While in some instances calves do well on it, in other instances death has resulted from feeding it even in small quantities over prolonged periods. The difference in the methods of feeding the meal and in the combinations in which it is fed, may account for the difference in the results referred to. Two or three pounds daily fed to young cattle when not on pasture, will prove very helpful in promoting growth. When the accompanying fodders are leguminous, not less than 50 per cent of the meal should consist of corn, barley or rye. A small amount of wheat bran or oats fed along with it lightens up the ration.

This meal is excellent for fattening cattle. The proportion of the cottonseed meal and corn to be fed will depend upon the stage of the fattening and the character of the fodder. The proportion of the corn should increase with the advancement of the feeding period and with increase in the carbonaceous character of the fodder and *vice* *versa.* Usually not more than 4 or 5 pounds per animal are fed daily at any stage of the fattening to a mature cattle beast. In some instances in the South, large numbers of cattle are fattened at the mills on cotton seed and hulls. At first, they are not fed more than 3 or 4 pounds of the meal daily, which is gradually increased to 6 to 10 pounds according to the capacity of the animals. They are given in addition all the hulls that they will consume, and in 90 to 120 days are ready for the shambles.

Cottonseed meal has proved a very satisfactory food for dairy cows. In certain trials made, it has been found superior even to wheat bran, pound for pound, in sustaining the milk flow, at least for a limited period. As much as 6 pounds per day may be fed for short periods of feeding, but not more than 4 pounds per day should be given in prolonged feeding for milk or butter production, and 3 pounds would probably be a safer amount. It is a strong concentrate, and if fed in excess, deranged digestion will certainly follow. It has been claimed that cottonseed meal should be fed with a prudent caution to cows within two or three months of calving, and for three or four weeks subsequently. It feeds well along with ground oats, as the oats furnish the necessary bulk. From the standpoint of nutrients, cottonseed meal and corn make an excellent combination, and cotton seed and rye or barley are suitable, but the addition of some bran to add to the bulk will improve the ration. Cottonseed meal adds to the firmness of butter, a fact of no little importance in warm climates.

For sheep, cottonseed meal judiciously used is quite helpful. Fed along with oats it makes a good concentrate for breeding ewes, more especially when the fodder is carbonaceous. One part of cottonseed meal and three parts of oats, or one and two parts of each when a small amount is fed, should prove satisfactory. At all times, however, it should be fed with a prudent caution to pregnant ewes, lest it should cause abortion. If the roughage were leguminous, corn could be fed instead of oats. For sheep and lambs that are being fattened, cottonseed meal and corn have been found to answer well in the South, when oats are fed instead of corn in whole or in part until the animals are on full feed. The safer plan is to start them on oats and then to add corn gradually. After about three weeks of feeding, add say 1/4 pound of cottonseed meal per day, and gradually increase the amount until the meal ration consists of one part cottonseed meal and two parts corn by weight.

For swine, cottonseed meal is not an entirely safe food when fed to them in any considerable quantities, and for a prolonged period, would seem to be a conclusion justified by the results of experience and also by those of experiment. It has been noticed that swine to which cottonseed meal is fed for prolonged periods eventually begin to show lack of thrift, and finally a large proportion of them sicken and die, unless the feeding of the meal should be discontinued when the first symptoms of sickness appear. These results sometimes follow, but not in all instances, when the meal is obtained through the medium of the droppings of cattle when cottonseed meal forms a considerable proportion of the concentrate fed to them. When only a small amount is fed, the injurious influences to the swine are seldom if ever manifested. The sickness in swine to which meal is fed directly, usually begins in 30 to 50 days, according to the inherent vigor of the animals, the amount fed, and the losses increase with the prolongation of the feeding. If swine thus affected are removed from cattle yards and fed on other food for a few weeks, they may again be allowed to glean for a time in the cattle yards without hazard. The symtoms of the sickness include moping and sluggishness in the victims, a tendency to lie apart and loss of appetite. There is labored breathing and weak heart action. Post mortems have shown that the digestive tract has been highly inflamed. These results follow when not more than 25 per cent of the regular ration is composed of cottonseed meal. Roasted seed has been found about equally harmful, but boiling the seed very greatly reduces the danger. The ill effects have been ascribed to the lint, to moulds, and to changes in the composition of the meal through exposure. Others think they are due to the presence of some principle in the meal itself that is poisonous to swine, and cumulative in its action Notwithstanding, some feeders affirm that cottonseed meal may be fed to swine with safety when it is fed in the form of a thin slop, about the consistency of buttermilk. This they clam will prevent injury from the lint which they believe to be the source of the danger.

For horses, as a concentrate, cottonseed meal should be fed only as a small part of the ration. In trials made, as much as 2 pounds per animal per day have been fed with safety, but when the amount fed was increased much beyond 2 pounds per day, the outcome was not entirely satisfactory. Experience in feeding it up to the present would indicate that it should only be fed in limited quantities to horses and mules.

Cotton seed hulls, in the ground form, are fed with much freedom to cattle and sheep that are being fattened, also to cows giving milk (see p. 425). To cows in milk as much as 14 or 15 pounds per day have been fed for each 1000 pounds of live weight in the cows, without producing harmful results. Feeding large amounts has resulted in deranged digestion, evidencd in some instances in a lax condition of the bowels, and in others in a constipated condition of the same. When fattening cattle and sheep in proximity to the mills, they are frequently given hulls to take the place of roughage and are allowed to consume virtually all that they will eat up clean.

While cottonseed meal is possessed of great value for feeding live stock, from what has been said, it will be evident that there are restrictions which must be observed in feeding it. Its highest value is found in fattening cattle and in feeding cows for milk. It should only be fed in small quantities to horses, while the wisdom of feeding it to calves quite young and to swine, is at least problematical. These restrictions upon feeding this by-product lower its value somewhat relatively, when comparing it with such foods as oil cake and gluten meal.

Sugar beet by-product.—Sugar beet pulp is the residue left from sugar beets after the sugar has been extracted. It is fed in the fresh form as taken from the factory, as ensilage and also in the dried form. It is probable that it will be a food product of much importance relatively in this country, as the sugar beet industry promises to become one of much magnitude in the near future. Owing to the bulky nature of the pulp in the fresh form and to the large amount of water that it contains, it should be fed at or near the factories, but in the dried form it is not more costly to transport than concentrated foods. Farmers who live near the factory may feed the fresh pulp with profit during a limited portion of the year. Feeders who save it by ensiling at the factory, may feed it with advantage during the major portion of the same, as it is not difficult to preserve it. It may be ensiled in the same way as corn and other green fodders, but it may also be preserved by putting it into large, basin-like pits excavated in the ground, into which it is dumped to the depth of several feet and allowed to remain until it is fed. Decay follows to the depth of a few inches from the surface. Underneath this decayed mass, the pulp will keep indefinitely. In proximity to the factories it is fed from these pits or silos to large numbers of cattle and sheep that are being finished for the market.

The undried pulp is not only too costly to transport, but it soon ferments when exposed. About 90 per cent of the pulp is water. But little of the protein is removed in the juice, hence, the pulp is particularly valuable as a food for young animals, and for producing milk. As it exercises a salutary influence on digestion, the pulp has a feeding value in excess of the nutrients which it contains, when judiciously fed and along with dry food. This physiological value, so to speak, decreases with increase in the quantity fed, and may be lost entirely by excessive feeding. When fed heavily, it induces a lax condition of the bowels, hence the wisdom of feeding dry fodders along with it. Wheat bran, clover and alfalfa make very suitable complementary foods. The pulp is not equal to the beets in feeding value, and for fattening its value is considerably lower.

For cattle, sugar beet pulp, like sugar beets, is excellent and for all classes of cattle. It is particularly valuable as a food for young animals, and it may be fed to them with much freedom, that is, from say five to 20 pounds a day, according to size and the other food fed. To cattle that are finished, as much as 75 pounds per day may be fed to mature animals under some conditions. Good, tender and juicy meat may be made from sugar beet pulp and alfalfa hay only, but usually some grain may be profitably fed in addition. The pulp is particularly valuable for dairy cows. As much as 50 pounds per day may be fed for long periods, and for short periods much more than that amount. The cost of the pulp should, of course, have an important bearing on the amount fed, and when fed, the usual meal ration may be proportionately reduced. In the dried form, as much as 3 to 5 pounds per day may be fed along with say 30 pounds of corn ensilage.

For feeding sheep, beet pulp is excellent, whether kept for breeding uses or in fattening them. A very fair quality of mutton may be made from pulp and clover or alfalfa without grain, but under average conditions, a limited amount of grain will tend to cheapen the ration. It will be seldom found profitable to feed sheep more than 10 pounds daily, and usually a less amount will be more profitable.

For swine, sugar beet pulp is useful especially during the growing period and for sows when not on pasture. Young and growing swine may be allowed to partake of the pulp with much freedom. Brood sows may be wintered on the same with the addition of a moderate amount of grain.

It should not, however, be fed to pigs that are being fattened in any considerable quantities, owing to its bulkiness.

For horses, sugar beet pulp in the undried form is not so valuable relatively as for feeding cattle or sheep, but a few pounds daily may be fed with considerable benefit to young animals and brood mares on dry feed. If fed in any considerable quantities to horses hard at work, it induces too lax a condition of the bowels.

Milk by-products.—The chief of the by-products of milk that are used in feeding live stock, are skim milk, buttermilk and whey. Skim milk is the residue left after the cream has been removed from the whole milk. Buttermilk is the residue left from churning the cream after the butter has been removed. Whey is the residue left in making cheese after the curd has been removed. Skim milk is chiefly fed to calves and swine, but is not infrequently fed to foals, and may also be fed to lambs. Buttermilk is chiefly used in feeding swine but may also be fed to calves. Whey is chiefly used in feeding swine, but is not infrequently used also in feeding calves. The value of these by-products, more especially the first, as a source of food for live stock, is very great.

Skim milk is obtained by two processes; viz., by hand skimming and by removal through the aid of centrifugal machines. By the first process, the whole milk, as soon as obtained, is strained and left in shallow pans or dishes, or in deep cans set in water, until the fat globules rise to the top of the milk, when they are removed by pouring off the cream. By the second process, the milk runs through a centrifugal machine termed a separator, which is driven at a speed so high that the fat globules are quickly separated and drawn off as cream. By the process of hand skimming, about twice as much butter fat remains in the skim milk as when removed by the centrifugal process, but even with hand skimming, it is seldom that more than .7 of one per cent of the fat is left in the milk and by the other process, more than one-half of that amount. This preponderance in its fat content gives skim milk obtained by the gravity process, some superiority for feeding to stock, but it is probably more than offset by the fresh and warm condition in which separator skim milk is usually fed.

For calves, skim milk is virtually the standard food during the first months of their existence, when they are not allowed to suck the dams, and it will become so more and more as the conditions of farming intensify. The market value of whole milk is such that under many conditions of feeding, it will not be profitable to feed it to any class of animals on the farm except when of tender age. The exceptions are, when range or semi-range conditions prevail, where high class beef producers are grown to provide baby beef (see p. 402), and where young animals of beef types are being prepared for the show ring. It would be approximately correct to say, that during the first three months of the life of a calf, from 9 to 10 pounds of milk would be required to make one pound of increase. During the first weeks, such increase should be made from half the amount named, but the gains which accrue from such feeding, will be much influenced by the individuality of the calves. Notwithstanding the high value relatively of whole milk, even when calves are grown substantially on skim milk, it is greatly advantageous to feed whole milk for a time, beginning, of course, with the birth of the young animal as no substitute has been found for whole milk that so completely meets the needs of young animals.

The duration of the period for feeding whole milk will depend first, on the use that is to be made of the calf, and second, on its inherent vigor. When the calf is to be sold for veal, the greatest profit will result probably from feeding it all the whole milk that it can profitably take, and selling it at the earliest age at which it will take the market. When it is to be sold between the ages, say of 6 and 15 months, the whole milk ration may continue for say two or three weeks longer. It may then be gradually changed to skim milk, taking two to three weeks to make the transition. It is made by withholding new milk in gradually increasing quantities until none is given, and by increasing the quantity of skim milk fed in due proportion. When the animals are reared for producing dairy products, whole milk is sometimes fed for a period not to exceed one week before beginning to feed skim milk, and frequently not more than one week is occupied in making the change from all new milk to all skim milk. In more instances, however, the period of transition covers two weeks. When the animals are to be grown for meat and finished when approaching maturity, it may frequently be profitable to feed all new milk for say three weeks, and to make the period of change to extend over two or three weeks more. Habit in digestion is usually influenced at an early age.

The earlier the animal is to be disposed of when reared chiefly on skim milk during the milk period, the more should the habit of fat production be encouraged by feeding new milk and *vice versa*. When grown for the dairy, muscular development is sought rather than fat, hence no more whole milk should be fed than is necessary to start the calves aright in the way of correct development.

The duration for feeding whole milk should be determined largely by the inherent stamina of the animal. It is greatly important in the development of both animals and plants, that growth at the first shall start vigorously. Should the digestion become impaired at an early age, satisfactory development subsequently seldom follows. Whole milk, therefore, should be fed for a period sufficiently long and enough of it should be fed to insure to the young animal a vigorous start.

The amount to feed will depend on the capacity of the animal to take the food, on its age, and on the extent to which the milk is supplemented by other food. When milk can be spared, it may be fed up to the limit of the capacity of the calf to take it without deranging the digestion, one of the first indications of which is a lax condition of the bowels. Usually 8 to 10 pounds per day will prove ample during the first week of feeding skim milk, that is to say, about the third week of the life of the calf. This quantity may be increased at the rate of, say ½ pound per week up to the age of say 15 or 16 weeks, or as long as the milk period continues. When desired, however, the skim milk may be so supplemented by other foods, that amounts considerably less than those named may be fed without serious detriment to the calves.

The duration of the milk feeding period may be influenced by such conditions as the milk supply, the needs of the animals, and the extent to which cheaper foods are substituted. Usually calves may be more cheaply reared on small or moderate amounts of milk than on larger amounts of the same, but such feeding calls for an intelligent selection and use of supplemental foods. When skim milk is abundant, it may be fed to calves for many months. Some feeders have fed it to yearlings when seeking much growth while preparing them for exhibition.

The nature of the supplementary foods to be given with the skim milk will vary somewhat with the purpose for which the calves are reared. But, whatever that end may be, it will be found advantageous to add ground flax seed, oil meal or flax seed gruel to the milk, as soon as the change from whole milk to skim milk begins. In this way, fat may be supplied from a cheap source in lieu of that removed from the skim milk that is fed. The amount of the meal required at the first may not exceed a heaped teaspoonful, but this should be increased as the calves are able to take it, but not to the extent of inducing too lax a condition of the bowels. The gruel is made by soaking flax seed for several hours in a plentiful supply of water, and then boiling it for one hour. It is then fed to the calves in the milk and when the milk is cold it will be advantageous to add the gruel while it is yet warm. When the calves are grown for veal or baby beef, no meal given in addition is more suitable than ground corn. Ground corn and ground barley are excellent. In such instances the calves may be fed grain to the limit of their capacity to consume it as long as they are fed milk, and in some instances for a period considerably longer.

For sheep, skim milk is not much used nor is it probable that it will ever be thus fed to any considerable extent. As sheep suckle their lambs, it is not required for such feeding. But should necessity require it, skim milk fed to lambs in the fresh form, will be quite as helpful to them as to calves. Such food may aid materially in the development of lambs that are being grown for exhibition.

For swine, skim milk is of great value. It may be fed to them with advantage and profit at all, or nearly all stages of growth, and under nearly all conditions of feeding. It is equally good for pigs not yet weaned, between the weaning and fattening period, and for brood sows during pregnancy and while nursing their young. It is probably true, that, as with calves, the relative profit from feeding it decreases as the birth period is receded from, and for the reason that other protein foods may be fed, adapted to such feeding, that may be obtained at less cost, from other sources. For the same reason it is also true, that more relative profit is usually obtained from feeding skim milk to swine subsequently to weaning in moderate rather than in large amounts. Even during the fattening period, skim milk is very suitable for feeding along with corn, but it can seldom be spared for such feeding. When judiciously fed, the feeding value of 100 pounds of skim milk is fully equal to that of one bushel of corn. But to obtain such value from it, very moderate amounts should be fed. In certain trials made, it has been found that the best results have been obtained when not more than 3 pounds of milk were fed along with 1 pound of meal.

For horses, skim milk is not much used, but in certain instances where the supply was plentiful, it has been fed to them in considerable quantities with results that were satisfactory, even when fed to horses at work of no little severity. It has been found highly useful in feeding foals that are being reared by hand, and also in some instances subsequently to the season of weaning.

The condition in which milk is fed to young animals exercises an important influence on the results that follow from feeding it. The aim should be to feed it as nearly as possible at the heat which milk possesses when drawn from the cow, that is at a temperature of 100 to 102°. While yet sweet it is considered superior for feeding to young animals to milk that is sour, but the experiments to determine this have not been entirely uniform. That milk which is curdled even has considerable feeding value when fed to animals well started in growth, cannot be gainsaid. The vessels in which it is fed should be kept scrupulously clean, otherwise they may readily prove the medium of conveying bacteria to the animals that may prove harmful.

Buttermilk, when undiluted, has about the same feeding value as skim milk, viewed from the standpoint of the chemist. Equally good results have been obtained from feeding it to swine when not of tender age, but it has not proved so generally satisfactory for all kinds of feeding as skim milk. It may be fed successfully to calves by those who are skilled in such feeding, but it has not proved so highly satisfactory as skim milk. Some caution is also necessary in feeding it to young pigs and to brood sows nursing them. Loss has been incurred by such feeding with sufficient frequency to render apparent the presence of an element of hazard. It may, however, have resulted from feeding the milk when not in the best of condition. Buttermilk is frequently diluted with water especially at creameries, and when so diluted, its value is, of course, proportionately lessened.

Whey is so bulky a food that it ranks relatively low in nutrition. Its value for feeding is influenced by the source from which it comes, by the class of animals to which it is fed, and by its condition at the time of feeding. Whey obtained from the manufacture of full cream cheese has considerably more fat than that obtained from the manufacture of skim cheese. Certain feeding trials conducted have shown that for feeding swine, about 800 pounds obtained from the former and about 1200 pounds obtained from the latter source are equal to 100 pounds of grain.

The best results have been obtained from feeding whey to swine in conjunction with such adjuncts as ground corn, wheat, barley or rye. It is less valuable for young animals than for those that are older. Calves reared on whey do not thrive so well as those reared on skim milk. The whey is so bulky and withal so low in nutrition, that calves thus reared carry an undue amount of paunch, and are characterized by a more or less unthrifty condition. Both may, of course, be measurably counteracted by feeding a liberal amount of such adjuncts as oil meal and other meal from nutritious grains. The outcome is more satisfactory when the calves are well started on whole or skim milk or both.

It is important that whey shall be fed while yet sweet and fresh. The acid or semi-acid condition in which it is frequently fed, especially when returned from cheese factories, is in a considerable degree responsible for the unsatisfactory results obtained from feeding it. The aim should be to feed it while yet sweet and care should be taken to scald the vessels daily in which to keep the feed.

Molasses by-product.—Molasses is a product obtained in the manufacture of sugar from cane and also from beets. Formerly much of this valuable feeding product was wasted, but during recent years its real worth is coming to be more generally understood. As the sugar beet industry increases, so will the use of this by-product in feeding increase, consequently it would not be possible at the present time to forecast the extent to which it may yet be used in feeding live stock. Its highest use is found in feeding horses at work and in fattening cattle and sheep, but it has also proved helpful in feeding in certain combinations for milk production. The real value of molasses in feeding is greater than chemical analysis assigns to it, since when mixed with other foods it adds to the palatability and so increases consumption. The belief is common among practical feeders, and it probably rests on a basis of truth, that the free feeding of molasses tends to sterility in males and to barrenness in females. It is probable that henceforth nearly all the molasses made at sugar beet factories will be mixed with the pressed pulp and dried before it is put upon the market. The product thus prepared is ready for feeding by simply mixing it with other foods or adding it to them dry, but more commonly with all the water added that it will absorb. The objection to feeding a substance so sticky as liquid molasses poured over the feed is thus avoided, more or less of which adheres to the feed boxes and in summer attracts many flies.

For cattle, molasses is being used in increasing quantities. Mixed with dried blood, it aids development in calves that are being prepared for the block. They furnish an excellent complement to such food as cottonseed meal when fed to cattle that are being fattened. The product has been much used in preparing animals for exhibition. It has thus led to increased consumption of the other food and improved the gloss of the coat. It is commonly poured over meal or what is better, over meal and cut fodders mixed. It is frequently diluted with water before thus mixing it. As a food for milk production, it is fed in smaller quantities. Dried molasses beet pulp may yet be used extensively as a supplementary food for dairy cows, summer and winter.

Until more light has been obtained, however, as to its innu-ence on the breeding properties of animals, it should be fed with prudent caution, more especially to young animals intended for breeding.

In feeding sheep molasses has not been mucn used, but recent experiments at the Michigan experiment station have shown that dried molasses beet pulp had a feeding value for fattening sheep even higher than that of corn.

To swine, molasses has been fed successfully along with skim milk. Its use, however, in feeding swine will probably be limited, as an appetizer is less necessary for swine than for the other classes of farm animals.

For horses, molasses is probably more valuable in feeding them when at work than in feeding any other class of farm animals. Not less than two quarts per day of cane molasses may be fed with advantage to work horses and mules for prolonged periods. The molasses is diluted with three times its bulk of water and poured over the morning and evening ration. It is common to feed a little bran along with cane molasses to correct a tendency to constipation which is said to result from feeding it. It is claimed that it is nutritious, healthful and economical. It may yet become popular to feed it to horses that are being wintered on products coarse and cheap, and fed in the cut form.

Miscellaneous by-products.—Certain by-products have been used in feeding which merit some attention, but the limited extent to which they are used in this country will scarcely justify discussing them at length. For convenience of treatment they are grouped as miscellaneous. These include tankage, dried blood, dried flesh meal and meat scrap, fish scrap, and various kinds of cake.

Tankage is made from certain waste products of slaughter-houses, as meat scraps and fat trimmings. The tallow is removed by cooking, and the residue when dried is put upon the market as tankage. Tankage varies with variations in the waste products which it contains, and also with the relative proportions of these, hence the need for careful discrimination as to the amount that shall be fed. It is used chiefly as a source of protein in feeding swine, more especially when the other food consists mainly of corn. For such feeding it has been found decidedly profitable even when the price of tankage is 30 to 40 per cent greater than that of corn. Tankage must be fed with some care as it is a highly concentrated food. Usually it is not fed so as to make more than 10 per cent of the ration. When feeding tankage it should be carefully mixed with the food, thus securing an even distribution. It must be kept dry or putrefaction will set in, which makes it offensive to handle and harmful to the stock, and it should not be allowed to soak very long before it is fed.

Dried blood is simply blood from slaughtered animals from which the water or liquid has been removed. In the process of drying enough heat is applied to kill any disease germs that may be present. Formerly it was used chiefly for fertilizing, but now it is more commonly used in feeding calves and swine. As shown in the table it is exceedingly rich in protein and the relative digestibility is high. It has been found highly useful in feeding calves. To some extent it is thought to be a corrective of scours. It may be fed in the milk or meal, beginning with say a teaspoonful and gradually increasing with the needs of the animals. It has also been fed to lambs with profit, the blood to some extent taking the place of milk. Its highest use probably is found in feeding swine, when fed in conjunction with carbonaceous foods as corn. Swine at three months may be given say one tablespoonful daily, younger animals being given a proportionately less quantity.

Dried flesh meal and meat scrap are more or less analogous in their composition. The former, properly speaking, is composed of the ground flesh of animals after the melted fat and moisture have been removed. The latter consists of the better grades of slaughter-house waste, somewhat similarly prepared. The preparation of flesh meal as a commercial food product was first undertaken in Uruguay at the instigation of Baron Liebig, in days when many animals were slaughtered simply for their hides. It has been used more for feeding swine than any other class of live stock, but it has also been fed successfully to ruminants. By feeding small quantities at first and increasing very gradually the amount fed, they will at length take with safety as much as 2 or 3 pounds per day. Lambs and sheep come to relish it in time, and they thrive on a due proportion of such food. Mixed with ground grain and made into cakes, it is claimed that horses, to which these are fed, show increased vigor and nerve power.

Fish scrap is the residue from fish that are being dried or canned after the oil has been expressed and the product dried. In some instances it is composed in part or altogether of fish that are not suitable for human food. It is fed as cake and also in the ground form. Because of its high fertilizing value, it has been designated fish guano, and is not infrequently applied directly to the land for its enrichment, but where the facilities are present, it will be found profitable to feed it to live stock and then to apply the resultant fertilizer to the land.

Both fish scrap and fish meal are fed to live stock in certain of the maritime areas of northwestern Europe. Good gains have resulted from feeding 3 to 4 pounds per day to mature steers of good size, and the quality of the meat was considered good. It is thought that incautious feeding to dairy cows will produce undesirable taint in the milk and butter but it may certainly be fed in reasonable quantities, that is, up to the limit of say 2 pounds per day without producing such results. It has been but little used in feeding cows in America, but in Norway it is freely used for such feeding. Mature sheep have made good use of as much as one-half to two-thirds of a pound fed daily along with suitable adjuncts. It may be fed more freely to swine than to cattle or sheep. Along the coast of Maine, it is used to some extent in feeding sheep, and to a considerable extent in feeding swine.

Sundry meals.—In addition to oil cake and meal and cottonseed cake and meal, already discussed (see pp. 275, 283), are certain other kindred products more or less freely fed in certain areas, but not much used as food for stock in the United States or Canada. Prominent among these are peanut meal, sunflower meal, cocoanut meal and palmnut meal. All these are valuable chiefly as a source of protein and a means of increasing the amount of the same in a ration. As with oil meal and cottonseed meal, all these are valuable for milk and meat production, and also in improving the tone of the digestion when judiciously fed. But for working animals, no kind of oil meal can take the place of grain.

Peanut meal, made from peanuts after the oil has been expressed, is one of the richest among foods in protein. In certain trials made it was found to have a feeding value fully equal to beans. Owing to the rapid increase in the growth of peanuts in the United States, and to the increase in the manufacture of oil from the same, peanut meal may yet become a food factor of considerable importance for live stock in the southern states.

Sunflower cake and meal are manufactured somewhat extensively in Russia, and are prized as food for stock in some of the countries of western Europe. As a source of oil, however, sunflowers are not grown in the United States to any appreciable extent, if indeed at all. Nor is their growth for such a use likely to increase in the near future, owing to the amount of hand labor called for in harvesting the crop. The equivalent in food nutrients can be obtained more cheaply in other forms.

Cocoanut meal, sometimes called cocoa meal, is the residue from the manufacture of cocoanut oil. This meal has been found useful as a concentrate adjunct in feeding cattle, sheep, swine and horses. The price restricts its use in the United States. It is considerably used, however, in feeding dairy cows in the coast regions of California. It is claimed that good, firm butter may be made from it even when it is fed with some liberality. It answers well as a food adjunct for sheep and swine.

Palmnut meal is the residue from the manufacture of palm oil. The oil palm is extensively cultivated in the West Indies and South America, also Africa, but not on the North American continent. In some countries of Europe, it is extensively used in feeding stock. It has good keeping qualities, and is much prized as a food for dairy cows.

CHAPTER XIV.

FOOD FROM PASTURES.

In the United States and Canada tame pastures as a source of food for live stock have not, as a rule, been taken at their true worth, owing probably to the large area of new or rugged lands that have furnished native pasture and to the very large area covered by the ranges of the West. The richness of the virgin soils, during the early years of their cultivation, encouraged the growing of crops on them, other than grass, to the comparative neglect of the latter. Hence it is, that the continent is possessed of but limited areas of permanent mixed grasses, and that but little attention has been given relatively to the improvement of pastures of any kind. Notwithstanding, food from pastures will always be one of the cheapest sources from which it can be obtained.

The sources of pasture may be said to be fourfold. These are: (1) The pastures of the range country; (2) pastures on rugged land in areas where tillage is common; (3) permanent pastures natural or made; (4) temporary pastures. Those, from the source last named, are by far the most important, not only because of the large areas devoted to their growth but because of the renovating influence which nearly all of them exert upon the soil, and because of the fertility which many of them bring to it.

The pastures of the western ranges will always be of large extent, though more and more circumscribed with the passing of the years. That the production of wide areas has already been greatly reduced by over depasturing is a matter of history. That even range pastures are susceptible of renovation is also being demonstrated. To discuss the methods by which they may be renovated would be foreign to this book which treats of foods rather than of growing them.

Native pastures on rugged or low lands, too low for successful cultivation until drained, are of course indigenous to the locality in which they grow. Usually those on forest land have come in, as it were, spontaneously on the cutting away of the trees. On wet lands they have grown unchanged, it may be, for centuries. Kentucky blue grass is one of the most common and valuable of the former and redtop of the latter. It is possible to transform some native pastures by simply sowing the seeds of other grasses at an opportune time, and in the case of wet lands by changing the conditions as to the extent of the saturation.

Permanent pastures include native pastures both on rugged and low lands referred to above, and also pastures specially prepared with a view to permanency. These may include only a single variety of grass, but usually they include a number of varieties of grasses grown together. Blue grass in the North and Bermuda grass in the South furnish instances of the former. More commonly, mixed grasses grown with a view to permanency, are sown on lands naturally moist and favorable to grass production. They are grown in combination, the better to furnish grazing at all times through the growing season and to furnish more grazing than would be obtained from a single variety.

Temporary pastures include, first pastures grown but for one season and frequently as a catch crop, and second, those grown for a longer term of years. The former include the small cereal grains grown alone or in mixtures; plants of the Brassica family; the sorghums, saccharine, and non-saccharine, and certain root crops. The temporary pastures usually grown for a longer term than one year include various grasses and clovers. These may be grown singly, but are usually grown in combinations. These are sometimes mown one or more years and are then grazed one or more years. Those readers who desire further information with reference to pastures are referred to the book, "Grasses and How to Grow Them," by the author.

The further discussion of this question will consider: (1) The leading grass plants; (2) the leading clover plants; (3) plants of the Brassica family used in grazing; (4) the saccharine and non-saccharine sorghums, and (5) cereals grown to provide grazing, more especially winter rye. These will be considered with reference to their feeding value and adaptation for grazing. Something will be added more or less general in character, with reference to the grazing of pastures and their care.

The leading grasses.—The leading pasture grasses are Kentucky blue (*Poa pratensis*), Russian brome (*Bromus inermis*), Timothy (*Phleum pratense*), Western rye grass (*Agropyrum caninum*), Redtop (*Agrostis vulgaris*) and in the South, Bermuda grass (*Cynodon dactylon*). These are probably generally valuable for pasture in the order named.

Kentucky blue, king among pasture grasses on this continent, is characterized by a reasonably early and late growth, and by a resting period in midsummer. It is probably the finest in its habit of growth and the most generally palatable of all the grasses. Although soils that have sustained forests have usually the highest relative adaptation for growing this grass, it is fast spreading over all the areas embraced in the western prairies. Close grazing tends materially to lessen the production. When done in the autumn, it very much tends to retard growth in the spring.

Even though grazing should be deferred until the autumn, it still furnishes pasture that is much relished, owing to the abundance of the fine leaf growth amid the relatively light production of matured stems. Such a pasture, held in reserve for autumn grazing, will tend to prolong materially its season, and to curtail proportionately the season for winter feeding. At least two or three seasons are required to bring this grass to a maximum of growth; hence it is illy adapted for temporary pastures. Owing to the close, firm nature of the sod which it makes, it will better resist injury from severe treading than any other valuable grass.

Russian brome grass, most highly valuable on prairie soils, is coming to be much prized as a pasture grass. Its season of active growth is longer probably than that of any other grass grown in northern areas. It grows up early in the spring and continues to grow until the coming of severe frosts. The leaf growth is very vigorous and is relatively abundant and no grass is more highly relished by stock. It will stand close cropping better than most grasses and when once established is not easily injured by treading. Its carrying power under favorable conditions is probably greater than that of any other grass. Its growth on average soils is greatly stimulated by top dressings of barnyard manure.

Timothy, king among the hay grasses, is more widely grown on this continent than any other grass, but is not so suitable for pasture as the grasses named above, as it does not produce so much growth relatively in the autumn. In palatability it is average. Nevertheless, it has higher adaptation for producing temporary pasture than either Kentucky blue or Russian brome grass as it can be fully established in a single season though sown with a nurse crop. Since maximum growth with timothy is reached in a relatively short period, as temporary pasture it is usually grown with clover.

The aim should be to graze timothy so that it will not throw up any considerable proportion of seed stems. Should it do so, cutting them off before the seed matures with the mower set high will add to the carrying power of the pasture.

Western rye grass, frequently called slender wheat grass, is probably the most hardy among the useful grasses. It is grown over wide areas and is preeminently the grass for dry conditions in the semi-arid belt. It tends somewhat to grow in bunches and should therefore be sown somewhat thickly. Although highly nutritious, it is not quite so much relished as some of the other grasses. Growth is chiefly made in the early part of the season. If allowed to throw up stems, these quickly become woody and are not eaten with much relish.

Redtop, valuable both as a hay and pasture plant, is more grown for pasture in some of the central and southern states than in those north. Though not so valuable in the Gulf states as Bermuda grass, it is grown over wider areas much further north than would be suitable for that grass. In northern areas it is also grown for pasture, but usually in combination with other grasses. It is permanent and enduring and eventually makes a good sod, but it starts a little slowly in the spring and also after it has been mown. In midsummer it loses much in palatability. In the states that circle around Tennessee and Kentucky, and also in other areas, it is much esteemed for winter grazing when the grazing has not been close during the summer and autumn.

Bermuda grass is a creeping perennial, the plants from which multiply through underground rootstocks and also through the rooting of the creeping stems where the nodes come in contact with the soil. Because of this habit of growth, new pastures are usually obtained through planting the stems and rootstems at certain intervals. It is strictly a summer grass and makes all its growth virtually in the portion of the year when frosts are absent. It is very enduring and stands grazing well, but it is difficult to completely remove it from the soil. It has much power to produce, even on worn soils. Reasonably close grazing during the season of growth is to be commended, as even slight frosts injure the palatability of the grass.

Chief among the other grasses, useful in providing pasture under American conditions, are Orchard grass (*Dactylis glomerata*), Meadow fescue (*Festuca pratensis*), and Tall Oat grass (*Arrhenatherum avenaceum*), but these are not so extensively grown as the former.

Orchard grass grows best in various centers all across the continent between parallels 35° and 45° north latitude. It is a leafy grass and a vigorous grower on good soils, and it will endure shade better than other grasses. It has the habit of growing in tussocks which may be modified by growing it with blue grass. It is not so palatable as blue grass, but is more productive. In the spring the grazing should be measurably close to keep the seed stems in check. The autumn growth is usually abundant and may be made to furnish much grazing for winter where the climates are reasonably mild.

Meadow fescue is hardy, palatable and nutritious. It has been grown in various centers widely distant from one another. It is slow in becoming established so as to produce a maximum amount of pasture; hence it is better suited for permanent than for temporary pastures. It grows better than blue grass in summer and has more power also to make growth in the cool and cold weather of autumn. It is prized for winter grazing in some of the Middle Atlantic states.

Tall Oat grass will grow north, south, east or west, but in climates not really severe it has proved of highest value. It comes up very early in the spring, grows quickly and is persistent in growth. The foliage is abundant but coarse and, owing to a bitter property which it possesses, is not so much relished as several other grasses. It should be kept from throwing up seed stems, which of course, are less palatatable even than the leaves.

Three other grasses are capable of providing much pasture, but they are so difficult of eradication that it is at least questionable if ever they should be sown under arable conditions. These are Quack grass (*Agropyrum repens*), Johnson grass (*Sorghum halpense*), and Crab grass (*Panicum sanguinalis*).

Quack grass is in a sense a scourge to the farmers, especially those whose lands, naturally rich and friable, are infested by it, owing to the great labor involved in cleaning it out of the land. Notwithstanding, when properly managed, it will probably furnish more grazing during the season than any other grass grown in the locality. In semi-arid regions this grass may have a useful mission. It multiplies chiefly by means of the creeping rootstocks which it sends out in great numbers in the soil.

Johnson grass, which grows luxuriantly in the southern states, cannot endure the cold winters of the North. When grazed it should be eaten down before the heads are formed. Heavy pasturing has the effect of injuring subsequent growth for a time. It is a better hay than a pasture crop. It is exceedingly difficult of eradication.

Crab grass is an annual which infests southern soils. It springs up luxuriantly in grain fields from which crops have been removed. The grazing which it thus furnishes is frequently considerable. This weed-like grass may be grown, it is said, in alternation with bur clover, the former furnishing grazing in winter and the latter in summer. The ground is simply plowed and harrowed between the crops, where both have obtained a foothold.

The leading clovers.—The leading clovers for pasture are the Common or Medium Red (*Trifolium pratense*), the Mammoth (*Trifolium maximum*), the Alsike (*Trifolium hybridum*), the White (*Trifolium repens*) and Alfalfa (*Medicago sativa*). These are probably valuable for pasture in the order named.

Common Red clover, is now grown in portions of almost every state in the Union. The great clover belt, however, is in the Upper Mississippi valley, and in the higher mountain states that lie to the west. This plant, biennial or perennial according to the soil and climatic conditions under which it is produced, grows during nearly the entire growing season. The growth is more vigorous and persistent when the plants are not allowed to go to seed, and they will also live for a longer period. No other variety of clover furnishes so much pasture in one season, and none is so highly palatable.

When clover is very rank and succulent, cattle and sheep must be grazed on it with caution, especially at first, otherwise loss may result from bloating. This danger is lessened, (1) by giving the animals dry food before turning them on the clover to graze; (2) by leaving them on the clover subsequently where this is practicable; (3) by giving them access to some dry food all the while and (4) by so arranging that some kind of grass will be present in the clover in that degree that will reduce the danger incurred to a minimum. Where clover is not grazed too closely in the autumn, on some soils it reseeds itself and thus perpetuates its growth.

Mammoth clover will grow virtually in about the same areas as the Common Red variety. The habit of growth, however, in the two, differs considerably. The Mammoth requires several weeks longer to reach a maximum of growth, does not grow so rapidly after midsummer, and is coarser in stem than the former. The danger to cattle and sheep from bloat is much the same as with the Common Red. Close pasturing in the late autumn is usually more or less harmful to all clovers, but not equally so under all conditions. Where seed is much grown from either the Common Red or Mammoth clovers, they are frequently grazed closely for a time after growth has begun. Such grazing is not only grateful to the stock, but it has been found favorable to abundant seed production.

Alsike clover is perennial in its growth and increasingly so as the conditions become more favorable. It grows best in moist soils. It is even more hardy than the Common Red and is fully as wide in its distribution. Though of finer leaf growth than the Common Red, it is not more palatable, takes longer to attain a maximum of growth, and makes less growth relatively late in the season.

Small White clover has a wider distribution than any other variety. It seldom requires resowing on soils where it has once grown unless where sown for seed production. It is seldom grown for any other purpose than to provide pasture. Spontaneously as it were, it grows along with blue grass and some other grasses, and is most in evidence in moist seasons. It is reasonably palatable, but less so probably than the clovers referred to above, although of finer growth, and it is charged with inducing slobbering in horses that graze upon it in the early summer. This useful and harmless weed-like plant considerably increases the producing capacity of pastures in which it grows.

Alfalfa grows on certain soils in nearly all the states and in nearly all the provinces of Canada. It is rather a hay than a pasture plant as it does not stand grazing well, and very frequently the grazing of cattle and sheep upon it is attended with loss. The danger from bloat is not present when it is grazed with swine and horses. When grown for grazing the aim should be to grow some grass along with it as Orchard grass or Russian brome, or to grow it as a factor of a pasture more or less permanent. The grazing of alfalfa usually shortens its life term, though the reverse is frequently true of clover.

The chief of the clovers of less importance in providing grazing than those referred to above, are Crimson clover, (*Trifolium incarnatum*), Japan clover (*Lespedeza striata*) and Bur clover (*Medicago maculata*). Sainfoin (*Onobrychis sativa*) may prove highly valuable in furnishing pasture, but it has not been grown on areas of any considerable extent in this country.

Crimson clover, usually sown in the summer or early autumn is grown chiefly in the Central Atlantic states and in some states westward and southward from these. This plant, which lives but one year, makes much and quick growth under congenial conditions, but it cannot endure severe winters unless protected by snow. It may be grown alone or along with other winter crops that will provide grazing, as vetches or rye. It may be grazed in the autumn or spring or at both seasons but close grazing in the autumn frequently endangers the life of the plants. They furnish grazing very early in the spring. Crimson clover is more grown as a fertilizer than as a pasture.

Japan clover is grown chiefly in the southern states. It is an annual but, like White clover, it has much power to reseed itself, and thus to remain in soil where it has once been grown. It is much prized as a pasture plant in considerable areas of the South, whether grown alone or in yearly alternation along with such plants as turf oats and sand vetches. The oats and vetches furnish spring grazing and the Japan clover grazing in the summer and early autumn. Stock do not take kindly to it at first, but soon become fond of it. If allowed to form seed before the grazing begins, it is less relished than if grazed earlier. It starts late in the spring and is easily injured by autumn frosts.

Bur clover, like Japan clover, is grown only in the South. Unlike Japan clover, which furnishes grazing in the summer and early autumn, Bur clover furnishes the same in the winter and early spring. It has sometimes been grown for successive years in alternation with Crab grass, the latter being used for hay or pasture. Both have much power to reseed themselves. Bur clover is not highly palatable, but in time animals become accustomed to it. It is most relished when the plants are young.

Plants of the Brassica family.—The most important of these, beyond all comparison, grown for pasture in America, is the Dwarf Essex rape plant. To a limited extent kale is grown for the same purpose especially on the slopes of western Oregon and Washington, beside the Pacific. Cabbage is also grown to a very limited extent to provide grazing for sheep. When fed to other stock, it is more as soiling food than as grazing.

Dwarf Essex rape, grown on rich soils in all the states and in all the provinces of Canada, is sown alone, broadcast, or in rows and cultivated, along with the small cereal grains, or in the last cultivation given to corn. After the grain and corn respectively are harvested, the rape provides abundant food according to the soil. It may be grazed by any kind of stock, except cows in milk, and these also may be grazed upon it for a short time after one or both daily milkings, but if allowed to remain on it long, the milk will be tainted. The plants may be grazed as soon as they will furnish much feed and will grow again, but the largest amount of grazing will be obtained, as a rule, when growth in the plants is nearly completed before the pasturing begins.

The rape plant is greatly relished by cattle, sheep, swine and horses. It is excellent for producing growth, fat, and also milk. These properties, along with its productiveness and wide adaptation, make it the most valuable fodder plant that has come into general use in this country during recent years. It furnishes excellent grazing for calves and older cattle, but the latter, when feeding on it, cause considerable waste through treading down the plants. For fattening sheep, no grazing is equal to it. It may be made to furnish good grazing for swine through all the growing season, except during the first six or eight weeks of growth subsequently to the opening of spring. Horses are fond of rape but, like heavy cattle, they injure it by treading. It furnishes food too succulent for horses at work.

Cattle or sheep should never be turned in to graze on rape while hungry, lest they should take harm through bloating. The aim should be, when either are grazed on it, to have a well-grown pasture at all times accessible, as this supplemented by a plentiful supply of salt, tends materially to prevent and also to lessen scouring. When once turned into graze, it is the common practice with many not to hinder freedom of access to the rape again until it is all grazed down.

Grain may be fed to cattle or sheep on rape, but such feeding is not indispensable with them as it is with swine that are being grazed on it. The grazing may be continued until the coming of hard frost, but in some instances digestive troubles arise from grazing sheep in the early morning on rape covered with white rime. Feeding them on grain previously is a safeguard.

Kale is frequently grazed in the spring in latitudes with mild winters, the kale having been started the previous autumn. The grazing of cabbage by sheep may begin as soon as growth is completed, and may continue later than in the case of rape. The amount of good grazing that may thus be furnished by an acre of cabbage is very large.

The saccharine and non-saccharine sorghums.—In some localities the saccharine and non-saccharine sorghums are frequently used to provide grazing, more especially in areas where, because of drouth or for other reasons, cultivated pastures are not so productive. Sorghums may be grown for pasture wherever corn can be successfully grown, but the non-saccharine sorghums, including Kafir corn, Jerusalem corn, Milo maize and Durra, can only be grown where the summer temperatures are warmer than those which prevail in the northern states and Canada. Pearl millet is somewhat akin to these in its adaptation and also in its habits of growth.

When grazed by cattle, the grazing should be deferred until the plants are old enough so as not to pull out of the ground while being grazed. The aim should be to keep them grazed down so closely that the grazing will not be greatly injured by the animals. This result is sure to follow when the stalks become so far advanced that they break down when the cattle walk through them. Such grazing is not so palatable as some kinds of grass, and yet cattle are fond of it. In some instances serious loss has occurred from grazing both saccharine and non-saccharine sorghum by cattle. This it is thought is due to the presence of a poisonous principle known as prussic acid, which collects in the plants usually, if not always, when the growth has been checked by drouth. These results, in some instances serious, are more frequent when grazing down the second growth but they are not entirely confined to such grazing.

Sheep are relatively better adapted than cattle to such grazing. With sheep the grazing may begin at an earlier age. They may be so grazed that but little waste will follow. None of the sorghums are so much relished by sheep as rape or certain of the grasses. Nor do they produce so much increase in the animals. But they furnish a large amount of grazing relatively in proportion to the area grazed.

In the central Mississippi states, these plants are frequently grazed by swine. Some writers praise them for such a use, but it is probably true, that, as with sheep, the grazing is not so completely satisfactory as that furnished by alfalfa, clover, rape and certain of the cereals, but such grazing may be furnished quickly in warm, dry weather

These plants may also be grazed by horses and mules but to such grazing there is the objection that the plants may be injured by treading. No instances of loss have been reported from grazing horses, sheep or swine upon the sorghums.

Corn may be grazed when sown on the broadcast plan, but when so grown it is best grazed by sheep; larger animals injure it much by treading and breaking it down. If sheep are turned in to graze upon it when it is about a foot high or even higher, they will get much grazing from it, but after it has reached the first joint it will not grow up again when grazed down. In some localities Squaw corn or some other small variety is grown and fed off by sheep or swine. In the northwestern states this method of fattening sheep and swine, especially the former, is attaining some popularity. Rape sown along with the corn at the last cultivation given to it improves the grazing.

Pasture from the small cereals.—Pasture is frequently obtained from the small cereals sown singly or in combination. Of these winter rye is more commonly sown alone, and because of its importance in grazing will be discussed separately. In some instances winter wheat is grazed in the winter season with benefit to both the stock and wheat. Such crops as winter vetches may also be sown alone in the early autumn to provide early spring grazing for all classes of farm stock. But such grazing, even under favorable conditions, must be conducted with a prudent caution or the grazing may injure the grain. On stiff clays it cannot be done at all. The same is true of the grazing of spring-sown crops by sheep in the spring on the northwestern prairies. In seasons unusually favorable to growth, such grazing benefits the crop but if it is continued too long it will lessen yields.

On the western and northwestern prairies spring grains are sometimes sown in combination to provide grazing when grass pastures are not available. The choice of varieties may depend somewhat on relative cheapness. A mixture, however, provides more grazing than a single grain, and also tends more or less to prolong the grazing. These grains sown thickly and in the usual way, are ready to graze as soon as the grazing is abundant. Such pastures have highest adaptation for milk production, owing to their succulence. They should be grazed so closely that no stems can be formed, otherwise the grazing will be lessened and also the palatability. Sowing the seeds of grasses and clovers with these mixtures still farther prolongs the grazing.

Pastures may be grown from the small cereals for sheep singly or in combination, and in a succession that may be made to cover the entire season of growth. When sown alone these pastures may consist of winter rye, winter vetches and winter oats where the winters are not too severe. When sown in combination, the mixtures may consist of winter rye or turf oats and sand vetches, of peas and oats, and of several of the small grains sown together.

The winter crops are of course sown in the autumn and the other crops in the spring. These may be sown in various alternations with each other and also with corn, sorghum and rape, more especially the latter. Thus sown, at least two crops of grazing per year may be grown on the same land. The grazing should begin reasonably early, on the principle that sheep prefer succulent grazing. It should not be deferred so long that the pasture will be seriously harmed from the tramping while being grazed. Cropping off the plants thus early tends to increase the stooling.

The small cereals more commonly grown to provide grazing for swine, are winter rye, barley, oats, peas and vetches. These are sown singly or in mixtures. The more common of the mixtures are, barley and oats and rye and winter vetches. The grazing of these plants should begin while they are still young, at least before the time of forming the seed bearing stems, except in the case of peas. These are allowed to near maturity before being grazed. The grazing of winter rye and barley is also sometimes carried into the maturing stages of the grain, but such grazing can scarcely be said to be entirely satisfactory in all instances.

Winter rye for pasture.—Winter rye is, beyond all comparison, the most valuable of the small cereals in furnishing pasture, as it can be grown in almost every part of the United States and Canada. It is the hardiest of the cereals, will grow on poor soils, comes earliest in the spring and may under many conditions, be made to furnish grazing both in the autumn and spring. But when sown quite early in the autumn, under some conditions, it becomes affected with leaf rust, and when sown too late, where the winter climate is rigorous, the plants become so weakened frequently, that the growth in spring is not of much value. Notwithstanding, under all conditions where winter rye is sown for pasture in the autumn, it is possible to obtain some kind of a crop after the rye the following season.

The practice of sowing winter rye in the spring to provide grazing is not to be commended, but it is admissible when the seeds of the grasses and clovers are sown at the same time with a view to prolong the grazing. Winter rye may be grazed by horses, mules, cattle of all kinds and ages, and sheep and swine. It is made to supply pasture to a much greater extent than any other cereal when this is short from other sources.

Although rye is frequently grazed in the autumn, the results are variable. In some instances close autumn grazing tends to weaken growth in the spring; in others, it does not seem to harm it. The difference may arise from a difference in winter temperatures. When sown very early, it is safer to pasture the rye in the fall. When sown later, but not in time to make too advanced a growth in the autumn, more grazing will usually be obtained in the spring, if the rye is not grazed in the fall.

Grazing in the spring should begin as soon as growth has really started. The aim should be to graze the rye somewhat closely, for if the plants are allowed to form heads, the grazing becomes woody and distasteful to live stock. Rye will furnish grazing for a much longer period when eaten closely than if not so grazed. In many instances the crop is grazed for a time in the spring, and the stock are then removed so as to allow the plants to mature a crop. Good crops of grain are thus frequently obtained when the grazing is not carried too far.

When cows in milk are grazed on winter rye and the grazing is abundant, the milk will be possessed of an odor and taste more or less offensive. This may be avoided by only allowing cows to graze on the rye for a short period after the time for milking. Owing to the succulence of young rye and to its tendency to relax the bowels, it is a good plan to feed more or less of grain, when practicable, to animals that graze upon it. It furnishes excellent grazing in the early spring for ewes that are nursing lambs and also for brood sows nursing their young.

The grazing of pastures.—The grazing of pastures should not begin as a rule until pasturing can be done without poaching the land, until the grass or other crop has made sufficient growth to meet the needs of the animals without an excess of expended energy in supplying the same, and until it has parted with an excess of succulence.

The injury from poaching is found, in part, in making the surface uneven, in part, in destroying some of the plants by pushing them down into the soil, and in part, in the excessive hardening of the soil after the excess of moisture has left it for the time being. Clay soils suffer the most from poaching and they suffer increasingly with the lack of firmness in the sod, with increase in the excess of moisture in the soil, with increase in the clay content in the same, and with increase in the poaching.

All excess of energy expended by animals in supplying their needs when grazing means loss. It means the utilization of unnecessary energy to enable the animal to graze. The expenditure of energy in excess of what may be necessary to keep the animal in good health while grazing is excessive, and should be avoided. It should be avoided for the further reason, that it involves unnecessary injury through needless treading on the plants.

Grass or other grazing is possessed of an excess of succulence when it induces a condition of the bowels so lax as to hinder increase in whole or in part. That excess of succulence varies in plants themselves with the advancement of the same in growth, and with the character of the season. Grain pastures would seem to be more succulent when quite young as a rule than grass pastures. Pastures that may physic animals at an early stage to the extent of preventing all increase, may lead to rapid increase at a later stage of development by which time they have parted with much of their succulence. Some seasons, pastures have much more succulence than in other seasons, owing to a difference in the amount of rainfall. The greater the degree of moisture in the air also, the more relatively of succulence will the pastures possess

Excess of succulence, however, is not to be measured alone by the degree of the succulence. That degree of succulence which removes an unduly dry condition from the fæces, is not excessive or harmful, but helpful. The trained eye quickly detects what is correct or otherwise in such condition. Succulence is excessive when it leads to a condition of the bowels so lax as to hinder production in milk, meat or labor. The degree of succulence in pastures that would be best suited for milk production would be excessive for meat production, and that which is best suited for meat production may be excessive for the best results from labor,. This explains in part at least why summer pastures, green and succulent, are best suited to the needs of milch cows, and why, when they become unduly dry, supplementary succulent food is necessary in order to properly maintain the milk flow. It explains why pastures well matured make beef much more quickly than pastures less matured and more succulent. It also throws light upon the necessity for feeding reasonably dry food to horses at hard labor.

The aim should be not to graze pastures close at any season of the year, for the reason, first, that when thus grazed, growth is hindered by reducing too much the breathing capacity of the plant through the leaves, and by removing the shade and protection furnished to the roots by the grass blades. When this covering is removed, the sapping of moisture is so far accelerated by the sun and wind. This loss of moisture increases relatively with increase in dryness of the climate. There is also loss of energy in searching for food by animals that are being pastured in order to supply their needs

Of course, the closeness of the grazing cannot always be regulated. When pasture is abundant, animals will sometimes graze close where growth is least luxuriant, because the pasture there is less coarse than in other parts and also probably sweeter, while they will not graze at all, or but little, on the ranker portions of the grass. Sheep especially, are much prone to graze thus. Notwithstanding, while the less productive portions are being grazed, grass is accumulating in the ungrazed portions of the fields, and this will be consumed readily when that season comes, which it usually does every year, when the close grazed portions of the field have practically ceased to produce grazing.

In the autumn, the aim should be to avoid grazing so close that fields will be left without any winter protection. This, of course, is more important in climates where the frost is intense, where the fields are much swept with bleak winds when bare, and where the snowfall is light. When the grass covering has been entirely removed in the fall, the blades are slow in starting in the spring, more especially where frosts are intense, and the early grazing is less suitable to the needs of plants than it would otherwise be. (See p. 319.) There are instances, however, in which want of grazing would result in the smothering of the plants to their complete destruction, especially where the snowfall is heavy, and there are other instances where the unremoved covering would be so much, that it would check the growth of the grass in spring even though it should not be killed by the covering.

Whether different classes of animals should be grazed together on the same pasture is a disputed question. Many are opposed to it. Notwithstanding, it would seem to be a question largely of conditions. When the pastures are not abundant sheep, for instance, should not graze with cattle. Because of their habit of close cropping, they will get the lion's share of the pasture, and through their habit of treading much while grazing, would render the grass more distasteful to the cattle. But when the pasture is abundant through all the season, grazing different classes of animals together is probably an advantage, as one class from choice eats portions that the other class will reject. A few sheep on such a pasture will aid materially in checking the growth of weeds, and a few goats in checking the growth of bushes, should they be present.

The care of pastures.—The care of pastures has reference: (1) To the extent of the depasturing; (2) to protection from weeds; (3) to improvement by drainage; (4) to improvement by fertilization; (5) to improvement by a renewal of the grasses. Due attention to these matters will greatly increase the carrying power of pastures. Very frequently pastures are kept eaten down too bare. Usually the power of plants to grow for the time being is crippled in proportion as the top growth is removed and in proportion to the earliness of such removal. Surface evaporation is always more rapid in proportion as the covering is removed from the soil, whether that covering consists of living or dead vegetation. Close grazing injures growth because it makes unnececsary treading by the hoofs of the animals grazing, and when winter comes, it injures through undue exposure of the vital power of the plants. It is perhaps an open question whether close grazing injures most the animals that graze or the pastures that they graze upon. If pastures must be grazed closely, such grazing should take place in the spring rather than in the autumn, as then the fields so grazed may reclothe themselves before the advent of winter.

Weeds injure pastures by drawing on their fertility for no useful end, by excessive shading and by crowding. Even bushes and shrubs become weeds in pastures when they hinder the growth of grass. Weeds that grow burs which adhere to stock are especially annoying. These evils may be mitigated by the free use of the field mower and in some instances of the scythe and spud. Annuals and biennials may thus be prevented from going to seed, and in some instances perennials may be thus destroyed, but not in all. Dense rooted grasses like Kentucky blue and Russian brome will crowd out many kinds of weeds through the density of their root growth.

The possible improvement of pastures by means of drainage is only limited by the opportunity furnished for making the drainage complete. The following are some of the benefits that accrue from it: (1) Drainage alone may completely change the character of the production, the change being from grass less valuable to that more valuable, because of increased growth, higher palatability and superior nutrition; (2) it may prolong the season of pasturing more or less each year; (3) the harbor for parasites, so prejudicial to the sheep industry where stagnant water abounds is so far removed; (4) the injury from poaching is reduced, if not entirely obviated. The methods of draining will not be discussed here, but it should be added that the benefits accruing from draining the wet places in pastures are usually far beyond the cost of the work.

But little attention has been given to the improvement of pastures on this continent through the medium of fertilization, owing largely, it would seem, to an extensively prevailing idea that more profit will result from applying fertilizer to other crops. The idea would not seem to be well grounded, especially where temporary pastures are grown. Dressings of farmyard manures and also of commercial fertilizers stimulate growth in the roots as well as in the leaves and stems, consequently when the pastures are broken up the humus in the soil is proportionately increased. Farmyard manures also act as a mulch, and the fresher and more bulky the manure and the more of it applied up to a certain limit, the more beneficial will be the result to the pasture. A threefold benefit results from applying farmyard manure thus. The wisdom of aiming to apply as large a proportion of the fertilizer as can be made available to pastures is to be commended.

Grasses may in many instances be renewed in pastures without breaking them up and resowing. This question is discussed in the book on "Grasses" by the author (p. 392), to which the reader is referred

CHAPTER XV.

FOOD FROM FIELD ROOTS AND TUBERS.

Field roots are distinguished from tubers first, in producing but one bulb or root, whereas tubers produce several; second, in usually making much of the growth above ground, whereas tubers grow wholly under the soil; and third, in larger average production than can be obtained from tubers. They also differ in chemical composition. Roots are relatively richer in protein and tubers in starch, and the starch in the two is found under different conditions.

The value of field roots and tubers in furnishing food for live stock has not been appreciated in the past by the growers of live stock in the United States as it has been by the growers of the same in Great Britain and Canada. The greater amount of hand labor required in growing them as compared with corn, has led to the centering of attention on the growing of corn. Nevertheless, the fact remains, that American supremacy in growing live stock is largely dependent on the extent to which field roots shall be fed to them while in process of development. No other food adjunct has yet been found that will equal field roots in securing the development of large frames and in covering them abundantly with fleshy tissue. The American exhibitor of cattle and sheep must continue to import his leading prize winners from Great Britain and Canada until he feeds his young animals more largely on field roots.

Those who have investigated with reference to the comparative cost of nutrients in corn and field roots respectively, have concluded, and correctly, that nutrients in corn can be grown in greater quantity and much more cheaply under average conditions than in field roots. But when the conclusion is reached, that in consequence, the net returns from an acre of field roots cannot be made as large relatively or as profitable as those from an acre of corn under some conditions of growth, that conclusion may be safely challenged. The favorable influence that the moderate or even light feeding of field roots exercises on the digestion of the animals (see p. 51), gives field roots a value far in excess of the nutrients which they contain.

The following conclusions with reference to the relative value of these and of corn will probably be found correct: (1) That in the main, under United States conditions, corn should be made the leading food crop for live stock rather than roots, but in some parts of Canada, because of climatic conditions, the reverse should be true. (2) That corn has much higher adaptation for fattening than field roots, hence they should be fed sparingly if fed at all to animals being fattened. (3) That field roots are so well adapted to milk production that, under many conditions, they may be fed for such a use, even in conjunction with corn and more especially with dry corn fodder. (4) That field roots have higher adaptation for young animals than corn, and that in consequence, the farmer should aim to provide young animals with such food even in areas well suited to the growing of corn.

The root crops discussed are: (1) Mangels, (2) sugar beets, (3) rutabagas and turnips and (4) carrots. The tubers dwelt upon are: (1) Irish potatoes, (2) sweet potatoes, (3) artichokes and (4) cassava. The miscellaneous crops included in the discussion are: (1) Cabbage, (2) pumpkins, (3) squash and (4) peanuts. The tops of roots and tubers are also considered with reference to their feeding value.

Mangels.—Mangels may be successfully grown in some portion of every state in the Union and of every province of Canada. Although they grow best where the temperatures are moderate and the climate is reasonably moist, they will stand more heat and drought than rutabagas or turnips. The yields ordinarily run all the way from ten to 20 tons an acre, the average under American conditions being about 15 tons, but far higher yields are easily attainable. The yields are usually higher than those of sugar beets and the labor of growing them is much less. Mangels, when grown, are easily injured by frost, even before they are harvested. The longer that mangels can be kept, the more they improve for feeding. This at least is true of them for several months subsequent to maturity, and it results from chemical changes which take place in the roots. If fed in large quantities for some weeks subsequently to maturity, they tend to produce scouring. The highest use of mangels when fed to stock is to promote growth in young animals and to stimulate milk production. As with all classes of field roots, mangels have a higher feeding value than chemistry assigns to them, especially when fed in small quantities. More commonly they are sliced or pulped before being fed, except when feeding them to swine.

For cattle of all classes, when on dry food, mangels are excellent and more especially when much of the food fed is carbonaceous, as in the case of corn. A few pounds fed daily to calves before and subsequently to weaning, and to growing cattle in winter, will tend to promote increase in frame and muscle in a marked degree. Usually not more than 20 to 30 pounds per day are fed to cows giving milk, but larger amounts may be fed without harm. They do not taint the milk, hence they are preferred to rutabagas and turnips for milch cows. The quantities named will also be suitable for animals that are being fattened under ordinary conditions in America, although as much as 100 pounds daily per animal is sometimes fed to cattle that are being fattened in Great Britain.

For sheep, mangels are nearly or quite as valuable relatively as in feeding cattle. Finely sliced, they are much relished by lambs. Two to four pounds a day fed to breeding ewes previous to lambing and larger amounts subsequently, prove very helpful to them. As much as 20 pounds per day is in some instances fed to large sheep that are being fattened but such feeding would seem excessive in cold climates and under American conditions would prove costly. Even when fed to breeding ewes in very large quantities, there is some hazard that urinary troubles may follow, and such hazard is increased in the case of rams.

For swine of all ages, mangels may usually be fed with profit, when not getting other succulent food. They are too bulky for feeding in large quantities to young swine or to swine that are being fattened, but to brood sows in winter they may be fed so freely as to form the bulk of the ration. When swine are first put upon a ration of new corn, a few pounds of mangels daily help to balance the ration. The Michigan experiment station has demonstrated the feasibility of harvesting mangels with swine so as to cheapen materially the cost of production. The swine are given grain in addition. The amount required is less than 50 per cent of what would otherwise be needed during the first part of the grazing, but toward its close, more grain would be required to properly finish the swine. Under all conditions of forced feeding or fattening with grain, a pound or two or even more of mangels fed daily will aid in regulating the digestion. Swine feeding after cattle that are being fed corn heavily, will be more healthy and thrifty if given mangels in addition, and will also withstand a visitation of hog cholera better than those not so fed. Swine are more fond of mangels than of rutabagas, turnips or carrots.

To horses, mangels are not much fed under American conditions, but there are no good reasons for not feeding them more or less when obtainable. Moderate amounts will aid in keeping the digestion of horses in tone as well as in the case of other stock. A few pounds fed daily with dry food will materially aid in giving draft foals that development of bone and muscle that is so much desired in this class of horses, and will prove greatly helpful to idle horses and brood mares in winter, but small amounts only should be fed to horses at hard work.

Sugar beets.—Compared with other field roots, sugar beets have a high feeding value, but the cost of growing them as grown for the factory, is considerably more than that of growing mangels under similar conditions. It is also more than would furnish an equal tonnage of rutabagas where the conditions are favorable to the growth of the latter. For feeding live stock, therefore, it is usually considered preferable to grow mangels or rutabagas. The labor involved in thinning and harvesting sugar beets is much more than that called for in thinning and harvesting either of the crops named. But there are varieties of sugar beets that have special adaptation for being grown for live stock, owing to their large size. The sugar content of these is higher than that of mangels, hence they are more suitable for certain kinds of feeding. Sugar beets, like mangels, may be grown in some portions of almost every state in the Union, and in many of the provinces of Canada. Owing to the high sugar content of sugar beets, they are more highly relished than other field roots and are also more valuable for fat production, but they are not more valuable for feeding young animals to promote growth, and are probably less valuable for producing milk.

As in the case of mangels they are usually fed sliced or pulped, but when fed to swine and especially to brood sows, they are generally fed whole. In practice, the difference in the feeding value of sugar beets and sugar beet pulp is less than chemical analysis would assign to these.

By cattle, sugar beets are highly relished. From 10 pounds downward may be fed daily to calves according to their age with gratifying results. Young cattle on dry roughage will take larger amounts. Milch cows will make good use of 20 to 30 pounds per day in the absence of corn ensilage, and smaller amounts in conjunction with the same. But, of course, it is not absolutely necessary to feed sugar beets to dairy cows that are being given a liberal allowance of corn ensilage. To cattle that are being fattened, large amounts may be fed daily, limited only by the cost and the capacity of the animals to consume them. Economy, however, points in the direction of the very moderate feeding of roots under American conditions, owing to the cost of growing them.

For sheep, sugar beets are excellent when fed to breeding ewes on dry feed. They are also particularly good for milk lambs that are being pushed for the market. For fattening sheep and lambs, sugar beets should be fed along with grain, notwithstanding their high sugar content. They are too bulky a food to admit of feeding them alone for fattening along with hay.

For swine of all ages, sugar beets are excellent, especially for growing swine. They are greatly relished by young animals and furnish an economical food for them when fed as part of the ration. Brood sows will winter nicely and cheaply on them with a small amount of grain added. A small quantity will be found helpful far beyond the cost, to animals that are being pushed along by heavy feeding of grain. Experiments conducted in feeding sugar beets to swine, have shown that from 4 to 8 pounds of sugar beets are equal to 1 pound of barley.

To horses, sugar beets are not much fed, but when available, moderate quantities will be as helpful relatively to young horses as to young stock of other classes. To horses that are at work, the same limitations in feeding should be observed as in feeding other roots, which means that they should not be fed to the extent of relaxing the bowels unduly.

Rutabagas and turnips.—The rutabaga is a variety of turnip which it is thought originated in Sweden, hence in Great Britain and Canada they are commonly designated Swedish turnips. They are by far the most commonly grown and also the most valuable of the turnip family, owing to the firmness of the bulbs and the long period during which they may be kept. Turnips, as distinguished from rutabagas, grow more quickly than the latter, are less firm in flesh, and do not retain their good feeding qualities so long as the former. The methods of growing the different varieties is substantially the same, although on suitable soils and at proper elevations, they may be grown over wide areas of the United States, the conditions best suited to their growth being on good, sandy loam soils where the temperatures in the growing season are moderate to cool, and where the atmosphere is moist. Large areas in Canada are admirably adapted to the growing of both. All kinds of turnips are at their best for feeding when the crop is first harvested, but rutabagas especialy retain their good feeding properties for a long period. More commonly these roots are sliced or pulped before feeding them, except, of course, when they are fed off by sheep where they grew. This practice, very common in Great Britain, is quite feasible in those portions of the United States where the soil is not heavy, and where frost does not lock the ground early in the season, but more commonly it is necessary both in this country and in Canada to store the crop for future feeding.

For cattle of all classes and ages, as a food adjunct both rutabagas and turnips are excellent, except that when fed to cows giving milk, both the milk and butter resulting will possess the odor of the roots unless they are fed with caution. From say 10 pounds downwards, fed daily to calves, according to age, will aid materially in the absence of other green food in maintaining them in good thrift, and in securing satisfactory development of bone and muscle. To young cattle, yarded in winter, and maintained chiefly or wholly on inferior hay or straw, they may be fed with much benefit up to that limit which would make feeding them too costly. Along with straw, 10 to 15 pounds a day will insure both thrift and growth in such animals. To cattle that are being fattened, 100 pounds per day is sometimes fed in Great Britain. Such feeding of roots would be too costly under American conditions. Such cattle in this country, if fed rutabagas or turnips at all, are seldom fed more than 10 to 20 pounds per animal, daily. Milch cows may be fed similar amounts without much hazard of taint in the milk, providing they are fed night and morning just after each milking.

For sheep, rutabagas and turnips have been used to a greater extent probably than in feeding any other class of live stock. When fed freely to young lambs, in a finely sliced condition, they aid materially in starting them into vigorous growth. When pregnant ewes are being given leguminous fodders, it is thought that large quantities of rutabagas or turnips in addition tend to produce lambs abnormally large, but deficient in vitality. From 2 to 4 pounds a day will probably be enough, but subsequently to lambing they may be fed in much larger quantities. Sheep may be fattened almost entirely on grain and turnips. When so fattened, the roots may be fed up to the limit of the capacity of the sheep to consume them. But such fattening is far too costly for American conditions. Only a few pounds daily are usually fed to such sheep when fed at all.

To swine, rutabagas and turnips may be fed as a part of the ration when not on succulent pasture, and more especially while they are being grown, but they are not so fond of them as of sugar beets or mangels. They may be fed sliced, pulped or whole and with or without the tops. There may be instances in which they may aid in harvesting the crop, as when turnips are sown along with the small cereals. Brood sows turn them to good account in winter when a small amount of grain is fed in addition. When the labor conditions will admit of it, they may sometimes be fed with profit to pigs that are being fattened, when cooked and mixed with meal.

To horses of all ages, though not commonly fed, both rutabagas and turnips may be so fed. They are commonly sliced or pulped when fed thus. When pulped they are usually mixed with cut fodder. One pound of hay has a feeding value equal to 4 pounds of rutabagas.

Carrots.—The carrot is one of the surest root crops that can be grown in the United States, and it may also be grown under the greatest variety of conditions. It is also one of the most valuable when it is grown. Nevertheless, it is probably grown to a less extent as a food for live stock than any other root crop devoted to such feeding. This arises, first, from the relatively large amount of labor involved in keeping the crop clean, and second, from the relatively large amount of the same called for in harvesting and storing the roots, which do not usually grow so large as other field roots. They furnish an excellent and safe food for all classes of farm animals. As with other field roots, they have a physiological value, so to speak, in addition to their feeding value, especially when the other food fed is dry. To produce this effect, it is not necessary to feed a large quantity. Notwithstanding, carrots are so safe a food that they may be fed in large quantities where such feeding will prove economical. It is not necessary to slice them for feeding unless when they are being fed to young calves or to lambs.

For cattle of all classes, carrots furnish an excellent food. A few pounds fed daily to calves will add greatly to their development, especially when the fodder fed is dry. They may be fed with the utmost freedom to milch cows, and without any fear of tainting the milk. They tend greatly to stimulate milk production in cows on winter rations. For milk production they may be fed up to the limit of at least 30 pounds daily, when they are not too costly. When they can be spared for such a use, a few pounds fed daily to cattle that are being wintered on dry fodder will result in great benefit to them. They will also tend to produce rapid gains when fed to cattle that are being fattened, but they are usually too costly a food to admit of feeding them thus.

For sheep, carrots are as valuable relatively as for cattle. From 1 to 3 pounds daily in the winter will add much to the thrift of store sheep and breeding ewes kept on dry food. For sheep that are being fattened, carrots will usually be found too costly, but a few pounds fed daily way be in order under some conditions.

For swine, tests conducted in Denmark have shown that on the basis of dry matter, carrots and mangels were about equal in feeding value. This would mean that pound for pound, carrots would be more valuable than mangels for such feeding, but the difference is not great. On the other hand, carrots are not so much relished by swine as mangels. The highest value from feeding carrots to swine will probably come from feeding them to brood sows in winter along with grain. Nutriment in the carrots will usually be furnished more cheaply than an equal amount of nutriment in the grain.

For horses of all classes, carrots have been found valuable. In Ontario, Canada, considerable quantities of carrots are grown for such feeding. A few pounds per day are excellent for promoting thrift and growth in weanling foals and also in those of more advanced age. They are excellent for keeping in tone the digestion of horses wintered on dry food, more especially when it is composed mainly of straw. Horses at work can also use a moderate amount to advantage, but, owing to the large amount of water which they contain, the quantity fed should be moderate, usually not more than a few pounds per day. They are also much prized in providing food for stallions when fitting them for service and also for the show-ring. Usually not more than 12 to 15 pounds per day are fed. They act beneficially on the glands of the skin and thereby improve the coat.

Irish potatoes.—Potatoes of a quality that would fit them for the market may sometimes be fed with profit to various classes of farm animals when market values run so low as to justify such feeding, but they are seldom or never grown primarily for feeding live stock. Field roots, as mangels and rutabagas, can usually be grown so as to produce more nutrients per acre than potatoes and at less cost, while the former are also more highly relished. Those rejected for cooking, however, because of insufficient size or because unshapely, may always be turned to good account when judiciously fed to farm animals.

Potatoes are rich in starch and, therefore, may be used with profit under some conditions in fattening animals, more especially swine. They are so bulky, however, and contain so much water, that it has been found more profitable when feeding them for fat production to remove much of the water by first cooking them. To other classes of stock they are more commonly fed raw. But potatoes, old and shrivelled, or that have sprouted, should not be so fed, as they contain a principle, *solanim* which is dangerous to live stock and which is removed by boiling the tubers. Like all classes of tubers and field roots, they have a beneficial influence on the digestion apart from the nutritive value, consequently when fed to farm animals maintained on dry food, they aid in keeping the digestion in tone. Except when fed to swine and grown sheep, they should usually be sliced. Cattle may choke on them when fed whole.

To cattle of all classes, potatoes may be fed with more or less benefit when they can be spared for such feeding, unless when the animals are being maintained on succulent food. A few pounds only should be fed to calves daily. Cows in milk should not be given potatoes in large quantities except in conjunction with protein foods, owing to their highly carbonaceous character, otherwise they may tend too much to the production of fat rather than milk. With such foods in plentiful supply, as many as 15 to 20 pounds per day may be fed without harmful results. Cattle that are being fattened will take as much as 30 pounds per day, but usually smaller quantities will suffice.

To sheep, a few pounds fed daily when on dry feed will aid materially in promoting thrift in the flock. Usually 2 to 4 pounds may be fed with benefit to breeding sheep not on grass. Twice these amounts and even more may be fed to sheep that are being fattened. When sliced they may be fed with satisfaction to milk lambs that are being pushed for the market. There may also be instances in which they may be allowed to feed on cull potatoes in the field.

For swine, especially when they are being fattened, potatoes are relatively more valuable than for other classes of live stock. They may be fed raw, but experience has shown that when cooked, the gains resulting are materially increased. They may be cooked by steaming or boiling. If cooked by boiling, as little water should be used as will suffice. Meal is then added and the whole is made into a mash. If cooked squashes or pumpkins are added, the ration will be cheapened, but such food is rather adapted to growing swine. Danish experiments have shown that 4 pounds of potatoes were required to make as much increase with swine as 1 pound of grain. Wisconsin experiments have shown that 4½ pounds fed raw are required to make as much increase as 1 pound of corn. Swine do not relish them when made into a thin slop. When cull potatoes are left as they fell from the digger, swine may be used in gathering them up, but should be given some grain also in addition.

Horses at work may be given from 10 to 12 pounds of raw potatoes daily. If fed larger quantities, there would be some tendency to an unduly lax condition of the bowels. Even larger amounts may be fed to brood mares and horses not at work, especially when they are in a low condition. Half the amounts named above should suffice for weanling foals.

Sweet potatoes.—These are primarily grown as food for man and yet they may be profitably grown as food for live stock in certain areas of those portions of the United States that are favored with a mild climate, so mild that no frost is present for 150 days during the period of growth, and the midnight temperatures do not reach lower than 45°. Although they have highest adaptation for being fed to swine, they are frequently fed also to cows, and may be fed to all classes of domestic animals on the farm. The yields of the coarse growing varieties are sometimes very large, as large as 9 to 12 tons of tubers per acre, and in some instances the enormous production of 18 tons per acre has been reached. The average yields, however, are considerably lower than 9 tons per acre. To grow the crop at its best, requires a loam soil, inclining to sandy, porous and naturally fertile or made so. Sweet potatoes may be grown even for live stock, southward from the Potomac and Ohio rivers, in the East, and southward from the latitude of Des Moines, Iowa, and in the mountain valleys, southward from say Walla Walla in Washington in the West. They are usually fed in the sliced form except when fed to swine. The perishable nature of sweet potatoes tends to shorten the season for feeding them, and to encourage the feeding of the crop as soon as is reasonable after it has matured.

For cattle, the aim should be to feed leguminous adjuncts along with sweet potatoes. Though relatively better adapted for fattening than for milk production, they are more commonly fed for the latter end. A few pounds fed daily to calves and young cattle will aid them materially. Large quantities may be fed with safety to beef cattle, but moderate quantities will probably be found relatively more profitable. In some instances 40 to 45 pounds per day have been fed to cows in milk. But these quantities would seem excessive of a food so rich in carbohydrates. The results will probably be more satisfactory when not more than 15 to 20 pounds are fed daily along with concentrates such as soy bean or cottonseed meal.

To sheep, sweet potatoes are seldom given, largely for the reason that where they are grown most extensively, sheep are not much grown. They may be used with advantage in feeding off the tops before the crop is harvested. For sheep that are being grazed on such pasture as cowpeas or Japan clover, especially with a view to fattening them, sweet potatoes should furnish a very suitable complement. A few pounds fed daily should suffice, but heavier feeding may also sometimes be in order.

For swine, sweet potatoes are better adapted to furnishing food than for other classes of live stock, as in addition to being very much relished by swine, they are a good food for fattening them, and they may also be harvested by the swine. Being a bulky food, some concentrated food should be fed along with them. For such feeding cowpeas and soy beans are very suitable, but corn may also be fed so as to form one-half the concentrate. When swine are thus fattened on sweet potatoes, they should not be required to glean closely lest the exertion thus made should be too much for the best gains to result. Such gleaning should be done by store swine.

For horses and mules, at work in the South, sweet potatoes are frequently fed. For such feeding they have been found quite suitable when fed sliced along with corn or other grain, in the proportion of say 3 pounds of potatoes to 1 pound of grain. There would seem to be no reasons why they should not be fed in moderation to foals and to young horses not yet matured, when they can be spared for such feeding.

Jerusalem artichokes.—These may be successfully grown in nearly all parts of the United States and Canada. The tops are sometimes used in providing food for stock where intensive conditions prevail, but even under such conditions, the chief value of the crop lies in the tubers. They are more watery than potatoes, but are richer in protein. In feeding value they have been found fully equal to potatoes, viewed from the standpoint of practical results. Their ability to resist frost without injury adds much to their economic importance, as it makes it possible to harvest them with swine or otherwise even after the winter has gone. The yields vary greatly with varying conditions, but 200 to 300 bushels per acre may be readily grown under average conditions. The persistency with which artichokes remain in the soil is one objection to growing them.

For cattle, the feeding value of artichokes is much the same as that of potatoes, and about the same quantities may be profitably fed. It is not probable, however, that they will ever be much grown as food for cattle because of the labor required in handling them for winter feeding, when they are more valuable relatively than at other seasons. They furnish good food for calves, for store cattle in winter and for cows in milk, also for cattle that are being fattened, when they can be spared for such feeding.

For sheep, both the roots and tops of the plants may be used in providing food. Sheep soon come to be fond of both, but, of course, they do not consume the woody portion of the stalk. Store sheep and breeding flocks will be much benefited from supplementing the other dry food fed with 2 or 3 pounds of artichokes per day. The less cost, however, of handling field roots, will to a great extent, preclude the growing of artichokes as a food for sheep.

For swine, the best and chief use of artichokes consists in furnishing them with food. They may be fed to swine at any age subsequently to the weaning period. When used as a part of the fattening ration, they may be fed in the same way as potatoes, that is cooked and fed along with meal. (See p. 334.) But their highest use in feeding swine is found in the food which they furnish to growing swine and brood sows when harvested by these. Ordinarily the labor of harvesting artichokes by swine that are being fattened is so much that it would so far prove adverse to laying on flesh. This labor, however, is very beneficial to brood sows, especially when they are pregnant. It furnishes them that degree of exercise which tends so much to promote stamina in the young animals when born. Swine that are being grown will be much aided in their development by having access to a field of artichokes, but a grain supplement is necessary to promote quick growth and it is also necessary though not in quantity so large for brood sows that are feeding thus on artichokes. The milder the climate, the more prolonged may be the feeding season, because of the shorter period during which the ground is frozen.

For horses, tests made in feeding artichokes have shown that they are excellent. They are also fond of them. They have been fed to horses to the extent of making a reduction of 50 per cent in the hay required with results that were satisfactory. They may be fed whole to all classes of stock, but in some instances they are sliced.

Cassava.—This is a tropical or sub-tropical American shrub of the genus Manihot and the order Euphorbiaceæ. It is a shrub-like plant at the base of which grow prong-like tubers. These are more or less extensively used in feeding live stock in the Gulf states. It is best grown on sandy land, and the yields range from 2 or 3 tons to 15 tons per acre. The tubers are exceedingly rich in starch, and they have been much grown during recent years to supply mills erected for the express purpose of manufacturing starch from them.

As the plants may be grown as annuals or perennials, and as it is not usual to dig them as food for stock during the active period of growth, they are seldom extensively used in feeding animals from May 1 to November 1. In other words, it is usual to feed them during other months of the year. As under ordinary conditions of exposure, they do not keep long when unearthed, they are usually dug as wanted for feeding. Should the supply be in excess of the needs for feeding, the unharvested residue may be left in the soil to increase for feeding the following season. The increase made, however, is partly counterbalanced by increase in woody fibre in the tubers. In addition to furnishing wholesome food for quadrupeds on the farm, they are coming to be much prized as a food for poultry. The tubers do not call for any other preparation than slicing, when they are being made ready for feeding.

For cattle, cassava tubers are very valuable, more especially when they are to be fattened. When properly fed to milch cows they also aid materially in the production of milk. Such feeding should only be done in conjunction with a liberal supply of protein foods, such as cottonseed meal and cowpea or other leguminous fodder. It is said that the free feeding of cassava to cows tends to give the milk a reddish tint and high color to the butter. Cottonseed meal fed with cassava aids in firming the butter. For beef production, as much as 20 to 25 pounds is sometimes fed to one animal daily. When thus fed, the cassava will go far to take the place of corn. For such feeding, the roots may be sliced with a spade in the absence of a cutting box.

For sheep, cassava has not been much used, but for such feeding it will doubtless be found quite as useful as for feeding cattle. Its highest use in feeding sheep will be in fattening them. From 4 to 6 pounds per day would probably be found ample for mature sheep along with suitable adjuncts.

For swine, cassava has proved an excellent food. They become very fond of it, and it may be fed to them even to the extent of producing excessive fatness. For young and growing swine it should be fed along with such foods as shorts or cowpeas. It should only be fed in moderate quantities to brood sows that are pregnant, but may be fed with much freedom to swine that are being fattened. Swine should never be allowed to harvest the crop, as the portions brought to the surface and unused by the swine would soon spoil, but the practice of allowing swine to glean in fields from which a crop has been harvested is commendable, as they search out and consume portions of broken prongs that have been left in the ground.

For horses and mules at work, when cassava is fed, the grain feed may be reduced proportionately. Cassava and corn do not make so suitable a food as cassava and oats, since the latter have a higher protein content than corn. If cottonseed meal is fed to horses (see p. 286), a small amount fed daily should answer well to feed with cassava. When large amounts of cassava are fed daily to horses, the aim should be to feed leguminous fodders along with it. Should it be fed to young animals also, the aim should be the same.

Cabbage.—This plant is usually primarily grown as food for the human family, but in some instances it is also grown as food for live stock, and even when grown primarily as food for the human family, the residue of leaves furnishes excellent food for some classes of live stock. No kind of green crop is grown over a wider area. The soil and climate, however, of northwestern prairies have highest adaptation for the growth of this plant. On such soils as many as 24 tons of heads per acre have been grown, not including a large amount of leaves. The leaves may be gathered and fed to live stock after the heads have been removed, or they may be fed off by sheep or even by swine where they grew. In some instances the entire crop is grazed down by sheep in the late autumn. Cabbage furnishes excellent food for some kinds of farm animals in winter, but the labor involved in storing them is such as to make the feeding of cabbage too expensive, unless when they are fed to milk lambs in order to hasten their development for the market. In some latitudes, however, the winters are so mild that cabbage will not take serious harm though left exposed where they grew. In such instances, the leaves and soft heads may be fed with profit to cows, ewes and brood sows.

For cattle, the highest use of cabbage is found in feeding them to cows for the production of milk. The leaves and soft or immature heads may thus be fed with satisfactory results, at least in a limited way. They are excellent for stimulating milk production. The plan of grazing cows on areas from which a crop of cabbage has been removed is not to be commended, as such grazing is likely to result in too lax a condition of the bowels, and it may also result in tainting the milk, more especially when decayed or partially decayed leaves are present. Such food will be helpful to calves, but even for them, the results are more satisfactory when the amount of cabbage or leaves fed is restricted. They are seldom or never fed to cattle that are being fattened.

For sheep, the best results, all things considered, are probably obtained from feeding cabbage, and in no way can they be more profitably fed than by grazing them off where they grew. An enormous amount of food per acre can thus be furnished from a crop of cabbage grown under favorable conditions, more than can be obtained from rape, but more labor is involved in growing cabbage. The grazing of cabbage may be continued later than the grazing of rape, as cabbage take less injury from frost. As when grazing down rape, the results will be more satisfactory when the sheep may have access also to a grass pasture in an advanced stage of growth. Sheep also answer admirably for gleaning in areas from which the merchantable heads have been removed. In mild latitudes sheep may be thus grazed far on into the winter, but on stiff clay soils, such grazing would tend to impact the land.

For swine, rejected cabbage may be profitably utilized at any season and under nearly all conditions of feeding, but the crop is never grown primarily for such a use. Cabbage leaves and soft cabbage may be fed to swine at all times, or they may be allowed to glean amid the unharvested portions of a crop after removing the marketable heads, but the waste will be greater than when sheep are used for such grazing. The rejected heads from stored cabbage may be better utilized by swine than by other stock, as they are less harmed by consuming partially decayed heads than other classes of live stock would be.

To horses, cabbage are seldom fed, but there are no reasons why they should not be fed to colts and brood mares except those which arise from inconvenience in feeding them. To work horses they would have to be fed with prudent caution.

Pumpkins.—This crop may be grown successfully under any conditions that are favorable to the growth of a crop of corn. They are very frequently grown in the corn crop, and they may be grown thus without in any way retarding the growth of the corn, but they are also frequently sown as the sole crop occupying the land. The small varieties are generally used as food for man, but more commonly the large varieties are fed to the various classes of animals kept upon the farm. The use of the binder in cutting corn will probably tend to lessen the growth of pumpkins in this crop, as unless removed in advance of the binder, they are much liable to be broken by the same. They are easily injured by frost, and when so injured will soon spoil, hence, the aim should be to feed them in the autumn and early winter, as the labor of storing them is considerable in proportion to their feeding value. Those immature will decay more readily than pumpkins fully matured, hence, the aim should be to feed them first. When feeding pumpkins, they are usually cut open with the spade, and for some kinds of feeding are cut into smaller pieces.

For cattle of all classes, pumpkins furnish excellent food, but they are most highly prized for feeding cows in milk. When so fed, the practice is common of drawing them daily or twice a day from the place where they grew to the pastures. They are then tossed out of the wagon, and in falling, the concussion usually breaks them open, so that further division is not necessary. Cows are exceedingly fond of them, and may with safety be allowed to consume them in large quantities. The claim has been made that the seeds are adverse to free milk giving, but this claim has not been sustained by the experience of feeders. The free feeding of pumpkins is highly favorable to abundant milk production. Pumpkins should always be fed in a clean place, hence, when fed to cattle in pastures, the exact place of feeding should be changed from day to day. They should be finely sliced when fed to calves. For such feeding they are highly suitable.

By sheep, pumpkins are much relished and also by lambs, as soon as they become accustomed to them. They will learn to eat them more quickly if first sliced and salted. They may be fed to sheep in the same way as to cattle. Except for a few days at the first, they may be allowed to eat them with much freedom. They will be found of much value in promoting development in lambs kept for breeding uses.

To swine, pumpkins are frequently fed with new corn. When so fed, they correct impaired digestion and improve the appetite. The portion of the crop that is immature is more commonly fed to swine than to other stock, as swine will consume pumpkins even when in partial decay which would be rejected by other farm stock. The practice which grows low-growing varieties of corn that produce ears abundantly, with pumpkins plentifully interspersed, and which consumes both crops with swine, is to be commended. It is labor saving and the combination makes excellent food for fattening swine.

By horses, pumpkins are much relished but they are seldom fed to them, as it is usually more convenient to feed them to other classes of live stock. In the absence of other green food, they render good service when fed to weanling foals. They must, of course, be fed with some caution to horses at work, as they may relax the bowels too much when fed over freely.

Squash.—This plant, commonly grown to provide food for man, is in some instances grown to specially provide food for swine. On ground properly prepared, when all the conditions are suitable, many tons may be grown on an acre. Preference should be given to the soft shelled varieties when of suitable size, otherwise the rinds may prove so hard as to make it difficult for animals to consume them, unless they are first softened by cooking. As considerable care and labor are involved in storing them so that they will keep into and through the winter months, and as they are easily injured by frost, the aim should be to feed them in the autumn, and to feed first any that may be immature, as they are the most perishable. Unless when feeding them to swine, it is necessary to slice or break them open as with a spade, and even when fed to swine, the hard shelled varieties should be thus prepared. When squashes are fed to live stock on dry food, as in the case of field roots, they have a physiological value in addition to the food which they furnish (see p. 51).

For cattle of all classes, squash may, of course, be fed when they can be spared for such feeding, but they are most prized for producing milk and are, therefore, more frequently fed to cows than to other classes of cattle. Where large areas are grown for the market, rejected squash, usually available in large quantities, may be turned to good account by feeding them to cows in milk. No harm probably will result from feeding them in liberal supply when they can be spared, unless the amount fed should too much relax the bowels. Usually, however, the most profit is made by feeding such adjuncts in moderate quantities, otherwise the benefit resulting in addition to nutrients furnished, may not be secured to the fullest extent. When the pastures dry in the autumn, squashes make an excellent supplementary food.

By sheep, squashes are much relished, though for a time they may refuse to eat them if not accustomed to them. Especially is this true of lambs. When fed to sheep in the autumn before the rinds have too much hardened, they will materially aid in promoting growth in lambs that have been weaned, and in bringing flesh to breeding flocks.

For swine, squash are an excellent adjunct when fed in the autumn. The most profit, when the labor involved is considered, is probably obtained from feeding them in the autumn along with new corn fed in the stalk or in the snapped form. The squashes are available at such a time, the rinds are less hard than later, and when fed at that season the cost of storing is avoided. Moreover, they furnish an excellent adjunct to such corn feeding, as they have a corrective influence on the digestion. A few weeks of such feeding aids in a marked degree in fitting the system for the heavy grain feeding that follows during the fattening period. For such feeding, one good sized squash fed daily to an animal weighing about 150 pounds will serve a good purpose, but more, of course, may be fed with benefit if available. For later feeding, especially to swine that are being fattened, they are frequently cooked by steaming along with meal, and when so prepared, the mixture is fed as a mash. Rejected squash with the hardest rinds may thus be turned to good account.

By horses, although some kinds of squash are eaten, in the nature of things they are not likely to be much used for such feeding. Relatively they are usually more valuable to feed to swine or to cows giving milk.

Peanuts.—This tuber has been grown chiefly to provide food for man, in the United States, but during recent years, they are also grown for live stock, more especially for swine, which harvest the crop in the fields where they grew. The tops also furnish hay that is much relished by live stock. The peanut crop may be grown successfully as far north as parallel 43°, where the soil conditions are suitable, but it has centered heretofore in the light soils of the Atlantic and Gulf states. That more food for swine may be grown from an acre of peanuts on the light soils of the South than from an acre of corn, is generally conceded by those who are conversant with the conditions for growing the two crops. With skillful cultivation, as many as 50 bushels of peanuts per acre may be grown on soils of only moderate fertility, weighing from 22 to 28 pounds per bushel. The nuts furnish one of the richest protein foods for live stock that is grown in this country. After the oil has been expressed, the cake resulting is fully equal to oil cake (see p. 300). The hulls also, when ground, furnish a valuable food. (See p. 346.)

For cattle, the nuts are not much used as food, for the reason that unless stained or otherwise injured for sale, they are too valuable for such feeding. In some instances, however, more or less of the nuts adhere to the vines which are fed as hay, dependent upon the mode of harvesting. If the vines are not removed before the crop is harvested, the rejected peanuts are sometimes fed as hay along with the vines. When thus fed, the value of the hay is proportionately increased. Without any peanuts adhering, the hay is nearly equal in value to peanut hay. Rejected nuts, in the form of meal, may be ground alone or along with hulls and fed to cattle and other stock. The richness of such meal will be proportionate to the amount of nuts and hulls respectively which the meal contains.

By sheep, the fodder and also the defective nuts will be turned to good account as soon as they become accustomed to such food. They may also be used with advantage in grazing off the tops before the crop is harvested. No class of live stock will effect such grazing with so little waste as sheep. Peanut meal may be fed to them also as to cattle, but the same necessity does not exist for grinding them for sheep. The cake may be fed to sheep in about the same way as oil cake.

For swine, peanuts have higher adaptation in furnishing food than for any other class of live stock, as swine only, of all the domestic animals of the farm, may be employed in harvesting the crop. When thus harvested, the tops are first removed by grazing them down with cattle or sheep, preferably the latter, or they are mown to be made into hay. When thus harvested by swine, it is greatly advantageous at the same time to give them access to about an equal area of corn, or to feed them a supplement of corn daily. It has been claimed that a bushel of peanuts, weighing from 22 to 28 pounds, will make 9 pounds of pork, in other words, that 3 pounds of peanuts will make 1 pound of pork, whereas about 5 pounds of corn are required to make the same. The crop may, of course, be fed to swine when confined in pens. When so fed, the tops are first removed and the roots are then dug and placed before the swine with the nuts adhering to them. Peanuts alone make soft pork, hence the necessity for feeding a supplement of corn in order to firm the pork.

For horses, peanuts whole or ground are not much used. The hay from peanuts is frequently fed to them, and the same is true of peanut cake or of the meal made from the same. (See p. 300.) When peanut hay is fed to horses with the nuts adhering, some caution should be exercised owing to the richness of the food.

Tops of roots and tubers.—The various roots and tubers, the tops of which may be used as food for stock, include mangels, sugar beets, rutabagas and turnips, carrots, sweet potatoes, peanuts and artichokes. The tops of Irish potatoes and cassava are possessed of little or no value for feeding. The value of the tops of roots in feeding live stock is measurably dependent on the way in which they are fed, and on the relative cost of handling them. The tops of field roots when fed, are either consumed in the field after the crop has been removed, or are drawn daily and strewn over pastures where live stock may gather them, or they are fed in mangers. When gleaned by the stock in the field, they are much liable to induce scouring because of their succulence and the extent to which they are consumed, but this tendency lessens proportionately with the wilting of the leaves. Because of this hazard, many growers simply spread them and then plow them under for the benefit of the soil. Sheep will consume them with less waste than other classes of live stock, and if given access to an old pasture while thus consuming the tops, the tendency to scours will be measurably removed. When drawn and fed, the amount consumed, may of course, be controlled. The tops of roots are specially valuable in furnishing milk.

Mangel tops.—The proportion of the tops to the roots of mangels varies much with the variety. With most varieties it is probably less, rather than more than 20 per cent The leaves of mangels are removed without any portion of the root adhering to them, as in the case of sugar beets, hence, they are less valuable relatively for feeding. Under intensive conditions, the lower leaves are sometimes removed from the growing crop and fed to live stock. This may be done as it approaches maturity with little or no detriment to the crop. The leaves of both mangel and sugar beets have considerable purgative properties, caused by the large proportion of organic acids which they contain, a fact that must be recognized when feeding them

Sugar beet tops.—With sugar beets, the proportion of the tops to the beets is large, usually more than 25 per cent, owing to the fact that a considerable proportion of the root is removed with the top when preparing the roots for the factory. The feeding value of the tops, therefore, is very considerable, but, because of the presence of oxalic acid in the leaves, they should be fed with moderation. In some countries of Europe, lime is sprinkled over the successive layers which form the earth-covered heaps in which they are sometimes kept for feeding, with a view to neutralize the acid.

Turnip tops.—The tops of rutabagas and turnips are usually from 20 to 25 per cent of the entire crop. Live stock are very fond of them and they do not possess purgative properties to nearly the same extent as beet leaves. But they must be fed with caution and discretion to cows in milk, or they will taint the same and also the butter made from the milk. To avoid such a result, they should be consumed only after each milking.

Carrot tops.—The tops of carrots furnish from 20 to 25 per cent of the total weight of the crop, but the dry matter in the tops is somewhat greater than in the roots. Carrot tops, like those of turnips and rutabagas, do not relax the bowels nearly as much as the tops of beets or mangels. Nor do any of these taint milk as do rutabagas or turnips.

Sweet potato tops.—The tops of sweet potatoes, though possessed of considerable feeding value, are seldom fed to live stock, owing in a considerable degree to the difficulty of harvesting the vines, because of the trailing character of their growth. This does not apply to the vineless sorts, which may be cut with the mower. In some instances they are grazed down before the tubers are dug. Sheep are best adapted to such grazing.

Peanut and artichoke tops.—These are sometimes fed both in the green and dry form. The former make excellent hay when cured with care (see p. 345). In some instances they are grazed off by sheep. The latter are too woody to allow of complete consumption, but the finer portions are much relished by stock (see p. 336).

CHAPTER XVI

PREPARING FOODS FOR FEEDING.

In the discussion of this question, foods are considered first, with reference to curing; second, to mechanical preparation; third, to blending; and fourth, to softening before feeding them. The discussion on curing considers: (1) Curing in the green form, (2) curing in the dry form and (3) storing. The discussion on their mechanical preparation considers: (1) Grinding or crushing grain, (2) pulping or slicing roots, and (3) chaffing and shredding fodders. The discussion on blending considers: (1) Blending mechanically, and (2) blending chemically. The discussion on softening considers: (1) Soaking foods, and (2) cooking them before they are fed.

Curing foods green.—Foods are sometimes cured, that is preserved, in the green form. When so preserved, the curing, so to speak, is accomplished by excluding the air. In some instances curing is done by placing the fodder while yet green in a large mow and tramping so as to make the mass lie closely. In other instances it is placed in stacks and subjected to heavy pressure while these are in process of erection. The aim is to exclude the air as far as possible. That remaining in the mass is removed by the heat which develops through fermentation. Preserving green fodders thus, though sometimes practiced in America, is not likely to become popular in the near future for several reasons that may be given. Chief among these is the reason that green fodders may usually be preserved in silos with less of labor and more of effectiveness, and they may also in nearly all instances be more easily fed from the same.

A silo is simply a structure in which green food is preserved, usually in the cut form, and through the walls of which the air cannot penetrate, at least to the extent of appreciably injuring the fodder. When the food is cut, it is the more easily preserved without waste and may also be more easily fed out. Silos are built of wood, bricks, stone or concrete. The circular form is preferred as it favors quick and even settling of the contents.

Almost any kind of fodder may be preserved in the silo by those who follow the correct methods peculiar to the proper curing of each. But corn is used to a far greater extent in filling silos than any other food. This is owing to the large production per acre, to superior adaptation for being cured thus, to the ready means which it furnishes for disposing of the crop without husking out the corn, and to its great value in general feeding. Next in adaptation are the sorghums. In some instances fodders are mixed in the silo while filling it with a view to aid in bringing the food more nearly into balance. For instance, such nitrogenous foods as soy beans are sometimes mixed in with corn.

The advantages from curing fodders and especially corn in the silo are the following: (1) The silo preserves food with but little waste even though the weather should be unpropitious. (2) It preserves such fodders as corn and the sorghums with little waste and insures for them more complete consumption than would be ordinarily possible from any other mode of curing. (3) It furnishes an excellent medium, and all prepared, with which to feed meal. (4) It puts fodders, particularly such coarse fodders as corn and the sorghums in a condition that admits of feeding it at a minimum expenditure of labor. And (5) it may be made to furnish succulence at all seasons of the year.

In feeding corn silage, unless it is removed at the rate of one to two inches of the surface daily, the parts exposed may take harm from the exposure. It is seldom advisable to feed more than 30 to 40 pounds a day, even to a dairy cow. Should ensilage become frozen, as it does sometimes around the edges of the silo, it may still be fed, if fed at once after the frost has left it. Any who may desire further information with reference to silos and silage, are referred to the book "Soiling Crops and the Silo," by the author.

Curing foods dry.—It is only fodders that require to be cured in the dry form. The curing of these in detail cannot be discussed at this time. The curing of each is discussed at some length in other works written by the author as, "Clovers and How to Grow Them," "Grasses and How to Grow Them," "Cultivated Crops and How to Grow Them," and "Corn, the Sorghums and Sugar Cane." Only some points of superlative importance and general in character can be here given.

In curing fodders, whatsoever their character, the aim should be to retain as far as possible the natural color of the fodder when harvested, to cure with the least possible exposure to rain, and to avoid an excessive loss of moisture. Of course, the curing of the fodders must be carried far enough to prevent them from moulding when stored The natural color of the plants will be lost in proportion as they are exposed to sunshine and to dew and rain. A certain amount of exposure to sunshine is unavoidable and is absolutely necessary to the curing of fodders, but the aim should be not to expose them to sunshine longer than will admit of completing their cure in the cock or shock. Unnecessary exposure to sunshine results in loss of aroma in all plants and leaves of legumes. The loss of aroma means loss in palatability and serious loss in nutrition. Clovers, for instance, properly cured, retain in a marked degree the natural color of stem, leaf and blossom. When the curing of fodders is completed in the cock or shock, only the outer portions are thus injured by sunshine.

Dews and rain not only tend to darken the color in proportion as they are heavy, but also in proportion as the exposure is prolonged and severe. They also dissolve and wash out of the plants much of the nutrition. The loss in aroma, as in the case of exposure to sunlight, also increases with the exposure to these influences. Legumes suffer the most readily from exposure to rain and dews, and corn fodders are more easily harmed than sorghum. Legumes exposed to much sunshine and to frequent wetting, at length become almost valueless as food. The grasses, proper, will suffer much less from such exposure and sorghum much less than the grasses.

The loss of moisture is excessive when it goes beyond the point at which the plants will keep without harm when stored. Loss of moisture virtually means loss of succulence. Plants fed in the natural condition are more beneficial to animals than the same plants fed in equal quantity in the dry condition. Were it not so, succulence in foods would have no specific value. Thus it is that hay, lying exposed for a long season on the ground, even in the entire absence of rain and with little exposure to dew, will at length become comparatively valueless for food, notwithstanding that when it was first cut it was possessed of high feeding value. It also explains why the desire is so prevalent to put corn in large shocks in the field after it has been husked, although other reasons may, and do exert an influence in favor of the practice. The fact, however, must not be lost sight of, that the mistake of storing fodders so little cured, that they heat so much as to make them dusty, the feeding value becomes greatly impaired, and if stored so uncured as to induce mould, to feed them even in moderate degree is attended with more or less of hazard to the health and it may be to the life of the animals.

Storing foods.—The proper storing of foods calls for attention: (1) To protect them from injury which follows undue exposure while yet in the fields, (2) to protect them from injury after storage, whether from exposure or from storing while yet undercured, and (3) to placing them in storage where they will be convenient for feeding.

All kinds of fodder suffer harm and loss, and increasingly so, with increase in the duration of the exposure subsequent to that time when they are ready for being stored.

Hay, for instance, when left unduly long in cocks, takes harm from the absorption of ground moisture and from undue drying and weathering of the outer portions. The straw of certain cereals, useful for being fed to stock when well saved, will soon become practically valueless for feeding if left standing in shocks for any considerable time after ready for being stored. Corn stalks gradually lose more or less and in various ways, from the time they are put in shock and probably in an accelerated ratio as the season advances. Cull potatoes soon deteriorate materially in food value if left exposed after being dug. The rule is a safe one that invariably aims to store foods at the earliest moment practicable after they are ready.

Fodders can in no other way be protected so perfectly after storage as when they have been stored under cover. Nor can they in any other way, as a rule, be stored so as to involve less labor while feeding them. The benefit from such protection increases with increase in the precipitation, increase in damp, snowfall and sleet, and increase in the rawness rather than in the degree of the cold. The extent to which such protection will be profitable must be determined in a considerable degree by the cost of materials used in building. When legumes are stored in stacks, they cannot be protected in a rainy climate from serious loss unless other materials are used in topping out the stacks that will completely shed rain. Field roots of all kinds, including parsnips and artichokes, must be protected from frost or they will take injury varying in degree from a slight lessening of the feeding value to a total loss. They must also be kept so cool that they will not begin to sprout.

The storing of food where it will be convenient for feeding, is greatly important. If it can be stored so that further handling is not necessary until given to the animals for consumption, the economy in handling will be apparent, as compared with an intermediate handling in addition. But intermediate handling cannot always be avoided. In the case of corn fodder, in some instances it is necessary to incur the cost of the intermediate handling involved in stacking the fodder rather than to draw from the shock and feed directly. Climatic conditions, more than anything else, determine which course is the better to adopt. When such fodder as hay must be stacked in the open, the aim should be to have it near the place for feeding, as when it must be drawn far from the place of storage during the winter season, the roads are frequently in a bad condition, notwithstanding there may be valid reasons for stacking such fodders on the fields where they grew. In storing roots, the aim should be not only to have them near the place of feeding, but also to avoid, as far as possible, the necessity for carrying them up steps in order to feed them. Supplies of ensilage and meal also should be obtained from the same plane as that on which the animals stand which are to consume them.

The wisdom of storing litter, not only where it will be properly protected but also where it is conveniently accessible, is very apparent. There are instances in which the proper storing of bedding may be quite as important as the storing of fodders. The conditions of storage are ideal when all the fodder and bedding required to carry the animals through the winter are stored above them when they are housed in a well constructed basement, but such buildings are becoming too costly where materials for constructing them are dear.

Grinding or crushing grain.—The necessity for grinding and crushing grain is dependent: (1) On the nature of the grain; (2) the animal to which it is to be fed; (3) the combinations for feeding of which it forms a part; and (4) the amount and kinds of noxious weed seeds present. As the grinding of grain when cured will cost from 5 to 10 cents a hundred pounds, to say nothing of the cost of conveyance and handling during the process, it becomes a matter of considerable importance that unnecessary grinding shall be avoided.

The necessity for grinding grain, based on the nature of the grain, is greatest with seeds naturally small and hard, as the seeds of the sorghums and of those that in addition contain large quantities of oil, as flax seed, millet seed and foxtail seed. Both properties resist the action of the gastric fluids when unbroken in mastication, hence they pass through the digestive tract to no good purpose, while meantime they have put a tax upon the energies of the system while in transit through it. The small cereal grains, which are most improved by grinding, are those which are smallest and hardest and which are possessed of the least amount of soft hull. The necessity for grinding wheat, for instance, is much greater than that for grinding oats. Corn, more than any other grain except oats, may be fed without grinding, but when it is to be fed in combination with other grain, it is usually profitable to grind it. It is absolutely necessary to do so when corn and cob are both fed.

Virtually all kinds of grain should be ground when fed to calves, the exception under some conditions being oats. All kinds of grain when separated from the straw, should be ground for beef cattle. The exceptions, but under some conditions only, are corn and oats. Unless when swine may glean among the droppings, the corn should usually be ground. Virtually all kinds of grain are improved by grinding when fed to dairy cows. Nearly all kinds of grain are improved by grinding for feeding to lambs quite young, but this is not necessary when they begin to eat grain freely, except in the case of corn, which is improved by cracking it to enable them the more readily to eat it. For lambs, subsequent to weaning, and all mature sheep, it is not necessary to grind grain free from noxious weed seeds. Grinding improves nearly all kinds of grain for swine, when fed unsoaked. The exception is corn when fed alone. For horses, oats and corn in the shelled form are usually fed unground. Barley, rye, speltz and wheat, especially the latter, are frequently, if not always, improved by grinding, and the grinding of sorghum and millet seed is simply indispensable when these are fed to horses. The necessity for grinding grain for horses is much greater when they are hard at work than when idle.

When grains are fed in combination, which is a common way of feeding them, they are usually ground. This is true of them whether fed in the form of meal directly or in admixture with cut fodders. The advantage from grinding them is based, first, on the necessity for grinding some of them; second, on the greater ease with which some of them are ground when blended before grinding, and third, on the more complete character of the mastication, when thus prepared. Some grains, as intimated above, must be ground under all conditions of feeding. Flax is much more easily ground with other grains than alone and especially when the mixture contains just enough of the same for ordinary uses and no more. Oats are ground more easily when blended with corn. The same is true of other mixtures. Especially is the mastication more perfect when the meal is mixed with cut fodders, because of the re-grinding given during the rumination that follows.

No kind of grain containing the seeds of noxious weeds should be fed unground. If so fed, they are much liable to escape mastication because of their small size, and to escape digestion because of their hard and oily character, hence, when carried to the fields, they grow, and thus infest the land. Even when weed seeds are fed to sheep, they ought to be ground, as many of them will fall amid the litter while the sheep are feeding upon the grain. Grinding is usually not more costly than complete winnowing, and it is much safer.

The crushing of grain, accomplished by passing it between heavy rollers, in preference to grinding, has some advocates. It calls for less power than to grind the grain, and in the case of grains that are pasty in character, and liable to adhere to the gums in mastication, as wheat, and to a less extent barley, it is preferable to crush than to grind for some kinds of feeding. When the crushed grain is soaked or mixed with cut fodder before being fed, the advantage from crushing is lost. Grinding grain, rather than crushing it, will always be more practiced on the farm, since the machinery for grinding is now in place on nearly all farms where grinding is done, since such machinery is better adapted to preparing small and hard grains for feeding, and since it has higher adaptation for varying the degrees of fineness in the grinding.

The degree of fineness to which grain shall be ground, should be determined by the kind of the grain, the way it is to be fed, and the animals which are to consume it. It will probably be correct to say, that the smaller and harder the grain is, the more finely should it be ground. Corn and cob meal should be more finely ground than corn meal for average uses, the cob being less digestible. When meal is to be fed directly to animals in the unsoaked form, it should be finely ground so that the digestive fluids may the more readily act upon it; but when thus ground, some kinds of meal call for admixture with some substance to render the mass less adhesive in the stomach. When meal is to be soaked sufficiently long to soften it, fine grinding is not necessary, and the same is true of meal which is first mixed with cut fodders before being fed to ruminants. Very young animals call for meal more finely ground than will suffice for those that are older.

Whether the meal should be ground on the farm and by the farmers own machinery, by portable machines which travel from place to place, or by stationary mills which take in custom work, is an economic question that must be determined by such considerations as the volume of the work to be done, the distance of the stationary mills, and the customary charges for grinding. When the volume of the work done will justify it, the aim should be to grind the feed at home. The power to be used in each instance is a question of no little importance. This, too, should be largely determined by the amount of the grinding called for. When this amount is not very large, wind power will probably prove the cheapest. The old-fashioned tread-mill, as a source of power, is perhaps not sufficiently prized. There is also a place, however, for motor, for gasoline and for steam power, under certain conditions.

Pulping and slicing roots.—Pulping roots means putting them through a machine, known as a root pulper. It is run by hand or by other power as desired and reduces them to a pulpy or finely comminuted condition. Slicing, in the true sense of the term, means cutting them into thin slices by putting them through a machine known as a root slicer, and run as in pulping, by hand or other power. In the absence of a slicer, they are frequently thrown into a box and chopped into pieces with a spade. Under some circumstances they are fed without either pulping or slicing. Whether to feed them thus, or to slice or pulp them, must be determined by the conditions present. Whether roots or tubers may be fed whole is determined by the kind and size of the variety, the class of animals to which they are to be fed, the age of these, and the degree of the temperature at the time of feeding. Carrots are about the only class of field roots which it is practicable to feed to all or nearly all kinds of farm stock without first cutting or slicing them. Artichokes, owing to their shape, and peanuts, owing to their small size, may be similarly fed. The danger is present in some degree, that when medium-sized potatoes are fed to cattle, they may choke upon them. The aim should be to avoid feeding all kinds of roots and tubers to cattle and even to horses in the unprepared form, notwithstanding that both will feed upon them in the natural state, but not with the same ease. Sheep will feed upon all kinds of uncut roots, but not so readily as when they are sliced, and the same is true of swine, but it is scarcely necessary to slice roots for swine well grown or for brood sows. They should be sliced or pulped for all kinds of young animals. When fed to animals exposed to low temperatures, they should be given in that form in which they can be consumed quickly, lest they should freeze more or less before they are all consumed.

Roots and tubers are more commonly sliced when they are simply being prepared for feeding in the direct form, that is, without admixture with other food. This method of preparing them is followed rather than that of pulping, because it takes less power and because slicers have been longer in use. But there is no objection to pulping even for direct feeding when it is as convenient or more so to prepare them thus.

When field roots or tubers are to be mixed with meal or cut feed, it is necessary that they shall be pulped rather than sliced, in order to obtain a more perfect blending of the foods. Field roots thus prepared and mixed with cut fodders, add greatly to their palatability and value. If the plan of pulping roots at the time of lifting and then storing the pulp after the manner in which ensilage is stored should prove successful, the questions of storing, keeping, and feeding would be simplified. No data can be gathered bearing upon the question, but the behavior of sugar beet pulp when ensiled, encourages the hope that such storing would be quite practicable.

Chaffing and shredding fodders.—By chaffing fodders is meant running them through a cutting box. The objects sought in chaffing food are: (1) To insure the consumption of a fodder low in palatability by admixing it with a chaffed fodder high in palatability, as when straw and clover hay are cut and mixed before feeding them. (2) To insure a larger total consumption of fodders by putting them in that condition in which they may be fed after being mixed with meal or field roots or both. (3) To prepare foods in that condition in which they will keep best in the silo, and in which they may be fed out with the least expenditure of labor. Straw fodders are also chaffed in some instances in order to put them in the best condition for being used as litter. When thus chaffed, straw absorbs liquid manure more perfectly than when long, and the manure is also in a better condition for being easily handled and promptly applied to the land as soon as made. But it will not be found profitable, as a rule, simply to run fodders through a cutting box and to feed them without admixture in order to increase consumption in the same.

When large quantities of meal are to be fed in the absence of silage, the plan is frequently adopted of chaffing only enough of the fodder to furnish bulky materials with which it is mixed before feeding it to ruminants, in order to insure its most thorough mastication while undergoing rumination. The plan is to be commended where the facilities are present for carrying it out. On some farms, the small cereal grains are threshed and chaffed by the one operation, all the straw grown upon the farm being cut in that way. Where the facilities are present for storing the chaffed material, the plan is excellent. The blowers now used on threshers will be greatly helpful in such instances as aids in storing such food.

Shredding fodder means tearing it into strips or shreds by machines made for the purpose. It is used only in preparing such coarse fodders for feeding as corn and the sorghums. Shredders husk the corn and separate the ears in the same while shredding the stalks. Opinions differ greatly as to the value of shredding, some regarding them with much favor, and others who have used them, have ceased to use them longer. These differences in opinion are due largely to a difference in the conditions under which they have been used. They can be used with more advantage in a climate naturally dry than in one naturally moist, as in the former the shredded fodder is much less liable to spoil through fermentation than in the latter.

Prominent among the benefits from shredding are the following: (1) The corn is husked, and thus made available for feeding as desired, which may not be possible in the absence of shredding. (2) The fodder is put in that condition which insures a much larger consumption of the stalks, and (3) it makes it possible to store the fodder where it is safe from injury from storms. The following are chief among the objections to shredding: (1) The accidents while running the shredders have been unusually numerous, but possibly the element of risk, in this respect, may yet be eliminated. (2) In moist climates it has been found difficult to keep the shredded fodder from moulding. But this may be obviated by mixing with straw. (3) The expense is said to be too great in some instances at least to justify the outlay and (4) the lower portions of the stalks, when very large and coarse, according to some authorities, will not repay the energy expended in digesting them. The difference in the character of the stalks before shredding as coarse or fine, probably accounts for the great differences reported in the amount of fodder left unconsumed when fodder is shredded.

Corn fodder is sometimes prepared for feeding by running the corn while yet unhusked through a threshing machine on the approach of winter. To this method of handling corn, the same objections apply as when shredding it, except that which applies to cost. But in addition to these objections are the large portions of stalk unreduced, and the broken condition of cob, which makes it difficult to preserve it.

Blending foods mechanically.—Foods are frequently blended in what may be termed the mechanical sense, in order to insure a larger consumption of those which, though plentiful are less palatable than the foods blended with them. The utilization for food of the straw of cereals and of corn and sorghum stalks, may not be a question of much moment at the present time in many parts of the United States, but the time is coming and is not very far distant, when in none of the states will such products be destroyed as now, as the best means of getting rid of them.

Where the supplies of hay are scarce and of fodders plentiful, when both are run through a cutting box and mixed before being fed, a much larger consumption of straw or of corn or sorghum stalks will be secured, than if these foods had not been so prepared. In this way, animals at rest may be carried through the entire winter season on relatively cheap food. Even in the absence of hay, when pulped roots are mixed with cut straw and other coarse fodders, results equally good, if not indeed superior, will follow, dependent upon the proportion of field roots fed. Should the dry food thus mixed be dampened, as by sprinkling, in the absence of field roots and a small amount of meal sprinkled in during the process of dampening and mixing, the consumption will be further increased. Where molasses is cheap, the addition of a small amount of this ingredient will tend much to add to the palatability of the food and, therefore, to increase the possible consumption of coarse fodders.

Food prepared as outlined above, has special adaptation to the needs of cattle and horses. It is not so well adapted to the needs of sheep, as they are more expert than cattle or horses in rejecting portions even of the cut food that may not suit them, but even with sheep, the relative consumption of cheap foods may thus be greatly increased. Similarly the consumption of dry fodders by swine, as clover and alfalfa, may be much increased by chaffing the fodder, adding meal to the mixture and then cooking it by boiling or steaming. Thus, also, the proportion of field roots or tubers may be increased.

The following method of preparing food for ruminants is common in some portions of Ontario. Hay and straw or fodders are chaffed, pulped and mixed in a feed room conveniently situated. The chaffing and pulping are done simultaneously that the mixing of the food may be as desired. Enough is prepared at one time to last for several days. The fermentation which follows tends to soften the fodder. Meal is added proportioned to the needs of the various animals as the food is fed. This method of feeding is economical of food and is eminently adapted to the needs of cattle, sheep and horses.

Much of what has been said applies mainly to the feeding of animals at rest. Should performance be sought from them as in the production of increase in meat or the production of milk or labor, it will usually be necessary to add concentrated food to make up for the deficiency in the nutrients.

It should also be borne in mind that a large proportion relatively of the nutrients in straw and coarse fodders are relatively low in digestibility. Because of this, it would be easily possible so to tax the energies of the system by feeding so large a proportion of such foods, that the most desirable results would not follow. This, however, is much less likely to occur with animals that are being simply carried through the winter at rest.

Blending foods chemically.—The mechanical blending of foods discussed in the preceding section did not in any sense consider the chemical blending of the same, and yet the aim should be so to blend them, that the ration shall be in at least approximate balance. For instance, when cut hay is added to the cut straw of the small cereals, or to cut corn or the sorghum stalks, the aim should be to add clover or other leguminous hay, as the straw of these are carbonaceous. Likewise, when molasses is added, the aim should be to make the addition when practicable to a mixture of cut fodders relatively rich in protein, as, for instance, when composed largely of pea straw. Field roots go well with straws rich in carbohydrates especially when fed in considerable quantities. Steamed potatoes and clover or alfalfa also go well together when fed to growing swine. In the absence of the clover or alfalfa, meal rich in protein should be fed. When meal is added to enrich the ration for cattle, sheep and horses, a due regard should always be had to the character of the fodder. Usually it will be advantageous to add meal rich in protein to mixtures composed mainly of straw fodders or of corn or sorghum stalks.

The proportions in which these shall be added cannot be discussed here. The aim, of course, should be to feed them so that the ration shall be in approximate balance, and yet there may be good reasons for feeding a ration not strictly in balance (see p. 187). The nature of the additions will, of course, be dependent on the ration. Where leguminous fodders are plentiful, the balancing of the ration is usually much easier than when the opposite is true, owing to the fact that the great food grain, corn, is so rich in carbonaceous elements.

Soaking food for stock.—The value of soaking food for stock will depend on the kind of food, the kind of stock to which it is to be fed, and the object sought from feeding it. As a rule food is seldom soaked when fed to horses, cattle or sheep, but is very frequently soaked when preparing it for swine.

It would seem correct to affirm that green fodders are never soaked to prepare them for being fed to live stock, and the same is generally true of dry fodders, but to this there are some exceptions. When horses are hard at work, it has, at least in some instances, been found advantageous to feed meal on chaffed and moistened hay, as when so fed the food could be more quickly consumed, that is, more of it could be consumed during the limited time allotted to horses for feeding, especially during the noon hour. With cattle, no such necessity exists. When fodder is fed dry, as compared with feeding it soaked, it is usually preferred by cattle and also by sheep, and it is amply softened in the various processes of digestion. Such food, however, will better answer the end sought in feeding swine if it is first soaked or steamed. Field roots and tubers also being of the nature of green fodders, are not soaked preparatory to feeding them, but in many instances cereals are soaked either in the unground form or as meal, more especially when fed to swine.

Grain of any kind is seldom soaked for horses or cattle, and the same is true of meal. Bran is sometimes made into a mash for horses by adding water, frequently hot, and stirring until it is all moistened. They can eat such food more readily, and so fed it may have a more laxative effect with them. It was believed at one time that meal moistened and even fed as slop to dairy cows tended to increase the yields of milk. It cannot be said that tests made to determine the question sustain this belief. Corn is in some instances soaked before feeding it both to cattle and swine. When long fed on dry ear corn, soreness of the mouth may arise. In such instances the corn should be shelled and soaked for not less than 12 hours, except when the weather is unusually warm. Under normal conditions, the increase from corn soaked 24 hours and fed to swine is much the same as when dry. All the small cereal grains are made more easy of digestion for swine by soaking them from 12 to 48 hours, but usually the results are more satisfactory when they are first ground before soaking them. When thus prepared, there is practically no waste in feeding. None of the food escapes undigested, as when feeding it whole, and a larger consumption of food is usually secured.

From what has been said, it is apparent that when food is soaked or moistened before feeding it to cattle and horses, the objects sought are specific rather than general, and that they are thus fed more because of the exigencies present in the feeding than because of the more favorable influence which, as such, they exercise on digestion. It is different with swine. They digest more perfectly food thus prepared. There are times, however, when almost any kind of a cereal may be fed to swine unground in limited quantities, as when fed to brood sows in winter on a hard surface.

Cooking food for stock.—Years ago the cooking of food for live stock was thought to be helpful to its digestion. Because of the prevalence of this view, large steaming plants were erected in various centers where it was proposed to steam practically all the dry food fed to cattle before it was fed. Usually it was first run through a cutting box and then mixed with meal, and fed directly to the stock. The fact that the practice has been virtually discarded is pretty certain evidence that it did not prove profitable. This is in agreement with the results obtained from the tests conducted by the experiment stations and it is all the more surprising in the face of the strong claims put forth even by some of the scientists of former generations as to its value. In some of the tests made, the cooking of the food seemed to reduce rather than to enhance its digestibility. This was true more especially of the protein, hence the adverse effects were most pronounced in foods rich in protein.

Until recent years this practice was common with the exhibitor of cattle to prepare the food for them by chaffing the hay, and after adding meal, to pour over the mass while still hot, such food as boiled peas. The box or trough containing the food was then covered and the mass allowed to steam. It was believed that such food added to the mellowness of the flesh and probably with some reason. It is pretty certain, however, that it does not add to the increase made, and it does add materially to the cost of feeding. In these facts it is probable that the explanation lies for discarding, at least to a great extent, such feeding during recent years.

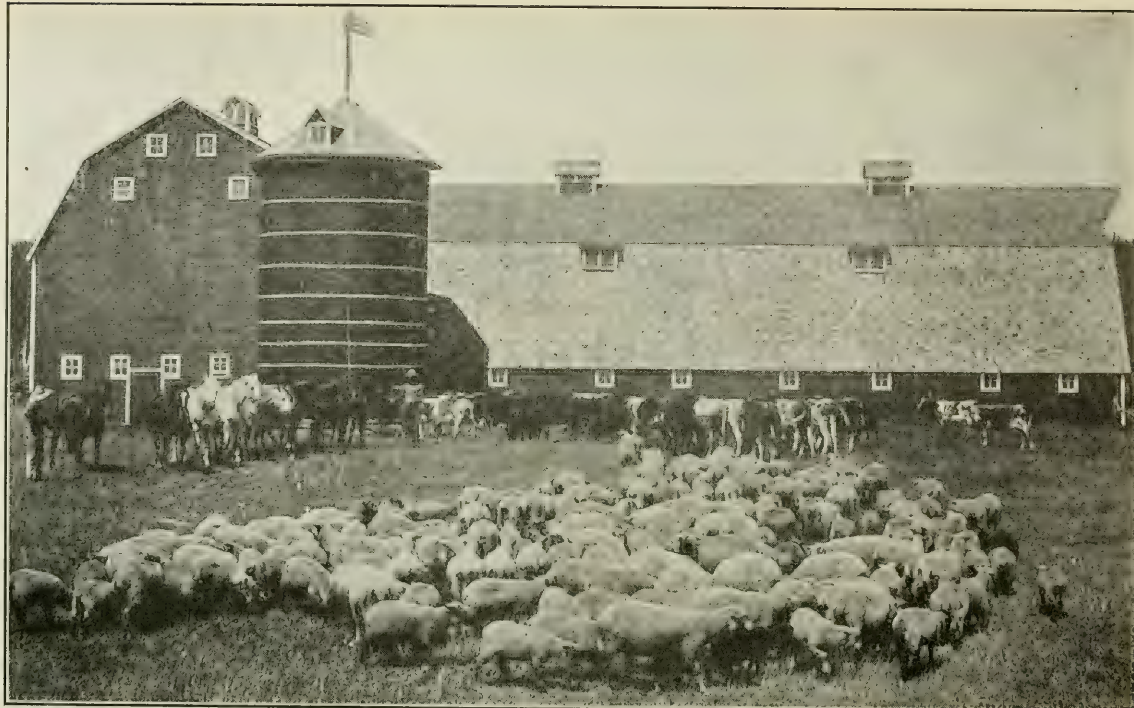
Years ago it was matter of common belief that grain food fed to swine would give better results if fed in the cooked rather than in the soaked form. This explains why cooking such food was so common in those days. But experiments conducted at the experiment stations have rudely shattered this belief. They have shown that, as a rule, cooked meal does not produce greater gains than soaked meal. Nevertheless, under some conditions, as when the cooked meal may be fed warm in cold weather, the cooked food is superior to the other. The added value, however, arises rather from the warming effect which the food has upon the system than from any superior digestibility which it possesses. Under such conditions, the profit from cooking food may be considerable. It is also true that certain grains, as barley and speltz, will give better returns when cooked or steamed than when fed dry.

Certain vegetable substances may be improved as food for swine by cooking them, for the reason first, that they are rendered more digestible and second, that thus prepared, they will be consumed in larger quantities. Potatoes are of the former class. Fed alone, they are an indifferent food for swine, but when cooked and fed along with meal in the form of a mash, they furnish a cheap food for growing swine, viewed from the standpoint of the food nutrients. Alfalfa and clover, when chaffed and mixed with meal, with or without vegetables, makes a good food for growing swine and for brood sows. A limited amount of boiled grain, especially barley, possesed of much water relatively, poured over cut fodder to soften it, and then fed to horses while still warm two or three times a week, will have a helpful influence on the digestive tract when the horses are on dry feed. Whether the additional labor and cost of fuel will justify such feeding, must be determined by the conditions under which the work is done. There can be no doubt, however, about the utility of the practice of boiling hay and feeding the extract thus obtained to calves when the milk supply is not sufficient to meet their needs.

PART IV.

The more important of the considerations that relate to successful feeding are discussed in Part IV. These considerations have not the strength of law and yet they are so important that they cannot be ignored by the successful grower and feeder of live stock. The benefits from having correct type in the animals to be fed and from feeding a balanced ration based on a wise selection of foods, will be discounted in proportion as these considerations are ignored.

They are discussed as outlined below: Chapter XVII dwells upon considerations that relate to meat production; Chapter XVIII on those that relate to milk production; Chapter XIX on those that relate to general feeding; Chapter XX on those that relate to the care of animals; and Chapter XXI on considerations that are miscellaneous in character.



DAIRY BARNS AND LIVE STOCK

[By courtesy of the owner, Ole Carlson & Sons, Erskine, Minn.]

CHAPTER XVII.

CONSIDERATIONS THAT RELATE TO MEAT PRODUCTION.

Prominent among the considerations that relate to meat production are the following:

1. Increase at different ages.
2. Increase during finishing period.
3. Leading up to full feeding.
4. Food consumed and increase.
5. Cost of increase.
6. Gains when fattening not worth their cost.
7. Duration of finishing period.
8. Season for marketing.
9. Marketing when ripe.
10. Shipping finished animals.
11. Loss of weight in marketing.
12. Feeding in stalls, sheds or yards.
13. Finishing animals on pasture.
14. Financial returns from purchased feeders.
15. Baby beef.
16. Winter lambs.
17. Growing bacon.

These are discussed in the order in which they are given.

Increase at different ages.—It has been stated previously (see p. 64), that with the exception of swine during the nursing period, and for some time subsequent to it, domestic animals may be made to increase more rapidly the nearer to the birth period the gains are made. The greater practical importance of this question and the bearing which it has upon profits, is a sufficient justification for enlarging upon it.

The figures now submitted approximate the increase in weight that may be obtained from the different classes of domestic animals at different ages: It has been found easily possible to secure 2 pounds of increase per day, not including the birth weight, from cattle of the large breeds at the age of one year. During the second year it requires careful feeding to secure an average increase of one and three-fourths pounds per day, and during the third year, equally careful feeding to secure an increase of one and one-fourth to one and one-half pounds per day. In other words, 730 pounds of increase can be secured as readily as 639 pounds of further increase the second year, and as, say 504 pounds the third year. It would be approximately correct to say that lambs of the medium-sized mutton breeds of sheep, if well nourished, will make a daily gain of 0.7 pound during the first month; 0.6 pound during the first three months; 0.45 pound during the second three; 0.3 pound during the third three and 0.25 pound during the fourth three. In other words, including the birth weight, the lamb will attain to a weight of 21 pounds at one month, and of 54 pounds at three months. During the second period it will gain 40.5 pounds, 27 pounds during the third, and 22½ during the fourth, at which time the weight will be 144 pounds. The subsequent gains will gradually decrease until the animal is mature. With well sustained swine of the middle breeds, it would be approximately correct to say that during the first 70 days of growth, about the average suckling period, the pigs would make an average daily increase of say 0.6 pound; during the second period of 70 days, one pound, and during the third, one and one-half pounds. In other words, they would make an increase during the first period, including the birth weight, of 42 pounds, 70 pounds during the second period, and 105 pounds during the third, when they would weigh 217 pounds at the age of seven months. The daily gains would probably be maintained and possibly increased for a month or two longer, after which they would decline until maturity was reached.

The figures submitted are based on the supposition that the animals are fed to their full capacity on suitable foods, but without excessive forcing. It pre-supposes that the foods fed are suitable for the production of the highest average gains that may ordinarily be looked for from such feeding. But in practice, such feeding is seldom followed during the entire period of growing and rearing the animal. In fact, it is never followed except when very high quality meat is sought from animals that are disposed of at ages less advanced than animals of the same class usually reach the market. This, however, does not apply to swine to the same extent as to sheep and cattle, more especially the latter. In a great majority of instances, during what is termed the growing period, animals are sustained on food less costly than that given during the period of feeding milk which precedes it, and the fattening period which follows. Such foods include pasture and coarse fodders, much of which, if not consumed thus, would be wasted.

The conditions amid which animals are grown, will therefore, have a markedly important influence on increase in the same, as it actually occurs in practice. If animals are grown so as to make only moderate gains during the growing period, and if they are then put upon a finishing ration, the gains made will, of course, exceed those made at a younger age. This, however, does not affect the contention that the possible capacity to make gains is greater before than during the finishing period.

The statement is sometimes made that the capacity to make increase in weight is a question of type and not of breed. The statement is only partially correct. It is to some extent a question of breed, and also to some extent a question of individuality within both breed and type. Take, for instance, two lambs of the Southdown and Hampshire Down breeds. Push the growth of both on a suitable forcing ration until they reach the age of 12 months. It would seem correct to say that the inherent capacity to make increase in a Hampshire Down lamb would carry him to a weight of 160 pounds as readily as inherent capacity in the Southdown would carry him to a weight of 120 pounds at the age named. The same line of reasoning will apply to all the large and small breeds of beef and dairy cattle, the large and small breeds of sheep, and the large and small breeds of swine. But it is more than probable that the difference in the capacity of the large and small breeds to make increase, lessens as the birth period is approached, and widens as it is receded from.

Nor is it true that increase in weight during the finishing period is almost wholly a question of type. Individuality within type exercises an influence on capacity to make increase only secondary to that exercised by type. Animals of similar conformation not infrequently show a difference in capacity to make increase that exceeds 50 per cent, though fed alike. It will also be found true that animals of the small dairy breeds of cattle and of some breeds of sheep, as the American Merino, will have less average capacity for making increase under prolonged feeding than heavier breeds of cattle and sheep, and the same is true, also, of large and small breeds of swine. Capacity to make gains, therefore, is influenced by age, breed and individuality.

Increase during the finishing period.—The increase made during the finishing period and also the rate at which it is made is determined by such conditions as the following: (1) The age of the animals; (2) their condition as to flesh when put on feed; (3) the nature of the previous feeding; (4) the character of the food fed; (5) the intensity of the feeding and (6) the duration of the feeding period.

That animals of uncompleted growth have capacity to make larger increase than those whose growth is completed is in a sense self-evident. The latter can only make increase by putting on fat, whereas the former make it by additional growth as well as by laying on fat. They may also be expected to make it more cheaply by that law of development which claims that increase can be made more rapidly and cheaply, the nearer to the birth period that it is made.

It is also evident that animals that are low in flesh or carry but a moderate amount when put on feed, and whose digestion has not been impaired, will make more gain under prolonged feeding than animals in good flesh, but not really fat when put on feed. They will also usually make such gains more rapidly and for the reason among others that in the system there is more room for increase.

But increase during the fattening period is increased or retarded by the nature of the diet given previous to its commencement. The system must be brought into what may be termed a sappy condition, that is, a condition in which the fluids of the body are abundant before gains can be rapid. It must be amply stocked with circulatory protein. It has been found that swine, for instance, grown largely on succulent pasture such as alfalfa or rape, will make subsequent increase more rapidly than swine equal in weight that had been fed chiefly on grain. Some foods that cannot be classed as being in themselves fattening foods are, nevertheless, highly useful in putting the system in a condition for fattening. Such are field roots and various other succulent and nutritious foods.

The character of the food as to its constituents, influences gains in a marked degree. The largest increase may be expected from foods fed in balance, and that balance will vary with the needs of the animal. An animal of incompleted growth, for instance, requires more of protein in the food than one of completed growth. When fattening only is wanted without growth, this will be best attained by a ration as rich in carbohydrates as may be safely fed for the purpose sought.

Intense feeding, that is, feeding a large proportion of concentrates to the roughage and concentrates rich in the nutrients that aid in producing fat, will produce the most rapid gains when properly fed, though not necessarily the most economical gains. Such feeding also tends to shorten the period in which gains are made.

The richer the ration and the more intense the feeding, the shorter will be the period for making gains, for then that condition of the system is sooner reached when quick increase is not possible. Such feeding judiciously done, insures more rapid increase for a time than more moderate feeding, but it also makes increase slower when the feeding is in any sense prolonged.

The daily increase secured does not necessarily vary greatly until the period is approached when animals under judicious feeding are coming near that condition of finish known as ripeness (see p. 389). Then it decreases, it may be gradually at first, but with accelerated quickness the longer the feeding is continued, and would at length reach a point when further increase would altogether cease.

The daily gains made will vary with the variations mentioned above. They are usually from the nature of things most rapid during short periods of forced fattening. When good cattle well grown are on feed for 150 days, the average gain for the entire period should be one and one-half to 2 pounds per day. The average will not be more than one and one-third pounds. Young animals not yet grown, with most careful and suitable feeding may make an increase of 2 pounds per day or even more than that amount. Cattle fed large amounts of corn for 100 to 120 days may increase even more rapidly, but usually such gains are relatively costly when corn is dear. Aged animals usually make a less gain than one and three-quarters pounds daily. Lambs of good types between six and 12 months when fed for 100 to 120 days will make a daily gain under normal conditions of fattening of 0.3 pound or 9 pounds a month. With all the conditions favorable an increase of 12 pounds may be made, but such gains are exceptional. Ordinarily lambs will not gain more than 0.25 pound daily or 7½ pounds per month. On rape pasture the gains should be 10 pounds per month. Mature wethers may gain as quickly as lambs, but the rate of increase will not be so long maintained. Swine when fed for 60 to 75 days should make an average daily gain of one and one-fourth to one and one-half pounds, providing they are not of less weight than 150 pounds when the fattening season begins. In a few instances a gain of 2 pounds per day has been made.

Leading up to full feeding.—With reference to this question, it may be said: (1) That animals which are somewhat thin in flesh cannot be fattened quickly for some time after the commencement of the fattening period, howsoever suitable and liberal the feeding may be; (2) that when such animals are first put on a fattening ration, they are not capable of digesting quantities of concentrated foods so large as at a later period and (3) that in consequence, it is necessary to bring them up gradually to what is termed full feeding, which means, feeding all the concentrates and roughage that the animals can digest and assimilate after having been given gradually increasing quantities of concentrates from the commencement of the fattening period onward.

As explained by Dr. H. P. Armsby in the "Manual of Cattle Feeding," cattle that are much reduced in flesh and fat cannot be fattened quickly until they are first brought into a well nourished condition. The animal body must first contain a sufficient amount of organized and circulatory protein, without which it cannot digest, resorb and store up protein and fat. To bring about this condition it is most economical usually to feed freely some leguminous fodder, as clover or alfalfa hay. This, however, may be supplemented with some grain or by-product, or the two combined, also reasonably rich in protein. Such foods as oats and bran, or oats and oil cake are well adapted to such feeding. The aim should be to feed foods that will give a nutritive ratio of say 1:5.5. Such food increases the stock of circulatory protein, and thus paves the way for laying on fat.

When fattening begins, animals are not capable of digesting and assimilating large quantities of grain, for the reason chiefly, that the digestive system requires time to accommodate itself to the changes of food, and also to the additional tax put upon it. All changes should be gradually made (see p. 459). Digestion and assimilation in a certain direction become strengthened by use or repetition. It is evident that animals accustomed to grain previously can be more quickly led up to a full ration than those to which it has never been fed. In some instances, as when growing baby beef, so much grain is being fed all the while, that the difference in the respective amounts fed before and during the finishing period is not marked. It is more a difference in kind than of quantity, and the same is true of cows that are fattened at once, when they cease to give milk. If undue haste is shown in putting animals on full feed, the digestion becomes deranged, and time is lost in recovering digestive tone, while in some instances it is never again fully restored.

The time required to bring the different classes of animals up to full feed varies. It is longest in the case of cattle and shortest in that of swine, in keeping with the time required in finishing the different classes. It varies also with the condition of the animals and as to whether they were given grain previously, and especially when the finishing period began. When cattle are lean and unused to grain, from 3 to 4 pounds would suffice at the first. This may usually be increased at the rate of say one and one-half to 2 pounds per week, for four to six weeks according to the kind of grain fed and the duration of the fattening period. The less concentrated the grain fed and the shorter the prospective period for feeding, the more quickly may the animals be brought up to full feed, and vice versa. As the fattening progresses, the grain fed is usually increased in the degree of its concentration up to a certain limit.

Sheep and lambs that have not had grain previously may be given say from one-fourth to one-third of a pound of grain daily at the first, preferably oats or mainly so, and this may be increased at the rate of one-third of a pound per week from three to six weeks, according to the kinds of food fed, the age of the animals and the probable duration of the feeding period. As with cattle, the grain fed may be more concentrated as the fattening progresses.

Swine may usually be led up to a full grain ration much more quickly than cattle and sheep. This is owing to the fact, first, that grain has probably been fed to them all along, and second, that before the final fattening begins, they have probably been given not less than half a full grain ration. In but few instances, therefore, is it necessary to take more than one to two weeks to bring them up to a full grain ration.

Food consumed and increase.—The relation between the food consumed and the increase from it widens from birth to maturity, that is, the more advanced the age of the animal, the greater is the amount of the food required to make the increase. That it should be so is the outcome, first, of the more active character of the digestive and assimilative organs near the birth period; and second, of the increase called for in the food of maintenance as the animals grow older. That it should be so is what may be expected from the gradual decrease in relative gains in cattle and sheep, as the birth period is receded from. But it has also been found true with swine, where the daily increase is less rapid during the first three or four months than subsequently.

With cattle and sheep it is not easy to draw the comparison between relative increase and the amount of food used in making it, between animals that are being grown and those that are being fattened, owing to the difference in the relative proportion of grain and concentrates fed to these. It is much easier to draw the comparison as to relative cost, and the difference in cost may be taken as an approximate basis, but not an exact basis of the difference in the amounts of food consumed. In "Profitable

Stock Feeding," Prof. H. K. Smith states, that in six different trials made with cattle, each 100 pounds of increase made during the first 12 months cost $3.45, during the second 12, $7.42, and during the third 12, $11.50. At the Kansas experiment station it was found that steers which were being fattened consumed 730 pounds of grain for every 100 pounds of increase made during the first 56 days of feeding. During the entire period of feeding which covered 182 days, they consumed 1,000 pounds of the same, which was an increase of practically 37 per cent. The testimony of other experiments is in keeping with the above.

The average results from several trials in feeding lambs which weighed approximately 75 pounds when put on feed, show that to make 100 pounds of increase calls for approximately 500 pounds of grain and 400 pounds of hay. To make similar increase with shearlings it has been found that from 25 to 45 per cent more food was required. Similar is the trend of testimony of the American Fat stock shows. Unfortunately, however, some of the testimonies from these must be accepted with much caution, as for instance the statement that in 1881, a Southdown lamb shown weighed 213 pounds at the age of 213 days, which means that up to that age it had made a daily gain of 0.9 pound.

In Denmark many experiments have been conducted by the Copenhagen station which throw light upon the relative amounts of grain or its equivalent, consumed by swine of different ages in order to make 100 pounds of increase. A large number of animals was included in these experiments. The results showed that pigs weighing 35 to 75 pounds consumed 376 pounds of such food when making 100 pounds of gain, while pigs weighing 195 to 235 pounds consumed 543 pounds to make the same. The average results from a number of experiments conducted in America show that with swine not more than 50 pounds in weight, 100 pounds of increase may be made from each 300 pounds of grain and grain equivalents fed, while with pigs from 200 to 250 pounds, about 500 pounds of the same were required to make similar increase.

Of course the relative amounts of grain consumed by animals, both when growing and during the finishing period, will be influenced by the amount of coarse fodder fed, whether fed in the green or dry form. The assumption is safe, nevertheless, that to finish animals properly on grain, the amount of the same required increases, first, with increase in the age of the animals, and second, with the continuance and prolongation of the fattening period. This, however, does not make it certain that long periods of feeding will be attended with less profit. That will only follow in instances where the degree of the finish is not superior in character.

Cost of increase.—It has been shown that animals as a rule make gains more slowly as the birth period is receded from (see p. 371). It has also been shown, that notwithstanding the slower gains, more food relatively and absolutely is consumed in making them, and that this also applied to the fattening period (see p. 379). It naturally follows, therefore, that the cost of increase is greater as the birth period is receded from, and as the fattening period advances. But to this there are some exceptions, especially during the growing period, as is shown below.

Many instances, all based on experiment, may be cited to show increasing cost in the gains made with increasing age. The following only can be given here: At the Wisconsin experiment station, it was found that with animals up to the age of 12 months, 100 pounds of beef, live weight, cost $4.20, while with the same animals during the next 12 months, it cost $6.13. At the Massachusetts station, with animals in the two-year form, 100 pounds of beef, live weight, cost $7.49, and with the same animals in the three-year form, it cost $12.38. At the Iowa experiment station lambs that were fattened cost $3.61 for every 100 pounds of live increase made, and wethers on the same feed cost $5.33 for each 100 pounds of the same. At the Wisconsin experiment station, swine which averaged 222 pounds when put on feed consumed 418 pounds of meal to make 100 pounds of increase the first four weeks of feeding, 461 pounds the second four, and 559 pounds the third four. The difference in relative cost was proportionate.

Under some conditions, however, it is possible to make 100 pounds of increase more cheaply at some distance from the birth period, and also from the commencement of the fattening period, than earlier. The growing of young animals, especially cattle, during the milk period, is more costly relatively than at a later period, because of the difference in the relative value of the foods. Milk and grain furnish the principal portion of the food of young animals for a time. Later they are usually maintained on coarser and cheaper foods, more especially on pasture. One hundred pounds of increase may, therefore, be made more cheaply on the coarser food thus given, because of its relative cheapness, notwithstanding the increase in the amount consumed. Likewise when cattle are partly fattened on dry food and are then finished on grass or grass and grain, the increase made on the latter may be made more cheaply than that made before turning out on grass. At the Iowa experiment station, it was found that from March to May, covering 92 days, steers fed on a ration of corn meal, oil meal, hay and roots, made 100 pounds of increase at a cost of $5.93. The same steers maintained for a similar period immediately following on a ration of corn meal and clover pasture made similar increase at a cost of $4.31.

The cost of increase varies with variations in the cost of food. Because of this, the same class of meat will cost much more in one locality than another. It has been estimated that during recent years the cost of making 100 pounds of increase during the fattening period was from $2 to $3 more than the cost of the same in the Mississippi states.

Gains when fattening not worth their cost.—During the finishing period, the increase made is more or less influenced by the following conditions, viz: (1) The individuality of the animal; (2) the stage in development at which the fattening begins; (3) the amount of flesh carried at the time; (4) the cost of the foods used; (5) the character of the feeding and finish made and (6) the relative value of the fertilizer resulting.

Individuality is a most potent influence in hastening or retarding increase. That it is so is shown in the fact that two animals of similar age and fed alike will differ greatly in the gains made, though consuming practically the same amount of food. This difference sometimes exceeds 50 per cent

The stage in development at which fattening begins influences the cost, first, by the greater relative increase made by animals that are not yet matured, by the less amount of food required to make these gains, and by the greater relative cost of maintenance in mature animals. It follows, therefore, that immature animals should make greater and cheaper gains than those that are mature.

The less flesh that animals carry when the fattening begins, providing leanness is not carried to the point of weakening the bodily functions, the more they will increase in weight, for the reason that there is more room for such increase. But of course the less flesh carried when fattening begins, the more prolonged must be the period of fattening, a fact which may go far to offset the consideration first named when purchasing animals for fattening.

No influence is more potent in determining relative cost of increase in fattening than the relative cost of the foods fed. It will be at once apparent without argument that with the same foods, cost in the gains made will fluctuate with cost in the foods fed.

Forced feeding beyond a certain degree will result in a waste of food. On the other hand under-feeding will result in loss through increased cost in the food of maintenance. Reasonably liberal feeding, therefore, is likely to give the best results. The character of the finish influences cost of increase so far as it influences the price paid for the finished product.

The value of the fertilizer made is a factor of much importance in some localities, in other places it is not an important consideration. While of course it does not influence gains, it does influence profits, and just in proportion to the grade of the fertilizer made and the relative value of the same in the locality.

Usually the increase during the fattening period costs more than it will sell for in the market. This generally holds true in fattening cattle, sheep and swine, but to a less degree probably in swine than in the other classes named. Such increase in fattening mature cattle usually costs not less than 1 to 3 cents per pound more than it will sell for in the market. But to this there are some exceptions as when the price of foods is relatively low and that of meat relatively high. The same is true also in many instances of growing baby beef, under normal conditions because of the quick gains made by the animals. The testimony, however, of nearly all experiments in fattening live stock in this country have shown that the cost of increase during the fattening season has been greater than the cost of the food.

Wherein is the profit from fattening live stock under such conditions? It arises from the increase in the value of each pound of the live weight of the animal when the fattening began. Suppose, for instance, that a steer is purchased and put on feed. Suppose that he weighs 1,200 pounds live weight and costs 4 cents per pound; suppose that the increase in weight from six months feeding is 300 pounds, each pound of which costs 6 cents to make it. The steer when finished is sold for 5 cents per pound live weight. Allowing the manure made to offset the cost of feeding and other incidental expenses, the transaction will stand as follows: $75 the selling price when finished, less $48 the purchase price, less $18 the cost of increase during fattening, leaves $9 as the net profit from the transaction. But what of the cost of growing the steer up to the time of fattening? It should be considerably less than 4 cents per pound, for, if grown on the range, he would be grown virtually on free pasture. If grown under extensive farm conditions he would be grown largely on cheap pastures. If grown under more intensive conditions he would be grown largely on coarse and cheap foods.

Duration of the finishing period.—Since, during the finishing period, the cost of increase made during its continuance seldom equals in value the cost of the food used in making it, the time covered by this period becomes a question of prime importance to the feeder. Its profitable duration will be influenced by such considerations as: (1) The condition as to flesh of the animals when the feeding period begins; (2) the character of the food fed; (3) the intensity of the feeding; (4) the relative cost of the food; (5) the season of the year when the finishing occurs, and (6) capacity in the animals for making high finish.

If animals are in a low condition of flesh when the feeding period begins, it is manifest that a proportionately longer period must elapse before they can be profitably sent to the block, than if they were in good flesh at the same time. Animals low in flesh when fattening begins cannot be brought to a high degree of finish in a short time. The digestive powers can adjust themselves only gradually to the changed conditions of feeding, and the same is true of the assimilative powers. This is shown in the fact that animals will digest and appropriate much larger quantities of concentrated food without injury when on what is termed "full feed," than when the feeding period begins (see p. 377). In some instances, as in making baby beef sold under the age of two years, the feeding has been of such a high character all along, that the transition to what may be termed the finishing period is scarcely discernible through any increase in feed (see p. 402).

Some kinds of food bring to a finish much more quickly than others, because of their constituents. Corn will fatten animals more quickly probably than any other cereal, and when fed in large quantities it will ripen them sooner. A ration consisting mainly of roots and grain will not fatten so quickly as one consisting mainly of corn and dry fodder. Similar differences may be thus shown in various other foods used in fattening.

The intensity of the feeding exercises an important influence on the length of the feeding period. Intensity of feeding has reference to strong feeding. It means feeding concentrates rich in nutrients for producing fat, and feeding to the full capacity of the animal to take such food. But little roughage is fed. Such feeding leads to increase more quickly than feeding concentrates less rich, or if rich, in moderate quantities, and along with these feeding considerable quantities of roughage. But it also leads more quickly to cessation of profitable increase, and the attendant danger is greater that the derangements in digestion will be of more frequent occurrence than when feeding is less intense.

The value of foods in relation to meat values should always be considered. When food values are high and meat values low, the shorter the period of feeding within reasonable limits, the greater will be the relative profit. Seasons do occur, but usually at rare intervals, when finishing is not attended with any profit, unless when it can be accomplished through some cheap food such as grass.

Capacity in the animals to make a high finish and to furnish a carcass that will command a high price is also important. When a steer for instance of dairy form is placed upon the market in high finish and sells for more than one cent less per pound live weight than the steer of orthodox type in equally high finish, it is very evident that it will not pay equally well to bring the former to so high a finish as the latter. The great advantage in high finish from the latter comes from the advance in value which it puts upon every pound of the weight possessed when the finishing period began (see p. 384). The advance thus made in the value of the animal of dairy conformation is much less as markets have ruled during recent years, notwithstanding that at least as large amounts of food relatively will be consumed in making it. It is less necessary therefore because less advantageous, to feed such animals and also aged cows, ewes and sows for long periods, that they may thus be brought to a high finish, than to feed well furnished animals with the same end in view. But a certain amount of feeding with them is necessary, that they may bring a respectable price.

The season of the year at which the finishing period draws near should also be duly weighed. If the finishing process draws near toward, or at the close of the grazing season, it would be better to close it then than to continue it only for a short period on food so radically different as a change from grass to dry food would involve, or if the finish was nearly completed when grass arrives and to complete it would involve turning the animals out to grass for a short period, it would be better to close it with the end of the dry feeding season (see p. 397).

It will be apparent from the above, that the duration of feeding periods cannot be definitely stated so many are the conditions that cause them to vary. It may be said, however, that cattle can seldom be finished properly in less than 120 days, sheep in less than 70 days, and swine in less than 40 days, and that high finish seldom calls for more than 180 days of feeding with cattle, 120 days with sheep and 60 days with swine. More commonly feeders err on the side of unduly curtailed feeding, accompanied by lack of finish than on that of feeding unduly prolonged and accompanied by over-finish. The aim should be to bring good animals to high finish, unless there are good reasons for not so doing. It has been estimated by competent authorities, that from 75 to 90 per cent of the cattle marketed in the United States are not properly finished.

Season for marketing.—The grower and feeder of live stock should aim as far as it may be practicable to have them ready at that season which will enable them to reach the market in the absence of a glut in the same, or even in the absence of supplies sufficiently plentiful to cause considerable depression in values. The exercise of timely forethought will usually make this feasible.

There are two seasons when the values of the common classes of meat are usually low. The first is that period covered by the entire season beginning with the middle of September, and extending over a considerable portion of January following. The second is embraced within the first and includes more particularly the holiday season during which poultry to a considerable extent substitutes the use of other kinds of meat. Only the best classes of beef and mutton at such times command good prices relatively.

Two classes of persons are compelled to sell at such seasons. The first is, ranchmen who may be unable to finish stock because of the entire absence of finishing foods which may not be shipped in because of cost. The surplus stock must be disposed of at the approach of or during the autumn. The second class includes all farmers who may not have the necessary food or necessary conveniences to enable them to finish surplus stock at home. So large and so constant is the supply from these two sources, at the seasons named, that it has a depressing influence on values. But it may be more profitable to market animals, as sheep which make a late finish on such foods as rape, at such a season, than to attempt to further finish them on dry food involving greater relative cost.

The values of meat are relatively higher at all other times of the year than those named, but there are seasons that are especially favorable to marketing viewed from the standpoint of relatively high values for meat. These include the late months of spring and all the summer months. But during those months lighter animals are wanted and more especially when the weather becomes hot.

The individual who has high class meat and of weights inclining to light at such seasons may expect good values for it. But to meet the conditions named requires forethought all along the line of development, and more especially with reference to the duration of the finishing period.

What may be termed timeliness in marketing is of much moment to the producer of live stock. Christmas beef must be of high quality and ready at the proper season. Milk lambs will ordinarily bring higher values in the interval between Christmas and Easter than at an earlier or a later season. When ready earlier they must be sold when supplies of meat are excessive. When marketed later, they must compete with early spring lambs. Heavy weight animals of all kinds usually command the best prices when the weather is cool or cold. While light weight animals of good finish are in demand at all times, they are most prized during the warm season. Swine marketed in the spring usually sell at higher rates than those sold in the fall, but they also cost more to produce them.

Marketing when ripe.—Ripeness as applied to live stock is a relative term. In one sense, it may mean marketing, when ready to meet the needs of a certain market, in the absence of completed growth and even of high finish, viewed from the standpoint of the amount of fat carried. Winter lambs are ripe when plump and fat at weights running from 35 to 45 pounds. Baby beef is ripe, when well grown for the age and fat, at weights varying from 900 to 1200 pounds in the yearling form. Bacon swine are ripe when they attain to weights varying from 160 to 220 pounds and carry but a moderate amount of fat. In another sense, ripeness means that stage of development reached by animals that are being fattened, when they become incapable of making increase proportionate to the food fed to them. This latter is the sense in which the term is more commonly used.

When animals become thus ripe, it is self-evident that further feeding, viewed from the standpoint of increase, will be done at a loss, hence the wisdom, under normal conditions, of putting them on the market promptly when they are ripe. When animals are being fattened, the increase as a rule is less rapid as the fattening period advances, and the cost of making increase continually advances. In fattening steers at the Kansas experiment station for 182 days, it was found that during the first 56 days, 730 pounds of food were required to make 100 pounds of gain, while for the whole period 1,000 pounds were required to make the same. At the Wisconsin experiment station, swine that were being fattened made 100 pounds of gain during the first four weeks from 418 pounds of food, during the second four from 461 pounds, and during the third four from 559 pounds. The average weight at the commencement was 222 pounds. In an experiment conducted by the author in fattening swine, at the Ontario experiment station, 1890-91, it was found that during the experiment proper which covered 90 days, the cost of making 100 pounds of increase was $4.65. The swine were then regarded as finished, but they were fed for 47 days longer on the same kind of a ration. During this period, the cost of making 100 pounds of increase was $14.93. The average weight of the swine, when the experiment proper began, was 150 pounds. If such feeding is continued long enough, increase will entirely cease, and in time retrogression will begin, on the principle, that after ripeness, deterioration begins.

Prominent among the indications of ripeness are a good covering of flesh on parts more usually bare, firmness of flesh as indicated by resistance to gentle pressure in the muscles of the body, and a plumpness of form which reveals a finished condition to the practiced eye. The weight scale, of course, is the surest indicator of that decrease or cessation of growth that accompanies ripeness and the service that it may thus render when used judiciously may be very substantial.

The necessity for selling animals promptly as soon as finished should certainly be given due regard. It would not seem justifiable to hold them longer in any instance, except to avoid marketing in a glut or when advance in price within a short time is practically assured. By exercising proper forethought, they will be made ready so that they may reach the market when prices for such meat are usually relatively good.

Shipping finished animals.—Since live stock have, in very many instances, to be shipped long distances to the market, both as stockers and in the finished form, and since the condition in which they reach the same materially influences the sale, it is a matter of much importance to the shipper that they reach the place of consignment under conditions that will be attended with a minimum of shrinkage and loss of bloom. To secure these results requires: (1) That they shall be fed properly in preparing them for shipment and when in transit; (2) that the transit shall be as rapid as possible and (3) that they shall be promptly unloaded and cared for when they reach the place of consignment.

Before shipping finished cattle and sheep, the usual grain allowance should be reduced gradually and materially, for two to three days before shipping, and in transit may cease altogether. Hay of good quality should be supplied and in quantity as much as they will consume. If they are on pasture and also receiving grain, they should be yarded a day or two before shipping, and fed hay, the grain allowance also being reduced. Stockers may be taken from well matured pastures and shipped at once. The continued full feeding of grain before shipping finished animals, in connection with the more than usual amount of exercise, and the excitement resulting from changed conditions, is much liable to result in scouring. This means much shrinkage in weight and a soiled appearance. Bedding should be plentifully supplied before loading. Unless driven far before loading, in a warm atmosphere, animals will not drink to excess when fed as indicated.

When loaded, the transit should be as rapid as possible. This of course is mainly in the hands of carriers, but it may be materially influenced by the choice of season made by the shipper, when traffic is not congested. Every additional hour spent on the road means additional shrinkage, as animals will not eat or drink freely when in transit by rail. When shipped long distances, the animals will take less harm if hurried on to the place of sale, than if the journey is prolonged by unloading at feeding stations every 24 hours. Experience has shown that runs considerably longer than 24 hours conduce to the well being of the cattle by reducing the time in transit, thus shortening the period of privation, notwithstanding the contrary view held by many humane societies. Watchfulness is necessary on the part of the attendant, especially in case of sheep lest they should get down and suffer injury by being trodden on, especially in crowded cars. Overcrowding of cars is, of course, a mistake, but no harm comes from filling cars to their full capacity. In shipping long distances weather probabilities should be considered at certain seasons. A blizzard may cause serious loss in transit, and the same is true of excessive heat, especially in the case of swine.

Delay in unloading is avoided when the animals have been consigned to a commission firm when shipped. The aim should be to unload them not later than 8 o'clock in the morning, before the buyers make their rounds, and hay and water should be present in ample supply. Any effort to induce the animals to drink excessively by giving salt previously or by withholding water, is to be deprecated.

Loss of weight in marketing.—The extent to which finished animals shrink in weight on the way to market is influenced chiefly: (1) By the time occupied in transit; (2) the foods used in fattening and the degree of the finish; (3) the age of the animals; (4) the extent to which they have been exercised while being fattened and (5) the character of the weather.

The time occupied in the journey from the feed lot or other place of fattening to the market is probably the most potent influence in causing shrinkage, even though the animals should be rested, fed and watered on the way. This arises from the little inclination which they evince to take food or water while in transit. The rate of the shrinkage, however, decreases with increase in the time occupied in conveyance, as the more prolonged the journey, the less the amount of food and water is there in the digestive organs to pass out of the system.

The more succulent the foods used in fattening and the less the degree of the finish, the greater will be the loss of live weight in transit on the supposition that the animals are given fair treatment on the way. Of course if the animals were driven to market, the more perfect the finish, the greater would be their distress in traveling, and this might result in a greater loss in weight. The flesh of animals fed watery foods, such as succulent grass and field roots, contains a higher per cent of water than that of animals brought to high finish on dry foods, and this is more readily lost than the fat in the system.

Young animals lose more in transit relatively than animals that are mature and that are possessed of an equal degree of finish. This arises first, from the larger per cent of water in the system of the former, and second, from the greater relative activity of the excretory organs. But this tendency may to some extent be counteracted by the greater power possessed by young animals to accommodate themselves to disturbing conditions.

The extent to which animals exercise while being fattened exerts a marked influence on the shrinkage in transit. Cattle finished in yards or feed lots will shrink much less than those tied in the stall and given but little or no exercise. Wethers fattened on alfalfa hay, wheat, corn and roots at the Colorado experiment station shrank 9 per cent of the live weight in transit to the Chicago market. Selected lambs shrank 9.4 per cent, and lighter and more active Mexican sheep shrank but 6.5 per cent.

The more comfortable the weather is, the less will animals lose in transit. Where they must be driven several miles to the shipping point the character of the weather is of much moment. If it is warm, the journey should be made in the night. In the experience of the author, fat steers weighing between 1400 and 1500 pounds lost on an average 75 pounds each in a journey of 15 miles made in the night.

While it is not possible to state exactly the amount of shrinkage from shipping finished animals, it will be more or less of an approximation to say that cattle loaded one day, the next day occupied in transit, and the third day sold and weighed, will shrink somewhere in the neighborhood of 5 per cent of the live weight, sheep about 4 per cent and swine 4 to 5 per cent. Locally, cattle are sometimes purchased on the basis of a shrinkage of 4 to 5 per cent on the weight in the stall or feed lot.

Feeding in stalls, sheds or yards.—Looking at this question from the standpoint of theory only, the conclusion would be reached that the largest and also the cheapest gains would be made from feeding in the stall as, when thus fed, the animals are kept absolutely at rest and the individual wants of each animal as to food may be exactly met. Until recent years, the view was almost universal that feeding cattle in the stall would be attended with the greater profit. The trend of the results obtained, however, from the experiments conducted is rather in the opposite direction. Of course the attempt is never made to feed sheep or swine in the stall. The former are almost invariably fed in sheds under average farm conditions, and are given access to well bedded yards at will. The latter are, in nearly all instances, finished in pens under cover, and are given access to small yards at will. But both sheep and swine are in some instances finished on certain kinds of pasture.

The chief arguments in favor of finisning in the stall are the following: (1) The food fed can be controlled at will. Where it is desired to feed a relatively large proportion of roughage to concentrates on the ground of economy, this is more easily accomplished than when animals are fed together in a wholesale way. In such feeding to animals, not confined in the stall, the stronger would get more than their rightful share of the concentrates, and the weaker less. (2) The food can be more perfectly adjusted to the needs of each animal. It frequently happens that some variation in the kind and quantity of food fed is helpful to the individual animal. This cannot be controlled when animals are fed loose. (3) The temperature can be more perfectly adjusted to the needs of the animals, as undue cold may thus be excluded, and in this way unnecessary waste avoided. (4) The degree of the exercise can be so completely controlled that no energy will be thus wasted at the expense of the food. (5) The resultant fertilizer can be saved without waste where an ample supply of litter is used.

The chief arguments in favor of finishing in the shed or yard are: (1) The saving effected in the labor of feeding. This cannot be gainsaid, as the difference equals that which results between doing work in a wholesale and retail way. (2) The saving in the labor of handling the manure. This is an important item. It is to some extent offset under certain conditions by the leaching which takes place in open yards in times of heavy rainfall, but this may be largely prevented by restricting the size of the yards and supplying ample litter. Manure made under cover with an ample supply of litter by animals at liberty is of the best, as it conserves all the liquid portion and does not suffer loss readily by excessive fermentation. (3) Experience has shown it to result in a majority of instances in larger returns absolutely and relatively in proportion to the food fed. This reason is very potent. That it is so arises probably from the fact that the more exercise taken by the animals at liberty causes them to take more food, which results in greater relative gains through the saving effected in the food of maintenance, and probably also through the more perfect assimilation of the nutrients. This increase is more than sufficient to overcome the increased loss of bodily heat by the animals that are loose, since they are more exposed to the cold. Animals confined are frequently allowed to become too warm and the discomfort resulting is adverse to their gains.

To secure the best results, however, from feeding cattle loose, it would seem correct to say that the following conditions should all be present: (1) They should be hornless, either naturally or made so to prevent bodily injury. (2) They should be fed under cover, unless in climates quite mild and dry. (3) The concentrated food should be fed in mangers in which the animals could be kept in place by stanchions adjusted by one movement of a lever until the meal is consumed. In this way the amount of meal fed could be virtually controlled. Unless fed thus, the strong may get more than their rightful share. (4) The yards should be small and kept well bedded to avoid unnecessary leaching of the manure. The litter should be sufficiently ample to prevent discomfort to the animals when at rest, either from the presence of frozen lumps or of miry or even unduly saturated conditions.

Finishing animals on pasture.—In the discussion of this question the following points necessarily come up for consideration: (1) The degree of the finish that may be expected from pasture alone; (2) the season for finishing to secure the greatest profit; (3) the amount of grain that may be used with highest profit in supplementing pastures; (4) the relative profit from such finishing and (5) the mistake of finishing on sparse pastures.

The degree of the finish that may be expected from pastures is influenced by the character of the pastures and duration of the pasturing period. Some pastures furnish decidedly more nutriment than others in proportion to the food consumed. The short pastures of the western ranges are proverbial for their fattening properties. All grass pastures are better adapted for finishing when reasonably well advanced in growth than earlier in the season, notwithstanding that early growth when abundant may produce more weight. Grasses alone, therefore, will not produce high finish on a period of grazing that does not cover several months. Nor will it give so perfect a finish as when grain is fed, as is evidenced in the extent to which range cattle are purchased and placed in feed lots for further finishing, after having grazed on the ranges during much of the entire season.

The season for finishing to secure the greatest profit will, of course, vary with such conditions as the flesh carried when the grazing begins, the influence of the season on growth and on the markets for meat. It would seem correct to say that the aim should be to finish grazed cattle not later than September, when they have been given a grain supplement, and not later than July when they have been given a reasonable grain portion from the beginning of the previous winter onward. After September the markets are frequently over-supplied with meats of somewhat inferior ades, which has a depressing influence on the same.

The amount of grain that may be fed with highest profit to cattle on pasture will vary with the age of the animals, their condition, the nature of the pasture, and the price of grain. The younger the animal up to maturity, the leaner when grazing begins, and the more sparse the pasture, the greater is the necessity for feeding grain and the larger the amount required. The cheaper relatively that grain is, of course, the greater is the profit from feeding it. Clearly then, it is impossible to formulate any hard and fast rules that will serve as infallible guides to those who finish animals on grass. The best feeders are not in agreement on this question.

The following conclusions based on the experience of practical feeders and on the results of trials made at the experiment stations, would seem to be correct: (1) That when cattle are turned out on grass to be finished not later than mid-summer, the grain ration given to them before the grazing season should be continued, and increased if necessary. (2) That when cattle are to be grazed through the season and sold from off the grass in finished form, it is questionable if the grain fed for two or three months while the pastures are at their best will give an adequate return, viewed from the standpoint of increase in weight, but as soon as the grasses begin to fail the reverse of this is true. (3) That the profit will probably be found greater relatively when a light grain ration is fed to animals grazing, rather than a full ration of the same, as grass is relatively cheaper than grain. It should also be noted, that when estimating the result from feeding grain on pastures, the influence exerted on the increase in the weight of the animal, on the quality of the meat and on the saving effected in the pasture should be considered.

Whether it will be found profitable to feed grain to sheep that are being fattened on pastures has not been made the subject of experiment to any very great extent in this country. The necessity for so doing, and the advantage from the same will probably be based, (1) on the character of the pasture; (2) on the shortness of the period in which the fattening is to be done and (3) on the extent to which fertilizers have to be purchased. Sheep and lambs may be finished in good form on well matured rape in 60 to 90 days from the commencement of the grazing. In the experience of the author feeding a grain supplement to lambs thus grazed did not secure enough additional increase to cover all the cost of the grain. Notwithstanding, when it is remembered that a light grain supplement, running from ½ to 1 pound per animal, per day, is to some extent a safeguard against certain digestive troubles that are liable to affect sheep thus grazed, more especially after hoar frost begins to settle on the rape, it would not be thus fed at a loss. When fattened on clover or amid grain stubbles, from ½ to 1 pound of some such grain mixture as corn and oats would be a necessity for quick finishing. When large sums are paid out annually for commercial fertilizers, to feed such a supplement freely as corn and oil cake to sheep while being grazed on arable pastures, would probably be found one of the cheapest possible methods of securing fertility. It is doubtless correct to say that a light grain supplement fed to immature swine on pasture will prove profitable in all instances in which the grazing does not consist of mature grain. Growing swine cannot consume enough pasture to insure quick growth. The amount of the supplement will vary with the size of the swine and the character of the pasture, but it is approximately correct to say that not less than half the amount of grain should be fed that would be necessary if the swine were wholly dependent on grain.

The relative profit from finishing stock on pasture with a grain supplement as compared with the same under confined conditions has been made the subject of experiment, and the conclusions reached favor the view that more profit results from finishing thus on pasture. This view is doubtless correct where the conditions favor such grazing but the fact remains, nevertheless, that very much of the live stock fattened must continue to be so fattened in the winter season, otherwise much coarse food would be wasted that is now turned to excellent account.

It would be a mistake to try and finish live stock on sparse pastures, even when a grain supplement is in ample supply, owing to the over abundant expenditure of energy on the part of the animals in searching for grass, which, when succulent, is always appetizing. Such expenditure would be at the expense of supplemental food. But it may be in order to feed breeding or store animals a supplement of grain rich in the elements of fertilization. When the object is to enrich the land as well as to benefit the animals, sheep are best adapted to such feeding, because of the even way in which their droppings are distributed, and the small amount of loss that accompanies such distribution. It would also be a mistake to require animals that are being fattened to consume closely shock corn fed on grazing lands in the autumn. The aim should be to have two pastures, and to allow store cattle and swine to glean after the animals that are being fattened. The two classes of animals would thus be alternated from day to day. Likewise it would be a mistake to compel swine that are being finished on unharvested corn or peas, to glean closely. That should be done by store swine that are admitted later.

Financial returns from purchased feeders.—When animals are purchased for feeding, the financial results from fattening them will be influenced: (1) By the age at the time of purchase; (2) by the weight; (3) by the condition as to the flesh they carry; (4) by the value of the food fed and the duration of the feeding period, and by the difference between the price paid at the time of purchase and received at the time of sale.

It has been shown (see p. 371), that animals young and immature make greater increase when being fattened than mature animals. But age also influences market values more or less. Of course with all animals, there is an age below which the market demands them only in limited numbers and to meet some special need, as in the case of "milk lambs" and "baby beef;" but when this age is past, the younger the animals are when put on feed, other things being equal, the larger are the profits likely to be, not only because of the greater and cheaper increase made, but because of the higher relative price which such animals bring when sold. With cattle the highest price and widest sale are made by animals from say 1,200 to 1,400 pounds when finished; with sheep from 90 to 100 pounds; with the lard types of swine, from 200 to 250 pounds, and with the bacon types, from 160 to 200 pounds. In former years animals much heavier were more in favor.

When animals are being fattened, it has been shown that the profit usually made comes from the increase in value of each pound of the live weight at the time of purchase (see p. 384). Theoretically, therefore, the highest profit should come from animals which weigh the most, but to this there is the offset; first, that animals lighter because younger gain more on less feed, and second, that they usually sell for more, relatively, when finished. It is probably true that generally more is paid relatively per pound for the lighter animals, which so far offset the returns.

It has been shown that condition as to the amount of flesh carried by animals when put upon feed influences gains (see p. 377). But it usually influences profits in another way, that is, through the lower price for which such animals can be purchased. Because of this, more profit is sometimes made from feeding animals so mature that they are no longer profitable for breeding uses. When cattle are purchased young and lean, in the opening of the grazing season, they usually make large gains relatively and give profitable returns for the season's grazing because of the light weight of the sparely covered frame at the time of purchase

The influence of the cost of food is discussed on page 382. The duration of the finishing period is largely influenced by such considerations as the flesh condition when the animals are put on feed, by the relative cost of food and the finished product resulting from it, and by the comparative fitness of the animals for medium or high finish. The higher the condition of animals when fattening begins, the shorter relatively is the period required in which to finish them and *vice versa*. The saving thus effected in the food of maintenance may go far to offset the difference in cost between lean and less lean animals when purchased for feeding. The higher the value of the foods fed and the lower the value of the finished product, the greater the necessity for curtailing the period of feeding and *vice versa*. The less fitness possessed by the animals for making a high finish, the shorter relatively should be the feeding period and the higher the degree of such fitness, the more may it be prolonged under normal conditions, as high finish usually insures a high selling value.

The difference between the price paid for animals when bought for fattening and when sold as finished, probably exercises a greater influence on returns than any single influence which bears on the fattening process. The difference between the buying and selling price to insure profit from fattening animals, especially sheep and swine, is influenced by the character of the animals, the cost of foods and the nature of the feeding. In this very complicated and many-sided problem, it will be found that the better the class of animals, the younger they are, the cheaper the foods and the cheaper the system of finishing, the narrower may be the margin of difference between buying and selling values. Finishing on grass with a supplement of concentrates is usually cheaper than finishing on dry food (see p. 397). With dry fodders worth ¼ to ½ cent a pound, and concentrates at 1 cent a pound, some net profit should be made when the margin of difference between the buying and selling prices is 1 cent per pound live weight. Considerable profit should result when it is 1¼ cents and a good profit when it is 1½ cents.

Baby beef.—During recent years the production of what is termed "baby" beef has increased materially. The discussion of the question involves the consideration of the following: (1) What is baby beef? (2) The objects sought in growing it and (3) where and how it should be grown?

Baby beef may be defined as beef made from animals subsequently to the milk period and not yet two years old. The animals are kept growing rapidly from birth and are then marketed in a high condition of flesh, more commonly in the one-year form, and between the ages of 15 and 21 months. The term has also been applied to animals marketed when a little beyond the age of two years, but clearly it should not be so applied, as animals beyond that age may be made to produce carcasses, approximating average carcass weights.

The following are chief among the objects sought from growing baby beef:—(1) To meet the demand for well finished carcasses of light weight and possessed of quality that commands ready sale. Such meat is juicy and tender; (2) to prevent the over-stocking which may result from maintaining meat making animals of a more mature age. Such overstocking may easily occur both on the range and on the arable farm; (3) to secure increase from a minimum expenditure of food, on the principle that increase calls for more food to make it as the birth period is receded from.

Baby beef can only be finished on the arable farm or under arable farm conditions, although its growth may be commenced and maintained on the range up to the weaning period. Dropped in the spring, the calves are purchased when weaned, pushed rapidly onward and disposed of during the following summer. Localities in which corn and alfalfa or corn and clover grow abundantly, have highest adaptation for such feeding, since they furnish growing and fattening foods in balance and cheaply, but in all localities where growth is abundant, baby beef may be grown from start to finish.

On the arable farm two methods of growing baby beef have been followed. By the first, the calves are dropped, preferably in the autumn or early winter, reared upon their dams, pushed rapidly forward by generous grain feeding, subsequently to weaning, and marketed the second spring from the stall or what may usually be preferable, from the pastures of early summer, a season when such meat is much in demand. Animals reared thus will probably bring more profit usually in the two-year form, since the proportion of cost to be charged against the dam will be materially less. By the second method, they are reared essentially on skim milk and adjuncts, the adjuncts consisting chiefly of concentrated foods and high class fodders. Baby beef from this source will be scarcely equal to that from calves that were suckled by their dams, but it will be made more cheaply, as none of the cost is to be charged against the dam, since maternity in her case was necessary to bring her into milk, and its cost, therefore, would have to be incurred, regardless of what would become of the calf.

The grain during the milk period in the case of hand-reared calves, ought to contain not less than 33 per cent of fattening food, such as corn, barley or rye from the first, when the fodders are leguminous, and this proportion should be materially increased, for several months previous to the disposal of the animals. Where non-leguminous fodder must be relied on, the protein equivalents being purchased, as oil cake and such foods, the cost of production will be materially increased. The necessity for an ample supply of protein when growing such meat is well brought out in an experiment conducted by the Nebraska experiment station in 1904. When yearling steers were fed alfalfa and corn, the daily increase was 1.97 pounds. When fed prairie hay and corn it was 1.35 pounds. The net profit with the former was $8.66, with the latter 38 cents. The test covered a period of six months.

Winter lambs.—By winter lambs is meant lambs that are born, say from November 1 onward until mid-winter, and are pushed forward rapidly in their growth and are then sold while yet suckled by their dams. The aim should be to have them fill the place in the market between the time of abundant fowl consumption at the Christmas season and the ordinary season for selling early spring lambs. To bring the relatively high prices usually paid for them, they should be made plump and fat and to reach 40 to 50 pounds in live weight at the age of 60 to 80 or 90 days.

To raise winter lambs, or as they are sometimes called, milk lambs, successfully, the following requisites must be present, viz:—(1) Ewes that will drop lambs at the proper season; (2) quarters sufficiently protected to shield the young lambs from harmful exposure; (3) food suitable in kind and ample in quantity and (4) facilities for marketing with dispatch and on easy call. If any of these are lacking, the success of the work will be proportionately increased.

The breeds at present in this country which have the habit of dropping lambs in the late autumn or early winter are the Dorset and the Tunis and high grades of these. If lambs of one or the other of these breeds are crossed upon common females of breeding more or less mixed, the habit of producing lambs at the desired season may be engrafted on the progeny in a limited number of generations. The change may be facilitated by judicious feeding and selection. Experiments conducted by the author at the Minnesota station, showed that in two generations of such breeding, the change was secured in a majority of instances.

As in northern climes, winter lambs are dropped in weather that is usually more or less severe, it is necessary in growing them to have shelter provided sufficiently warm to protect the young lambs from hazard through exposure until they are a few days old. Such shelter may be provided by a basement of a barn, dry, airy and sunny, or by a lambing pen or house built or fitted up for such use. As soon as the lambs are well started, it is not especially necessary that they shall be kept in quarters much warmer than would be suitable for a breeding flock, but of course temperatures lower than a certain degree will retard increase and will make it more costly. The dams should be in reasonably good condition when the lambs are weaned, and must then be heavily fed on foods suitable for milk production until the lambs are sold. The fodder should be leguminous, fine in growth rather than coarse, and well cured. The grain should be rich in protein. Equal parts of bran, oats and corn or barley make a good grain ration, and it should be fed nearly to the limit of the capacity of the dams to consume it. Field roots sliced or corn silage are excellent, especially the former. The roots may be fed with much freedom, but usually not more than 3 or 4 pounds of silage are fed daily.

The lambs are started on such food as sifted ground oats and oil cake or oil meal. This food and that which follows it, is fed inside a creep, which the dams may not enter. Ere long the lambs will take unground oats, cracked corn and oil meal, and these properly blended aid in pushing them rapidly. Corn may usually be profitably fed to the extent of making half the grain ration, as quick fattening is wanted. The other factors may be fed in equal proportions where the prices will admit of such feeding.

As winter lambs are usually sent to a market that furnishes meat for a special and high class trade, they are frequently ordered as wanted. To fill such orders with dispatch, it is essential that the shipping facilities shall be of a reasonably high order. This means that winter lambs can be most profitably reared in proximity to railroad stations.

Growing bacon.—To grow bacon of high quality, the following requisites are essential: (1) The animals must be possessed of correct form; (2) they must be managed on correct principles and (3) they must be grown on foods that will secure the end sought. The question of form is discussed elsewhere. (See p. 153).

Correct management calls for feeding that will secure the requisite growth within a reasonable age, for steady and continuous rather than fitful development, for that amount of exercise that will insure the requisite amount of muscle in the carcass, and for that degree of finish that gives the desired firmness and thickness to the carcass without excess in either of these.

The most desirable weights in high class bacon run from, say 160 to 220 pounds. Other things being equal, the lighter weights are preferred. These weights should be attained in from six to seven months. To reach them more quickly would involve feeding that would produce meat with an excess of fat and softness. To produce them more slowly would cut in seriously on the profits.

Unless the growth is steady and continuous, the desired weights will not be attained. It should average about 30 pounds a month during each month. Of course it will not average that much the first three months, but will average more during the months that follow. Food that will produce very quick development, especially during the later stages of growth, will produce meat more or less lacking in firmness.

Exercise is essential to the development of muscle. Too little exercise accompanied even by ordinary feeding would result in the production of too small a percentage of lean meat. The bacon carcass should possess not only a large proportion of lean in the sides but also in the hams and elsewhere. Too much exercise will retard growth unduly. Because of the exercise which it furnishes, the pasturing of bacon swine during the season of growth has an important bearing upon the development of muscle.

With bacon swine, the fattening or finishing period is less pronounced than with the other types of swine. It is more a firming and thickening of the carcass than a fattening of the same, and yet it is not to be understood that a bacon carcass is synonymous with a lean and thin carcass. The finishing of bacon is accomplished through feeding foods which contain a reasonably high percentage of protein and carbohydrates, but not an excess of either.

During pregnancy and the nursing period that follows, the food fed to the bacon and lard types of swine is essentially the same, that is to say, in both instances it should be essentially nitrogenous in character (see p. 124). But during the growing period subsequently to weaning, the bacon types call for food more nitrogenous than the lard types, and during the finishing period the food fed to the former should be considerably less carbonaceous. Leguminous pastures are in order. Corn may form say 33 per cent of the grain fed while the swine feed upon such pastures. During the finishing period it should not furnish more than that proportion of the same. Skim milk and barley furnish an excellent ration for growing bacon, and no grain furnishes bacon of a higher quality than barley if fed as the sole or principal food during the finishing period. In the absence of skim milk, shorts is one of the best substitutes, while skim milk, shorts and barley are particularly excellent when fed in reasonable combination. These are the standard foods fed in Denmark, so justly noted for the high quality of its bacon. Other grain, as peas, oats and rye, when available, may be fed along with barley and with much success.

CHAPTER XVIII.

CONSIDERATIONS THAT RELATE TO MILK PRODUCTION.

Prominent among the considerations that relate to milk production are the following:—

1. Formation of milk.
2. Composition of milk.
3. Foods and milk production.
4. Milk production and cost.
5. Quantity in milk production.
6. Quality in milk production.
7. Breeds and milk production.
8. Lactation and milk production.
9. Age and milk production
10. Large and small cows.
11. Relative milk giving capacity.
12. Protection for cows in summer
13. Shelter for cows in winter.
14. Feeding grain to cows on pasture.

These are discussed in the order given.

Formation of milk.—As has been pointed out by Armsby, milk is not simply a secretion from the blood, as urine is in the kidneys, or as the digestive juices are in the stomach and intestines. That it is not a transudate, that is a variant, a filtrate of the blood, the result of the passage of its fluid constituents through membrane, is shown in its composition. Milk differs from blood: (1) In that it contains factors not found in blood; (2) in the marked contrast in the ash in blood and milk respectively and (3) in the sustaining power of each. Cow's milk contains from 2 to 5 per cent protein, and from 3 to 5 per cent milk sugar. But the protein of the blood exists as albumin or fibrin, while the greater portion of that in milk exists as casein, which is found in considerable quantity only in milk. Milk sugar has not been met with elsewhere in the animal organism. The ash of milk contains from three to five times as much potash as soda, while the ash of blood contains from three to five times as much soda as potash. Milk, therefore, cannot be a secretion, in the ordinary use of the term. Moreover, milk contains within itself all the essential constituents for sustaining animal life and in due balance which is not true of blood.

Milk is secreted in the mammary glands. It is formed in the milk glands and from the cells of the same. That its formation shall be possible, it is essential that the animal which has not heretofore produced it shall become pregnant. When conception takes place, the cells begin to enlarge and to fill with fat globules. New cells also are formed, a process which increases until the birth period, at which time it becomes very rapid. The secretions first formed are those also first drawn from the udder, and form the colostrum of milk (see p. 411). In three or four days, this is followed by the true milk. After a period in lactation, the glands decrease in size, and the milk flow is reduced, hence the necessity for recurring periods of pregnancy to secure corresponding periods of abundant milk production.

Milk elaboration does not proceed at a uniform rate between milkings. It is most rapid by far while the milk is being withdrawn. It is greatly accelerated by the manipulation of the udder in the act of milking, and is also much influenced by the nervous condition of the cow. The character of the manipulation exerts an important influence as well as the fact of the same, as is shown from the increase or decrease which frequently results from a change of milkers. The results from nervous influence are shown in the marked difference in quantity and to some extent in the quality of milk withdrawn by those whose work is gentle and kind, as compared with the same withdrawn by milkers harsh and rough.

That the quantity and quality of the milk are not dependent entirely on the food, is evidenced in the great difference in the amount and character of the milk from two cows fed on precisely the same kind of food, the other conditions being similar. These are determined by the size and quality of the milk gland. But the relation between food and milk is very close, nevertheless. The milk cells consist largely of protein. The fat also and probably a part of the milk sugar is formed from albuminoids, hence it is to be expected that their formation will be more or less dependent on the protein in the food. This logical expectation has been abundantly verified by experiments, which have shown that the most abundant milk yields have been obtained from a fodder rich in protein. Before leaving the subject, it may be said that, notwithstanding all that is known about milk elaboration, many things about it are not yet understood.

The composition of milk.—Milk is the opaque whitish liquid secreted by the mammary glands of female animals, and primarily designed for the nourishment of their young, but in every age, it has also been made to furnish food for the human family. In America about the only milk used for man is that taken from the cow, but the milk of sheep and goats and even of mares is also used thus in various countries. Cow's milk is easily digested, and contains in equilibrium all the constituents requisite for maintaining life and promoting growth in bovines and also in the human family, at least during the earlier periods of development. Notwithstanding considerable and even wide variations in the composition of milk from individual animals, the following may be given as approximately the average constituents of the milk of cows, sheep and mares respectively:—

ind of milk	Dry matter in 100 pounds lbs.	Digestive nutrients in 100 lbs. Protein lbs.	Carbo-hydrates lbs.	Ether Extract lbs.
From cows	12.80	3.60	4.90	3.70
From ewes	19.18	6.52	4.91	6.86
From mares	9.22	1.99	5.67	1.21

Because of the difficulty in obtaining samples, but few analyses of sow's milk have ever been made. At the Wisconsin station the average of nine samples gave the following in 100 pounds of milk: Dry matter 19.65 pounds, protein 6.4 pounds, carbohydrates 4.75 pounds and ether extract 8.24 pounds.

The protein is found in the above tables as casein and albumen, the proportions being as about 5 to 1. When the casein is coagulated, as by the use of rennet, it forms curd which is made into cheese. The greater portion of the fat also enters into the curd. The albumen does not coagulate, and in making cheese, along with the milk sugar, passes into the whey.

The carbohydrates are formed as milk sugar, which in chemical composition closely resembles cane sugar, but is not equal to the latter in sweetening power, and it is less soluble. It is thought to have about the same feeding value as an equal weight of starch. When milk sours coagulation is caused by some of the milk sugar being changed to lactic acid.

The ether extract, which is simply fat, exists in the form of minute globules, which are essentially a mixture of several fats. These are exceedingly minute, so much so that their number is almost incredible. When the milk is left at rest, these rise to the surface and form cream. They are also separated by what is known as the centrifugal system, which subjects the milk to a rapid whirling motion, at least soon after it is drawn from the cow. By churning the cream thus gathered, butter is obtained.

Whole milk is also rich in mineral matter. Were it otherwise, it would not furnish sufficient material for the further development of the bony structure in young animals. Cow's milk contains about seven-tenths of a pound of mineral substance in each 100 pounds of milk, spoken of as *ash*. It consists chiefly of phosphates and chloride of potash, soda and lime.

As a food for young stock, whole milk is without a rival. Substitutes are of course frequently used as supplements or substitutes for it, but none of these have been found to answer quite so well the purposes of rapid growth. This explains why it is so generally given without stint to young animals that are to be fitted for exhibition purposes, far beyond the usual age for weaning. Although by far the safest food for young stock, some caution must be exercised in feeding it, especially when very rich in fat, or digestive troubles may follow.

From the table it will be noticed that ewe's milk has in it a much higher proportion of protein and fat than cow's milk. This would suggest the wisdom of adding cream to cow's milk used in starting lambs quite young on the same, or of using strippings for such feeding. As mare's milk contains only about one-half the protein and fat of cow's milk, but considerably more sugar, when cow's milk is given to young foals, it should be diluted with water and sugar added. These additions may of course be reduced gradually as the digestion becomes accustomed to the change. Sow's milk is much richer in fat and sugar than cow's milk, hence it would seem prudent to add cream and sugar for a time, when cow's milk is substituted for the former with quite young pigs.

Foods and milk production.—To furnish milk economically the cow should be supplied with food: (1) In balance as to chemical constituents and of easy digestibility; (2) in quantity limited only by the consuming power of the cow; (3) obtained from sources relatively cheap and (4) possessed of at least a reasonable amount of succulence. The yield in milk production, other things being equal, will be reduced in proportion as these essentials are lacking. The Wolff-Lehmann standards recommend the following organic and digestible nutrients for milk production per day, in a cow possessed of 1,000 pounds live weight and producing 22 pounds milk daily:

Digestible protein	2.5 pounds.
Digestible ether extract	0.5 pound.
Digestible carbohydrates	13.0 pounds.
Total dry matter	29.0 pounds.

This gives a nutritive ratio of 1:5.7. In nearly all foods the inorganic or mineral constituents are sufficiently present to supply all the needs of the animals. The one common exception is salt.

The above constituents are much the same as those contained in good pasture grass, and this fact constitutes a strong presumptive argument in favor of its approximate correctness. Good pasture grass, when at its best for milk production, constitutes more nearly a perfect ration for cows giving milk than any single food that can be furnished for them. This is evidenced in the doubt that exists in the minds of many practical men as to whether anything can be added to such a ration, as grain for instance, that will make it more effective in producing milk. Good pasture for milk production may be defined as pasture so far advanced in growth that it will not induce under-laxity of the digestion, not far enough advanced in growth to make it in any marked degree less palatable or less digestible, and sufficiently abundant to supply the needs of the animals without calling for any unnecessary exertion from it while grazing.

The tendency with some American investigators, however, is to reduce somewhat the protein requirement in the food for dairy cows as given in the Wolff-Lehmann standards. Some of these favor a reduction of as much as 10 per cent of protein. This would make the digestible protein requirement 2.25 instead of 2.5 pounds per day, and would in no inconsiderable degree cheapen the ration. The wisdom of making such a reduction has found considerable support. The difference in the protein reqirement thus advanced for the respective countries may be owing to a difference in the condition of the foods as to the amount of moisture which they contain, or to some other difference. Nor should it be overlooked that heifers immature require more protein relatively than mature cows to aid in completing growth, and large milk producers more than those which produce less freely, since with the former more is required for the larger yield of milk furnished.

Much depends on the relative digestibility of the food. Concentrated foods as grain and the by-products of grain are not only richer in the per cent of nutrients which they contain, but the per cent of these digestible is also larger. This explains in part, why it is advantageous and even necessary to feed more or less grain or meal along with dry fodders. The cow is unable to consume enough bulky fodder to produce maximum milk yields, and with increase in the relative proportion thereof fed to cows, comes increase in the energy expended in digesting the ration. For instance, a ration that produces a given return on the basis of nutrients when 60 per cent of the nutrients are digestible, will not produce the same return if but 55 per cent are digestible. Nor should the same return be expected if the nutrients in the less digestible ration were increased so as to make the total digestible nutrients in the two equal. In the latter instance, there would be a diversion of energy in digestion from milk production to the mastication of the extra digestible matter in it, and in carrying the same through the various digestive organs. But, on the other hand, as a matter of economy and to maintain sufficient distension in the digestive organs, a certain proportion of roughage is necessary.

The necessity for feeding cows freely in milk production will be apparent when it is remembered that more than half the food fed in many instances is required as the food of maintenance before any return can be obtained for the same. Production can only begin from the food fed after this requirement has been satisfied, and is only limited by the amount consumed and the capacity of the cow to produce milk from it. The only limit to be observed in feeding cows applies to the relative proportion of concentrates fed. This should not be so high as to react in reducing digestive capacity, which will certainly follow prolonged and excessive feeding of concentrates (see p. 115).

That the aim should be to feed foods relatively cheap when efficient, does not require to be argued. But how to secure and feed them thus stirs a large and ever recurring question in the experience of dairymen. Grass and soiling foods, as well as dry fodders, are usually cheaper than concentrates, and therefore should be fed to the greatest extent compatible with the highest profit attainable. To secure this it may be necessary first, to sacrifice something in highest yields, attainable through feeding more grain, and second, to feed more carbohydrates relatively than the feeding standards call for, because of their greater relative cheapness.

That succulence in foods exercises an important influence on milk production has already been noticed. Why it does so is not so well understood. This relation is constant in the sense that it is always present, though varying in degree with the foods that contain the succulence. The influence thus exerted is greater with some foods than with others of equal succulence. The result follows probably from the favorable influence which they exert on the digestive tone, as when they lessen the tendency to constipation, and also because of the more favorable condition in which they are for being suitably acted upon by the gastric juices, because of their soft condition. Green corn is certainly more favorable to milk production than the same amount of dry matter in corn fed in the cured form, notwithstanding that the amount of water taken into the system should be the same in the two instances.

Milk production and cost.—The cost of producing milk will depend on such conditions as the following: (1) The value of the food fed; (2) the capacity of the cow to turn food into milk; (3) the season of the year at which the milk is obtained; (4) the cost of the plant and the value of labor involved.

So far as food is purchased, it is of course to be charged not at the value in the open market but at the price paid, with the cost of conveyance added. When grown upon the farm, it is to be reckoned not at the market but at the home value, which may be set down as approximately 20 per cent less than the market value under average conditions. This important factor should be taken into the account when studying the reports of experiment stations on animal production, as these usually charge food at market values.

Variations in the value of foods, the result of location and other conditions may make a difference of not less than 50 per cent in the cost of production. Fertility or the lack of this has an important influence on the cost of home grown foods. The proportion of roughage to concentrates fed, especially when succulent and nutritious, as silage, tends to cheapen production. In an experiment at the Utah station, the cost of maintaining a dairy cow for a year was $22.28; while at the Cornell university it was $45.25.

The influence of adaptation in the cow for production is, in some instances, greater even than that of food values on the cost of production. In the test referred to above at the Cornell university, the particulars of which are given in Bulletin No. 32, issued by that institution, there were 20 cows. The cost of producing 100 pounds of milk varied all the way from 44 cents to $1.07 per cow. The cost of food with the former was $43.12 for the year and with the latter $36.24. In the case of a very young heifer, the cost of producing 100 pounds of milk was $1.46, but because of her tender age she is excluded from the comparison. The cost of producing butter fat varied from 11 cents to 27 cents per pound. Excluding the heifer referred to, the yields of milk for the year varied from 3,387.75 to 11,165 pounds. To produce the former cost in food $36.24, and to produce the latter $52.06. Valuing the milk at 70 cents per 100 pounds, the difference in the net production would be $51.04 and in the cost of the food but $15.82. The wisdom of careful selection and close culling in the dairy are thus emphasized.

Experiments have shown that production costs more in winter than in summer, in keeping with the relative change in food values. The maximum of cost is usually reached in March and April, and the minimum in the early months of pasture. As winter approaches, the cost again increases. This does not mean that summer dairying is more profitable. It is usually less so, owing to the relatively cheaper value of dairy products. On the average farm it would be correct to say, that winter dairying, all things considered, is the more profitable and generally advantageous.

As the cost of the plant, that is, the cost of rent of land and buildings, cows and dairy utensils increases, so does the interest on the investment. The difference in this respect on cheap land and fertile, and dear land and not much fertile, is very considerable. The difference in wages may also vary materially in localities. The cost of transportation must be considered, and the difference here also may be material in the case of milk.

In the face of influences which thus vary, it is impossible to give mean averages of the cost of producing 100 pounds of milk, or one pound of butter fat. With a whole herd it has seldom been found possible during recent years to produce the former at a less cost than 50 cents and the latter at a less cost than 12 cents.

Quantity in milk production.—The influences that affect quantity in milk production include the following: (1) The food fed; (2) the breed or grade; (3) type; (4) inheritance; (5) size; (6) age; (7) time from calving; (8) exercise; (9) discomfort arising from any source, and (10) habit in milk giving. It is not possible to state the relative degrees of the influence thus exercised, since it will vary with variation in the attendant conditions.

That the food fed exercises a most potent influence on the quantity of milk produced is evident from the fact, that though all the other influences should be present in the most desirable form, the quantity of milk produced can only be proportionate to the suitability of the food ration. The essentials in foods favorable to milk production are: A high relative protein content, enough of succulence, sufficient concentration, and at least a reasonable degree of palatability.

The influence of the breed or grade on milk production, more especially with reference to quantity in production, is recognized in the classification of cows, as dairy, dual purpose and beef breeds. This classification carries along with it the thought that the class first named possesses dairy qualities in the highest degree, including, of course, quantity in milk production. Experience in grading has also shown that the influence of breed on production in the grade is so marked, that a limited number of generations of up-grading will so effectively enstamp milking qualities, that these will bear a close resemblance to the same in the breed from which the sires have been chosen. When accompanied by careful selection, this result should follow within, say four to six generations of careful breeding. For the standing of the dairy and dual purpose breeds with reference to production see page 135.

That type or form exercises a most potent influence on quantity in milk production cannot be questioned. (See p. 143.) It is possible nevertheless that some writers on dairy form have assigned a higher relative value to it, as generally outlined, than it is entitled to, and that some breeders have sought it to an extent that has led to a lessened production. The most that can be claimed for it is, that it is an indicator of quantity in milk production, so reliable, as to furnish a reasonably safe general guide when selecting or judging dairy cattle. That it is not an infallible guide is shown first, in the inability of the best judges to certainly determine the rank of the various animals in a dairy nerd in the order of tne relative milk yields obtained from each. This inability is based on the fact that highest type, as based on generally recognized interpretation, is not always associated with highest milk yields. Second, with some breeds, notably the Brown Swiss, large milking capacity is associated with some indications of form, notably strong shoulders and heavy hams, that are usually looked upon as being antagonistic to large milk production.

Furthermore, some essentials of the recognized dairy type in what may be termed the extremest form, are to some extent antagonistic to the retention of the highest degree of inherent stamina. These include thin, and long necks, sharpness and steepness at the withers and downward spring of rib, beyond a certain degree. Extreme in degree, these point to and are associated with a vitality not of the strongest and most vigorous type. Some regard must be had then to the law of equilibrium in dairy form, even though it should be necessary to sacrifice something in milk yields in order to maintain it.

The influence of inheritance on quantity in milk production is very potent. As with all other forms of transmission, such inheritance is not invariably uniform and certain, but it is sufficiently so to enable the skillful breeder to maintain high averages in milk yields, and even to increase them. In up-grading, the increase from such transmission is most marked.

That there is a relation between large size up to a certain limit and quantity in milk production cannot be questioned. What may be regarded as phenomenal milk yields have nearly all been made by cows of large size. Such a result is in harmony with the known laws of physiology, as, with increase in size, other things being equal, there is increase in capacity to take the food from which milk is made. The proportion of the food nutrients diverted for maintenance is also relatively less. The relation between size, milk production and cost is discussed elsewhere. (See p. 433.)

That age influences production is potent to everyone conversant with dairying. During the first years of lactation, general experience has shown that the milk yields, though advancing from year to year toward maximum, are lower than maximum, and that when the meridian of vigor is passed, they gradually decline. The time required to reach maximum yields and to maintain them, varies with such influences as individual vigor, based upon individual or breed inheritance, care and management.

In nearly all instances maternity is a pre-requisite to milk production in any degree, and in all instances, it is a pre-requisite to the same under normal conditions. Uniformity in the quantity of the milk flow cannot be maintained for any considerable period.

The largest milk yields are obtained during the weeks which follow the first week or two subsequently to parturition. They then gradually decrease, howsoever suitable for milk production the food may be, until finally they cease entirely. The duration of the period of lactation is influenced by several conditions and may be greatly prolonged but it cannot be maintained indefinitely in the absence of the renewing influence of maternity. (See p. 429.)

Exercise, in so far as it tends to maintain normal vigor, is favorable to increase in the amount of milk given. When, however, it draws upon the energies beyond the necessity mentioned, it tends proportionately to reduce milk yields. Cows in milk do not call for much exercise when kept under proper sanitary conditions. Every step taken in pastures when grazing beyond actual health requirements, tells so far adversely on milk production. When given it should always be gentle in character.

Discomfort to cows during the period of lactation may arise from many sources. Prominent among these are: (1) Exposure to the extent of producing unrest whether from cold or heat; (2) irritating influences such as lice, mange and flies; (3) irregularity in feeding, watering or milking and (4) disturbance of equilibrium in the nervous system. Anyone of these influences acting singly when present in any considerable degree may result in a marked reduction in the milk yield. For the discussion of the influence of cold and heat see pages 439 and 436.

In a well ordered dairy, lice and mange may give but little or no trouble. In fact where cows are not bought in to any extent, they may never be present. Not so, however, with flies (see p. 437). From the two sources of irritation first mentioned, they may with the exercise of due precaution be protected, but no precaution of an entirely practical nature can altogether protect them from flies. The remedies for such visitations do not come within the plan of this work, but the absolute necessity for removing lice and mange when present, or any other form of skin disease, is emphasized, as also the wisdom of protecting from flies as far as practicable.

The absolute necessity for observing the strictest regularity in furnishing food and drink to cows, if highest milk yields are to follow, cannot be too strongly emphasized. It has not been shown that the hour for giving food or drink exercises any special influence, providing the time is the same from day to day. Of course such hours should be chosen for giving food and drink as will best suit the purpose of the individual, providing they do not interfere with the natural season in which the cow is accustomed to rest. Two feeds a day, ample in quantity, have been found quite as satisfactory as three. When these are given twelve hours apart, it is reasonable to suppose that equilibrium in digestion will be more perfect and more easily maintained, than when the intervals between feeding are of unequal length. When they are unequal, the digestive organs are more severely taxed during the shorter interval, and in proportion as it is shorter. But regularity in feeding is more important than duration between the periods of feeding or even the number of feeds per day. Irregularity in milking interferes with function in the milk gland. (See p. 480.) When milk is being elaborated in large quantities, the retention of the same beyond the usual time produces discomfort. No more certain method of reducing the milk flow can be adapted than that which withdraws the milk from the udder at irregular intervals, and the reduction is further increased when the milk is not all taken from the udder, a neglect of which careless milkers are frequently guilty.

Milk elaboration is more or less influenced by the nervous system preceding and accompanying such elaboration. Nervous calm is favorable to the process, and nervous unrest unfavorable. This explains in part at least why it is so harmful to chase cows in milk with dogs. It also explains why noisy and rough herdsmen, even though not necessarily cruel, cannot bring the herd up to highest possible capacity in milk-giving. It also makes it plain why gentle milkers who are uniformly so when milking, will get more milk from cows than those opposite in their ways.

The influence of habit on quantity in milk production is shown in various ways. Among these are the following: (1) In the tendency in the average cow that suckles her calf to produce no more milk than the calf can utilize when the feeding is not forced; (2) in the relatively short period during which she provides food for her calf and this period usually does not cover more than six to seven months; (3) in the relatively large quantity of milk produced by the average dairy cow properly cared for; (4) in the difficulty frequently found in drying off good dairy cows to give them a period of rest before calving; (5) in the great increase in milk production that may be obtained even from a cow possessed of what may be termed the beef form, through patient, persistent milking from year to year. The relation between the influence of habit on quantity in milk production and inheritance is close. The same may be said of the various influences that offset quantity in milk production. In fact they are in a sense a more or less complicated inter-related whole, which react upon each other, so closely that it would be impossible to tell the degree of the influence that should be assigned to each.

Quality in milk production.—Quality in milk relates chiefly to its composition as to constituents, also to taste, flavor and color. The more potent of the influences which affect quality in the milk of the cow and also probably in that of other domestic animals are: (1) Food; (2) breed or grade; (3) individuality within the breed or grade; (4) the time of the lactation period and also of the milking season when it is taken from the udder and (5) quantity in the milk flow. The milk of mares is influenced to some extent by work.

Food affects quantity in milk to a far greater extent than quality (see p. 419). But it also affects quality to some extent with reference to constituents of the milk as to the proportion of the solids and other components which it contains, and in a greater degree, taste and flavor in the same. Food rich in protein may considerably increase the proportion of solids but the increase relates to other factors rather than to fat. This would seem to explain how the quantity of butter may to some extent be increased by correct feeding without increasing the proportion of the butter fat. The popular view that watery food increases the proportion of water in milk has not been sustained by experiments conducted to throw light upon this question.

That food exercised an important determining influence on the percentage of butter fat in milk was matter of universal belief until recent years. So deeply rooted is this belief in the minds of a considerable number of practical dairymen, that they still cherish it in the face of evidence based on experiment to the contrary. Many experiments carefully conducted have shown that while food may and does increase or decrease materially the total yield of fat, that it does not essentially increase or decrease the percentage of the fat. It is true, nevertheless, that if a cow has been fed so long on innutritious food that her condition as to flesh and bodily vigor have been greatly reduced, and if such food is supplanted by a ration rich in character, there will in time be some increase up to a certain limit in the fat in the milk. Under normal conditions there may be slight variations in the percentage of butter fat following a change of food, but these are more or less temporary in character. It is also true that food may in the course of generations exercise some influence on the normal quality of milk as to butter fat, as witnessed in the essential difference in this respect with reference to the milk of cows maintained on the bulky and watery foods of moist lands of the Netherlands, and those maintained on foods less bulky and watery as grown in the Channel islands. But selection also with the cows in the two countries has had its influence. How much is to be attributed to each can never be known. Food also influences the mechanical condition of the butter fat and to some extent its chemical condition, as shown in its keeping qualities. Some foods, as cottonseed for instance, render butter more firm, and others as oil cake when fed in very large quantities, render it less so.

The influence of food also extends to taste, flavor and color. Taste and flavor are so closely allied, that usually if not indeed always, what influences one also influences the other. Among the foods that influence both favorably are fresh succulent grasses, nutritious in character. Among those that influence both unfavorably, when eaten in large quantities are rye and rape among pastures; turnips, rutabagas and the tops of these, and to less extent potatoes among roots and tubers; and leeks (*Allium tricoccum*) and penny cress (*Thalsapi arvense*) among weeds. The taint thus imparted to the milk extends also to the butter. Color in milk is more influenced by breed than by feed as shown below, but it is true also that foods which furnish the most palatable milk also furnish it of good color.

Breed influences the constituents of milk more probably than anything else, with the exception of species. The difference in the components of the milk of mares and of cows is greater than the difference in the same between cows of one and the same breed. Some breeds produce milk with a higher percentage of butter fat than others. The difference is marked, averaging in many instances as much as 1 per cent. Milk richest in butter fat comes from the Channel island breeds. Breed also affects color in milk and in some degree taste, since increase or decrease in percentage of fat influences taste. Taste may vary in individuals, but, usually the more fat the milk contains, the more agreeable is the taste considered. The bright straw colored tint in milk increases with the percentage of fat and *vice versa*. The influence on color extends also to butter made from the milk. The Guernsey breed is proverbial for producing butter that is rich in color, that is butter of a bright yellowish hue. The influence of grade on milk in the cows is the same in kind as that of breed but less in degree. This means for instance that the higher the percentage of Jersey blood in Jersey grades the higher relatively will be the percentage of fat in the milk. But not until quite a number of generations of Jersey grades have been produced will the per cent of fat in the milk test as high on the average as the milk of the pure Jersey, (see p. 41).

The difference in the quality of milk, more especially with reference to the amount of butter fat which it contains is sometimes greater within the breed or grade than it is between breeds. In extreme instances it may average as much as 2 per cent. The immediate cause is the character of the milk gland. One cow of the same age and breed, fed on precisely the same kind of food, and under exactly the same conditions, will furnish much less milk and milk also less rich in butter fat than another cow and no amount of forcing can make the former produce equal to the latter since the milk gland has not the same capacity for producing milk equal in quantity or quality to the milk gland of the other. But the primary cause must trace back to the variations which accompany inheritance.

As the time of calving is receded from, the quantity of the milk produced decreases more or less gradually. With such decrease comes an increase in the proportion of casein and to some extent decrease in the proportion of fat. The fat also contains a larger proportion of volatile fatty acids during the earlier periods of lactation, hence the butter made from it is more highly flavored.

The variations found in the percentage of fat in the same animal from whatever source they may arise are slight, compared with those found in milk as it is drawn from the udder. That first drawn is lowest in butter fat and the increase in the per cent of the fat is continuously progressive, the richest milk being taken last. The difference is in some instances considerably more than 100 per cent.

Quantity in the milk flow influences the proportion of solids in the milk. It may be affirmed that as a rule: (1) Large yields of milk from cows are more watery than small ones; (2) that milk is less watery as the lactation period advances and (3) that the longer the intervals between the milkings the more watery is the milk.

Breeds and milk production.—Breed influences: (1) Quantity in production; (2) quality in the same and (3) adaptation for production with reference to environment. It is by no means the only influence bearing upon any one of the phases of production just mentioned, but it does bear upon each of them sufficiently to entitle it to careful consideration when deciding upon the breed or high grade of the same that shall be chosen for dairying.

That breed influences quantity in milk production is well brought out in the considerably higher averages obtained from Holstein-Friesian cows as compared with the Jersey. The same is true of high grades of these respective breeds. The difference in this respect cannot be stated in percentages, owing to the great variations in individuality in single animals and in whole herds, the outcome of breeding, selection and other influences. It has been sufficiently recognized, however, by practical men, to influence them in establishing their herds. When milk is wanted for sale, as in cities, the preference has been in favor of the Holstein rather than the Jersey. The same preference has been shown on many farms where large quantities of skim milk are wanted for feeding swine and kindred uses. Of the four distinct dairy breeds in America, the Holstein, the Ayrshire, the Guernsey and the Jersey, it would be correct to say that the Holsteins rank highest for quantity in milk production, the Ayrshires second, and if there is a difference the Guernseys will rank third. The dual types, including the milking Shorthorn, the Red Poll, the Brown Swiss and the Devon, all rank at least medium in the quantity of milk produced, higher probably than the Guernsey and Jersey, and lower than the Holstein.

For quality in milk based on the percentage of the butter fat, the Jersey and Guernsey are unquestionably entitled to first place. If there is a difference in the balancing, it would probably incline toward the Jersey. Next in the percentage of butter fat comes the Ayrshire, and the Holstein stands lowest. Where cream and butter are the chief considerations, aside from the influences of adaptation to environment, it is very evident which of the breeds will best answer the purpose. Without additional light it would not be possible to classify the milk of the dual types in the order of richness in butter fat. The milk of each of these ranks at least medium in this respect. Like that of the Ayrshire it is equally well adapted to the production of butter and cheese. For the last named purpose, the milk of the Holstein also ranks at least medium. The milk of the Jersey and Guernsey are not so much used in cheese making as that of the other breeds named, not from any want of adaptation for such a use, but from the smaller relative yields frequently obtained.

The adaptation of breed to the environment should never be ignored. That relatively light breeds fare better on rugged lands and pastures extensive in production is now generally conceded. It is also generally accepted that the Ayrshire and the Devon have higher adaptation for stern climates than some at least of the other breeds.

The milk of high grades of all the breeds named has essentially the same peculiarities as that of the breeds in the pure form, but probably they do not possess these in the same degree. It would seem to be true that changing the quality of the milk produced is not so easily or quickly accomplished as changing the animal form.

Lactation and milk production.—With reference to milk giving it may be said: (1) That the period of the lactation exercises an important influence on production; (2) the milk yield is greatest a short time subsequently to the time of calving; (3) after a time it lessens gradually under normal conditions, until finally it ceases; (4) it is, of course, chiefly dependent on the food fed, but not entirely so.

Milk giving is dependent on maternity, first with reference to its possibility, and second, with reference to its renewal. The instances are exceedingly rare though not entirely unknown, in which cows can be made to produce milk in the absence of maternity. It is a provision arranged for by nature, whereby suitable food is prepared by the cow for her progeny to sustain it from birth until it is old enough to live upon other food. In cows left to the influences of nature only, it ceases entirely as soon as the calf is able to provide otherwise for itself, but, subject to man's control, it may be prolonged indefinitely within certain limits. Beyond these, no power or skill can prolong its continuance, hence the necessity for renewal from time to time through the production of progeny. Such renewal is customary with the cow, under normal conditions, about once a year, but frequently it occurs at irregular periods, owing to various causes.

The milk yield is greatest a short time subsequently to the time of calving. That it is not greatest at the time of calving is also a wise provision of nature, otherwise the calf could not take a sufficiently large quantity of the milk from the udder, in consequence of which disaster might result to the cow. When deposited beyond a certain quantity in the receptacles of the udder and not removed at such a time, milk fever and other ills may follow. The increase is gradual and continuous until maximum production is reached. The duration of this interval varies in cows and in the same cow, owing in part at least to the condition of the udder. The greater the degree of inflammation, which to some extent is frequently present at the time of calving, the longer is the time required. Usually maximum yields are reached in from two to three weeks from the date of calving.

Maximum yields having been reached, they remain normal for a time. This period is usually short, only covering a few weeks at the longest. Its continuance is dependent to a considerable degree on the food fed, but it would seem also to be influenced to some degree by inheritance and habit as well. Declension then begins gradually and continues at a ratio more or less regular, until milk giving finally ceases. Professor Sturtevant concludes that the average decrease in the milk yields from month to month is about 9 per cent.

While the absolute amount of milk produced is largely dependent on the kind and amount of the food fed, it is by no means entirely so. No amount of food fed to two cows practically equal in milk giving power, can secure from them equal milk yields, when one is considerably more advanced in lactation than the other. Milk yields are largely dependent on the activity of the milk gland, which is greatest shortly after parturition, and which gradually lessens until finally it ceases altogether. Food that is eminently suitable and persistent and careful milking may greatly prolong the milk-giving period in the absence of renewal in the natural way, sometimes to the duration of two or three years, but in such instances the yields become so small after a time as to prove unprofitable.

It is also important that the milk yields shall be well sustained during the normal season for milk-giving, by feeding liberal supplies of suitable food. Should declension in milk yields result at a period unnecessarily soon, from want of food suitable and sufficient in quantity, and should the attempt be made to advance the milk yields subsequently by giving proper food, it will be only partially successful. The yield may be increased but not to what it would have been under proper management. The increase possible would be proportionate to the extent of the declension in the milk yields, and to the duration of the period covered by such declension.

During the period of highest milk yields, the cow and also other females generally lose more or less in flesh. The loss in body weight is proportionate to the relative milk yields, but it may be affected to some extent by other influences such as inheritance and the nature of the food. As the milk yields decline, the lost weight is gradually restored under normal conditions, until it reaches the former level.

Age and milk production.—Milk producing capacity in cows may be divided into three periods, as follows: (1) The period which leads up to maximum yields; (2) the period of maximum yields; and (3) the period of declension which follows. These vary in individual animals and to some extent in breeds. A good cow properly managed should be profitable in the dairy for nine or ten years. This period, however, is longer than the average dairy cow is retained in the average herd. Assuming that the cow produces profitably for, say nine years, the three periods above referred to will cover three years each. The discussion that follows is based on the assumption that cows come into milk when two years old, which is usually the case with dairy cows.

During the first period; viz., from two to five years, there is gradual increase in milk-giving capacity. This increase is material, frequently amounting to considerably more than 50 per cent. The relatively low production during this period is caused in part by the diversion of food nutrients to promote increase in growth. This, however, does not furnish a complete explanation, as milk production increases more relatively than weight, and it continues for a time after increase in weight has ceased. It would seem fair to assume, that there is increase in capacity of function in the milk gland, the outcome in part at least of use, on the same principle that use strengthens any other organ of the body up to a certain limit.

During the second period; viz., from six to nine years, the yields should not vary much, but toward the latter portion of the same, the tendency toward declension is accentuated in many instances. On the whole, however, the years covered by this period are those of the most profitable production in the cow, notwithstanding the greater activity of the digestive and assimilative functions during the previous period.

During the third period; viz., from nine to 12 years, the decline in production continues, although it is not rapid, not nearly so marked as a rule as the increase during the first period. The value of a cow in the dairy, therefore, is greater during the third period than during the first.

It is to be understood, however, that in actual experience, the variations may be considerable, owing to the way in which a cow is fed. The machinery of digestion may be driven at a rate so rapid through high feeding, that the first period may prove the most profitable, and that a cow's usefulness may be at an end before the close of the second period. In some instances maximum production may not be reached until the seventh year, in other instances it is reached at five years, and yet again production may be more profitable in the ninth year than in the eighth.

The relation between actual and profitable production is close and intimate. Actual production in the first period has been found by experiment to be less profitable the first period than the second, and more profitable the second than the third. In other words more food relatively is required to produce 100 pounds of milk during the first than the second period and less food relatively during the second than the third.

Large and small cows.—Authorities are not all agreed as to the relative profit from large and small cows, respectively. Such disagreement results probably from the observed fact that experience has shown that the bearing of size on production if operative at all, is much less so than that of various other influences apart from size, such as inheritance and individuality. The balance of testimony, however, favors the view that, other things being equal, large cows of the breed or grade are on the whole more profitable relatively than smaller ones.

Three experiments conducted by Brandl with small and large sows, respectively, gave the following results: The small cows gave less milk relatively than the large ones, and consumed more food relatively in making it, but the milk was somewhat richer in fat. The result last stated is in keeping with the general relation between quantity in milk production and the fat which it contains, (see p. 427). The large cows not only produced more milk relatively and absolutely than the small ones and on less feed relatively, but when farrow they proved more persistent milkers and sold at a greater relative profit per head, after having been kept almost a year. Fifteen of each class were included in the experiment, the average weight of the lighter cows being 979 pounds and of the heavier 1,205 pounds.

Woll gives a summary of the results of breed test No. 1, conducted at the Columbian Exposition in Chicago, 1893, and bearing on this question. The cows, 75 in number, are divided into three groups, and each group contained the same number of Jerseys, Guernseys and Shorthorns respectively. They are classified as light, medium and heavy. The cost of producing 100 pounds of butter fat with these respective groups was $17.93, $17.79 and $17.42.

The following facts are noteworthy: (1) The 25 Jersey cows entered in the competition at the Lousiana Purchase Exposition in St. Louis, 1904, were considerably larger in size than the average of the breed. They weighed 911.2 pounds on an average at the commencement of the test and 983 pounds at its close. These cows were used in a test of which economic production was a prominent factor. (2) The cows that have proved the world's record makers are considerably above the average in size. (3) The same is true of a majority of the cows entered in the various advanced registry associations.

While the difference in relative profit from large and small cows respectively is not large, it unquestionably belongs to those of large size. It is probably the outcome of the relation between size and the relative amount of the food maintenance required. This in mature animals is even more than one half the entire ration. Probably more than nine-tenths of the heat generated by the food goes to supply the loss through radiation, perspiration and respiration. The loss through radiation is greater relatively in the small than in the large animal, owing to the relatively larger body surfaces in the former.

But aside from relative milk production, there are some reasons why breeders should aim to produce relatively large rather than small cows for the breed. These include the following: (1) Good constitution and stamina are more frequently associated with well developed animals, including cows, than with those less well developed. (2) Uniformity in size should be the aim of the breeder as an evidence of good and skilful breeding, and the standard thus set should favor at least average size for the breed, as a guaranty of the absence of degeneracy. (3) Animals of full size, or rather more, take the market more readily than those under size, whether sold for the dairy or the shambles.

Relative milk-giving capacity.—But little information can be given with reference to the milk-giving capacity of any of the classes of live stock, except cows, that is based on American experience. Nor can it be said that the question is greatly important except in the prospective sense, that is, in so far as it relates to the possible sources other than cows, from which milk may be obtained. In discussing the question, therefore, something may be said: (1) Regarding the milk-giving capacity of cows; (2) the probable milk giving capacity of other domestic animals, as mares, ewes, and female goats, usually spoken of as nannies and (3) the probable sources of milk production in the future.

The difference in capacity in cows to give milk, is simply surprising. In well regulated dairies, 6,000 pounds a year per cow may be set down as the minimum of possible production. It would be safe to affirm that the average annual yield of all the cows milked at the present time in the United States and Canada is not more than half that amount. With individuals of some breeds and also of some grades, it is easily possible to obtain 10,000 pounds of milk a year without resorting to feeding unduly forced. For the facts regarding maximum production, see page 418, and for the discussion of the influences that affect quantity in production, see page 424.

While no data based on American experience with reference to the amount of milk produced by mares during lactation is available, the average amount given by a mare is fully equal to and probably more than that given by the cow which merely suckles her calf up to the period of weaning. Basing the amount of milk given on the increase in the weight resulting, the average foal will consume more milk than the average calf. It would seem probable, therefore, that mares could be so managed as to produce milk yields fully equal to those of cows. At the Wisconsin experiment station it was ascertained that through weighing the lambs, both before and after nursing, certain grade Shropshire ewes gave from 2.51 to 3.96 pounds daily. Experiments at the same station conducted similarly with sows of the lard types, found that they gave from 4.1 to 5.8 pounds daily. The tests were made at intervals during the nursing period.

Under American conditions, it is more than probable that the cow will continue to be the source from which the greater portion of the milk needed will come. Mare's milk is not likely to be used as food for man, if for no other reason than the much greater ease with which cow's milk can be drawn from the udder. The milk breeds of sheep in certain areas of West Central Europe are credited with giving in response to hand milking, fully 8 pounds per day soon after coming into lactation. But, should even greater yields be obtainable, as doubtless they could be under judicious management, it may be said that, under American conditions, ewe's milk is not likely to supplant cow's milk for the reason, first, that cow's milk is more readily obtained; second, it is more difficult to rear lambs under artificial conditions than calves, and third, the sheep is much liable to be preyed upon by dogs. It may be different, however, with milking goats which have been recently introduced into America. It is not improbable that, in the future not distant, many artisans on the outskirts of cities may yet each keep his goat to supply fresh milk for the family. They are much less dainty of their food than sheep, and are much less liable to be harmed.

Protection for cows in summer.—In summer cows require protection: (1) From the sun's rays when these are so warm as to produce discomfort; (2) from flies during the fly season and (3) from rain storms, cold, prolonged and severe. Neglecting to furnish any one of these will seriously lessen milk yields. While such protection is markedly beneficial to all classes of domestic animals, its importance is especially emphasized in the case of cows, because of the relatively high value of the milk product which they furnish.

Cows are, of course, protected from the sun's rays when they are furnished with shade. This may come from trees growing in the pastures, singly or in clumps, or in places accessible to them, by a cheap roof in the pasture sustained by poles and covered with straw, or by the stables in which they are kept in winter. Trees and roofs provided in the pastures answer the purpose until the season of flies. To shade from either of these sources during the continuance of the fly season, is the strong objection that they furnish breeding places in which flies multiply with great rapidity. This is owing to the droppings which accumulate in such centers in which the flies deposit their eggs. Because of this, shade furnished by the stable is preferable, since when properly provided it is cooler, and as shown below, flies may be in a great measure excluded. Basement stables are especially suitable for summer -rotection because of their greater relative coolness.

Absolute protection from flies in the fly season is not practical without excessive outlay in the materials used in spraying the animals, or in the labor involved in applying them, or in the two combined. Nevertheless very much may be done with profit to promote their comfort at such seasons. These methods of protection are adopted: (1) They are kept in stables during the day. These are thoroughly ventilated and yet kept so dark that flies do not care to stay, much less to work in them; (2) they are sprayed with some preparation offensive to the flies, either through its odor or its sticky character, with sufficient frequency to effect the purpose and (3) they are covered with blankets, light, coarse and cheap, and these are kept in place by elastic bands, so that the underline also is protected.

Of these three methods, the first is unquestionably the best, as it furnishes more of coolness than the other forms of shade, gives the most perfect of the three forms of protection from flies, and makes it easily practicable to give the cows supplemental food which is necessary during much of the grazing season. The chief objection to it is the labor involved in removing the droppings, but this is largely offset by the increased value of the same as compared with having it deposited in the pastures where much waste follows. Much may also be done to prevent the multiplication of flies by promptly removing all the manure from the yards in the spring, and by drawing daily or at quite short intervals that made subsequently and applying it when needed. A free use of lime in the yards is also further helpful. The methods of darkening and ventilating the stables, the mixtures used in spraying and the exact nature of the blankets are foreign to the design of this work and will be discussed in one that is to follow on the Feeding and Management of Cattle.

Gentle summer rains do not harm cows in milk while in the pastures. They may prove grateful to them. It is different with violent rains. Even though not cold, they are in some degree harmful. But most of all is exposure to long and cold rains harmful, and all the more so when these are intense. Such rains occasionally occur both in the late spring and the early autumn, lasting in some instances for three days at a time. Prolonged exposure to one such storm may result in a lessened milk flow which may not be recovered from for many days. The wisdom of housing milch cows at night as soon as the nights are cool enough to produce any discomfort, will be readily apparent.

Shelter for cows in winter.—The necessity for providing cows with suitable shelter in winter is based: (1) On the relative inability of the system to resist the influences of low temperatures when not in high flesh; (2) on the marked susceptibility of the function of milk secretion to changes of temperature, especially to those that bring cold, and (3) because of the favorable influence which furnishing such protection exerts on the economy of production.

The cow in milk usually carries only a moderate amount of flesh and but little fat. On the other hand, the cattle beast that is being fattened usually soon lays on a covering of external fat, which goes far to protect the system from the penetrating influences of cold. Expose a milch cow in moderate or lean flesh to cold beyond a certain degree, and soon she stands with the back drawn up as an evidence of her discomfort. The fat steer similarly exposed will show no signs of discomfort.

The susceptibility of the function of milk secretion to the influence of low temperatures is shown by the quickness of the reduction which takes place in the milk yields consequent upon such exposure, and by the constancy of the same. The effect of such exposure will be manifest in the shrinkage in yield in the first milking following, and in every succeeding milking during the continuance of the exposure. If continued for a period of considerable length, the result will be that the yields will not become normal again, though the cause of the reduction should be removed. It is probably caused to some extent by the relaxed and somewhat reduced condition of the system consequent upon maternity, and in part by the diversion of a portion of the nutrients that would otherwise be concerned in making milk to the defense of the system against the cold.

In an experiment conducted at the Indiana experiment station, it was found that the cows that were housed during the 48 days of the experiment, gained in flesh considerably, while the latter lost flesh. The former also gave considerably more milk on less feed. Professor Plumb, who conducted the experiment, concludes that a saving of $4.26 per cow was effected by the shelter furnished, notwithstanding that the cows exposed were given the protection of an open shed in a sheltered place, and that they were not confined to it daily for a longer period than eight hours in the warmer portion of the day.

In view of the above, the following practices are to be deprecated: (1) Allowing cows in milk to roam through corn stalk-fields in winter in search of what is at best inferior milk producing food; (2) allowing such cows to remain out on pasture after the nights begin to turn cold or even during the day in weather that produces discomfort because of its inclemency; (3) allowing them to stay in the yard during the larger portion of even mild days in winter, because of the fact that they rest more contentedly in their accustomed stalls.

The nature of the protection required will depend upon such conditions as the character of the climate and the cost of providing it. The question cannot be discussed here further than to say, that it matters not what the nature of the materials may be which furnish it, providing it secures a temperature between 40 to 60° in winter, ample light, freedom from dampness and a constant supply of pure air. It should also be mentioned that cows not in milk gather more reserve power for the milking period which follows when given large liberty and more exposure during the non-milk-giving interval.

Feeding grain to cows on pasture.—The discussion of this question involves the consideration: (1) Of the direct return in milk and butter fat from feeding the grain; (2) the residual effect from such feeding; (3) the saving effected in the pasture and (4) the influence on fertilization. Notwithstanding that several trials have been conducted at various experiment stations, practical men are much divided in their opinions with reference to the advantage from feeding grain to cows on pasture.

Judged by the direct results obtained from feeding grain to cows on succulent and abundant pastures, the conclusion would be reached that there is no profit in such feeding. In nearly all the trials made there was increase in the milk yields and consequently in the butter fat, but not in the percentage of the same. The increased return did not in all instances pay for the grain, but it did in some instances. Little or no direct profit, however, resulted. But there was more increase in weight from the animals to which grain was given, which so far meant a laying up as it were of reserve power in the system, to be utilized in future production.

By the residual effects from feeding grain to cows on pasture is meant the influence which such feeding exerts on future production, more especially on production the following season. An interesting trial was conducted at the Cornell experiment station in order to throw light upon this question. Six cows which had been fed grain somewhat freely the previous summer and six that had not been so fed were grazed in the same pasture. In the test now considered no grain was given to either lot. The return from the lot which had been fed grain the previous season was 16 per cent greater than that from the cows in the other lot. The heifers in the grain-fed lot also made better development, which meant the promise of superior future usefulness. These results coincide with the opinions of many practical men regarding the utility of feeding a light ration of grain to cows in milk through all the season of pasturing.

The saving effected in the pasture is in some instances an item of material importance, although in some of these trials it has apparently been lost sight of. It is fair to assume that a pound of dry matter fed in the form of grain will effect a saving of an equal amount of dry matter in the form of pasture. This would be of little or no importance where the pasture is superabundant, but when pasture is insufficient in supply as is frequently the case, the importance of such a saving would be material.

The influence on fertilization would also mean something. It would depend on the kind and amount of the grain or meal fed. If cottonseed meal or wheat bran were fed, the enrichment added in the droppings would be material. The advantage, however, from such fertilization, would be much less than would result from feeding the same amount of grain or meal to sheep that are being grazed.

The whole question may be summed up as follows: (1) When cows are first turned out on grass in the spring, grain feeding should be continued at least for a time because of the corrective influence which it has on the tendency to undue laxity in the bowels caused by the grass; (2) whether grain is fed or not during the weeks when grass is abundant and succulent, it should be fed as soon as the pasture becomes insufficient in quantity or dry in character; (3) that when pasture is abundant and succulent no direct profit will be obtained in the return in milk. But, (4) when the residual effects are considered on future production, the saving that is effected in the pasture, and also the results on fertilization, it would seem profitable in all or nearly all instances to feed more or less grain at all times to cows on pasture. The only exception would be, instances in which the pasture supply for the season exceeded the needs of the cows. But, the amount fed should, of course, be much less when pasture is at its best than at other times.

CHAPTER XIX.

CONSIDERATIONS THAT RELATE TO GENERAL FEEDING.

Prominent among the considerations that relate to general feeding are the following.

1. Generous feeding during pregnancy.
2. Feeding the first milk.
3. Food for maintenance.
4. Growth and future production.
5. Foods vary in adaptation.
6. Foods that influence digestion.
7. When to feed concentrates.
8. Proportion of concentrates to roughage.
9. Changing foods.
10. Adjusting foods and needs of animals.
11. Foods, home grown or purchased.
12. Relative food values.
13. Sustaining power of pastures.
14. Condimental foods.
15. The place for self-feeders.
16. Relative profits from domestic animals.

These are discussed in the order named.

Generous feeding during pregnancy.—The opinion has become widely prevalent that what may be termed high condition or fleshiness in the pregnant dam tells adversely on reproduction. It has been claimed that it tells adversely on the development of the young animal *in utero* and that it is the harbinger of trouble at the time of parturition. This opinion rests doubtless on the observed facts, that the progeny of very fat dams when born is of small size, and that trouble does arise more frequently with such dams and also with their progeny at paturition than with dams less fleshy. But it fails to take into account the source from which the fat has come, as is shown below. In discussing this subject, it will be safe to affirm: (1) That the food of dams that are pregnant should be generous; (2) that it should be richer for pregnant dams that are immature than for those that are mature, and (3) that when harm comes to such dams or their progeny from liberal feeding, it is because the ration is unsuitable in kind, rather than in quantity.

Dams that are pregnant should be fed generously for the following reasons: First, at such a time they are sustaining two animals. The food which results in development of the embryo comes, of course, from the dam. Otherwise she would utilize it herself as far as necessary to meet her needs. Second, because of the heavy drain upon the system of the dam in supplying the progeny with milk after birth. She is almost certain to loose flesh at such a time and all the more so if she is a generous milker. This loss in some instances is not less than 100 pounds within say 150 days of the time of calving even though the feeding is generous. This means that to some extent she draws upon certain of the organized constituents or materials of her system, particularly the fat to furnish food for her young offspring. The more fleshy she is at the time of parturition, the more of this reserve is there to draw from, the less will she suffer from emaciation, and the more generously will the progeny be maintained. Third, it is almost impossible to prevent some loss of flesh in a generous milking dam for a time at least, during the early part of the milk giving period, howsoever liberal the feeding may be. If such a dam is in low flesh at the time of parturition, the further loss of flesh which follows lowers her vital energies to such an extent that her progeny is not so well sustained, and her future usefulness is so far lessened. Her system must be built up again before profitable conception will follow.

When pregnant dams are immature, a threefold burden is put upon them. The first is, that of maintenance; the second, that of nourishing the embryo, and the third, that of further development. It is very evident that more food relatively must be given to such an animal than to one mature, and that it should also be richer relatively in protein to sustain properly the dual development that is required. With such a division of the energies of the system, poor feeding would be doubly harmful.

It would seem correct to say, that when pregnant animals are supplied with food rightly balanced as to its nutrients, and with proper adjustment between the roughage and concentrates, they are not much likely to accumulate flesh to the extent of working harm to themselves or to their young. It is when the nutrients are not rightly balanced that such harm occurs. This may and does happen, when sows for instance are fed mainly on corn while pregnant, or when cows in a similar condition are fed mainly on carbonaceous food, such as rye and corn fodder. In addition to possessing a large proportion of protein, the food for such animals should be of such a character as to keep the digestion correct. Constipation is to be carefully avoided. The judicious feeding of such supplements as bran, oil cake and field roots at such a time is to be strongly commended. Instances may also occur when the animals would become so fleshy as to disincline them to take enough exercise for the well-being of their unborn progeny, but usually this occurs only when the carbonaceous elements in the ration are in excess.

Feeding the first milk.—The properties of the milk first drawn from the dam after parturition are very different, in degree at least, from those which it possesses when normal. This milk, known as the colostrum, is more dense in its consistency and yellow in color than natural milk. The protein, that is the casein and albumen, in the first milk of the cow, is about five times the amount of these products in ordinary cow's milk and may considerably exceed the proportions named. But it is much lower in milk sugar and is also lower in fat. The composition of the first milk is a provision of nature to meet the needs of the newly born progeny. In addition to providing nourishment, it tends to cleanse the intestines, and thus to pave the way for the natural processes of digestion.

The importance of giving such milk to the young animal as its first meal cannot be over-estimated. In its absence, constipation is likely to follow, which will terminate fatally, unless relieved. No substitute can be given that will in every respect take the place of colostrum. Even though it is known that the dam is tubercular, it would be a mistake to withhold her milk from her young calf, until the processes of digestion have been properly begun. The laxative properties of the milk would seem to make such feeding safe.

But it sometimes happens that colostrum cannot be obtained from the dam of the young animal, as in instances when the dam dies while bringing forth her progeny. In such instances, if colostrum can be obtained from some other dam of the same species, it will usually effect the end sought. This, however, is seldom possible, hence, it may be necessary to administer some substances that will cleanse the digestive tract before any food is given. Castor oil is generally used for this purpose. The ordinary dose for a colt or a calf is an ounce; for a lamb, a teaspoonful, and for a young pig, about half a teaspoonful. Sometimes an injection of warm water will effect the end sought. In other instances, an injection should accompany the administering of the purgative, as the latter, especially in the case of foals, will not in all instances effect the end sought without such aid.

When accident occurs so that the dam's milk cannot be given, the substitute on which nearly all domestic animals must be reared is cow's milk. This differs materially in its constituents from the milk of other domestic animals. Cow's milk is much richer in casein and albumen, also in fat than mare's milk, hence, when it is substituted for mare's milk, it is customary to add one part water to two or three parts of the milk, and also to add a teaspoonful of common sugar to each quart of the milk thus diluted. Ewe's milk is much richer in protein and fat than cow's milk. When cow's milk is substituted, cream added is helpful as intimated previously, but the strippings from the cow will probably be even more suitable. Sow's milk is richer in all constituents than cow's milk, hence when the latter is fed to pigs quite young, the addition of some cream and sugar would probably make it more suitable for them.

It should be noticed, however, that such feeding applies to the first days and it may be weeks of feeding, rather than to giving the first meal. The additions mentioned will not make cow's milk to closely resemble colostrum in its properties. It only makes it to approximate the milk of other animals in its constituents under normal conditions, hence the wisdom of the treatment referred to when colostrum cannot be obtained.

Food for maintenance.—Food for maintenance means the amount of food that will keep an animal from gaining or losing when at rest, that is, when not producing in the form of meat, milk or labor, and when not taking more exercise than is really necessary in order to maintain health. It is frequently referred to as the food of support. To find the food for maintenance, as practically applied to animals of all classes and ages, furnishes a complicated problem, owing to the variation caused by growth and individuality. Because of this, experiments in regard to it have been conducted more frequently with mature animals. However, the following may be safely affirmed with regard to it: (1) It increases with reference to the total nutrients required with advancing age; (2) production is not possible, unless the food given exceeds the amount required for maintenance; (3) the profit from food consumed is proportionate to the amount of the same that is properly assimilated when suitable in kind.

That more food would be required for maintenance up to maturity is apparent, from the larger bulk in the animal economy to be maintained. That more is required also after maturity has been reached and as age advances, is evident as a result of the less perfect assimilation of the food consumed as the animal grows older. Individuality also exercises an influence, as animals of the same breed, sex and age, differ much in their ability to assimilate food. Armsby, quoting from German investigations, gives the following with reference to the food of maintenance called for to support 1,000 pounds of live weight with oxen and sheep: Oxen required daily, 0.6 pound digestible protein and 7.5 pounds digestible non-nitrogenous nutrients. The coarse wooled breeds of sheep required, 1.2 pounds and 10.8 pounds, and the fine wooled breeds, 1.5 pounds and 12 pounds respectively, of these nutrients.

That production of any kind is not possible unless the amount of food given exceeds the amount for maintenance is self-evident. Notwithstanding, the instances are frequent on the farm where the food of support is all that is required. Such is frequently the case with horses that are being carried through the winter. There may be instances when it is judicious to feed a quantity somewhat short of maintenance as when animals designed for breeding carry an excess of flesh, or when show animals are to be reduced temporarily, subsequently to the season during which they have been exhibited.

That the profit from the food consumed is proportionate to the amount that is properly assimilated, is also self-evident, hence the wisdom of feeding animals in excess of the needs of maintenance, according to the production required of them. Pregnant animals must be given more than the food of maintenance to develop the fœtus which they carry. Horses at work must be given food in excess of maintenance according to the work required of them. Cows in milk should be given all the suitable food that they can properly digest without overtaxing the digestion, and the same is true of animals that are being fattened. Growing animals should be given enough suitable food to produce full development and proper in kind within the shortest period that this may be attainable. To withhold rations from animals up to the limit stated is false economy. In the aggregate the amount thus lost in the maintenance of live stock is very great. More than half the food fed to live stock is used as food for maintenance.

Growth and future production.—If maximum production is to be obtained from domestic animals, they must be fed and managed at all times with reference to future production. This principle applies: (1) To the nourishment of the fœtus carried by the pregnant animal; (2) to periods of arrested development at any time prior to maturity; (3) to the growing of animals with reference to the production of milk, meat or labor; (4) to the foods used in making growth with reference to future growth, and (5) to the over-taxing of the physical powers, whether digestive or muscular.

Unless the young animal *in utero* is properly sustained through suitable food taken by the dam, it begins life with a handicap, which no food or care subsequently can ever completely overcome. The food and management of the dam, therefore, during the entire period of pregnancy will exert an influence on the producing capacity of the progeny during the whole of the life period. (See p. 124.) For the discussion of arrested development and the influences that result from it, see page 65.

If the heifer is to produce milk abundantly in the dairy during development, the habit must not be encouraged of laying on fat beyond a certain limit. But this idea in practice must not be carried to the extent of in any way hindering a vigorous and robust development. On the other hand, if the young animal is grown to furnish meat, good steady growth which carries along with it a reasonable amount of fat will influence favorably future production. If food is insufficient in quantity or nutrition, or excessive in both respects, the influence on future production will be unfavorable. Likewise if the growing colt is fed improperly for the end for which it is being grown, the results will be disappointing.

The influence which food has upon future development is very potent. Feed a young animal on food low relatively in mineral matter and protein and the framework is deficient and weak, while it carries too large a proportion of fat. The outcome is dwarfed development. Corn when fed to excess produces these results. This has been abundantly shown by experiments at the Wisconsin station and also in the experience of individual feeders. Swine grown largely on pasture, succulent and nourishing, as clover, alfalfa or rape, will make greater and more prolonged gains than those grown entirely on grains. Succulent foods also put cattle and sheep into that "sappy," condition of flesh that is favorable to quick gains and prolonged fattening. Present results, therefore, are not the only returns obtained by feeding certain foods. The skilled fitter of show animals feeds foods that will insure size, and enough but not too much of flesh to ripen the animal too soon. It is thus prepared for the highest pressure feeding, until within a reasonable time of the show season. Such feeding is reserved for the last spurt, as it were, since if this were done too soon, the necessary bloom, that is fine appearance, could not be maintained.

The influence of driving the machinery of the digestion at too rapid a rate is discussed elsewhere. (See p. 115, also p. 377). Overwork in the young animal hinders development and correspondingly hinders useful performance. Overwork in the mature animal lessens future usefulness and shortens the period of the same.

Foods vary in adaptation.—Foods vary in their adaptation not only for animals of the same class at different ages, but also for animals of different classes. Due recognition must be given to those variations by those who are to make a success of growing live stock. That foods vary in their adaptation for animals of the same class at different ages is self-evident, but the precise nature of the adaptation calls for careful thought and forethought, that a proper supply of each factor may be on hand when wanted.

It is important, for instance, that calves shall be given hay, fine and well cured. Cattle one or two years old may utilize, without any loss, fodders much coarser and rougher. To have a supply of such hay for calves, calls for forethought in growing the same, in cutting it at the proper stage of growth, in curing it, and in storing it so as to be accessible when wanted. The same is true of food provision in other lines.

The variations in foods for the different classes of live stock are much greater than for those of the same class. They are: (1) Such as grow out of the necessities arising from original bestowment; (2) such as relate to digestive peculiarities and the needs growing out of these, and (3) those which are at least measurably qualified by the nature of the production required. These are additional to variations called for by variations in age.

Nature made the ox graminivorous, hence, grasses and grains are the proper food of cattle. Likewise it made the pig omnivorous, hence, swine may properly be given a much wider range of foods than would be suitable for cattle. Animal food may be fed with advantage betimes to calves in the form of blood meal, but flesh is so foreign to the needs of cattle that it is ill-adapted to supplying these. Not so, however, is it in regard to swine. Tankage has proved a profitable food for swine, and it is possible to maintain them on the offal of slaughter-houses alone. Nature has made the sheep dainty as to the condition in which food is given to it, hence, unless good in quality, it will reject it, except under the pressure of hunger. On the other hand, swine will consume offal to such an extent that they may be regarded as scavengers.

The greater relative ability of cattle and sheep to digest bulky foods as compared with horses, and especially with swine, is discussed elsewhere, (see p. 456). Experience has shown that meal is best administered to cattle in the dry form, but to swine after having been soaked. It should be given to swine directly and without admixture, whereas for cattle, it is deemed preferable to mix it with a certain amount of more bulky food. Nearly all kinds of grain are ground before being fed to cattle, a process of preparation not deemed necessary when feeding them to sheep.

The kind of production called for has a powerful influence in determining how foods may best be used. Timothy hay, for instance, has high adaptation for feeding horses, since it is well adapted to furnishing heat and energy, and is not so laxative as alfalfa and some other foods. As a fodder for horses, it is considered inferior to clover. For cows it is not considered equal to clover, and for sheep its adaptation is considerably lower, especially if coarse and harvested late. Succulent food such as soiling foods, corn silage and field roots, are admirable for milk production, also young grass, whereas to give the same in large quantity to horses when hard at work would be very unwise. In furnishing pasture such adaptation should also be studied. The rape plant, for instance, is probably without a rival in its adaptation in providing pasture for sheep, whereas, it is ill-suited to providing pasture for horses at work. The importance of using foods in the best line of their adaptation cannot be easily over estimated.

Foods that influence digestion favorably.—(1) Some foods in addition to the sustenance which they furnish, exercise an influence on digestion so salutary as to place their value as foods far away above what is represented by the nutrients which they contain and the digestibility of the same; (2) the influence thus exerted tends to correct the harmful results that grow out of constipation or undue laxness of the bowels, according to the kind of food; (3) because of this, when used mainly to give proper tone to the digestion, the real value of such foods is usually far above their market value; (4) when fed mainly for such a use, small and moderate rather than large quantities should be fed.

The list of these foods includes all kinds of field roots, as turnips, rutabagas, mangels, sugar beets, carrots, and parsnips. It also includes such by-products as wheat bran, oil cake of various kinds; such fodders as alfalfa and clover; such green foods as grass and rape; grass in different stages of maturity and condiments of a salutary character, as salt and mixtures that act as a tonic when fed.

All kinds of field roots, bran and oil cake have a tendency to relieve constipation and are possessed of highest value when fed with dry food, as straw for instance, in winter. The real value of these foods fed to animals on succulent pastures would therefore be much less than the value when fed with foods that tend to constipate. Alfalfa and clovers tend to correct digestion according as they are fed. When fed along with a food too constipating, they exercise some influence in correcting such a condition, but when fed along with green food such as tends to produce scouring, the effect is the opposite. Grass, rape and also alfalfa and clovers fed in the green form in suitable quantities all tend to counteract constipation, but grass more or less matured, on the other hand, tends to correct scouring. Salt, though not a food at all in the sense of furnishing nutrients, exercises, nevertheless, a salutary influence on digestion when fed in due proportion, (see p. 521). And the condiments referred to tend to stimulate the digestive organs to increased action (see p. 469).

The real value of such foods will vary in proportion to the extent to which they tend to correct digestion. When the necessity for such a correction is not present, the nutrients which they possess and the digestibility of the same is the true measure of their value. Because of this, the aim should be to feed them in a way that will add to their value. Field roots, for instance, may be fed to the extent of being a chief source of nutrition, but when so fed they will probably prove relatively an expensive food, whereas if they were fed in limited quantity as a corrective to digestion, they would be found relatively a very cheap food.

The wisdom, therefore, of feeding foods when thus used in moderate quantities will be apparent. The amounts required will of course vary with the necessities which each individual instance gives rise to, hence no hard and fast rules can be formulated in regard to feeding them. It would seem approximately correct to say, however, that from one-fourth to one-third of the amount fed on the basis of the nutrients contained, will usually effect the end sought. To illustrate: Should a dairy cow be fed 8 pounds of bran when bran is fed alone as the meal portion, from 2 to 3 pounds along with other meal would act as a regulator of digestion.

When to feed concentrates.—Nutrients in the form of concentrates are usually more costly than an equal quantity of the same in the form of roughage. The supply of the latter is also generally more abundant on the farm than the supply of the former. Because of this, practical growers of live stock have erred in the extent to which they have fed roughage and withheld concentrates. This is especially true in corn-growing areas where much of the fodder grown is never reaped, and in grain-growing areas where much of the straw grown is still burned. It is important, therefore, to know when to feed concentrates and when to withhold them.

It will always be in order to feed grain: (1) To foals that are nursing and especially at, and subsequent to the weaning period; (2) to dams that suckle them when not on pasture, plentiful and succulent and (3) to horses when at work. If the pastures are particularly good, nursing foals may do without grain without detriment, till toward the weaning season, but grain fed to them would not in any sense be wasted. With good protein fodders and corn ensilage in winter, nursing dams may require but little grain. The amount required by horses at work is gauged chiefly by the character and amount of the work done. It will usually be in order to feed a limited amount of grain to foals that are growing in the winter season, more especially during the first winter. The amount called for will depend chiefly on the character of the roughage fed, but the necessity for feeding more than 2 to 4 pounds per animal seldom exists. As a rule mature horses that are idle do not require grain until within a few weeks of the time labor begins.

It will in nearly all instances be found profitable to feed concentrates to cattle under the following conditions: (1) To calves that are being reared on skim milk and to all calves from the weaning period onward for a time; (2) to young animals that are being grown to furnish baby beef (see p. 402); (3) to cattle that are being fattened under all conditions of fattening; (4) to cows in milk during the entire period of lactation. A liberal supply will be in order for calves grown on skim milk (see p. 404), and those grown for baby beef should be given practically all they will consume without injury. The amount fed to cattle that are being fattened may be much reduced when they are on good grass, and possibly withheld for a time, (see p. 398). The necessity for feeding large amounts of grain to cows in milk on good pasture is still in a way, an open question (see p. 440), but it is about certain that to feed a limited amount to cattle that are being fattened and to cows in milk will be attended with some profit. It will usually be profitable to feed calves 2 or 3 pounds of grain per animal per day the first winter, and also the second winter, if they are to be finished on grass the following summer. It may not be profitable to feed grain to young cattle after the first winter where the grazing is abundant. It is not usually necessary to feed it to heifers intended for the dairy, except for a time, subsequently to weaning. Nor is it usually necessary to feed grain to cows not in milk.

Sheep will profit from being given concentrates under the following conditions: (1) It will always be in order to feed grain to lambs before the season of grazing and subsequently if they are to be sold as milk lambs; (2) to lambs for a time subsequently to the weaning period under arable conditions, unless they can be provided with rich pasture such as rape furnishes; (3) to pregnant ewes when in the yards and also after parturition and (4) to sheep and lambs that are being fattened except when grazed on rape. Milk lambs may be given all they will consume, and pregnant ewes a small allowance before lambing, but liberal feeding subsequently. Whether grain will be profitable if fed to sheep and lambs that are being fattened on rape, will depend upon such conditions as relative values. Shearling ewes do not usually require grain winter or summer, nor do breeding ewes ordinarily need it when on good pasture.

It will be found profitable to feed grain to swine at all times, with one exception. The exception is that of mature, brood sows on good pastures, when only one litter is required of them each year. Young pigs that are nursing and for some weeks subsequently should be given all the grain that they will take. Later when on good pasture, about half the normal grain ration that would be necessary were they confined will suffice. During the fattening period, they should be given all they will consume with a relish.

Proportion of concentrates to roughage.—In discussing this question it may certainly be assumed: (1) That roughage has a mission in addition to furnishing nutriment to animals; viz., the proper distension and enlargement of the digestive organs in all animals, especially ruminants; (2) that roughage is more plentiful relatively than concentrates and because more plentiful it furnishes nutrients relatively more cheaply than grain and (3) that because of the above the aim should be to utilize roughage to the greatest extent consistent with highest profit in the live stock so fed.

The necessity for feeding roughage to horses, cattle, sheep and swine is based on the need for proper distension of the digestive organs to enable animals to consume larger quantities of food than would otherwise be utilized. The necessity for feeding it in relatively larger quantities to ruminants than to horses or swine is indicated in the relatively greater capacity they have for storing it and also for grinding large quantites of it in the process of rumination to prepare it for digestion. When young animals are given too large a proportion relatively of concentrates during the growing period, for want of sufficient distension in the digestive organs, they are unable to take sufficiently large quantities of food and especially of roughage, compatible with highest production. This is evidenced in the want of largest attainable growth, even in swine that are reared entirely on a concentrated grain ration in addition to the food furnished by the dam during the nursing period. Such distension is of highest relative importance in the dairy cow, because of the necessity that requires her to consume relatively large quantities of food in proportion to her weight to properly sustain the milk flow. It is possible to sustain ruminants that are mature for considerable periods without apparent injury, as was shown several years ago in the experiment of Mr. Linus W. Miller of New York, who successfully wintered during several seasons dry dairy cows on a ration of corn meal and water. But that such feeding is practical is of but little economic importance, because of the greater cheapness relatively of roughage.

The greater plentifulness and subsequently greater relative cheapness of roughage arises, first from the fact that large quantities are furnished along with grain when growing the latter; second, large quantities may be grown and cheaply which furnish little or no grain relatively, as in the case of corn fodder grown thickly; and third, the entire grass and hay crops consist of roughage without grain, except when grown to provide seed for sowing. Roughage, therefore, will always furnish nutrients relatively cheaper than concentrates with rare exceptions. But this is in some degree offset by the higher relative digestibility of concentrates.

The wisdom of trying to utilize roughage to the greatest extent practicable will be apparent from what has been said. It is simply impossible to lay down rules that will apply in every case as to the proportion of roughage and concentrates that shall be fed respectively. Much must be left to the judgment of the intelligent feeder, but some things may be said that should prove helpful to the less experienced. These include the following: (1) Young animals including foals, calves, lambs and pigs should be provided with all the roughage that they will consume from the time when they begin to feed upon it to insure the requisite distension in the digestive organs; (2) to encourage them to take such food, it should be provided for them superior in quality and possessed of high palatability; (3) with animals grown for future breeding or labor the relative proportion of roughage to concentrates should increase until they are matured; (4) the proportion of concentrates to roughage in feeding mature horses may extend from none at all with idle horses to considerably more than 50 per cent in digestible nutrients with horses at hard labor; (5) the proportion with mature cattle that are being fattened or with those nearing maturity may run all the way between 33 and 66 per cent according to the character of the nutrients in the roughage and the duration of the feeding period; (6) the proportion with cows in milk may range between 33 and 50 per cent of all the nutrients, according to the nature of the roughage fed, but when on pasture it may be less than 33 per cent even to the extent of not feeding any; (7) the proportion with sheep that are being fattened should range between 33 and 66 per cent of all the nutrients, also based on their character and the duration of the feeding period; (8) the proportion with swine between weaning and fattening should be in the neighborhood of 50 to 65 per cent of all the nutrients, and for all other swine, save breeding animals when not producing, it should run from 75 to 100 per cent; (9) roughage fed in the form of legumes of high palatability lessens the requirement in concentrates in proportion as the former are fed; (10) this reduction may in some instances be fully 50 per cent, as when cattle and sheep that are being fattened and cows in milk are being fed freely on high class clover or alfalfa hay.

It is to be borne in mind that the figures submitted above are to be regarded as only approximate. They are intended to be general rather than specific guides.

Changing foods.—In discussing this question, it is safe to affirm: (1) That any marked change in the diet of farm animals should be made gradually; (2) that a change from dry food to pasture in the spring will result in a loss in live weight if made suddenly and (3) that changing from plentiful pastures in the autumn to dry feed will also result in lessened gains for a time, unless made with great care.

Sudden changes in the food given to animals are to be avoided, for the reason that the digestive system has in many instances shown that it is unable to accommodate itself at once to such a change, hence digestive derangement follows, which in all instances means loss. Such changes sometimes result in scouring, as when animals are changed suddenly from a dry to a watery diet, as for instance from winter to summer food, or when large quantities of field roots are quickly added to the winter ration, also when large quantities of the tops of field roots are added to the autumn pastures. Sometimes they induce constipation, as when changing from autumn pastures to a diet without any succulence in it. In other instances they overtax the digestion so as permanently to weaken it, as when animals unused to grain are too quickly led up to a full feed of the same. If the change is gradually made, after the lapse of a sufficient time, the system can digest without hazard or harm, quantities of the newly introduced food elements that would assuredly have produced serious digestive derangement had they been given at the first.

Moreover, such changes affect the quality of the milk of dams to such an extent as in some instances to be seriously harmful to the young which they are nursing. This may happen when the change is made to a diet that is well adapted to the production of good milk. Should brood sows, for instance, be suddenly put on abundant clover pasture when young and fresh, the danger is present that scours will affect the young that they are nursing. It sometimes happens also, that when ewes nursing young lambs are quickly changed from dry food to abundant pastures, the change in the quality of the milk and its superabundance lead to derangement in digestion so serious that death may follow.

When herbivorous animals are changed suddenly from a dry diet to one of succulent pastures, the change is probably accompanied in all instances by a loss of weight. This results from the lax condition of the bowels. This loss may be so serious as to call for three or four weeks grazing before the weight is recovered that was thus lost. Even though the change is made prudently with animals on a full grain ration, the gains will probably be lowered more or less for a time. Cows also will be reduced in flesh somewhat, notwithstanding that the milk flow may be greater.

The change, therefore, should be made from dry food to succulent pastures very gradually. It is considered good practice to turn cattle that are being given a full grain ration out on pasture just after the noon meal has been consumed, and to leave them on the grass for not more than an hour the first day. The period of grazing is then lengthened each day, and not less than 15 days should be covered in making the change. The grain ration is in the meantime continued, and the animals are encouraged to eat fodder suitable in kind. If, however, the fresh young grass is mixed with dead grass uneaten from the previous year's growth, the time occupied in making the change may be shortened, as the tendency to scouring will not be so marked.

A second method sometimes adopted is to turn the animals onto the pasture so early in the season that they cannot eat grass to excess, because it is not present in sufficient quantities. This method may be commendable in some instances with sheep, which are usually benefited by taking much exercise, but it is not to be commended in the case of cattle, as they injure the pasture by poaching. They hinder growth through too early cropping, and the over exercise taken by them is adverse to increase in flesh.

The change from autumn pastures to dry food is less difficult to make. If the animals have been given a daily supplement of dry fodder on the pastures before yarding them, the check to increase should be but little felt. A constipated condition of the bowels, however, should be guarded against by feeding some food, as oil cake or field roots in sufficient quantity to prevent such a result.

Adjusting foods to the needs of animals.—The proper adjusting of foods to the needs of the animals so that they will be fed with the greatest economy as to the utilization of food and the utmost benefit to the animals, requires much forethought and judgment on the part of the feeder. It calls for the adaptation of foods: (1) To animals of different ages; (2) to those of different classes and (3) to the purposes for which they are kept.

With reference to young animals during the milk period, in nearly all instances it will be profitable to supplement the milk with grain or meal that will promote the proper growth of bone and muscle, and to feed in addition, unless in the case of swine, fodder, the finest and most palatable that can be obtained. Subsequently to the milk period the grain ration should be increased and the quality of the other food maintained for several months. The period between the age of, say one year, and maturity in the case of foals and cattle, eight months and maturity in that of lambs, and three months and maturity in the case of swine, is the period when they can be fed most cheaply, because of the small amount of grain required relatively and of the extent to which the more coarse fodders can be fed. The only exception is in the case of mature animals that are not producing. When kept to that age beyond which the teeth begin to fail, then foods richer and prepared so as to reduce the labor of mastication are essential. It should also be noted that, viewed from the standpoint of age only, the necessity for foods rich in protein and mineral matters gradually decreases with advancing age, hence, the nutritive ratio widens proportionately.

With reference to the different classes of animals, it may be said that cattle and sheep can profitably consume larger quantities of bulky foods relatively than horses and swine, owing to the greater relative capacity they have for storing the same and to the better equipment they have for thoroughly masticating the food when preparing it for digestion. The average capacity of the stomach of the horse has been given as 19 quarts, of the ox as 266.9, the sheep 24.7 and the hog 8.5. To some extent, however, this is offset by the greater relative intestinal capacity of the horse and the hog. It follows, therefore, that horses require as a rule, more concentrated food relatively than cattle and sheep, and that because swine are not so well equipped as horses for masticating coarse fodders, they require a still larger proportion of concentrated food.

With reference to the various purposes for which animals are kept it may be said: (1) That horses at work call for increased concentration in the food fed with increase in the amount and severity of the work done; (2) that with cattle, the need for protein is greatest during the milk taking period, that the diet of cows in milk must be richer in protein and possessed of more succulence than that for cattle that are being fattened, and that the food of the latter must be increasingly rich in the main in fat producing elements as the fattening process advances; (3) that the same reasoning applies equally to sheep and swine and (4) that while swine between the weaning and fattening period can utilize pasture to much advantage the food should be concentrated and rich in protein during the former period, and in carbohydrates during the latter. It may also be added that mature animals not producing require but little grain, hence, the aim should be to maintain them on relatively cheap foods.

Foods home grown or purchased.—Whether the foods fed should be entirely grown upon the farm or purchased in part or in whole will depend upon several considerations. These include: (1) The relative area of the land holdings on which foods may be grown; (2) the relative values of foods; (3) the natural adaptation of the country for certain lines of production, and (4) the necessity for applying fertilizers from some outside source.

It is evident that where the holdings are small, the amount of live stock kept cannot be large, unless foods are purchased in addition to those grown. The purchase of foods to supplement those grown may in certain instances not only be necessary but also commendable. Nevertheless the fact remains that the profit from feeding home-grown foods should be greater than from feeding those purchased. It will probably be correct to say that the home value of foods is 20 per cent less than the value of the same on the market. In other words, other things being equal, a food can usually be grown for about 20 per cent less than it can be purchased, hence, the advantage to the grower and feeder of live stock of being able to grow all or nearly all the food which he needs. This should be his aim to the greatest extent possible, but of course all the food needed cannot be grown on small farms when they are heavily stocked.

The relative value of foods exercises an important qualifying influence on the amount and kinds that it will pay to purchase, and also on the conditions under which they may be fed. In some instances, as when the prices of food products are low, when live stock of suitable age and at moderate prices for feeding can be obtained and when the demand for the properly finished product rules reasonably high, it may be possible to buy both food and live stock and feed them at a profit.

Feeding sheep and cattle at stockyards and other centers has been made possible under the conditions named. More commonly such feeding has centered at various points in the Mississippi basin and in proximity to the great grain growing centers of the central west and northwest. Sheep especially from the western ranges have been thus fattened oftentimes in very large numbers and on screenings taken out of the grain and supplemented. Fattening animals thus, of course, effects a saving in labor. But, viewed from the standpoint of the influence which it exerts upon farming in states where it is practiced, it is open to the following objections: (1) It centers feeding at a limited number of points which should be done on the farm, because of the profitable employment that it would furnish to the farmers on many farms during the leisure season; (2) it consumes fodders and frequently grains drawn from the farm which should be fed on the same for its enrichment; (3) the fertilizer made at the various feeding centers is usually in a large degree wasted.

In certain sections, it is possible to grow one product in great abundance for a certain kind of feeding, while its best complemental food does not grow well there. Under these conditions, it may be profitable to buy that food which helps to balance the ration. In alfalfa areas in the western valleys, it may pay well, under certain conditions, to buy corn and other grain to feed with the alfalfa. In corn-growing areas where protein is much wanting, it may pay well to purchase some protein food as bran or cottonseed meal to feed along with the corn. In other areas which may be made to grow corn ensilage in food form but which produce grain shyly, it may be well to purchase the latter to add to the silage rather than to try to grow them.

When it is necessary to supplement the fertilizer made on the farm by purchasing fertility, this may sometimes be obtained more cheaply through foods purchased and fed than through purchasing the fertilizer directly. Where the soil is low in fertility, this may frequently answer the purpose much better than the application of commercial fertilizers, since the manure resulting will act as a mulch and also as a fertilizer when spread on the surface, and when buried it will furnish the soil with humus and also with fertility. Commercial fertilizer only enriches the soil. It does not act as a mulch nor does it supply humus. One of the best methods of enriching soil thus is by feeding to sheep on pasture some supplemental grain product, rich in fertilizing elements (see p. 398). The pasture may be composed of grass, clover or other plants sown for the purpose.

Relative food values.—It has been stated elsewhere that the aim should be to grow the foods fed upon the farm to the greatest extent possible upon the same. (See p. 463.) But it frequently happens that foods need to be purchased to make it possible to feed them in balance. It is also necesary in some instances to purchase them to make production profitable in the highest degree, because of the limitations in the variety of the foods grown in the locality. In such instances a due regard should be had, first, to the relative values of foods, and second, to their relative suitability for the end sought. In yet other instances, because of a difference in the relative values of foods, it may be profitable to sell grains grown upon the farm and purchase other products to feed in lieu of those sold.

A due regard must be had to the relative values of foods. These vary with the seasons. In one instance, barley may be low in price and corn relatively high. In another, the opposite may be true. This may be brought about by some peculiarity in the weather during the period of growth. One season is may be more profitable to purchase corn, another season, barley, and yet again rye. In some instances, oil cake may be freely purchased and fed with profit, and yet again the cost of this food may put it out of the reach of the feeder. The same is true of other by-products. In some instances bran may be purchased and fed with great advantage. In other instances it would be fed at a loss. But because of the favorable influence of bran and oil cake and some other products on digestion apart from their feeding value, it may be profitable to purchase and feed them in small quantity when the price gets beyond the value of profitable feeding based on the nutrients which these foods contain.

The relative suitability of foods purchased to the use that is to be made of them should be duly considered when purchases are made. The cheapest concentrate viewed from the standpoint of nutrients may not be the cheapest, because it does not contain the requisite nutrients to furnish a balanced ration along with the other foods already on hand with which it must be fed. In yet other instances, the food thus purchased may not be the cheapest, though it is the best balancer of the ration, because of its relative expense. Another food which does not furnish so perfect a balance may be cheaper because of its low price or because it exercises a favorable influence on digestion.

Grains may sometimes be sold with profit in order to purchase other foods to feed in their stead. The grower for instance may have an abundant supply of oats and be short of corn for feeding. Oats may be relatively high and corn relatively cheap. In such instances profit may result from selling oats and buying corn, rather than from feeding oats without corn. Another who is a swine grower may have an abundant supply of both corn and oats. Since neither of these fed alone is suitable for young pigs as the sole ration, and since the same is true of them when fed in conjunction, it will usually be profitable to sell a certain amount of one or the other of these grains and to purchase wheat middlings to be fed in its stead. That, of course, should be sold which will bring the best price. But when these exchanges, so to speak, are made, a due regard must be had to the cost of transportation of the food sold and also of that purchased.

Sustaining power of pastures.—The sustaining power of pastures is a question of much moment to the stockman. With reference thereto it may be said: (1) That it will be found to vary greatly with varying conditions; (2) that under average conditions, it may usually be greatly increased and (3) that the effort to increase the carrying power of pastures in this country has seldom been given that attention which its importance demands.

The sustaining power of grazing lands will vary with climatic and soil conditions, with the grasses that grow on them, with the method of grazing and with the fertilization bestowed. The sustaining power of the best grazing lands of the United States and Canada has apparently not been tested in a systematic way. It has been estimated that from 10 to 30 acres of land comprised in the western ranges are required to graze a mature cattle beast through all the season, practically through all the year. In striking contrast is the statement of Sir J. B. Lawes, to the effect that in a certain pasture in Leicestershire, England, which comprised 14 acres, 17 oxen were grazed throughout the entire season and that from 500 to 600 pounds of increase was secured from each acre. The averge fertility of the range lands referred to is probably greater than that of the Leicestershire grazing lands, the difference in the outcome being caused mainly by lack of rainfall. In support of this statement it may be mentioned, that Prof R. S. Shaw secured 904.8 pounds of increase per acre in one season at the Montana experiment station, from grazing young cattle on alsike clover pasture subject to irrigation.

A mixture of grasses will usually produce the largest amount of pasture, since these grow more or less at different seasons and they usually occupy the ground more fully than one variety. Such pastures, however, should be permanent in character, and they should only be made on soils good and naturally moist, and in localities favored with occasional rains during the period of growth, because of the expense and time required to secure them.

The method of grazing exercises a most important influence on the production of pastures. This is particularly true of pastures essentially composed of blue grass. In practice they are usually eaten too bare. When not cropped too closely, the covering of grass tends to shield the ground from the evaporating rays of the sun in summer, and from the severe freezing of the roots in winter. By prudent grazing, the sustaining power of pastures may certainly be considerably increased, but the author has not been able to find figures bearing on such increase.

Nor can data be found based on American experience to show the increase that may be obtained in pastures from suitable fertilization. Reasoning from analogy, however, it would seem correct to assume that the fertilization of pastures would increase production relatively as much as it increases the production of meadows in the same locality similarly treated. In many instances, the production of New England meadows has been increased two-and three-fold, by dressing them annually with compost, farmyard manure or commercial fertilizers, or with two of these or all three combined.

The prevailing pasture on arable farms in the northern and central states is blue grass, in the southern states, Bermuda grass, and in the Canadian Northwest, Russian brome. The claim has been made for all these, that in some instances one acre has been found capable of sustaining a cattle beast between the ages of one and three years during the period of grazing, that is for, say six months. This would mean that one acre of such grass would furnish from 300 to 400 pounds of increase. Usually, however, it would seem correct to say, that from two to three acres are required to carry one such animal through the season. One average acre of well-grown rape will produce from 200 to 250 pounds of mutton. One acre of irrigated alfalfa with a suitable grain supplement will make from say 600 to 900 pounds of pork in a single season, to be credited to the alfalfa.

It would probably be safe to affirm that under average conditions on arable farms, the sustaining power of pastures could be doubled, and that this would be possible of accomplishment in a way that would add much to the revenue accruing. Securing meat through pasture to a very considerable extent eliminates costly labor.

The little attention that has been given to increasing the sustaining power of pastures has doubtless arisen in a measure from the extensive character of the farming. Along with the advent of intensive farming, it is reasonable to suppose that the improvement of pastures will be given that increased attention of which its importance is deserving.

Condimental foods.—Condimental foods are certain preparations added to the usual food ration for longer or shorter periods. They are mixed with some kind of meal as a basis and certain ingredients added. Some of the latter are of the nature of spices, some possess medicinal properties and yet others possess both. Of the first class is ginger; of the second, gentian, and of the third, anise. They are thus blended and fed usually with concentrated food to increase the relish for the food and to tone up the system. As put upon the market they are proprietary, and are generally sold as "Foods" or "Stock Food," with some distinguishing name prefixed to indicate the ownership. In many instances, the claims made for them are extravagant, and they are frequently sold at a price unreasonably and unnecessarily high.

The foods more commonly used as the basis of the mixture are corn meal, wheat middlings, oil meal and locust bean, but other kinds of meal are also used, alone or mixed. The ingredients added more commonly include several of the following; viz., gentian, fenugreek, ginger caraway, anise, cumin, saltpeter, common salt, charcoal, and sulphur. Sometimes they include others of a similar class. It is absolutely necessary to use some common food as a base, otherwise the mixture would have so little bulk that it would not be practical to spread it over prepared food or to mix it with the same in order to improve its palatability. As the amount fed is usually not more than a tablespoonful at one time, and in some instances it is less, the necessity for such blending will be apparent.

At the present time, it is popular to write and speak against the use of such foods. The more vehement characterize them as absolute frauds. The more temperate argue that when animals are in health and provided with good wholesome food, condiments are not needed, and that since wholesome food is always accessible, they are never needed. As a result of various experiments conducted to test their worth, the conclusion has been reached in some instances, that they are practically valueless, and in nearly all instances that to feed them is unprofitable. In the judgment of the author, all three classes have erred in the conclusions reached. To grant the correctness of the first view would be to assume that no honest person could engage in compounding them, a conclusion that is not tenable as some of these foods have merit for certain lines of feeding as is shown below. To grant the correctness of the second view, would imply by parity of reasoning that foods are always good, that animals are always healthy, and that when members of the human family are ailing, they should use no stimulant or tonic to promote recovery. To grant the correctness of the third view would be substantially to sustain the correctness of the first and second views.

The author believes that these so-called foods as a rule contain ingredients that are seldom, if ever harmful, when judiciously fed to animals, and that on the other hand, they may be so fed that they will be helpful and in some instances profitable, dependent on the conditions that attend the feeding. They are appetizing, stimulating, and act as tonics, consequently, they should not be fed when animals are in good health. But when domestic animals are ailing, or unthrifty, a suitable condiment given to them for a time will frequently aid in restoring normal conditions. Some of these foods fed for a short time may prove very helpful in fitting yard horses for spring work, in stimulating the milk flow in a cow whose stomach is out of tone, and in toning up the digestion of cattle and other animals near the finishing period, when it has become deranged through over-heavy feeding. No sooner, however, is the object accomplished, than all such feeding should cease. Tonics long continued cease to be operative both in men and lower animals.

The findings of the experiment stations would seem to be based on the untenable view that they are foods, and they have so been fed to animals in good health. The idea of feeding them as foods is far from correct, as the amount of nutriment which one feed contains is not worth mentioning. But those who compound them have no right to complain, as they usually speak of them as foods.

Nearly all feeders of long experience use more or less of such ingredients, but not necessarily in the proprietary form. More frequently probably they buy two or three of the more important ingredients and compound them at home. Such preparations should cost less than proprietary foods, but the makers of the latter have a very great advantage in the opportunity they have to purchase wholesale. In any event it would seem that such foods should yield a reasonable profit to the owner when sold in large lots at not more than 5 cents per pound. It is not necessary to use more than a few pounds of the costlier ingredients to make 100 pounds of the mixture.

The place for self-feeders.—Self-feeders have been used in feeding cattle, sheep and swine, but more commonly they are used in feeding sheep. They are simply covered boxes of any desired length and width, but wider at the eaves than at the base. They are supported by legs or frames and may be stationary or movable. They have troughs along one or both sides as desired, the bottom of the trough being on a level with the bottom of the box, and of suitable height to allow the animals to eat without discomfort. The food comes into the troughs as fast as eaten, through an opening along the side, and just above the bottom of the box. Cattle are frequently fed in flat boxes with low sides, the meal or corn being replenished to the extent of always keeping food before them.

It has been found practicable to fatten live stock when fed thus, with results that have been, at least, fairly but not eminently satisfactory. It has been practiced more commonly at feeding centers, where animals are fattened in a wholesale way, and to a far greater extent with sheep and lambs than with any other class of live stock. The chief object sought is to save labor. The roughage fed in such instances is also replenished in suitable racks, so that it also is constantly before the animals.

To this method of feeding there are the following objections: (1) Animals may not be fed thus with safety until that time is reached when they are on full feed, that is on a full allowance of grain. To feed them in this way at the beginning would disturb digestion to their serious detriment (see p. 377). This period of preliminary feeding usually covers several weeks, in some instances one-third of the entire finishing period. (2) It is less economical of food. Animals fed thus will live chiefly on concentrates, and just to the extent that they do, they consume a less amount of roughage, which in nearly all instances, furnishes nutrients more cheaply than is furnished by concentrates. In areas where concentrates are relatively high and roughage cheap, as is usually the case where alfalfa grows at its best, such feed would add materially to the cost of increase. (3) The increase made is not usually quite so satisfactory as from the other system of feeding. Such has been the trend of the results of trials at the experiment stations. While taking the food, the animals breathe on more or less of the unconsumed portion, which makes it less appetizing for them and leads to decreased consumption. (4) Digestive troubles are less frequent when the food is proportioned out from meal to meal, and in quantity just sufficient to keep the appetite in tone. In this way surfeiting is prevented. The author found when feeding sheep at the Minnesota station, by the two systems, digestive troubles were much less frequent with the animals on a limited grain ration.

While it is quite practicable to fatten animals on unlimited feed, from what has been said above, it would seem undesirable to follow this method on the arable farm or western ranches, where alfalfa grows abundantly. Where animals and more especially sheep are congregated at feeding centers, and where screenings of grain are used as the chief concentrate in fattening, it may be the cheaper method. Finishing on the farm, however, is to be encouraged rather than at feeding centers, because of the favorable influence which it exerts on fertility, and also for other reasons, as furnishing employment in winter that should prove profitable, and utilizing coarse foods that may otherwise be to some extent wasted.

Relative profits from domestic animals.—The relative profit from producing milk, beef, mutton and pork has been discussed, and frequently to but little purpose. With reference to economy in production the following conclusions will be found correct: (1) Judged from the standpoint of the return in nutrients for food consumed, the cow is the most economical producer of food for man, but (2) the relative profit in producing milk or meat is in a marked degree the outcome of conditions, hence (3) under some conditions, the time is never likely to come when milk, beef, mutton, or pork cannot be produced at the greatest profit.

That the cow is a more economical producer of food for man, than the steer, the sheep or the pig, cannot be questioned, if considered only from the standpoint of the nutrients consumed in producing the same. Lawes and Gilbert have shown that in the milk of a cow giving 10 quarts of milk daily, there are 6.6 pounds of nitrogenous substance, 6.33 pounds of fat and 1.35 pounds of mineral matter produced in one week, whereas during a similar period a steer gaining 2 1-7 pounds daily will produce 1.13 pounds nitrogenous substance, 9.53 pounds of fat and 0.22 pound of mineral matter. The cow also produces 8.32 pounds of milk sugar for which there is no equivalent in the ox. The ox will call for as much food as the cow, if not indeed more, while thus producing. The showing made is strongly in favor of the greater economy in production from the cow.

It should be noticed, however, that the comparison relates to production from mature animals, which is, so far, against meat production. Meat is usually produced much more economically by the cattle beast not yet mature. It makes no allowance for maintenance while the cow is dry, which usually covers from one-sixth to one-fifth of the year. Nor does it consider the items of labor, which is greater in the case of milk production. The necessity also for meat in the human dietary, will make its production imperative in progressive communities.

That conditions largely govern profits in milk and meat production cannot be gainsaid. Under range conditions, meat is produced at a very low cost, whereas, in the very nature of things, milk cannot be produced at all under the same conditions. On the other hand, nutrients can certainly be produced more cheaply in the form of milk under intensive conditions, but even under these, much coarse food can be made into meat, not well suited to making milk.

That the time will never come when producing beef, mutton or pork under all conditions will be less profitable than producing the other classes of meat, or less economical, will be evident to the reflecting mind. A small flock of sheep, for instance, can be kept during the grazing season on the average farm on the food grown in by-places. This food in the absence of sheep would probably be wasted. The nutrients in mutton thus grown are furnished more cheaply than they could be furnished in the milk of dairy cows kept on the same farm. Again, suppose swine are grown largely on alfalfa pasture and fattened on peas which they harvest in the field, while being fattened, food nutrients will doubtless be furnished more cheaply in the pork thus made, than they could be furnished by harvesting the food and feeding it to other animals. It is not wise to conclude, therefore, that because as stated by Lawes and Gilbert, a mature cattle beast calls for 12 to 13 pounds of dry matter to make a pound of increase, and mature sheep call for but 8 to 9 pounds to make the same, growing mutton is under all conditions more profitable than growing beef. Under some conditions beef can be profitably grown where mutton cannot and *vice versa.* Again, there are conditions where either can be more profitably produced than milk or milk products. The important matter is to produce each of these products with reference to highest adaptation for producing them

CHAPTER XX.

CONSIDERATIONS THAT RELATE TO THE CARE OF DOMESTIC ANIMALS.

Prominent among the considerations that relate care of domestic animals are the following.

1. The feeder.
2. Regularity in caring for stock.
3. Water for domestic animals.
4. Amount of water required.
5. Furnishing water to animals.
6. Shelter from weaning onward.
7. Shelter for young animals.
8. Protection for stock in summer.
9. Temperature in stables.
10. The sources of litter.
11. The uses of litter.
12. Preparing and using litter.
13. Amount of exercise.
14. The season of breeding.
15. The dam at parturition.

These are discussed in the order given.

The feeder.—The importance of adaptation in live stock to the end for which they are kept, and to the environment surrounding them has already been discussed. (See p. 31.) It is further discussed on page 74. The advantage from feeding foods in approximate balance has also been pointed out. (See Chapter X.) But no matter what the adaptation may be, or the suitability of the foods fed, adequate results will not follow unless the feeder, who has the animals in charge is in every respect at least reasonably qualified for his work.

The qualifications of a feeder are many. They include: (1) Some knowledge of animal physiology and chemistry; (2) an industry and patience that are untiring; (3) a fidelity that is unswerving; and (4) an innate love for the work.

The feeder who has some knowledge of animal physiology is better qualified to adjust the foods fed to the needs of the animals than the feeder without such knowledge. He will understand better the necessity for maintaining relative adjustment between the proportion of concentrates and bulky fodders fed. He will also have a more correct idea of the treatment suitable for ailments and diseases not sufficiently important to call for the skill of the veterinarian. Some knowledge of chemistry will prove valuable in the compounding of the food factors of the ration and also preparing them for feeding. This does not mean, however, that some men are unable to make their mark as feeders without such knowledge. This has been done in instances not a few. But it does mean that, other things being equal, the feeder possessed of the knowledge referred to should succeed better in his work than the one not possessed of it.

The successful feeder must be a man of industrious habits. His work, like that of woman, is in a sense never done. Her ministrations to the needs of humanity are never ending and his likewise to the needs of the live stock which he feeds are continuous. Giving food and water to the animals which he has in charge, though an important part of his work, is by no means all of it. The necessity for attentions in various ways is ever present during his waking hours, and at certain seasons, as when animals bring forth their young, giving these attentions frequently deprives him of his accustomed slumbers.

In no line of work is fidelity of greater importance. This is owing to the ever present necessity of furnishing the animals in charge with food and protection. In some lines of work the neglect of one day may in a considerable degree be made up the next, but in caring for animals it is different; with them injury resulting from neglect is always attended with loss, and in many instances, it cannot be atoned for even by extra care subsequently. So important is fidelity on the part of the feeder that without it he cannot make a success of his work.

An innate love for the work is an important bestowment on any feeder, on the principle that a liking for the work in hand is a great aid to anyone prosecuting a definite line of work. Its importance is enhanced in the case of feeders by the influence which it exerts on the degree of the attention bestowed, and the character of the same, and on the self-control of the individual. The feeder who has no love for his work does it in a perfunctory way. Food is fed by rule regardless of the individual needs of the animal. He is much prone also to be impatient with waywardness in animals, in some instances to the extent of being positively cruel. The feeder who loves his work has a most careful regard to the individual needs of the animals. If any is to wait for a meal beyond the usual time, it will be himself rather than the animals under his care. He will be gentle, though firm in dealing with them. The animals in charge will go to meet him on his approach rather than flee from him as in the case of the other type of feeder. It has been said that feeders are born, not made, and there is a large measure of truth in the adage, but a love for feeding may also be cultivated to a marked degree.

Good feeders are always in demand. This is one of the lines of work which is never over-filled. It is shunned by many when deciding upon their life work because it is in a sense confining work. It calls for continued attention during much of each of the 365 days in the year, and it is exacting in the long hours called for and at certain seasons additional hours are taken from the usual time for sleeping. To such an extent is this line of work shunned by the average American youth, that his adventurous spirit prevents him from choosing it. As a result, it would seem safe to say, that a majority of those in this country exclusively engaged in feeding animals have come from certain countries in western Europe, especially Great Britain, Denmark, Holland and Germany. The demand for this class of work is likely to continue, indefinitely, and the remuneration will be more, relatively, than is paid for other lines of physical labor. The calling is also less subject to change than in any other line of work, since a change of feeders frequently brings with it more hazard than change in many other lines in which animal life is not a factor. The skilled feeder is practically assured of work, liberal maintenance, and in some instances competence through all the changes of the times.

Regularity in caring for stock.—The importance of regularity in everything that pertains to the keeping of live stock cannot be easily over-estimated. While this applies to every phase of management, it does not so apply equally. While giving food and salt irregularly are both to be deprecated, animals will take greater harm from irregularity in supplying the former. This source of hindrance to well doing is especially significant when it applies, (1) to the giving of food; (2) to the giving of drink; (3) to the milking of cows and (4) to the working of horses.

Opinions do not always agree as to the number of times that food should be given daily. This probably should be gauged by the age of the animal, by the nature of the digestive organs, and by the amount of work performed. There can be no question but that young animals should be fed more frequently when young than at a later period, owing in part, at least, to the greater activity of the digestive organs. Animals with relatively large stomach capacity do not of necessity call for food supplies so frequently as those in which such capacity is not so large. Two feeds a day have been found sufficient for cows, even when in milk, and also for animals well grown that are being fattened, though a considerable number adhere to the practice of giving a light feed of fodder in the middle of the day in addition to the morning and evening feeds, which should be given 12 hours apart, as nearly as may be found practicable. The stomach of the horse and pig being less capacious than that of cattle and sheep, would seem to demand three feeds per day, rather than two, and given as nearly as practicable six hours apart.

But there can be no disagreement with reference to the wisdom of giving food regularly. The digestive system of animals is such that it adapts itself at least measurably to the system of feeding adopted. To change that system for even a single meal, produces more or less of digestive disturbance in the animal, as in the individual. If food is not forthcoming at the accustomed time, animals will proclaim their sense of deprivation, each in its own peculiar way. The neighing of the horse for food, the lowing of the ox, the bleating of the sheep and the squealing of swine, are simply echoes of the outcome of the desire for another meal. Undue fasting is followed by taking an excessive supply, which in turn calls for excessive drinking, hence, digestive disturbance follows. The effects from irregular feeding and changed conditions are well brought out in the fact that animals usually lose in weight when making the circuit of the autumn fairs.

When water is withheld beyond the usual time, a sense of deprivation is felt, then it is taken to excess. Disturbance follows in secreting the digestive fluids, and just in proportion to the irregularity will be the loss that follows. Warm temperatures and hard work may and do call for taking water more frequently than at other times, but under normal conditions, the aim should be to supply it at stated times.

Nowhere in the management of domestic animals is the importance of regularity more clearly shown than in the milking of cows. A single instance of milking deferred for any considerable length of time will be followed by decrease in the next milking and in some instances in several milkings. It has been noticed that to defer milking for an hour or more, as for instance on Sabbath morning, will tend to diminish the yield perceptibly for more than one milking immediately following. For the discussion of other influences that affect milk yields, see page 419.

The exertion of work calls for more food and for taking it more frequently than when animals are at rest. Because of this, while horses that are idle and that are simply being carried through the winter, may fare well enough on two feeds a day, it is imperative that those at work shall have three feeds, and it is important that food shall be given on time. Work carried beyond the usual time for taking food means a more rapid expenditure of energy than at other times, and this means so far a lowering of digestive capacity when food is given. Hence it is, that irregularity and want of uniformity in feeding are always followed by results not entirely satisfactory.

Water for domestic animals.—Water is furnished to domestic animals for the three-fold purpose of aiding the digestive processes, cooling the body and allaying thirst. Of these uses, the first is probably the most important. Before food can be digested that portion of the nutrients appropriated by the body must first be reduced to a soluble condition before they can be so utilized and to effect this end, water is usually necessary in addition to that contained in the food. Where the supply of water is insufficient for the needs of the body, the tissues are not kept sufficiently moist, nor is there enough to maintain proper action in the excretory glands of the skin, consequently the temperature rises and thirst is induced in proportion as the water supply is insufficient. In hot weather, water applied externally to the bodies of swine tends to cool the same in a marked degree and is, therefore, conductive to thrift.

Thirst is always present when the supply of water is insufficient. It is a source of irritation and unrest. It also hinders more or less the digestive processes and so far hinders performance. When animals become thirsty beyond certain limits, they drink abnormal amounts of water and this also is adverse to performance. The necessity, therefore, for furnishing them with an ample supply of water is ever present, notwithstanding that water is in no sense a food.

The primary source of water is of course the clouds. The natural channels by which it is conveyed to animals are two-fold; viz., directly, as in the act of drinking, and indirectly in the plants consumed as food. The sources of supply from the clouds may be classed as natural and artificial. The natural sources include springs, running streams and basins made by nature. The artificial sources include ordinary and artesian wells, cisterns and basins made in the earth. The supply furnished in plants is considerable. The amount thus furnished is influenced by the class to which the plant belongs and the condition in which it is fed. Succulent grass, green corn and field roots contain about 90 per cent of water, speaking roughly, and the concentrated grains about 10 per cent. The amount of water called for from other sources will of course be reduced in proportion as water is present in the food. Because of the amount of water in the food, some classes of animals may not need water from other sources. This is true in some instances of cattle and sheep that are fed a large amount of roots, and of sheep grazing on succulent rape pasture.

Water is helpful to animals in proportion as the supply is abundant, sweet, pure and of the right temperature. The necessity for a plentiful supply is self evident. Water is sweet when it does not contain any chemical substances distasteful to live stock. In some areas of the range, water is so strongly impregnated with alkali and other substances, that animals will not drink it. Water is pure when it does not contain any foreign substances that render it in any degree unwholesome.

The sources of the purest water are springs, running streams and, in some instances, surface and artesian wells. When first collected in cisterns and in natural or artificial basins, it is pure, but when it remains long in these, in a stagnant condition and without renewal in the supply, its purity lowers, unless in cold latitudes. Motion is necessary in water under normal conditions in order to maintain its purity. Of the sources of supply named, water obtained from artificial basins or ponds, as they are sometimes called, in which large numbers of animals are allowed to drink from time to time, is the most impure. Such water will not furnish good flavored milk when drunk by cows, and it is prejudicial to the health of sheep. The same is true of water in basins into which the soakage of or seepage from barnyards finds its way. Nor is the stagnant water which collects in marshes wholesome in hot weather, and especially late in the season. Such water is especially injurious to sheep, since it seems favorable to the growth of parasites which prey upon them. Swine seem to be less injured by impure water than other animals, but unquestionably pure water is best for them also. They are oftentimes greatly wronged by the impurities in the water given to them.

Amount of water required.—The amount of water required by animals is influenced: (1) By the character of the food; (2) by the nature of the weather; (3) by the copiousness of the dews and (4) by the nature and extent of the performance. Sometimes these influences act singly, but more commonly they act more or less in conjunction.

Food influences the consumption of water more through the presence or lack of succulence than in any other way. But the proportion of protein in the food, it is thought, exercises some influence, and the same is unquestionably true of salt. Salt increases the circulation of the juices of the body and thus favors increase in protein consumption. Many experiments have shown that the addition of field roots, corn ensilage or soiling food reduces the consumption of water in at least approximate proportion to the extent to which they are fed and to the amount of water they contain. Such food may be given under some conditions to the extent of satisfying the needs of the animals as to water. Experiments conducted at the Kansas and also at the Wisconsin station showed that increase in the protein in the food increased the consumption of water. Salt consumed in excess by animals salt hungry, will invariably lead to the consumption of a large amount of water.

But there is something in the nature of certain foods that influences the consumption of water apart from the amount of water they contain. Corn and barley, for instance, contain virtually the same amounts of water and in experiments conducted at the Wisconsin station, it was found that the swine fattened on barley meal required about 3 pounds of water for every 2 pounds required by those fed on corn meal. The water used in soaking the meal is included in both instances. Bran and oil cake when freely fed lead to increased water consumption.

The weather exercises a potent influence on the consumption of water. The quantity of water consumed increases as temperatures rise, other things being equal. This is owing in part at least to the greater activity of the excretory organs especially the glands of the skin as previously intimated. The necessity for water is so great in hot weather that it is probable no diet, however succulent, will completely obviate the necessity for taking it.

The copious character of the dews or the opposite exercise an important influence on water requirement, but no amount of dew will preclude the necessity of any class of domestic animals for taking water when the grazing has but little succulence. The moistness or dryness of the atmosphere exercises an influence on the consumption of water both directly and indirectly. The indirect influence comes through increase or decrease in the succulence of the plants. The same plant grown in a dry atmosphere has less of moisture in it than if grown in a moist atmosphere.

It would seem correct to say that the consumption of water increases relatively with increase in performance. A horse at labor takes much more water than one at rest or that is idle, and a horse severely exercised will take more than one moderately exercised. A cow giving milk will drink more water than one dry. A steer that is being fattened will take more water than a store steer and the same is true of sheep and swine when going through the fattening process, as compared with animals of the same class that are simply being grown. More water is called for as exercise increases in the horse to replace the amount lost through a corresponding increase in the activity of the glands of the skin and of the respiratory organs. With cows giving milk and animals that are being fattened, the increase is due to increase in food consumption which calls for corresponding increase in water consumption to carry on properly the digestive processes.

From what has been said, it will be apparent, that it is not possible to state the exact amount of water required by animals. It has been claimed that cattle require about 4 pounds of water for each pound of dry matter in the food and that sheep call for half that amount. A number of experiments have been conducted to throw light upon this question and findings may be given, but why give them? As a rule the water supply is unlimited. It is also certain that under normal conditions, animals will not drink it to excess. It is equally true that they should have access to it with reasonable frequency and to the extent of their needs. The important considerations, therefore, are not such as relate to the amount that will be consumed, but rather such as have a bearing on the abundance of the supply, its easy accessibility and its temperature.

The temperature of water for stock is of considerable importance both winter and summer. In winter it is too cold for best use when ice forms on it. Especially is this true of water for cows giving milk. On the other hand, experiments have shown that but little advantage comes from heating water for dairy cows that is entirely free from ice, when taken in a comfortable place. Water should be heated, however, for animals when given immediately subsequently to the time of parturition, lest a chill should follow taking it when the system is thus fevered. In winter water heated more or less will be found more suitable for swine than ice cold water. In summer cold water is more agreeable to animals than warm water, but horses in a much heated condition should not be allowed to drink it in large quantities at the close of a labor period, lest it should result in producing that stiffening of the limbs often spoken of as "founder."

Furnishing water to animals.—In the pastures, water is best supplied from springs and running streams, also by flowing wells, where one or the other of these can be obtained. Next to these in suitability and convenience are wells of limited depth, from which the water is pumped up into troughs by wind power which works automatically. When the supply must be secured from artificial basins, the aim should be to construct these on elevations so high as to admit of conveying the water by gravity to the place or places where it is wanted.

In the winter when the stock is confined to stables or sheds, the aim should be to have the drinking tanks or troughs under cover as matter of protection for the animals while drinking in stormy weather, and also to insure more warmth in the water. When the tanks are in the yards, it will be found profitable to furnish them with heaters to prevent the temperature of the water from falling too low. For the proper temperature, see page 485. When the water is pumped by hand, if the pumping is done immediately before the animals which drink are given access to it, the temperature will be about right. The same is true of water supplied automatically in basins in the stalls. For work horses and cattle that are being fattened, this method of supplying water is not really objectionable, if the basins are kept reasonably clean, but it has been found difficult to keep them clean enough to meet the needs of dairy cows, because of the traceable adverse influence sometimes exerted on milk flavor. For nearly all kinds of domestic animals, water of swift current running through a yard will meet their needs, and at a minimum expenditure of labor. But sheep cannot always be induced to drink from such a source. In large lots they are best supplied with water in a low tank and where it will not congeal. Where it does, the tank should be in a yard and supplied with a heater. In small lots, the water is best supplied in a shallow tub in each compartment, from pails or hose, and these can be overturned in cold weather after the sheep have been supplied. It is simply cruel to deprive sheep of water in winter, except in so far as they can take it from the snow, although the practice is common. Water is usually supplied to swine not on pasture, in conjunction with the food.

The frequency with which water should be furnished to animals is dependent upon such conditions as: (1) The nature of the food fed; (2) the amount of performance required as to labor or the production of meat or milk, and (3) the temperature of the weather.

The food may be given so succulent as to entirely obviate the necessity for giving water in addition, as when sheep are grazed on succulent pastures. When animals are fattened on field roots and meal only, with a very small addition of fodder, they require but little additional water. It would probably be correct to say, however, that no class of domestic animals except sheep can be kept long on pastures so succulent as to entirely eliminate the necessity for giving additional water.

When labor or road driving is required of horses, they should be given water more frequently than when at rest. There are conditions when water supplied once a day for horses is ample when at rest and the same is true of other classes of domestic animals, but when exercised severely, especially in warm weather, a moderate amount furnished between meals in addition to what is furnished at other times is helpful. Ordinarily work horses are given water three times daily, that is, morning, noon and evening. Once a day may be sufficient to furnish water to store cattle, especially when on moderately succulent pasture and in cool weather, but when kept entirely on dry food, they should have it twice a day. When being fattened or fed heavily for milk production, and largely or chiefly on dry food, they should be given water at least twice a day to meet the largely increased demand the increase in such food calls for. Similarly the demand for water increases with sheep and swine, with increase in grain fed. It is usually easily possible to supply water to sheep where it will be accessible much of the day or all of it, and this is the ideal way of furnishing it to them. Ordinarily water is supplied to swine in the slop fed to them, that is, it is given to them three times a day, but generally when pushed as in fattening, they should be given water additional to the extent of their needs.

The excretory organs, especially those of the skin, are so active in hot weather that much water is needed to supply the loss. This means that it should be given more frequently in proportion as the heat increases, otherwise it is liable to be taken to excess.

Opinions differ as to whether water should be given to horses before or after meals. The preponderance in opinion favors watering before meals to avoid washing out much of the food too soon from the small stomach of the horse, into the intestines. This would follow more or less, watering deferred until after meals. Some persons favor offering water before and after meals. With cattle, water is more commonly given between meals. They seem better satisfied when food is given before water. The stomach of cattle and sheep being large and therefore capable of holding large quantities of water, there would seem to be no physiological reasons why water should be given at one time rather than another.

Shelter from weaning onward.—The degree of the shelter required from the weaning period onward, varies in the different classes of animals. It is decreasingly necessary with swine, cattle, sheep and horses, in the order named. It is more necessary for cows (see p. 438) than for growing cattle beyond calf-hood, and more necessary for growing cattle than for cattle that are being fattened. In fact it is more necessary for all classes of growing animals than for those of the same class that are being fattened, as the food which produces fat generates much heat, and the layer of fat underneath the skin is an additional protection. Climate also exercises an important influence. Stock exposed in latitudes where the air is dry and where the sunshine is relatively abundant, will suffer much less than animals exposed at equal temperatures where the air is damp and the weather dark and gloomy.

Shelter for swine must be of a character to protect them from draughts and also from low temperatures. The temperature of the pens like that of the stables for dairy cows should range from, say 40 to 60°. Trials conducted at certain experiment stations show very clearly the benefit from fattening swine with suitable shelter as against fattening under conditions the opposite. In a trial conducted at the Kansas experiment station, it was found that swine furnished with shelter during the 10 weeks of fattening, made 100 pounds of increase on 25 per cent less corn than those exposed to yard conditions. The feeding began November 27.

The following includes some of the essentials best suited to furnishing shelter for stock cattle: (1) A suitably ventilated shed or dry and well lighted basement, warm enough to practically exclude freezing temperatures; (2) doors on the sunny side facing a yard protected from wind, and that may or may not be left open; (3) a well bedded yard that may at all times be kept dry. But even with these conditions it may be necessary to tie some of the weaker animals in stalls to adapt the food to their special needs. Successive experiments conducted with yearlings at the Missouri station resulted markedly in favor of such protection as against yard conditions, with open shed. With cattle that are being fattened it may be different (see p. 395), unless care is taken not to keep the sheds too warm.

The following includes some of the essentials best suited to furnishing shelter for a breeding flock of sheep: (1) A well-ventilated building enclosed and facing on the leeward side a sunny and protected yard; (2) except for the lambing-pen it is not necessary to seek additional warmth to that furnished by one thickness of matched boards; (3) doors cut across the center and hung on the yard side, to be kept open above or below as may be desired; (4) a yard at all times dry and kept well bedded when occupied. For sheep that are being fattened an open shed will suffice.

An open shed will also suffice to furnish protection for colts subsequent to the age of one year and for idle horses. These should face protected yards, and the latter should have communication with paddocks or pastures to enable them at suitable times to take larger exercise. Work horses and foals need enclosed quarters in winter. The former being tied, usually profit by blanketing in addition.

Shelter for young animals.—The degree of the shelter required for young animals, more especially during the first few days of life, is much greater than in the case of animals that are older. This is true of all classes of animals, as foals, calves, lambs and pigs, but it is by no means equally true of them. The smaller the animal, the larger relatively the amount of surface for the radiation of body heat, and consequently the loss of heat is relatively greater. The leaner the young animal is also, the more intensified is this condition.

Foals, of all young farm animals, can best endure cold, owing first, to the greater relative size, and second to the naturally more active habits which they possess. But, in cold climates, the protection of an open shed which may be ample for colts more than one year old, would not be sufficient for the sucking foal.

Young calves would fare badly under conditions of exposure that would bring no harm to cattle that are older. If tied and thus prevented from taking exercise, the necessity for protection is considerably increased. One course of sheeting, in the absence of some additional covering as tar paper, on the side of a stable, does not in all instances make it warm enough for such calves. The necessity for better protection continues until they have passed the first winter, at whatsoever season they may have been born.

Lambs are much more tender than calves during the first few hours of existence. When born in winter in cold climates, it is imperative that they come into life under conditions that will protect them from intense cold, as for instance in a lambing-pen or apartment, or in some portion of a dry basement. After lambs are a few days old, they do not take much harm from low temperatures, and when they reach the age of two or three weeks, they seem capable of enduring about as much cold as the older sheep. The explanation is found in part in the covering of wool given to them by nature, and in part in their active habits.

Young swine are the most tender of the young quadrupeds kept upon the farm. This arises in part from the sparse covering with which nature has furnished them. Under some climatic conditions, it may not be easy at all times to preserve life in the newly born pig, unless the apartment is specially well fitted to shut out extreme cold. A division of a well ordered basement may furnish such a place. In cold weather the quarters suitable for swine during the suckling period should be at least as warm as those suitable for dairy cows in milk.

It is especially important that young animals be given the benefit of ample sunshine, that the places on which they rest shall be well bedded and dry, and that they are not exposed to falling storms, as snow, sleet or rain. The more of sunshine they enjoy, the better relatively will they prosper, but when they are to be slaughtered young, it is not necessary to provide sunlight or even much light. Damp sleeping places are greatly injurious, and exposure to a cold rain or sleet storm may prove fatal. It should also be remembered, that the degree of the protection required in climates naturally damp is greater than in those naturally dry.

Protection for stock in summer.—Although the necessity for protecting stock in winter is more important relatively than in summer, yet certain forms of protection in summer exercise an important influence on the returns which they will give for the food. They require protection: (1) From excessive heat; (2) from the disturbance caused by flies, and (3) in some instances from prolonged storms.

Protection from heat in the case of horses, cattle, sheep and swine, can only be secured by shielding them from the hot rays of the sun, under conditions that will not tend to check the movement of air currents. With swine, the additional provision of a wallow will add much to their comfort. Protection from excessive sunshine is secured by means of shade in, or accessible to the pastures, and from the same buildings that furnish protection in winter.

The ideal conditions for shade in pastures are found in a natural grove beside running water. A remnant of forest included in a permanent pasture and made accessible to other pastures is very suitable for providing shade. Clumps of trees are to be preferred to single trees, as they interfere less with cultivation. In planting trees to furnish shade, they do not virtually interfere with cultivation when planted in the corners of the pasture or field, and when planting them, those varieties should be preferred that grow quickly and that send their roots so far down as not to take harm readily because of the treading of stock. For this purpose no other tree excels the American elm. In the absence of trees, shade may be provided usually without much cost, by making a flat roof of poles sustained by posts and covered with straw.

The stables used for shelter in winter, when properly ventilated, are usually cooler than groves in very hot weather. Basement stables are also cooler than ordinary stables. The stable protection has the further advantages of being less wasteful of the droppings and of protecting from flies. Where it can be arranged, especially during the season when flies are numerous, the ideal way for keeping cattle and sheep is to house them in the heat of the day and to give them the liberty of the pastures at other times.

When stock are housed to protect from flies the stables or sheds must be darkened and yet ventilated. This is accomplished by opening the windows to make air currents and by covering them at the same time with material, as coarse sacking, that will exclude much of the light, keep out flies, and that will at the same time, admit the air freely. Much may also be done to keep down flies by promptly removing the manure made which is a favorite breeding ground for flies, and strewing lime occasionally where it may do good around the buildings.

Cattle are sometimes further protected from flies by spraying them every few days with some preparation, as sheep dip, or kerosene emulsion applied as a very fine spray. Where the number of animals is limited, it is applied with a brush. Such offensive preparations as fish oil, have also been used with good effect. These preparations are only effective for a few days at a time, hence, unless special apparatus has been fitted up for applying them quickly, as in a narrow passageway through which the animals are forced to pass, the labor involved is very considerable. To apply them thus, however, has been found perfectly feasible. Horses that are being driven are protected, of course, by covering them with suitable netting. The darkened sheds which furnish protection for sheep at the season indicated, would seem to furnish a safe asylum from the assaults of the gadfly, (*Tabanus ruficornis*), which is the source of that trouble known as "grub in the head." The wallow for swine is a great source of comfort in hot weather, and is to some extent a protection from flies.

Usually in the hot summer season, it is not very often that such stock as horses, cattle, sheep or swine, need protection from storms. In some instances, they may, however, when these are prolonged, and especially when the rainfall is of the drenching character. In the late spring and early autumn, storms sometimes occur so prolonged and severe as to result in much harm to live stock that are not housed during their continuance. The reference is to cold rains. They are more harmful to stock than many of the snow storms of the winter. Lambs and young swine, and animals of all classes that are weakly, suffer much from them. The pastures also may suffer much from treading at such times, especially should the animals be possessed of much weight.

Temperature in stables.—The degree of warmth required by domestic animals differs: (1) With the species (see p. 98); (2) with condition in the animals (see p. 395); (3) with the age (see p. 490), and (4) with the climate (see p. 79). In many instances those differences have not been sufficiently regarded in the management of live stock.

From what has just been stated, it will be manifest that the proper degree of temperature to be maintained in stables for domestic animals will vary considerably. For work horses that are tied and blanketed, the temperature should not go below, say 36°, nor above 60°, with, say about 48° as a mean. When not blanketed it may properly range higher by a few degrees. When loose in box stalls, it may be a few degrees lower. The degree of temperature named would also be suitable for foals, while young animals but older than foals would do as well or better with temperatures a few degrees lower. The temperature suited to dairy cows would run from, say 40 to 60°, with say, 50° as a mean.

For animals fattening it would run from 32 to 50°, with 40° as a mean. The more advanced the fattening period the lower should be the temperature. For calves the temperature should be the same as for cows, and for young animals that are older about the same as for cattle that are being fattened. For sheep unshorn, the nearer the temperature is to the freezing point but without freezing, the better. The aim should be to have the same range between 32 and 50°, the latter being sufficiently warm for even newly born lambs and also for sheep that are newly shorn. For swine the temperature should be about the same as for dairy cows, 60° being sufficiently warm for newly born swine.

Of course, in practice, it is not possible to keep temperatures within the ranges named either in winter or summer, but much may be done to approximate them to the figures submitted, which are only given as general and not as absolute guides. The temperature in stables may rise higher than those named and no harm come to the animals, but they should not fall in any instances below the freezing point, where this can be avoided, except probably in the case of unshorn sheep which will take no harm though the temperatures should be lower. The lower the temperatures can be kept without harm to the animals, the better, because of the relatively greater abundance of the oxygen supply.

To secure proper temperatures in winter in the absence of artificial heat, is no easy matter, and to provide artificial heat is not practical. Warmth must be secured through proper construction in the buildings, and not through air heated by the breathing of the animals in the absence of suitable ventilation. The temperature will then be regulated through ventilation, but the construction of buildings and ventilation cannot be discussed in this work. It may be said, however, that good ventilation in buildings is absolutely essential to highest performance in animals that are housed.

To secure suitable temperature in summer is more difficult than in winter. At certain times it may be impossible because of atmospheric conditions without. But much may be done to regulate temperatures by keeping animals in airy stables by day, and outside at night. Basement stables are relatively the cooler in summer.

The sources of litter.—The following are the principal sources from which bedding or litter is obtained: (1) The straw of cereals in all the varieties thereof used directly; (2) the rejected portions of straw and hay material supplied as food; (3) the uneaten parts of corn stalks and the sorghums when properly prepared; (4) refuse from certain manufactures; (5) the leaves of trees; (6) certain kinds of soil; (7) peat, in various stages of decay.

The straw of cereals is by far the most important source of litter, and also the most suitable all things considered. Viewed simply from the standpoint of suitability, oat straw probably stands at the head, because of its softness. Rye straw does not break up so much as some varieties in threshing, is less soft, and is slower of decay, hence it is so far less suitable. The straw of peas does not shake apart so readily as the straw of non-leguminous cereals, and this is so far against it. So convenient and suitable is the straw of the cereals for litter, that to grow an ample supply of this to be used alone or with other absorbents, as loam and peat, is worthy of the careful consideration of the grower of live stock. The forethought which holds over straw for litter and properly protected, from seasons when it is abundant against the need of seasons when it is scarce, is to be commended.

Many kinds of straw are considered too valuable, more especially in old settlements, and justly so, for being used directly as litter. They are first fed and the refuse portions are then used as litter. This applies most markedly to the straw of legumes, which, when harvested properly, is more valuable as fodder than hay overripe or damaged. When hay is overripe at the time of harvesting, when it is damaged in the curing to the extent of lessening much of its palatability, and when it grows so as to be coarse and possessed of many large stems, live stock well fed will reject more or less of it. This may generally be used with highest profit as litter, although in some instances it will be more profitable when cleaning out the feed boxes to give such refuse to animals that are being carried through the winter on a less palatable fodder ration. Hay rejected by work horses, cows or cattle that are being fattened, may thus be utilized by store cattle fed in sheds or otherwise.

The rejected portions of corn stalks or of the sorghums do not furnish suitable litter when fed in the unprepared form, that is, when fed as they grew. Because of their stiffness and shape, they are not well suited for bedding, and there is the further objection that they add much to the labor in handling the manure. The objections to such litter may be in a great measure, and in some instances entirely overcome, by shredding or cutting up the stalks before they are fed.

Prominent among the refuse from manufacturing establishments used as litter, are sawdust, shavings and spent tan bark. The supply of these is more or less limited. Sawdust has the merit of being clean and easily handled and will absorb three times its weight of liquid, but it is low in fertilizing ingredients, decays slowly and promotes firefang in manure heaps when present in the same, unless the contents are speedily applied to the land. Shavings do not fork readily and decay slowly. Spent tan bark is quite low in fertilizing constituents and may generally be better applied as a mulch.

Leaves furnish suitable litter and rank considerably higher than straw in absorbing liquid, but they are not equal to straw as fertilizers. Moreover, the labor of gathering and storing them is considerable. The profit from using them, therefore, as litter, is sometimes to be questioned, unless where cheaper sources of the same are not obtainable, or when they are necessary for the absorption of urine, much of which would otherwise be lost.

Loam may answer for bedding in the absence of other materials, and may be used in conjunction with them, as when used in stables to absorb the liquids. Humus soils are also good because of their relative lightness and absorptive power. Clay soils are ill-suited to such a use, because of the tendency in them to bake when handling or tramped on while wet. One chief objection to soil as bedding is the labor involved in handling it.

Moss and peat are frequently used for litter. Both stand high in their power to absorb liquids, but peat is richer in the elements of plant food than moss, although in this respect it varies much, dependent on the sources from which it is obtained and the stage of reduction which it has reached. It must, of course, be secured, allowed to dry and stored, before it can be thus used, which means considerable labor, but there may be instances in which its use, especially as an absorbent, is to be commended.

The uses of litter.—The principal objects sought in using litter are: (1) To add to the comfort of animals, more especially when they are taking rest; (2) to absorb the urine and to arrest volatile gases as ammonia; (3) to increase the quantity of the manure. The first of these is, of course, primary, but usually all three are important.

Bedding or litter adds to the comfort of animals by furnishing them with a soft and dry bed, and in many instances by increasing the warmth of the same. From choice, animals will soon learn to select places where soft litter is most abundant, when given such liberty, thus plainly indicating that benefit will result from furnishing them such a bed. Animals also instinctively shun taking rest on a wet bed. Rather than do so they will go for long periods without lying down, hence the importance of keeping yards well bedded and also sheds, when animals must take rest in one or the other. Litter supplies warmth in cold weather. It is particularly helpful in this respect when animals in the stall must take rest on cement or concrete floors, and when its presence in yards or sheds removes dampness. It is also very helpful in increasing warmth in swine when abundantly supplied.

The liquid portion of the manure is very valuable, and the plant food in it is readily available, hence the importance of saving it in a way that will conserve its properties and make its application easily possible. The old method of draining it into tanks and drawing it from these is objectionable, first, because of the expense and second, because of the extent to which nitrogen is lost when it is kept for any considerable time in these. It is considered preferable to absorb the liquid by using some kind of litter which may then be applied to the land. Certain gases, as ammonia, escape from manure in considerable quantities, especially from horse and sheep manure, and to prevent the same through fixation, certain substances are used. These are also used in cow stables to lessen the presence of odors that are injurious to milk.

To absorb the liquids, straw is more commonly used because of its plentifulness, but leaves, moss, peat, and dry loam or muck, may also be used. Peat, loam, and muck in addition to their absorptive powers also lessen the extent to which odors are present. To prevent the escape of ammonia, land plaster has been much recommended and used. But the question of the profit resulting is not fully settled. Some good authorities claim that acid phosphate is superior to gypsum. Others claim that, cost considered, the use of dry peat, loam or muck is superior to either gypsum or acid phosphate.

In localities where fertilizers are much prized, the free use of the absorbents named adds greatly to the quantity of fertilizing materials saved and also made. The increase is usually more cheaply secured than it would be by composting, more especially when the manure thus made is drawn at once and spread on the land. A saving is thus effected in labor, and the loss of plant food in the manure through leaching and excessive fermentation is reduced to the lowest minimum possible. But, of course, it is not always practicable to apply manure to the land thus quickly. Through the use of suitable absorbents, it should be easily possible to more than double the amount of the fertilizing ingredients made and saved in the absence of these.

Preparing and using litter.—The proper preparation for use will, of course, vary with its nature, and the source from which it is obtained. Prominent among the processes to be followed are: (1) The proper housing or stacking of straw; (2) the chaffing of straw and the shredding of the stalks of corn and sorghum, and (3) the storing of earth, the gathering of moss and the drying and storing of peat.

Wet litter is worse than none, as it is prejudicial to the well-doing of all kinds of domestic animals. Straw may most easily be kept dry by housing it, but frequently this may not be practicable. When it is not, it should be stacked with care and conveniently to where it will be used. The "blowers" used so extensively in threshing, as generally used make careful stacking almost impossible, with the result that a large proportion of the straw is made useless for bedding through the rain which penetrates it.

Straw of the small cereal grains is more commonly used without being chaffed, but where this can be done in conjunction with the threshing of the grain, the benefit which results from the less quantity called for, and the superior condition of the manure for immediate application, more than pay for the added cost. When thus chaffed, the length of the pieces are from, say 2 to 4 inches. Corn and sorghum stalks are greatly improved as litter by shredding, a process which tears them up into strips and makes them in a sense like straw. The shredding is primarily done to prepare them for food, and only the rejected portions are ordinarily used for litter. In moist climates it is not easy to preserve fodder shredded thus, but it is quite practicable in the more dry regions of the West. Earth must be drawn and stored when dry to be properly serviceable, light loams and humus soils are to be preferred and clays should be rejected. Moss must, of course, be gathered and stored when the condition of the marshes which supply it makes this practicable, and the same is true of peat. In some instances, the peat must first be dried by laying it open to the sun.

The mode of using litter will vary with its nature and with the conditions under which the animals are kept. Earth and peat are more commonly used as absorbents in conjunction with other litter used to provide a suitable bed on which the animals may lie. When thus used, they are more commonly spread in the trench behind the stalls in which the droppings and urine accumulate. But in some instances, especially in western Europe, these substances are used as the sole sources of litter. They are placed in the stall to the depth of several inches and are removed at intervals.

When straw or fodder is first fed, and the rejected portion used as bedding, the source of supply is very convenient since the labor involved consists simply in removing the refuse from the manger or food box and spreading it in the stall in the one instance or in the shed or yard in the other. Cattle that are being fattened or cows fed plentifully on good food will not eat any considerable quantity of straw, but this does not hold true of cattle or horses that are being carried through the winter, and it is even less true of breeding flocks of sheep. When fed at the noon hour, the refuse is ready for use as litter just when it is most wanted, that is as night approaches.

When animals are confined in stalls the larger portion of the day, care should be taken by the attendant to throw back the droppings that may have fallen upon the platform several times during the day, to insure greater cleanliness. When they run at large in sheds and yards, the frozen droppings should be removed occasionally, when they cannot be deeply covered with litter. It is usual to supply litter but once a day.

The amount of litter required will vary with the class of animals, the food fed and the materials used. Horses call for the least in proportion to their weight and swine probably for the most in cold weather. Show animals must be supplied plentifully with bedding. Animals loose in box stalls, sheds or yards call for more than those tied in the stall. The minimum supply of straw bedding for a horse, has been put at 5 pounds by some authorities. For a mature cattle beast in the stall, it has been put at about one-fourth to one-third of the dry matter fed, or at, say 7 to 10 pounds. When earth only is used, as much as 150 pounds daily will be wanted. A bushel basket full of dry peat daily per animal will usually suffice as an absorbent of the liquids.

The season for breeding.—The season when the young animals may be produced with best advantage will depend: (1) On the use that is to be made of them, and also of the dams; (2) on the conveniences available in properly caring for them, and (3) on the time that may be secured in giving them the necessary care.

Foals are usually born in the spring, a result that is probably to be attributed to custom more than to anything else. The reasons are weighty, however, why the aim should be to have them produced in the autumn. In a majority of instances idleness, from the very nature of farm work is enforced on the dams in winter, and work is desired of them in summer, which means that such mares can better sustain their foals in winter and can also render more efficient service in summer. The work thus given, if not excessive, would be beneficial to the foal in embryo which she might carry at such a time. There has been complaint that conception in the autumn is not so sure as in the spring, and it is probably well grounded, but if true, there are no good reasons why this greater shyness of conception on the part of brood mares at that season may not be overcome.

The advantages of having cows produce their young in the autumn include the following: (1) It secures abundant milk in winter which is more profitable than at any other season; (2) more time can be secured for taking care of the calves during the period of feeding milk, and (3) the weaning season comes at a propitious time, that is, when grass is succulent. The second and third of these advantages apply equally to foals.

The season for lambs to arrive is from November 1 to June 1, according to the market for which they are grown and as to whether they are grown for breeding uses. Milk lambs are best in season when produced between November 1 and February 1. Easter lambs are best produced from January 1 to March 1. Spring lambs for the general market come most opportunely in March and April, and lambs for autumn and winter feeding, from April onward. For breeding uses they usually develop somewhat better when born in the early rather than the late spring.

When but one litter of swine is reared in a season it may be produced any season that may be most convenient after settled cold weather is gone, which will give the pigs time to develop sufficiently for the market for which they are intended. When two litters are wanted, March and April are auspicious months for the first litter, and September and October for the second. The earlier month in each instance is to be preferred.

Where the conveniences are not at hand for properly protecting young animals from inclement weather, or for furnishing them and the dams with suitable food, they should not be brought forth under such conditions. These conditions sometimes exist on the arable farm and are very frequently present in range areas.

Young animals, from the nature of their necessities, call for more attention than animals that are older. The time for giving it is less easily secured from the beginning of seed time to the end of harvest, when farm work is always pressing. Because of this and for other reasons, the aim should be to avoid having young animals brought into existence at such a time.

The season at which young animals shall be born cannot be completely controlled by the owner of the stock, but usually it can. He can control the time of mating, but of course, not in all instances the time of conception. The extremes in the duration of the period of gestation in the mare may be set down approximately as 295 to 370 days; in the cow as 265 to 300 days; in the ewe as 145 to 154 days, and in the sow as 110 to 118 days. The average duration approximately of the period of gestation in the mare is 330 days; in the cow, 282 days; in the ewe, 149 days, and in the sow 113 days. Usually when breeding animals are in a normal condition as to health and flesh and are properly fed and of sufficient age, they may be depended upon to breed with much certainty and near to the time desired.

The dam at parturition.—The time of parturition is a more or less critical one with the dam. Neglect or injudicious feeding at such a time may readily prove fatal to both the dam and her offspring. With reference to it, the following recommendations will always be in order: (1) The food preceding parturition should be more or less succulent and slightly laxative; (2) the owner or person in charge should aim to be present when it occurs, and (3) the dam should be fed with a prudent caution for some time subsequently.

Succulence in the food is beneficial: (1) In the tendency which it exerts on the digestion in preventing constipation, (2) in the influence which it exerts in consequence in counteracting all tendency to feverishness such as a constipated condition of the system is sure to induce, and (3) in furnishing in plentiful supply, food for the progeny as soon as born. Some caution, however, is necessary in the case of cows known to be free milkers, lest the strong tendency to superabundant milk secretion should so react on the vital forces of the system as to result in milk fever, that dread malady, which, until recently, proved so fatal to dams when it appeared. In summer, no food is superior to grass, and at other seasons, such food adjuncts as field roots, wheat bran, oil cake and corn ensilage with but little of the grain in it, are all good.

The advantage from the presence of an attendant may result from various occurrences. These include an abnormal presentation which may call for assistance; feebleness in the progeny such as may require aid without which it would succumb; and in rare instances a viciousness on the part of the dam which would result in harm to her offspring. In inclement weather, the necessity for the presence of an attendant is proportionately increased. The profits that occur from keeping live stock are probably influenced more by the results at the time of parturition, than by those occurring at any other period.

The condition of the dam at parturition is always more or less fevered. This fever creates thirst. To relieve this, water should be supplied to the extent of the desire of the dam to take it. But in no case should the water be cold. In all instances the chill should be removed from it to prevent a chill being given to the system, which, at such a time, would almost certainly prove fatal. This caution should be observed for some time subsequently to parturition.

No harm is likely to result from allowing dams to eat all the dry fodder they will consume after the birth of their progeny. But in no instance should they be given large quantities of concentrates for several days after parturition. Feeding them thus freely at such a time tends to produce disturbances in the udder which may readily prove fatal to both dam and progeny. Any excess of milk in the udder should be taken from it by hand milking, where this is practicable. The time required to put dams on a full grain ration subsequent to parturition varies from one to three weeks, according to the conditions present.

Amount of exercise.—Live stock cannot be grown to maturity with highest success unless they are given the opportunity to exercise according to their needs during the process of development. The necessity for exercise varies, as also the amount of the same: (1) With the age of the animals; (2) with the class of the same; (3) with the object for which they are kept, and (4) with the nature and amount of the food given to them.

The necessity for exercise is greatest when animals are young and decreases with advancing age. It is based on the relation that obtains between exercise and the removal of waste matter that would otherwise accumulate in the system, and also between exercise and the firming of the muscles, to enable them to fulfill effectively the respective functions required of them. It stimulates the circulatory blood flow and quickens all the vital processes. The necessity for taking it is indicated in the eagerness with which young animals exercise, and the amount of it which they take when the opportunity for the same is furnished. Young animals, therefore, should in no instances be closely confined unless they are to be slaughtered at an early age.

The importance of exercise is greatest in the horse. This arises in part from the fact that he is kept for purposes of labor and travel. The measure of the ability for both has been found to co-ordinate in a marked degree with the amount of exercise taken during development and also subsequently. Exercise for sheep comes next in importance, as a result of inherent original endowment. The sheep by nature is much inclined to travel while grazing. Swine can be reared with less exercise relatively than cattle, but they also must be given large liberty to exercise if they are to maintain sufficient health and vigor.

Animals kept primarily for labor require the largest amount of exercise. Those kept primarily for breeding come next, and those that are being fattened call for the least. The necessity for proper exercise with horses is only second in importance to the necessity for proper food. Experience has invariably shown that the larger the amount of exercise taken by breeding animals up to that point at which exercise would begin to draw on the energies of the system, the more valuable are they as breeders, and the more successfully do they breed. With animals that are being fattened, exercise beyond a limited amount would draw on the energies of the system, and as a result there would be antagonism between exercise beyond this point and the most abundant laying on of flesh.

When animals are kept for purposes of labor, or for breeding, or for both uses, it is very evident that a low condition of flesh calls for less exercise than a condition the opposite, sustained by high feeding. Every pound of flesh in excess of the complete needs of the animal becomes burdensome and should be removed by increased exercise or reduced feeding, or both. On the other hand, a condition of flesh below the complete needs of the animal should be strengthened by increased feeding and curtailed exercise.

It is impossible to formulate rules for exercising animals that will exactly meet the needs of all conditions that may arise, but some things may be said that will in a sense serve as a general guide under some conditions. Much must be left to the judgment of the owner or attendant. The aim should be to give young and growing animals, grown for labor or for breeding, all the exercise they will take voluntarily, under favorable conditions for taking the same. Horses, when mature, if given liberty, will take enough of exercise voluntarily, except it may be in the case of pregnant draught mares (See p. 120.) Stallions should be exercised daily, especially in the breeding season. Draught stallions will profit by being walked half a dozen miles a day, and other stallions will profit by a longer journey and a somewhat quicker but easy gait.

All pregnant animals should be given the opportunity to move about daily in a yard, paddock or field, except in stormy weather, and the same is true of stock males. When snow is deep, it may be beneficial to give sheep a part of their food at some distance from the sheds, in a sheltered place, to encourage them to take exercise. Roads may have to be opened in some instances with snow ploughs. Likewise it may be advantageous to encourage brood sows to take exercise by strewing grain in various places that will give the sows exercise while gathering it. Pregnant cows seem to take harm less readily from confined conditions than pregnant dams of other farm animals.

In some instances, these have produced progeny with reasonable success when tied in the stall uninterruptedly for months in succession. It is questionable, however, if the plan is a wise one.

The amount of exercise that cows in milk should have, is in some respects an undecided question. When out on pasture, every step taken in excess of the needs of the cow, viewed from the standpoint of good health is taken at the expense of milk production. But in winter another factor, viz., cold, has to be contended with. This beyond a certain degree is antagonistic to milk production, even when cows are taking outdoor exercise that would otherwise be beneficial to them. The best solution of this question probably is, to turn them daily into a well lighted and well bedded closed shed, in which they may exercise daily in cold weather, and to give them access to protected yards in warmer weather.

Animals that are being fattened for the block do not require much exercise, and yet experience has shown that even with them, some exercise is helpful rather than antagonistic to increase, and that they also ship better when given some exercise. The more forced the feeding, the more beneficial will exercise be up to a certain limit. Animals with some exercise do not get "off feed" so readily as those with none.

CHAPTER XXI.

MISCELLANEOUS CONSIDERATIONS.

Prominent among the miscellaneous considerations are the following:

1. The weigh scale as an educator.
2. Weight of animals at birth.
3. Variation in weights of animals.
4. Influences that affect palatability.
5. Feeding subsequent to weaning.
6. Feeding for quick conception.
7. Salt and its uses.
8. Silage a varying quantity.
9. Feeding miscellaneous products.

These are discussed in the order given.

The weigh scale an educator.—When animals are being fed large quantities of food with a view to the production of milk or meat, it is of prime importance to the owner that they shall give an adequate return for the same. The exact nature of this return cannot be known, without frequent recourse to the weigh scale. Even the skilled feeder may be deceived as to the nature of the gains, when animals are being fed liberally, and more especially when they are nearing the finishing period. The weigh scale, therefore, aids in the economical feeding of live stock: (1) In making the comparison of foods possible and practicable; (2) in indicating exactly the product resulting from the food, and (3) because of the information thus given, it tends to make the person who uses it a student of the science of feeding. The benefit last named is by far the greatest, because of the influence which it exerts on future feeding and management.

Without the weigh scale, the feeder cannot tell exactly which of two or more rations that he may choose from will best suit his purpose. He may have an approximate idea from the results obtained by previous experimenters in feeding the same rations, in the same way and under the same conditions. But, should the conditions be changed, or any of the ingredients in the rations, or the amounts of these fed, factors are introduced which will lead to different results, how far different, the weigh scale only can accurately determine.

In the fattening processes, the various foods fed are usually relatively costly, so costly that the increase in live weight seldom equals in value the foods used in making it. (See p. 384). This result follows, even though the food and feeding are both well adapted to the end sought. It is greatly important, therefore, that the gains shall bear a due relation to the cost of the food, and that they shall be liberal and continuous. The daily cost of food for a mature cattle beast, while being fattened, runs all the way from 10 to 25 cents per day. Where only partial gains result, the loss resulting piles up rapidly. The same is true when cows in milk are liberally fed without making corresponding returns.

In stables where the milk of each cow is weighed as soon as taken throughout the year, relative capacity in the cows for production soon becomes known. This of course, does not tell the whole story, unless the food also is weighed that is given to each cow, which is scarcely practicable in the ordinary stable. But it gives an approximate idea of relative production in proportion to cost of food, so approximately accurate that it enables the keeper of cows to weed out those least profitable and to supplant them with others without the hazard of serious mistake. Likewise, the weigh scale may be made to indicate the degree of the return for food fed at any stage of development. But when taking the weights alive, the liability to fluctuations in the same must not be overlooked. (See p. 514.) When due attention is thus given to the extent of the production that is being secured, the invariable result is to stimulate the owner to increase these. To do so, he becomes a student of methods. It would be safe to say that no person who weighs daily the milk of all his cows will long be content with low average production in his herd.

Weight of animals at birth.—The following are chief among the influences that affect the weight of animals at birth: (1) The size of the dam; (2) the age of dam; (3) the breed of both sire and dam; (4) the food given to the dam during gestation; (5) the performance of the dam during the same period; (6) the number produced at one birth, and (7) the size of the sire.

It is but reasonable to suppose that there is a relation between the size of the dam and her offspring. This relation may not be uniform and constant, owing to the many influences that affect size in the progeny. The belief in such a relation on the part of practical breeders is shown in the preference which they give to well developed dams when seeking progeny of superior development. This fact is also recognized by scientists who have studied the question, when they seek to establish an approximate relation between the weight of the dam and her offspring based upon her weight.

It has been observed that the best averages in size have been obtained in progeny from females in the meridian of vigor and maturity. Since it has been noticed that progeny of the first birth from a dam not yet mature is usually of less size at birth than the progeny of future births, practical men are chary about rearing such animals for future breeding. They give the preference to the former. That progeny of animals yet immature or past the meridian of vigor would be of less average size, is in accord with the known laws of physiology. The food given to the former is more or less diverted from the fœtus to complete growth. That given to the latter is less perfectly assimilated than at a later period.

That breed exercises an influence on the relative size of the progeny at birth is in accord with the first law of breeding; viz., that like produces like. It is only reasonable to suppose that the average size of the progeny at birth would be larger from the Clyde mare than from the mare standard bred; that from the Shorthorn cow, larger than progeny from the Jersey; that from the Lincoln, larger than progeny from the Southdown, and that from the large Yorkshire, larger than progeny from the small Yorkshire. And so it is on the average in these respective instances.

It could not be otherwise than that the food given to the dam during pregnancy exercised a determining influence on the size of the progeny at birth, since fœtal development is a direct result of the constituents contained in the food. An excess of carbohydrates is adverse to development and an excess of protein is liable to result in impaired vitality.

Performance in the pregnant dam influences size through the diversion of the energies of the system. Normal and ordinary exercise of those energies is favorable to fœtal development, through the healthy influence exerted by use in the various functions of the system. For instance, regular breeding not excessive in frequency, will produce more desirable progeny as a rule than fitful breeding. But should the energies of the system be over-taxed during pregnancy, as when the cow is carried through a high pressure milking test, or the pregnant mare is overworked, or the pregnant ewe is put into high show condition, the influence is adverse to both size and vigor in the progeny.

That the number produced at a birth influences size at birth is sustained by the evidences of observation and experience. Although the results are not constant, and in the nature of things cannot be, the average weight of single lambs at birth is greater than that of twin lambs in the same flock. This also is true of the average weight of pigs in large litters as compared with those of small litters.

That the sire exercises an influence on the size of the progeny at birth has been denied. Of course, such influence is less on the part of the sire than on that of the dam in the very nature of things. But that the sire does exercise such an influence is clearly shown in cross breeding where the size of the sire is much in excess of that of the dam. The influence thus exerted by the sire, however, in determining the limit of possible development in the progeny at maturity is greater than in determining actual size at birth because of the various influences intra uterine in character that offset fœtal development, and that cease to be operative subsequently. In other words, ultimate development, the outcome of influence exerted by the sire, may be greater relatively at maturity than at the birth of the progeny.

It follows, therefore, that possible size at maturity is not fixed by relative size at birth, although there is doubtless some relation between these. Possible size at maturity is determined by inheritance from both sire and dam, and to some extent from the ancestry of these. Illiberal feeding may result in possible development being unattained. But no feeding, however liberal, can result in development beyond the limit set by inheritance, that is to say, feeding more food than would be regarded as a sufficient ration will not carry development beyond what it would attain by giving simply a sufficient ration, but it may reach such development more quickly.

It is evident, therefore, that it is not possible to state exactly the maximum, minimum or average weights of young animals at birth. However, basing the estimates on records of weights that have been taken, it would be approximately correct to say that the average weight of standard bred foals whose dams and sires range between 1000 and 1100 pounds would be somewhere in the vicinity of 100 to 110 pounds, and that draught foals would be proportionately heavier according to the weight of the parents, in normal condition as to flesh. The weight of calves runs all the way from 50 to 125 pounds, the average being somewhere in the neighborhood of 80 pounds. The average weight of lambs, large, intermediate and small breeds, is somewhere in the vicinity of 7 to 8 pounds. The average weight of pigs of the different breeds is somewhere between 2 and 2½ pounds.

Variations in weights of animals.—The live weight of animals varies so much from day to day, that in experiments which call for frequent weighings, it becomes a disturbing factor to the extent of leading to incorrect conclusions, unless the weights are taken as the average of several weighings rather than as single. These variations occur in weights taken at different hours the same day or on successive days, insomuch, that even with animals that are neither gaining nor losing in flesh, the same weight precisely can seldom or never be attained from weighing at different times.

These variations are relatively more pronounced in cattle and sheep than in horses and swine, owing probably to the less relative capacity in the digestive organs of the latter to hold large quantities of food, and to the shorter period during which it is retained in the system. But even in the case of horses, the difference in live weight from day to day has been not less than 25 pounds, though weighed at the same hour each morning and before any food or water had been given to them. The difference in the daily weighings of mature cattle similarly weighed has, in some instances, exceeded 50 pounds.

These variations are the outcome chiefly: (1) Of the different amounts of food consumed and retained in the system, and (2) of the different amounts of water drunk and also retained beyond the time when the weights were taken. They are also influenced to some extent by the increase or loss in flesh, by the water content of the tissues, and in the case of animals in milk by the amount of milk withdrawn.

The variations resulting from food is caused more by irregular movement in the evacuations than by a difference in the amount of food consumed. The difference in the amount of solids excreted by mature cattle at rest has been found, in some instances, to vary fully 25 pounds per day. With animals that are exercised, the difference may be greater. It has also been noticed that the movement of food in digestion is less regular when the diet has recently been changed.

The difference in the amount of water consumed from day to day is likely to be much greater than that in the food consumed. It is more likely to be influenced by a change of temperature in the atmosphere. It is also influenced by a change of temperature in the water itself. When it is called to mind that the stomach of a mature ox is capable of holding from 100 to 150 pounds of water, and that the excretion of urine is more or less irregular, it will be readily apparent how the amount of water consumed may lead to variations in the live weight of animals.

These variations account for the extravagant gains that are sometimes claimed for animals on full feed. A well grown steer at the Kansas experiment station showed, in one instance, a loss of 2 pounds as the result of seven days feeding on a fattening ration. At the end of the following seven days he showed a gain of 47 pounds or nearly 7 pounds per day. They also show the necessity for the utmost care in drawing conclusions based on weights while conducting experiments with live stock that relate to increase or decrease. Some stations have adopted the safe plan of weighing three days in succession under exactly the same conditions and taking the average of these as representing the true weight.

Influences that affect palatability.—The great importance of palatability in foods has already been discussed (see p. 51). The influences that affect it will now be considered. These include: (1) The intrinsic properties of the plant; (2) the nature of the growth; (3) the inherent tastes of the animals to which the foods are fed, and (4) the extent to which those tastes have been cultivated by feeding upon plants different from those to which the animals have been accustomed.

The intrinsic properties of the plants are influenced: (1) By the class to which they belong; (2) by the amount of leaf growth; (3) by the extent to which woodiness is present or absent, and (4) by the aroma. Legumes are usually more palatable than other plants but this does not always hold true, as blue grass when young is more palatable than red clover at the same stage of advancement in growth. Usually, however, domestic animals show a fondness for legumes. Sugar in plants also affects their palatability. This in part accounts for the fondness of domestic animals for corn and more particularly for sorghum, both of which are non-leguminous. The more abundantly that leaf growth is present, the greater is the degree of palatability in plants. This is owing in part to the absence of woodiness, in part to the fine character of the growth, and probably in part to the higher nutrition which they possess. As plants become woody, they lose in palatability. This is very clearly shown in the consumption of the leaves and finer portion of the stems of coarse clover hay, while the coarse stems will be rejected in the same. The same is true of corn plants. In nearly all instances, plants which are rejected by animals for which they are the natural food when far advanced in growth, will be eaten by the same when young. Foxtail (*Alopecurus pratensis*) for instance, is readily consumed by sheep when young, but when advanced in growth they will not eat it at all if they can secure other food. The same is true of some other plants even of plants as valuable as timothy. The aroma of plants also influences their palatability in a marked degree. The presence of this property is conveyed through the yielding up or giving off of certain volatile odors, which are gratifying to the sense of smell. These are emitted in a marked degree by new mown hay. When much exposed, as by bleaching, or when wet with dew or rains, these properties are dissolved or washed out of the plants, and in proportion as they are they lose in palatability.

The nature of the growth affects the palatability of plants: (1) Through the rapidity or slowness of the growth; (2) through the relative amount of the bulk produced, and (3) through the proportion of the stem to the leaf growth. The more quickly that plants grow as a rule, the more palatable are they, as quick growth is favorable to succulence and adverse to woodiness. The more bulky the foods are, the coarser are the fibres of the plants, and the coarser the fibres are, the less is the degree of the palatability. Slow growth is unfavorable to a large proportion of leaf growth, and a large proportion of stem growth is adverse to palatability.

The inherent tastes of animals have an influence on the degree to which foods are palatable to them. The horse, for instance, is fond of timothy hay, but the sheep does not take kindly to it. The goat is more fond of leaves and small twigs than of grass while sheep are much more fond of grass, and cattle will consume leaves only to a small extent except under pressure of hunger. Horses are usually more fond of carrots than of other field roots, while swine are less fond of these than of any other varieties of roots. Instances illustrating this subject could be multiplied indefinitely.

Palatability in foods may be influenced by cultivating the taste so to speak of the animals which feed upon them. Sheep grown upon the western ranges will usually refuse to feed upon rape when first turned in upon it if they have access to grass at the same time. Soon they become so fond of it that they prefer it to grass. Cattle in northern areas will not feed upon sweet clover unless compelled to do so through hunger, but catttle in the southern states in certain areas will eat it with more or less relish. The liking for certain products may thus be cultivated to the extent of engrafting it as a permanent feature of the organization.

Feeding subsequent to weaning.—The importance of keeping animals intended for meat pushing without any period of stagnation in growth, or even without any period of seriously retarded growth, has already been dwelt upon. (See p. 371.) Such a period is more likely to occur just after weaning than at any other time during growth. It is of considerable importance, therefore, that it shall be prevented. This is quite possible where the necessary measures are taken to prevent it.

The hazard at such a time arises, first, from cutting off a supply of food that is greatly relished by the young animals, that the digestive system is accustomed to, that is easily digested and that is very nourishing; second, substituting therefor a diet that is less relished, that the digestive system is less accustomed to or not accustomed to at all, and that is not so easily digested. And third, because the weaning season frequently occurs at a season when the grazing has lost much of its succulence and when cold weather, with its rigors, is approaching. The earlier the age at which the weaning occurs, the greater is the degree of the hazard referred to.

Arrested development at such a time, may be almost or entirely prevented, by gradually accustoming the young animals before weaning, as far as may be practicable, to the foods that will form their diet afterward.

This may not be easily practicable in all instances, as for instance, when cows suckle their calves on the range or even on the farm, or when lambs are born in the pastures, the dams in neither instance being given grain during the nursing period. But, when the dams are fed grain, it is easily possible to get the progeny which they suckle accustomed to eating the same, by allowing them to learn to eat it, at first apart from the dam, and later if thought best, as a matter of convenience, with the dam.

The weaning will, in such instances, be so gradual that it will not in any way hinder growth. When animals are hand-fed, the conditions that relate to feeding may be easily and completely controlled.

When weaning animals, the aim should be to secure the following conditions, as far as may be practicable: (1) Shutting off the milk supply gradually. This is most easily done by giving it less frequently, as by feeding but once a day instead of twice; (2) furnishing a liberal supply of concentrated food such as is best adapted to the needs of the animals. Oats should furnish the basic grain food for foals and lambs, and even for calves when not too expensive, but some corn and a small amount of oil cake added will be an improvement. Shorts is the basic food for young swine, but here also, corn will improve the ration, and it may be freely fed along with skim milk. The supply of grain ought to be liberal; (3) fodder of high quality should be provided to encourage large consumption of the same, or if in season, the pastures should be succulent and nutritious. When weaning takes place in the spring, as soon as the pastures become abundant, the grain allowance may be gradually reduced.

In the case of young animals not accustomed to weaning, the best that can be done is to place grain in the fields, paddocks or stables in which they are kept. In time they will begin to eat it, but not until some loss may have occurred in development. If one or more animals of nearly similar ages are turned into the enclosure, the example which they set will lead the others to eat grain sooner than they would without such example.

The age for weaning will, of course, vary. Foals should be allowed to suck their dams for not less than six months, and the same is true of calves. Lambs are usually weaned in four to five months from birth. Swine should take nourishment from their dams for 10 to 12 weeks, unless when two litters per season are required of the dams, in which instances, the nursing period is cut down to eight weeks. When calves are hand-fed, the period of milk feeding is not usually extended to beyond four months. The more completely the young animals are accustomed to food supplemental to the milk taken, the earlier the age at which they may be weaned without hindering development.

Feeding for quick conception.—It is frequently a matter of considerable importance that females shall breed at a certain season of the year and within the limit of a somewhat short period. The object sought is to meet the demands of the market better than if the progeny are produced at other seasons. These demands relate in some instances to the progeny itself, and in others to the accompanying or resulting milk product. This may frequently be attained, though not in all instances, by the nature of the food given to the dam for a short time previously to the mating season.

Mares and cows maintained in reasonably high flesh will usually come in heat at regularly occurring periods, beginning with the former within a few days subsequently to the birth of the foal, and with the latter within three to six weeks of the birth of the calf. But in a considerable proportion of instances, cows do not breed that suckle their calves until a considerable proportion of the nursing period has passed. Ewes and sows will not breed as a rule, while nursing their young. Nor will females of any class breed when the condition of the system is reduced beyond a certain point. But when thus reduced and nourishing, succulent food is given to the extent of making a marked improvement in the vigor possessed by the animal, all the vital forces share in such invigoration, and also all the functions that may be operative at such a time, including those which pertain to conception. From what has been said, it will be apparent that it is much more difficult to influence conception in animals already in good flesh.

To secure quick conception in cows of moderate or low flesh, they should be given more stimulating and nourishing food rich in protein. It is in a sense imperative also, that it shall be possessed of a considerable degree of succulence. Usually the object sought will be accomplished within a few weeks from the time when such feeding begins To secure the same in ewes, they are usually put on rich and juicy pasture subsequently to the weaning of the lambs. The pasture is supplemented with a fairly liberal allowance of nutritious grain. For this purpose oats and barley have been found superior to corn or rye. Wheat also answers the purpose well. Rape pasture is particularly adapted to such feeding and if well advanced in growth, it may not be necessary to supplement it with any grain. The result with generously fed brood sows, subsequent to the weaning of the pigs, will be similar.

When females are well nourished and yet do not come in heat, they may in some instances be made to breed by reducing the flesh in a considerable degree, through withholding food and enforcing exercise, and then giving again enough of suitable food to commence again building up the reduced energies of the system. The success following will be dependent on the cause or causes that prevented the animals from breeding previously.

Salt and its uses.—The desire for salt in nearly all classes of domestic animals is so strong as to amount to a craving, if it is withheld from them for any considerable period. That it serves an important end in the animal economy would seem to be thus indicated by nature. Swine seem to crave it less than other domestic animals, but they also profit by its moderate use.

Salt is not a nutrient in the sense of furnishing food, nor is it certain that it adds directly to the digestibility of foods, as such, nevertheless, it plays an important part in sustaining the animal by the influence which it exerts on the digestive processes. When supplied in suitable quantities, it increases the energy of the vital processes. It does so by facilitating the passage of albuminoids from the digestive tract into the blood, and by increasing the secretion of the juices of the body and quickening their circulation. In doing so, however, it increases protein consumption.

A second and important use of salt is the favorable influence which it exerts upon the appetite. It renders foods more palatable and, therefore, when judiciously used in preparing them, increases their consumption. But, to feed quantities abnormally large would lead to harmful results as shown below. The craving for salt is influenced to some extent by natural location and also by the food. Animals grazed near the sea frequently secure a sufficient supply from the herbage upon which they feed. Relatively large quantities seem to be required by animals grazing on plants watery in character, as young grass and succulent rape.

A third action of salt is to increase the excretion of urine, which may probably in part explain the craving for much salt by animals on watery food. This explains also why animals which are given much salt, drink much water. The consumption of much salt accompanied by an insufficient supply of water, would result in diverting to the kidneys water that would otherwise pass off through the organs of respiration, and in consequence there would be a more or less quick loss of weight. When abnormally large quantities of salt are taken, this is followed by the drinking of abnormally large quantities of water, which results in a waste of nutrients in the body through increased protein consumption. Death has even resulted from allowing cows to drink large quantities of brine, which had been used in salting pork.

It is particularly desirable, therefore, that domestic animals shall be given enough salt at all times to meet their needs, and that they shall not be given an excess of the same. It is scarcely possible to adjust the amount of salt given to the exact needs of the animals in any other way than by giving them constant access to it, that they may take it at will. If supplied only at intervals, they take it to excess, but not otherwise, although it has been claimed that some horses will eat it in excess even under the conditions stated above.

That it would not be quite practicable in any other way to adjust exactly the amount of salt given to the needs of the animal will be apparent from the different amounts called for by animals of different classes, different ages, fed under different conditions as to performance, and on different kinds of food. It would not be quite possible, therefore, to name amounts to be thus fed except in the most general way. The amount mentioned as suitable for a dairy cow is ¾ of an ounce per day, and for a steer of 1,000 pounds weight as 1 ounce per day when fattening begins, and an increase of the same up to more than 1½ ounces before the finishing period. That the exact amounts of salt required cannot thus be perfectly adjusted, however, is not inconsistent with feeding salt in small quantities in the food to make it more appetizing, providing it is not thus fed in excess of the needs of the animals.

This is not the place to discuss the exact mode or modes of giving salt to animals. But it may be mentioned that the aim should be to have it accessible to them at all times, whether in the stall, the yard, the feed lot or in the pasture. It is given in the form of common salt or of rock salt. When given as common salt, it must be protected from rain, which dissolves it. The objections have, in some instances, been raised against rock salt that animals do not always get enough of it and that sometimes the process of licking it makes the tongue sore.

Silage a varying quantity.—Corn silage is one of the most important fodders in feeding dairy cows, and that it will become more important relatively cannot be questioned. But in feeding it to cows and also to other stock the fact should not be overlooked that relatively its value varies so much, that the character of its nutrients should be carefully taken into account when deciding upon the other food factors that shall be fed with it. These variations arise: (1) From the method of growth adopted; (2) from the degree of maturity at which the crop has been harvested; (3)

from the proportionate amount of the grain which it contains, and (4) from the way in which it has been preserved in the silo.

Tests conducted at different experiment stations have shown that the method of growth has a marked influence on the bulk product per acre. At the Illinois experiment station, it was found that corn grown with the stalks 3 inches apart in the rows, the latter being 44 inches distant from one another, produced 4.8 tons of stover per acre, while corn with the stalks 9 inches apart in rows equally distant produced but 3.1 tons. But with the former, the proportion of the stover to each pound of ears was 3.6 pounds, and with the latter 1.5 pounds. The difference, therefore, in the feeding value of equal quantities of silage grown thus will be at once apparent.

The increase in the dry matter in corn between the milk and the grazing stage is very great. At the experiment station at Geneva, N. Y., it was found that the dry matter in an acre of corn increased from 4,643 pounds when in milk, to 7,202 pounds when glazed. When matured, the dry matter was 7,918 pounds. Since it is claimed that a pound of the dry substance of well matured ensilage has a higher nutritive value than at any previous period in its growth, the influence of maturity on the feeding value of ensilage will be apparent. In some localities, corn cannot be taken past the milk stage for ensilage because of early frosts.

The proportionate amounts of grain and stover vary exceedingly in ensilage. Corn may be grown so thickly, that it will not produce ears at all, and yet it may make good silage. Again, it may be grown so as to produce nubbins, varying from ears not much below the normal size down to very small. When grown to furnish a maximum amount of ears, more than half the weight of the entire crop will be ears. Here again the difference in the feeding value of a pound of silage will be clearly evident. The bearing which this should have upon the amounts of grain or meal to feed with the silage should not be lost sight of, more especially when feeding large quantities of silage.

Silage differs considerably in the degree of the acidity which characterizes it. The difference may be so much as to justify the use of the terms, "sweet" and "sour," as applied to silage, with all manner of gradations between these. The differences are usually owing in great part, at least, to a difference in the stage of maturity in the corn when it is put into the silo. In other words, it is owing to a difference in the amount of water which it contains. Corn so immature that it carries much water is likely to make sour ensilage, unless the quantity of this has been reduced by wilting the corn. Sour ensilage cannot be fed with safety in quantities so large as sweet ensilage.

Feeding miscellaneous products.—Certain products are occasionally fed as food to stock which do not constitute a part of any regular ration in prolonged feeding These include eggs, weed seeds, sugar, oil of various kinds, and nuts. Certain other products are sometimes fed for a time with sundry kinds of food, to increase the supply of some element or elements lacking in the food. These include hardwood ashes, charcoal and bone meal.

Eggs contain all the essential elements of body growth. Although too valuable as human food to admit of their being much fed to live stock, in some instances they are fed to calves in the uncooked form as a corrective to scours, and in other instances to improve the gloss of the coat. For both uses, other ingredients may be used that are less costly and even more effective. They are sometimes used also in feeding stallions undergoing the strain of severe service, and the benefit resulting will probably justify the outlay.

Weed seeds are grown in large quantities in grain-growing areas of the Northwest. Usually they are sold as screenings and are largely used in feeding sheep, (see p. 272). Many weed seeds are rich in oil, and because of this, should not be fed without admixture. The seeds of foxtail (*Alopecurus pratensis*), more commonly called pigeon grass, usually constitute a principal portion of the weed seeds found in western grains. Experiments conducted at the Wisconsin experiment station showed that this food was not relished by swine when fed uncooked, that for such feeding it should be both cooked and ground, and that when so fed along with 33 per cent of corn meal, it is a superior food to the latter when fed alone. All kinds of weed seeds should be ground for swine and also for cattle, otherwise many of them will escape digestion.

Sugar, such as is used in the human dietary, but of lower grade, is oftentimes fed directly to live stock. When so fed it is commonly mixed with the grain or meal fed to them. Animals are very fond of it, and when fitting them for exhibition it not only aids in quick fattening but also improves the coat. Mixed with other food, it increases the consumption of the same. For ordinary fattening, it has a place when not too costly, but it is thought to exert a deleterious influence on the breeding powers of both males and females when fed to them in any considerable quantities, in prolonged feeding.

Oil of various kinds has been tested in feeding different classes of stock. At the Massachusetts experiment station, it was found that very small quantities of some kinds of oil, as corn and cottonseed oil, could be fed to calves on milk with benefit, but when any considerable quantity was fed, indigestion followed. None of these are so completely satisfactory for feeding calves as ground flaxseed or oil cake. It has also been ascertained that the fat in milk cannot be permanently increased by feeding oil or tallow, even when fed to the extent of affecting adversely the appetite of the animals.

Nuts, more especially acorns, in some areas furnish considerable quantities of food for swine. The same is true of beech nuts. These promote quick growth and rapid fattening when plentiful in supply, but the latter produce oily pork. In order to firm it such animals should be fed for 20 to 30 days or even longer, on some such grain as corn, barley or peas.

Ashes have been found highly useful in feeding swine that are much restricted to a diet of corn. In trials made at the Wisconsin experiment station, swine to which ashes were fed freely with a reasonable amount of salt added, the other food being corn meal, made increase much superior to that made by swine fed on corn meal only, with salt added. The bones of the former were not only larger and stronger than those of the latter, but they contained fully 30 per cent more ash. Foods other than corn and the sorghums usually supply potash in quantities sufficient to obviate the necessity of feeding ashes.

Charcoal serves about the same use in feeding swine as wood ashes (see paragraph preceding). Swine, insufficiently supplied with ash in the food, will consume considerable quantities of charcoal. This in corn-growing areas, and in these the principal need for such feeding exists, may be cheaply supplied by charring corncobs in a hole in the ground of any convenient size, and covered with a metal cover, after the mass of cobs have become sufficiently aglow with flames coming up from beneath. Wood charcoal or charred corncobs may be most conveniently fed from self-feeders from which the swine may partake at will.

Bone meal when pure, fresh, and made from healthy animals, may be fed with profit under some conditions to both swine and cattle. It will serve about the same purpose in feeding swine as hard-wood ashes, when about one-third of the quantity is fed. When cattle are much prone to chew bits of bone or wood, which happens in some instances, it indicates an insufficient supply of phosphates in the food. This deficiency may be made up by the judicious feeding of bone meal. The necessity for such feeding, however, exists but seldom.

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