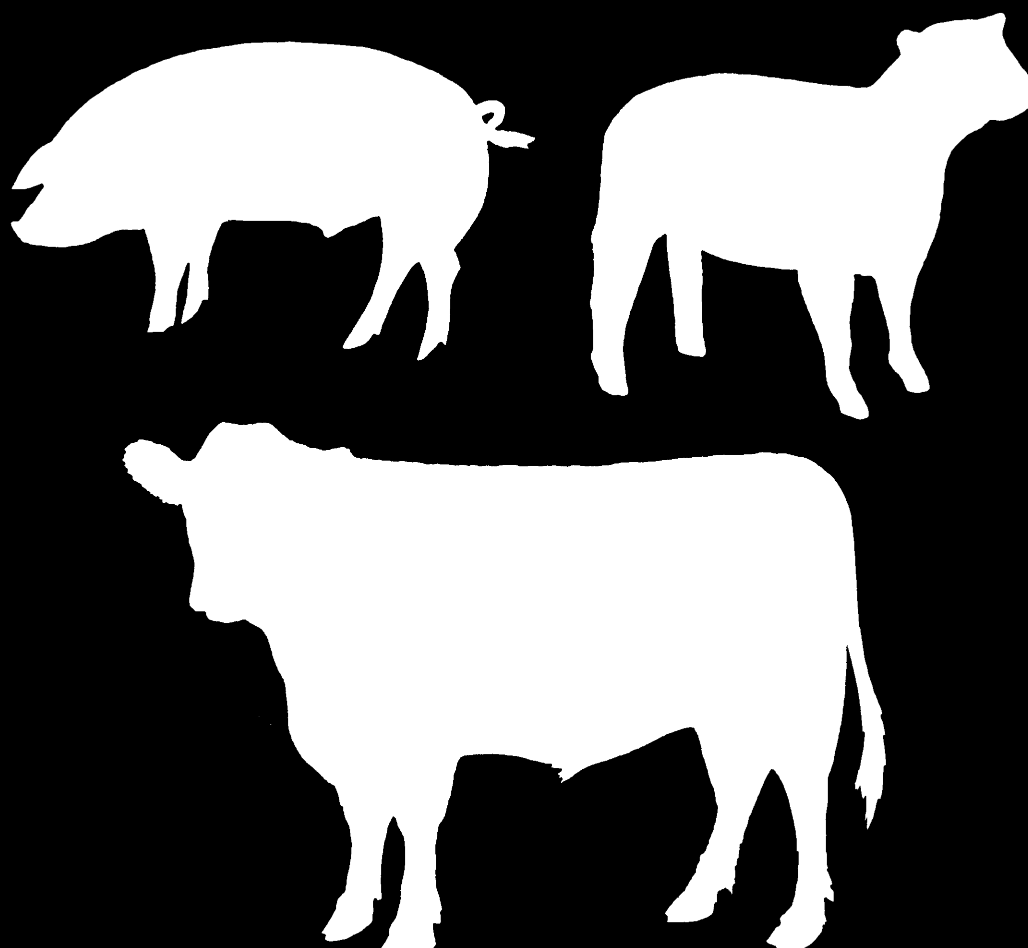
EM3125

4-H MEMBER MANUAL



ADVANCED LIVESTOCK SCIENCE

COOPERATIVE EXTENSION
WASHINGTON STATE UNIVERSITY

CONTENTS

This manual was adapted from a publication by T. W. Wickersham, Extension Animal Scientist at Iowa State University. B. E. Ricketts, University of Illinois Assistant Professor of Animal Science Extension, contributed material on sheep. Minor revisions were made by Joe B. Johnson and William E. McReynolds, former Extension Livestock Specialists at Washington State University. The beef, pork, and lamb charts on pages to were prepared by the National Live Stock and Meat Board, Chicago.

INTRODUCING ANIMAL NUTRITION

Something amazing happens when you feed your 4-H pig, lamb, or calf. Forage is turned into beef or lamb. Grain becomes pork. A quiet-looking scoop of grain becomes bursting energy as a calf romps in the feedlot.

You feed your animal every day. It is something you do automatically, probably without thinking about what you are really doing. You are giving your animal the energy it needs to move around and to fatten. You are giving it vitamins and minerals needed to keep healthy. You are giving it the "building blocks" of protein that make it grow. When the animal is grown, the feed you give it will help it reproduce and provide milk for its young.

In other words, you are giving your animal nutrients. You are part of the world of animal nutrition.

Animal nutrition is the science of all the processes that take place when feed is given to animals.

Chemistry is very important in animal nutrition. Biochemistry—the chemistry of life—is largely involved.

The feed you give your animal is made up of various combinations of chemical substances. After the feed is eaten, more materials are added to it by the animal's body. These materials bring about reactions which break down the feed into very small particles—so small they cannot be seen by the naked eye.

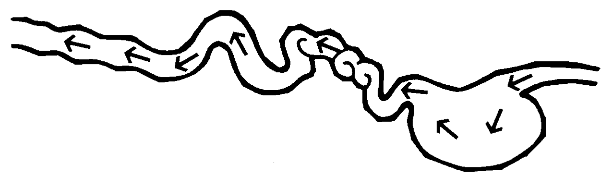
These particles are then taken into the blood stream, which carries them to all parts of the body. Throughout the body the particles are "burned" for energy, form body tissue, or are stored as energy in the form of fat.

These first reactions—the breaking down of the food—are called digestion. Digestion takes place in a special system called the digestive tract. This tract begins with the mouth and teeth, where food is broken into fine particles by chewing. The mouth is connected to the stomach by the esophagus. The stomach empties through a valve into the small intestine. The small intestine empties into the large intestine, which terminates at the anus.

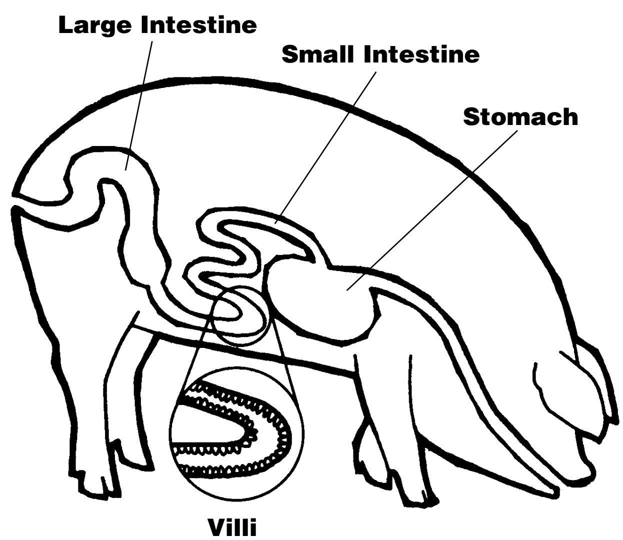
The Digestive "Factory"

Think of the digestive tract or gastrointestinal tract (the G.I. tract) as a hollow tube.

Food entering the mouth is broken down by the teeth. As it passes through the rest of the tract, the chewed feed is gradually broken down into smaller and smaller units.



There are four main parts of the digestive tract where chemical reactions take place. In each chamber, different chemicals—digestive juices—are added to the food. These will be explained in detail later.



The job of the digestive tract is the same in all animals. But there are important differences in the digestive tracts of different animals. Cattle and sheep are fed much hay or other materials high in fiber. Pigs are fed grain or other materials low in fiber. The reason for this is that cattle are able to digest fibrous materials more efficiently than pigs. The differences in the digestive tracts of cattle and pigs explain this.

Through the Digestive Tract

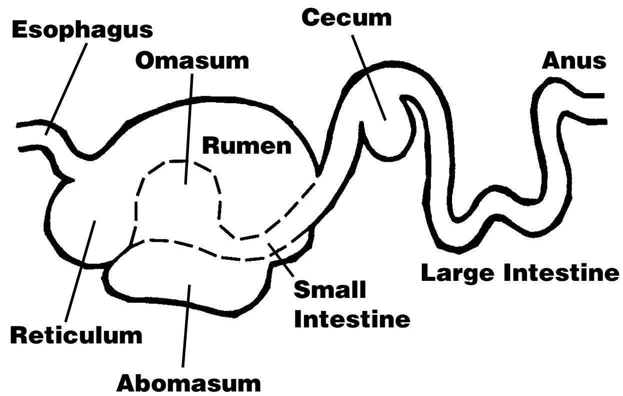
The first part of the tract is the *mouth*. This, of course, is the place where food enters the digestive tract and where the food is broken into small particles by the teeth. In pigs an enzyme is added by the saliva in the mouth to start carbohydrate digestion. Digestion of food by man starts in the mouth, too. The second part of the digestive tract is the *esophagus*. It is a tube which carries food from the mouth to the stomach. A series of muscle contractions moves the food through the digestive system. The first of these is swallowing. It is responsible for moving food from the mouth to the stomach. (This works about like pinching toothpaste out of a tube.)

The *stomach* is the first reaction chamber. It is a kind of vat where chemicals are added to the food. Certain cells of the stomach wall produce hydrochloric acid. Other cells secrete gastric (stomach) enzymes.

The stomach is where carbohydrate and protein digestion gets underway and fat digestion starts (except in ruminant animals). Digestion produces very small particles of protein, carbohydrates, and fats. Some of these pass through the stomach wall into the blood stream. Food which the stomach is not designed to completely digest and to absorb passes to the small intestine.

Food passes from the stomach through a valve to the *small intestine*, which is the next chamber. The intestine is a very complex tube which lies in a spiral. In some animals, it is 130 feet long. Digestion and absorption continue in the small intestine, where more digestive juices are added. The cells lining the walls of the small intestine produce enzymes that aid digestion and absorb the digested feedstuff. In addition, two important glands deposit their juices in the small intestine. The first of these is the *liver*. The bile duct runs from the gall bladder (which is closely associated with the liver) to the small intestine. Through it pass bile secretions. These react with fats to help digest them. The second gland is the *pancreas*. Through the pancreatic duct, it delivers several digestive juices to the small intestine. These juices help digest several food components, including carbohydrates, fats, and protein. More food nutrients are absorbed through the small intestine than from any other organ.

ESSENTIAL PARTS OF A RUMINANT STOMACH



A "blind gut" called a cecum is found at the junction of the small and large intestines. In most animals, the cecum is small and has few functions. But it is very important in some animals such as horses and rabbits. In these animals fibrous feeds are digested in the cecum.

The next part of the digestive tract is the *large intestine*. It is the fourth major part of the tract. This intestine is shorter, but larger than the small intestine. Its main function is to absorb water. It is also the site of some bacterial digestion, as is the cecum. Another job of the large intestine is to add mucous material to the remaining food. This is a lubricant that makes passage through the tract easier. Muscle contractions move food through the large and small intestines.

The last part of the digestive tract is the anus. It is simply an opening through which the undigested portion of the feed taken into the mouth is eliminated.

So, this is our "hollow tube." Its main jobs are to digest and to absorb food.

Cattle and Sheep Have Special Stomachs

We mentioned that cattle and sheep can digest large quantities of fiber, but pigs cannot. How do they digest roughage?

The answer lies in their special kind of stomach.

Cattle and sheep are ruminants. This means they have compound stomachs. Goats, deer, and many other grazing animals are also ruminants.

A ruminant animal's stomach has four compartments. The first compartment is the rumen or paunch. Next is the *reticulum* (reh-tik-u-lum) or honeycomb. There is no division between the rumen and the reticulum. They are generally thought of as one compartment. In the adult cow, the rumen and reticulum can hold 40 to 60 gallons of feed material. They almost completely fill out the left side of the middle part of the animal. In the average size adult sheep the capacities of the four stomach compartments are: rumen, $6^1/4$ gallons; reticulum, 1/2 gallon; omasum, 1/4 gallon; and abomasum, 3/4 gallon.

The rumen and reticulum make up a huge "vat." In it, food is agitated, fermented, and digested. Many bacteria and protozoa are found in these two compartments. Feed high in fiber (roughage) eaten by cattle is digested in the rumen and reticulum with the help of these bacteria. (Bacteria and protozoa are really small animals.)

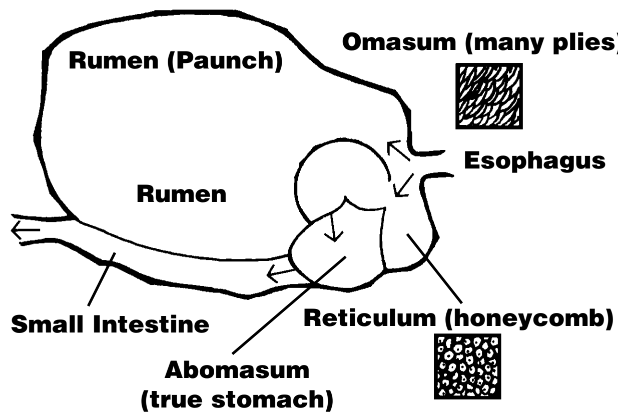
This is not the only job of the rumen and reticulum. Muscle movements in the two compartments help break food into smaller particles so bacteria and protozoa can do their job better. Also, digestion is aided in these compartments by the addition of much saliva and water.

The third compartment of the ruminant stomach is the *omasum* (o-may-sum) or manyplies. It makes up about 8 percent of the stomach. Scientists do not yet know the exact role of the omasum. For one thing, it acts to grind food. But just how much grinding it does is uncertain. The omasum may also squeeze water out of food that has come from the rumen.

The fourth compartment is the *abomasum* (ab-o-may-sum) or "true stomach." It is about the same size as the omasum. This is the only compartment of the stomach where digestive juices are produced. It works similarly to the stomach in nonruminant animals such as the pig. From the abomasum on, the ruminant digestive tract is the same as the nonruminant tract.

Together, the omasum and abomasum make up about one-fifth of the adult ruminant's stomach. They are mostly on the right side of the animal.

THE RUMINANT DIGESTIVE SYSTEM



A Few Nutrition Terms

Digestion. The process that breaks down food before it is absorbed from the G.I. tract into the body. It includes all the activities of the digestive tract and its glands.

Metabolism. The changes that take place in digested food after it has been absorbed from the digestive tract. In metabolism body tissue is built and energy is used.

Ruminants. Animals with more than one compartment in their stomachs. They are sometimes thought of as having four stomachs. Cattle and sheep are ruminants. Only ruminants chew a "cud."

Nonruminants. Animals that have one stomach. Pigs and horses are nonruminants.

Enzymes. Digestive juices that act as catalysts. They speed up chemical reactions in digestion.

Mechanical factors. Chewing and swallowing are mechanical factors in digestion. Regurgitating the cud and muscle action in the stomach and intestines are other mechanical factors.

Secretory factors. Glands do not act directly in digestion. They secrete enzymes to help digestion.

Chemical factors. Chemicals that aid digestion. They include both enzymes and other chemicals.

Hydrochloric acid is one of the others.

Microbial factors. Bacteria that play a part in digestion. Sometimes protozoa (one-celled animals) are also involved.

PATHWAYS OF FEED

A shady pasture dotted with resting cattle looks like a quiet scene indeed. Cattle leisurely chewing their cud are the picture of ease.

But, beneath this calm surface is a bustle of activity. In a huge vat inside the ruminant animal, feed is being mixed, ground, moistened, and fermented. Bacteria in this vat are breaking down feed. The muscles of the digestive organs are contracting and expanding. Digestion is underway.

Digestion is a complex chemical process. But, much more than chemistry is involved. Muscle actions of the digestive tract and the different routes that feed takes through the digestive tract are also important.

Cattle and sheep are ruminants. Pigs are nonruminants. As a result, the pathways of feed in these animals are different. This, in turn, affects their nutrition.

Pathways in Ruminants

Differences in the digestive tracts of ruminants and pigs are reflected in the ways they eat.

You can watch cattle use their strong tongues to pull in great amounts of feed. They eat rapidly, seldom pausing, and hardly bothering to chew. In fact, they eat so hurriedly that they sometimes swallow nails, wire, glass, or other debris left around the farm. This is why ruminants sometimes get "hardware disease."

No matter what kind of feed is being eaten, cattle only partially chew it. Only about half the whole-kernel corn eaten by cattle is crushed before it is swallowed. This is why you will often find undigested corn in cattle manure.

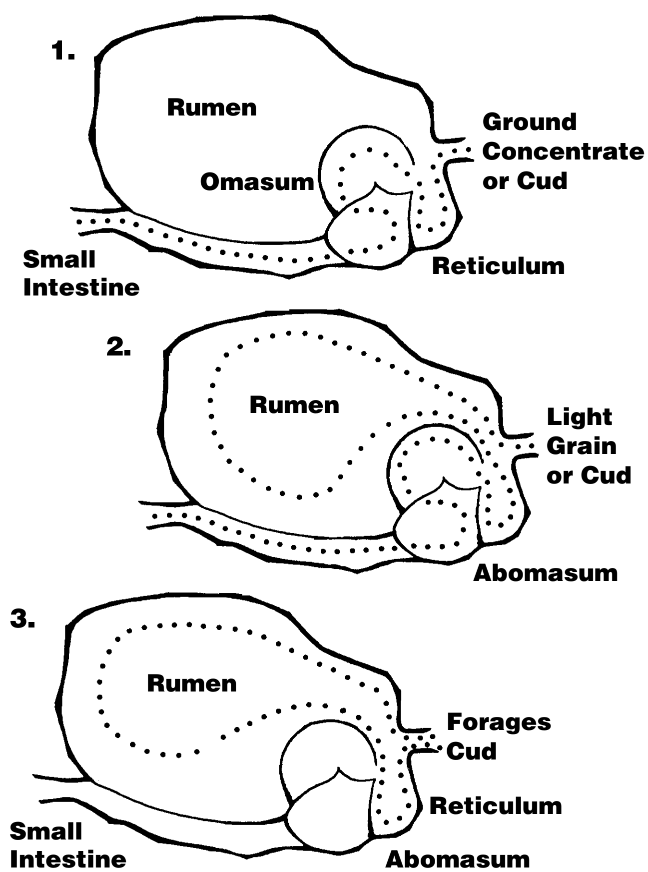
After cattle and sheep have taken in enough feed to fill their rumens, they usually find a comfortable spot to lie while they "chew their cud." The feed in the rumen is hardly changed from the form in which it was swallowed except that water has been added. The rumen and reticulum work to prepare the feed for digestion. The rumen and reticulum act as a holding vat. Feed is stored here for several hours while bacteria digest it. Meanwhile, much of the coarse feed is regurgitated into the animal's mouth for rechewing.

The exact route followed by feed during this process is not always the same. The route taken by the feed depends upon what kind it is. There are three possible routes:

1. The most direct route is from the esophagus to the reticulum and then into the omasum. This is the route of ground concentrate and "heavy" feed. From the omasum, feed enters the abomasum. From there it passes through the small intestine, the large intestine, and is then eliminated through the anus as waste.

2. Food may be flushed into the back of the rumen. After traveling around the rumen, it enters

THREE POSSIBLE ROUTES OF FEED IN RUMINANTS



the reticulum and passes on to the omasum. From there it enters the abomasum, and passes through the small intestine, large intestine, and anus.

3. The feed may complete the circuit of the rumen. After entering the reticulum from the rumen, the food is regurgitated as a cud. It is rechewed and swallowed again. The feed may then follow either route 1 or route 2.

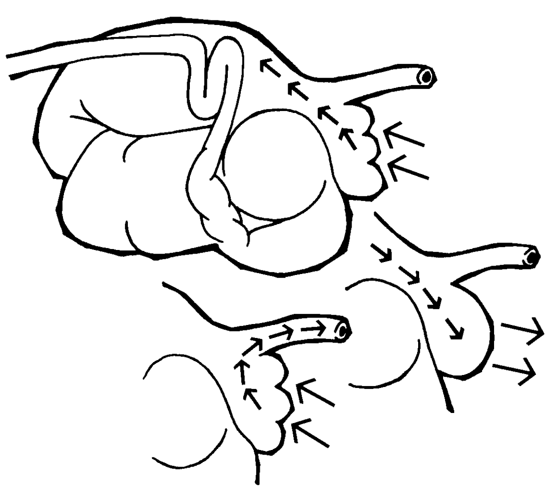
Mechanical Factors

Liquids constantly circulate between the rumen and reticulum. This helps digestion by keeping the feed in these compartments moist. It is one of the mechanical factors in digestion.

Stirring a cup of coffee causes the sugar to dissolve more quickly than if it is not stirred. Mechanical factors of digestion work the same way. They help the chemical reactions in digestion.

Chemistry is very important in digestion. Chemical reactions break down feed so it can be absorbed. Mechanical factors are important also.

In rumination,
the reticulum acts as a pump



The first mechanical factor is chewing, which is followed by swallowing. The process in which the cud is chewed (rumination) comes next in ruminant animals.

Rumination in cattle begins about an hour after eating. It continues for about 45 minutes. Feed is regurgitated and rechewed. Saliva is added and the feed is reswallowed.

During rumination, the reticulum acts as a sort of pump. At the beginning of rumination it contracts. This forces feed in the reticulum upward and backward into the rumen. When the reticulum relaxes again, it fills up with feed that has been fermenting in the rumen.

Then the reticulum contracts again to trap another supply of feedstuff for rechewing. This food is forced up the esophagus into the mouth. The process is aided by gas and muscle pressure in the rumen.

The first contraction of the reticulum takes about 1 minute. The second contraction is stronger, but lasts only about half as long.

Cattle usually have six to eight rumination periods each day. A total of 5 to 7 hours is spent in rumination. About 90 to 130 pounds of feed is regurgitated and rechewed daily.

Dry feed, such as grass or hay, must be ruminated, or it cannot be digested. Most of the grains do not appear in the cud. They probably pass straight to the abomasum (true stomach), since they do not need rechewing and do not require long exposure to the more powerful forces of digestion at work in the rumen.

Slow Feed Passage in Ruminants

After the cud is chewed it is swallowed and passes down the esophagus into the reticulum. Most of it then goes on to the omasum. When the omasum contracts, water is squeezed out while the feed is being forced into the abomasum.

As the feed continues through the digestive tract, more mechanical factors are involved. Most of them are muscle contractions in the digestive organs which push feed along the tract.

The appetite of ruminants depends somewhat on how much feed is left in the digestive tract. Animals fed an easily digested feed (such as ground corn) have better appetites than animals fed hard-to-digest feeds such as hay. This is because the easily digested feeds pass through the tract more quickly and leave the tract empty. The empty tract stimulates appetite.

In a normal ration, these are the times it takes feed to pass through each compartment in the digestive tract of cattle:

Rumen and reticulum	61 hours
Omasum	8 hours
Abomasum	3 hours
Small intestine	7 hours
Large intestine	8 hours

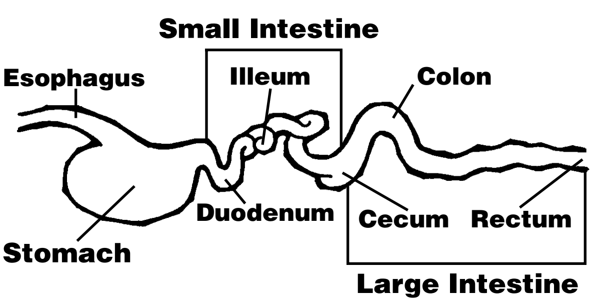
That's a total of almost 4 days for feed to pass through cattle. With some portions of the diet the time is even longer.

Pathways in Nonruminants

Compared with the time required for cattle, the 24 hours required for feed to pass through the digestive tract of a pig is short.

Pigs do not have a rumen where feed can be stored while it is digested. Nor do they ruminate or chew a cud. Pigs must chew their feed for good digestion before it is swallowed, or the feed must be ground for them. Pigs chew and swallow slowly so feed will be mixed with an enzyme in the mouth.

DIGESTIVE TRACT OF A PIG



From the mouth feed passes down the esophagus into the stomach. Then it passes through the small and large intestines

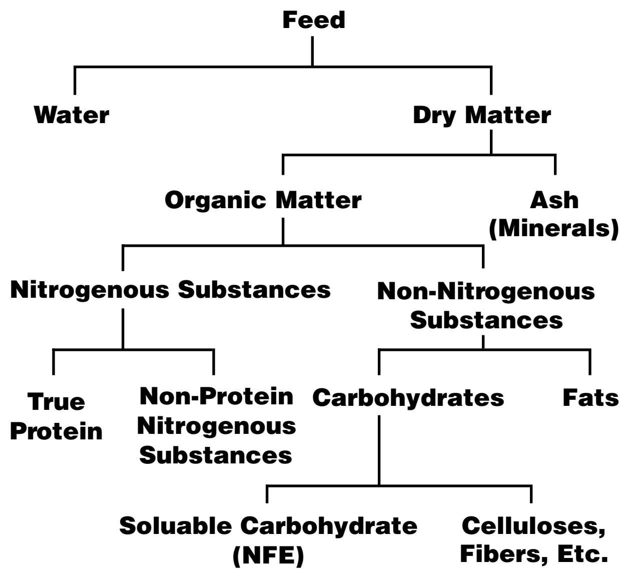
FEED NUTRIENTS

You probably feed your 4-H animal supplement. If your project is a calf, you feed one kind of supplement. If it is a pig, you feed another kind. You know that the supplement will make your animal grow faster and make more economical gains. The animal will be in "better shape" than if you just let it root or graze.

Different animals need various kinds and amounts of nutrients This is where the science of animal nutrition comes in. Part of the animal nutritionist's job is to find out what nutrients animals need.

Nutritionists search for the best combination of feeds for the kind of animal being fed. For dairy cows the feed must help produce lots of milk. For a brood sow the feed is designed to help produce healthy litters. For a steer or lamb fast gains at the least cost are desired.

FEED COMPONENTS



After experiments are conducted, they are checked and rechecked. Then the results are used to make recommendations to farmers. This means more profit for the farmer and better, cheaper meat and meat products for everybody.

Kinds of Nutrients

There are many chemicals in feeds. Animals need some of them in large amounts, and others in only tiny amounts. Some haven't been discovered or named yet.

These feed constituents are divided into five main types of nutrients. Each type has a different job in the animal's body. The five types are (1) energy nutrients, (2) proteins, (3) vitamins, (4) minerals, and (5) water.

None of these is more important than the others. All are essential. But with the exception of water, the energy nutrients usually make up the greatest bulk of feed.

Energy Nutrients

Energy nutrients are the body's fuel. In fact, they are chemically similar to fuels we use—gasoline, oil, and coal.

After digestion, the energy nutrients are carried by the blood to the cells of the body. In reactions very much like burning, they are used by the cells for energy. Energy or fuel is required to power the movements of muscles—walking, breathing, blinking eyes, contractions of the digestive system. At the same time, heat is produced to maintain body warmth.

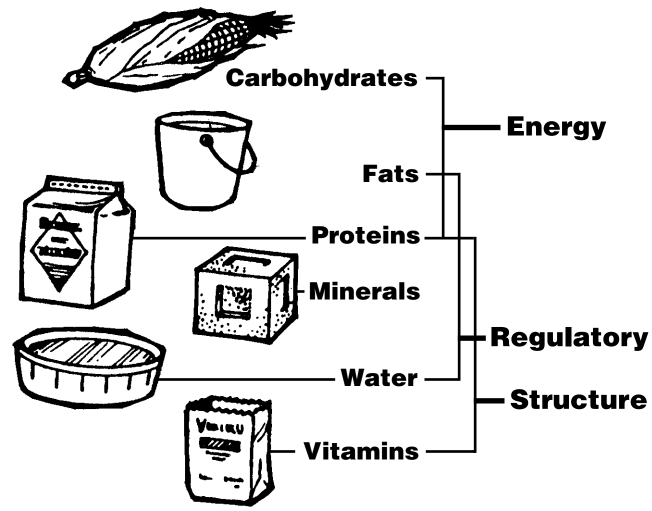
The main energy nutrients are *carbohydrates.* There are many carbohydrates and even the relatively simple ones are what chemists call complex compounds. All carbohydrates are made up of carbon, hydrogen, and oxygen. Carbon is the key to carbohydrates. This element can behave in several different ways. As a result, there are thousands of possible combinations of carbon, hydrogen, and oxygen.

Sugars and starches are carbohydrates. They are relatively simple compounds. Cellulose is one of the more complex carbohydrates.

The sugars and starch are easy to digest. They have a high "feeding value" because very few of them pass through the body undigested. Grains such as corn and oats contain much sugar and starch.

Cellulose is chemically a carbohydrate. It makes up the fiber in plants. Grass has much cellulose. Cellulose is hard to digest and for most animals it has a low feeding value; however, ruminants can digest large amounts of cellulose with the aid of bacteria in the rumen.

Another group of energy nutrients is the *fats* and *oils.* Fats and oils are chemically alike. Their main difference is that fats are solid at body temperature; oils are liquid. Both are usually called *fats.* Like carbohydrates, fats are made up of carbon, hydrogen, and oxygen. They are also used to provide energy for movement and heat. Fats contain a higher percentage of carbon and hydrogen atoms than carbohydrates. So, the energy in fats is more concentrated. Fat has 2.25 times more energy value than carbohydrate.



The Proteins

Proteins supply the material from which body tissue is made. They are the bricks and mortar from which bodies are built.

Proteins are highly complex. In addition to carbon, hydrogen, and oxygen, they contain nitrogen. Some proteins also contain sulfur and a few contain phosphorus or iron.

Like carbon, nitrogen can be combined with other chemical elements in various ways. The various combinations result in many different proteins. Each protein is made up of several nitrogen compounds called *amino acids.* These amino acids are the "building blocks" from which proteins are made. The chemical arrangement of the amino acids determines the quality of the protein.

During digestion, proteins are broken into amino acids. These are absorbed through the intestine into the blood stream and carried to all parts of the body. Then they are recombined to form body tissue.

Proteins that are eaten eventually become muscle, internal organs, bone, and blood. Skin, hair, wool, hooves, horns, and many other parts of the body are also made of protein. If an excess of protein is fed, the nitrogen portion of the protein can be separated from the rest of the nutrient and discarded in the urine. The remaining materials can then be converted into energy by the animal.

The Vitamins

Although animals need large amounts of both energy and proteins, other nutrients are just as vital, but needed in much smaller amounts. The *vitamins* are such a group.

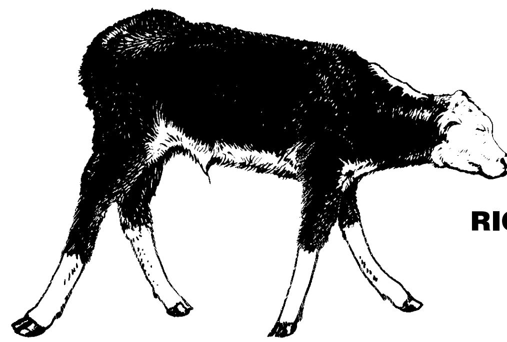
For a long time, people noticed that certain diseases were caused by the lack of certain foods. Then modern science began analyzing the foods. They were found to contain small amounts of certain complex chemicals. Other foods did not contain them.

These nutrients were called vitamins or "life amines." They are essential to normal body functioning.

The vitamins are not chemically alike. Each one also has a different job in the body. Still, they are all classed together under the term vitamins. This is because they are all organic compounds. (They contain carbon.) Also, all of them are needed only in very small amounts. For example, the vitamin A requirement for a steer is about 50 milligrams daily. This is about the amount represented by the heads of 5 common pins.

Vitamin A is responsible for the health of the eye and the tissue of the nasal passages and lungs. Vitamin D is responsible for the strength and proper development of bones and the mineral balance in the blood. Other vitamins have just as important functions.

Some animals require only certain vitamins in their feed, whereas others can manufacture some of their own. Feeds are a good source of certain vitamins. Carotene in green grass is a good source of vitamin A, while sunshine and sun-cured hay are good sources of vitamin D.



RICKETS

RESULT OF VITAMIN-D DEFICIENCY

The Minerals

Like vitamins, *minerals* are usually needed only in small amounts. Unlike vitamins, they are inorganic—they do not contain carbon. Iron, copper, phosphorus, calcium, and magnesium are examples of minerals.

Minerals are important in the chemical reactions of the body. Without them, many life processes could not take place. Without iron in the blood, for instance, oxygen could not be carried to the body's cells. Anemia is a nutritional disease of baby pigs caused by a lack of iron and copper (specific minerals) in the sow's milk.

Without calcium and phosphorus proper bone and tooth formation would not take place. These are examples of the need for minerals.

Water as a Nutrient

The last item on our list of nutrients is so common that we seldom think of it as a nutrient. But water is the largest single part of nearly all living things. The body of a pig, calf, or lamb is three-fourths water.

Water performs many tasks in the body. It makes up most of the blood, which carries nutrients to the cells and carries waste products away. Water is necessary in most of the body's chemical reactions. In addition, water is the body's built-in cooling system. It regulates body heat and acts as a lubricant.

Life on earth would not be possible without water. An animal can live longer without food than without water.

Finding Out What's in Feeds

Research has provided the information that is available about the different kinds of nutrients. The scientist has developed methods by which the amount of each nutrient in a feed can be accurately determined. Knowing the nutrient content of a feed is very important to livestock raisers.

Water is one of the nutrients that is fairly easy to determine. Simply take a sample of a feed and weigh it. Then heat the feed sample slightly above the boiling point of water. Hold it at this temperature until the feed stops losing weight, then weigh the feed. This weight is subtracted from the weight before heating. The difference between the two weights represents the amount of water driven off by the heat. To find the percentage of water, divide the dry weight by the original weight.

Another fairly simple analysis is to find out how much mineral is in the feed. Recall that minerals are inorganic chemicals. As such they will not burn. When feed is completely burned, a whitish-gray ash is left. If the weight of this ash is divided by the original weight of the feed before burning, the percent mineral or ash is obtained.

The chemical analysis gets more complicated when you are determining how much protein is in a feed. Recall that protein is made up of carbon, hydrogen, and oxygen, plus nitrogen. Scientists have learned that protein is about 16 percent nitrogen Using certain chemical tests, the amount of nitrogen in a feed can be determined. Multiplying this amount by 6.25 (16 percent nitrogen divided into 100 = 6.25) gives the amount of crude protein in a feed. It is called crude protein because it includes all nitrogen compounds. There may be some nitrogen compounds in the feed that are not true proteins.

Another test is for the amount of fat in a feed. Since fat dissolves in ether, a sample of the feed is heated in ether for several hours. Then the feed is removed, and the ether is evaporated. The residue that is left is the fat or ether extract.

It is important to know the fiber content of feeds. This is because fiber is hard to digest. Therefore, feeds with a high fiber content are less nutritious.

To find the fiber content, some of the feed is dissolved in a weak acid or alkali. Fiber (very complex carbohydrates) will not dissolve; it is left over. Any material that the weak acids or alkali will not dissolve is considered to be indigestible by animals. Keep in mind that the cells in the lining of the stomach secrete a weak solution of hydrochloric acid.

If the percentages of water, minerals, fat, fiber, and protein are added together, the total will be something less than 100 percent. The difference is referred to as the nitrogen-free extract and includes the more soluble carbohydrates, sugars, starch, and some cellulose. All of these are readily digested.

When the amounts of different nutrients in a feed are known, the quality or feeding value of the feed can be easily determined. By adding the digestible organic nutrients (protein, nitrogen-free extract, and fat x 2.25), you can tell the "energy value" of a feed. TDN—total digestible nutrients—is the term used.

DIGESTION, ABSORPTION, METABOLISM

Any of three things can happen to the feed you give your 4-H animal: (1) it can be used for energy or for fattening, (2) it can be used to build body tissue, (3) that which is left over passes through the body as waste.

Of course, feed is not used in the form in which it is fed. Beef isn't much like hay, nor is pork much like corn. Feed must be taken apart before it can be used, then put back together in another form.

You have learned that feeds are made up of various chemicals. Digestion is a series of reactions during which feed is broken into the units of which it is made. These are the end products of digestion.

The end products are absorbed through the lining of the digestive tract. They are carried to all parts of the body by the blood where they are built into body tissue, used for energy, or stored as fat.

This process of using end products is called metabolism.

Digestion of Carbohydrates

Remember that carbohydrates are energy nutrients. Ruminants usually get most of their carbohydrate from hard-to-digest feed such as grass. Pigs (nonruminants) get most of theirs from grain. The main carbohydrate in grass is cellulose. The main one in grain is starch.

In cattle and sheep, carbohydrate digestion starts in the rumen. There, with the aid of bacteria and protozoa, carbohydrates are broken down into particles called short-chain fatty acids. These are the end products.

Short-chain fatty acids are very mild. One of the more common ones is acetic acid, with which you are probably familiar. Common vinegar is mostly acetic acid and water.

Some carbohydrates get through the rumen of cattle without being digested. Those which do get through the rumen are digested just as in nonruminant animals in the true stomach or abomasum.

Carbohydrate digestion in pigs begins in the mouth. While the animal chews, saliva is added to the feed. Saliva contains an enzyme called salivary amylase which acts on starch by breaking it down into sugars. A scientist would call these disaccharides, which are a combination of two simple sugars. Common table sugar is a disaccharide. Salivary amylase continues acting on starch for a time after it reaches the stomach. Then, stomach acid stops the reaction.

Nothing more happens to carbohydrate in pigs until it reaches the small intestine. By that time, most carbohydrate has been broken down into disaccharides. Those which have not been broken down react with another enzyme—pancreatic amylase.

Finally, several more enzymes are added to the contents of the small intestine. These enzymes continue the process of breaking the disaccharides into simple sugars. These are the end products of carbohydrate digestion.

Digestion of Fats

The other main type of digestion is the digestion of fats. These, like carbohydrates, are energy nutrients. They are made up of fatty acids and glycerol. These fatty acids are more complex than the short-chain fatty acids in ruminant digestion of carbohydrates.

Digestion of fat is about the same in ruminants and pigs. In cattle and sheep, fat digestion takes place in the abomasum and small intestine. In pigs, it takes place in the stomach and small intestine.

In the stomach or abomasum, an enzyme called gastric lipase acts on fats. It breaks them down into fatty acids and glycerol. In the small intestine, the breaking down process is continued with pancreatic lipase.

The process is aided by bile from the liver. Liver bile softens fats, physically breaking them apart. This makes them easier to break into fatty acids and glycerol—the end products.

Digestion of Protein

Another nutrient that is digested differently in ruminants and nonruminants is protein.

Proteins are the nutrients from which body tissue is built. Humans and certain other animals eat meat because it is a source of high-quality protein. The high quality of the protein in meat is caused by the excellent combination of essential amino acids that it contains. During digestion the proteins are broken into the amino acids of which they are made. These amino acids are the end products of digestion in pigs.

Protein digestion in pigs begins in the stomach. There, an enzyme called pepsin initiates the action on protein. The result is the formation of small protein chains. The protein chain pass on to the small intestine, where more enzymes are added. These enzymes break the protein chains into amino acids. The amino acids are absorbed through the small intestine wall.

In cattle and sheep, protein digestion is more complicated. It begins in the rumen with the aid of bacteria. Bacteria are small animals and require a certain combination of amino acids to develop their own bodies. These bacteria break the proteins in the rumen into ammonia gas. This is one of the simplest forms of nitrogen.

Nitrogen must ordinarily be combined in the proper proportion with many other elements before it can be used by an animal. But, the bacteria in the rumen have a special ability to build new amino acids. They may be the same or different from the amino acids in the feed. The bacteria use these new amino acids in building their own bodies. As bacteria in the rumen die and pass on into the abomasum and small intestine, the protein in their bodies is digested and used by the ruminant. The amino acids are then absorbed into the blood stream from the intestine.

This cooperative arrangement between rumen bacteria and ruminant animals makes animals easier to feed. For one thing, since the bacteria in the rumen can use simple forms of nitrogen, cattle and sheep can be fed nonprotein nitrogen such as urea. Also, since the bacteria can make one amino acid from another, or make new amino acids from simple nitrogen, there are no "essential" amino acids for cattle. Cattle and sheep need a source of nitrogen, but they do not have to be fed a specific balance of essential amino acids.

Most absorption is from the small intestine. Its surface is covered with millions of small, finger-like projections called villa. These have the effect of increasing the surface many times, hence its function is absorption.

Both proteins and carbohydrates are absorbed mostly in the first part of the small intestine. The rate of absorption decreases as the food moves along.

Most fat is also absorbed in the small intestine. This is done with the aid of liver bile, which is essential to fat absorption.

After absorption, the end products of digestion are carried through the blood stream. Most of them end up in the muscle cells or the liver. This is where most metabolism takes place.

During metabolism, most end products are broken down a little further to provide the specific type of fuel or material that is needed by the cells. Some are used to replace worn-out cells and are used to build new body tissue. Some are used for energy, while others are stored for later use.

Absorption and Metabolism

We have talked a lot about end products being absorbed after digestion. Absorption is a general term. It means the passage of a substance into the blood stream. It may occur from the surface of the body, from body cavities, or from any of the body organs. We are concerned with absorption from the digestive tract.

There is practically no absorption from the mouth or esophagus. The tissue in these organs is not suited for absorption. Also, food is not yet broken down enough to be absorbed. Nor is food present in them long enough to be absorbed.

In nonruminants, the stomach tissue is also not suited for absorption, except to a small extent. The same is true in ruminants, except for the rumen. Short-chain fatty acids are quickly absorbed from the rumen.

LEARNING ABOUT NUTRIENT REQUIREMENTS

How did you find out what to feed your 4-H animal? Perhaps it was from your parent, your 4-H leader, or county Extension agent. You were probably told what to feed and exactly how much to feed. Or perhaps you followed instructions given by a feed company. Specific feeding instructions are usually printed on the back of feed tags.

But how do these people know? How do you figure out the right balance of proteins, fats, vitamins, and all the other nutrients?

The science of animal nutrition can help you. Scientists have learned a lot about nutrient requirements and constantly search for knowledge which will improve the performance of livestock.

Underlying the scientists' search for the right nutrients are certain principles that guide them in their research and guide livestock raisers in their feeding programs. Four principles that you should know are discussed below.

1. Species differ in nutrient requirements.

   This principle simply means that various animals need different nutrients. The digestive tracts of hogs and ruminants are different. Their nutrient requirements are also different. You know that the bacteria in the rumen of cattle or sheep can manufacture amino acids— the nitrogen building blocks of protein. For this reason there are no essential amino acid requirements for ruminants. Cattle and sheep must be fed nitrogen in some form, but they do not need specific amino acids.

   Pigs, on the other hand, must receive all of their amino acids in their feed. There are 23 known amino acids. Pigs must have 10 of them, so there are 10 essential amino acids for pigs.

   There are other examples of how various animals need different nutrients. Take vitamins, for instance. Hogs need at least 6 of the B vitamins. Cattle and sheep do not need any.

   Bacteria in the rumen can manufacture B vitamins. That's how vitamin B_{12} was discovered. Before its discovery, scientists had guessed it existed. It was often called the "cow manure factor." People had noticed that pigs root in cattle droppings. Scientists then learned that pigs got a needed nutrient from the manure This nutrient was being manufactured in the digestive tract of cattle. Some of it was passing through the body into the manure. The nutrient was isolated and named vitamin B_{12}. Later it was discovered that B_{12} is a by-product when antibiotics are manufactured. This makes a good, cheap source of the vitamin.

2. Nutrient requirements depend on the stage of the life cycle and on the performance desired.

   The first food a newborn calf, lamb, or pig receives is milk.

   As the animal grows, its diet changes. This is because its nutrient requirements change. When an animal is young, it needs lots of nutrients to help it grow. A grown animal, however, simply needs nutrients to maintain its body. You can see this in the protein content of pig rations. A pig starter ration contains 20 to 22 percent protein; a creep ration contains 20 percent; the grower, 16 percent; and the finisher, 12 percent. Scientists have found these to be the right amounts of protein according to the pig's life cycle.

   Nutrient requirements in cattle change as the development of the rumen occurs. At birth the rumen makes up about 25 percent of the stomach. At 4 months, it makes up 75 percent. And at maturity, the rumen makes up 80 percent of the stomach. This is the reason why calves cannot digest roughage as mature cattle can.

   Then, too, nutrient requirements are different for animals being kept for different purposes. For example, a beef heifer being fattened for market would receive a certain ration. This same heifer would have a different ration if she were being grown out for a herd replacement.

3. Nutrients are needed in amounts that will promote maximum growth or production and prevent nutritional deficiencies.

   You want the best possible production from your animals. You want a good rate of gain, feed efficiency, litter size, or calf crop percentage. Nutrient requirements are calculated to insure maximum performance.

   On the other hand, to overfeed is a waste. It may be harmful to the animals, too. Research with sows and beef cows, for instance, shows that the reproductive rate is lowered by overfeeding.

   Nutritional deficiencies must be prevented in all livestock. Protein is the nutrient from which muscle is built. But, it would be a foolish farmer who fed his hogs nothing but protein. Animals need a balance of nutrients for their bodies to function properly. Vitamins, minerals, proteins, fats, carbohydrates are all needed.

If an animal does not get enough of a single needed nutrient, there is a general deficiency. The result is poor performance, ill health, inferior reproduction, or other symptoms. One common example is rickets in calves. Rickets occur when a calf is kept out of the sun with no vitamin D in its diet. Such deficiencies usually happen only by mistake.

So these are three principles of animal feeding. An animal's diet depends on the kind of animal, its age, and the purpose for which it is fed.

4. Nutrient requirements can be met with different feeds.

   There are many feeds that an animal will eat and that can be fed. A combination of feeds is often needed to meet the nutrient requirements, but you often have a choice of feeds with about the same nutritional value. It is usually logical to feed the one lowest in price.

   The proportion of different ingredients in the ration can also be altered within limits. When the price of corn goes up, cattle feeders some times feed more roughage than corn. In feeding hogs, more or less supplement and corn-could be fed, depending on the price of each.

   The nutrient requirements of animals must be met, but the requirements are not so exact that prices of ingredients are ignored. The goal in feeding is to get the desired performance at the least cost.

Nutrient Requirement Tables

With these principles to guide them, scientists have figured out the nutrient requirements of certain animals. Their findings are published in what are called "nutrient requirement tables." (See pages 16 to 19.)

There is a different nutrient requirement table for each kind of animal. There are tables for beef cattle, dairy cattle, swine, sheep, dogs, laboratory animals, and so on.

Nutrient requirement tables indicate the needs of an animal for each major nutrient in its daily feed. Requirements are given according to stage in the life cycle (age or weight of the animal) and the desired performance (growing, fattening, breeding, wintering).

The amounts of nutrients are given in two different systems. You may see a nutrient requirement table with the heading "Daily Nutrient Requirements of Beef Cattle." This table will tell how much of each nutrient the animal needs each day. The amount is given in some unit of measure such as pounds, grams, or milligrams.

Or, you may see a table with the heading "Nutrient Requirements of Beef Cattle Expressed as a Percentage of Air-Dry Ration." This kind of table indicates the total pounds of feed an animal should have each day and the percent of each nutrient in the daily ration.

The "daily nutrient requirements" table is usually used for cattle. For hogs, a table giving percentages is most often used. This is because hogs are often fed complete ground rations. When you know the percent of each nutrient, you know the formula for the ration.

Column Headings

In both types of tables, the individual column headings are about the same.

1. *Body weight.* Nutrient requirements vary with the weight or age of the animal. To find the nutrient requirements for a calf, you must first know its approximate weight. Then find this weight on the table and read across for the nutrient requirements. Swine tables usually give requirements related to both weight and age.

2. *Average daily gain.* This figure tells you about what gain in weight you can expect from your animal when it is fed the amounts of nutrients shown on the chart. The figure is an average, so your animal's daily gain may be either higher or lower. For some types of cattle, zero or little gain is indicated. For many mature breeding cattle, the nutrient requirements only maintain weight, they do not add to it.

3. *Daily feed.* This figure indicates, in pounds, about how much of the common feeds an animal should eat daily in order to meet its nutrient requirements. In some cases this is enough to satisfy the appetite. In other cases, the figure is much lower than the appetite of the animal. This is because the real nutrient requirements are sometimes met with less feed than the animal would eat by itself.

4. *Nutrients.* Finally, the tables indicate the amounts of nutrients needed by animals.

   For cattle and sheep, the nutrients given include: total protein, digestible protein, total digestible nutrients (TDN), calcium (Ca), phosphorus (P), carotene, and vitamin A.

   The tables for swine include: percent protein, calcium, and phosphorus; units of vitamins A and D; micrograms of vitamin B_{12}; and milligrams of riboflavin, pantothenic acid, niacin, and choline.

   Since nutrient requirements vary with the life cycle and the purpose, the tables list nutrients in purpose categories.

   Categories for beef cattle are: fattening calves finished as short yearlings; fattening yearling cattle; fattening 2-year cattle; wintering weanling calves; wintering yearling cattle; wintering pregnant heifers; wintering mature pregnant cows; cows nursing calves; normal growth heifers and steers; normal maintenance, growth, and activity of bulls.

   In swine the categories are: young boars, adult boars; bred gilts and sows; lactating gilts and sows; growing pigs, and finishing pigs.

   Categories for ewes are nonlactating and first 15 weeks of gestation; last 6 weeks of gestation; first 8 to 10 weeks of lactation; last 12 to 14 weeks of lactation; and replacement lambs and yearlings. Other categories for sheep include rams and fattening lambs.

A Nutrition Glossary

Crude protein (total protein). A measure of all the nitrogen-containing compounds in a feed. Some nitrogen compounds are not true proteins, so this is only a rough measure.

Digestible protein. The approximate amount of true protein in a feed. In roughage rations it is figured at 60 percent of crude protein. In high-concentrate rations it is 75 percent of the crude protein.

Ether extract. A term applied to the material that can be dissolved out of a sample of feed heated in ether. Fat has 2.25 times the energy value of carbohydrates. When the energy value of a feed is being calculated, the ether extract is multiplied by 2.25.

Fiber content. The amount of hard-to-digest carbohydrates in a feed. Most fiber is made of cellulose.

Nitrogen-free extract (NFE). The more easily digested carbohydrates in feed. The NFE is mostly starch and sugars.

Essential amino acids. Amino acids that cannot be made in the body from other substances or cannot be made in sufficient quantity to supply the animal's needs.

USING NUTRIENT REQUIREMENT TABLES

You can use Nutrient Requirement Tables in at least two ways: (1) to check your present rations to see if they are nutritionally adequate, or (2) as a basis for formulating rations that will meet the nutrient requirements of the animals.

The materials needed are: (1) the nutrient requirement tables, (2) a table giving the composition or nutrient content of common feedstuffs, and (3) a worksheet for systematically recording the results of your calculations. You will need scratch paper for the multiplying, adding, and dividing necessary.

You will note that some nutrients are required in very small amounts. This shows that we are out of the "scoop shovel" era in nutrition into a much more scientific period. Livestock feeding is moving rapidly from an art to a science.

Before You Start

It will be necessary for you to multiply, add, subtract, and divide accurately. You will be working with percentages, so be sure you are careful about decimal placing.

Some of the nutrient requirements are given in grams (gm.). Feed is given in pounds. To change pounds to grams, multiply by 454. This is the number of grams in a pound. You may find some requirements given in milligrams (mg.). For these nutrients the composition of the feed is also given in milligrams so you need not make any conversion.

Calculations are made of feedstuffs on an air-dry basis. This means that there is some moisture in them (10 to 15 percent). We do not correct for this much moisture. However, it is necessary to convert feeds such as green chopped forage, haylage, or stage to an air-dry basis. You need to know the moisture (or dry matter) content to correct to an air-dry basis. For example, 35 pounds of corn stage containing 70 percent moisture are equivalent to about 11 $^{2}/_{3}$ pounds of air-dry material. This correction is made by multiplying the weight of the material as fed by the percent dry matter and then dividing the product by 90 (85 to 90 being the dry matter content of most feeds that are "air-dry").

Follow This Procedure

1. Choose the kind of animal, weight, and purpose. Your present 4-H project would be a good choice.

2. Record pounds, grams, milligrams, or I.U. (international units), and the amounts of the required nutrients. (Use Table 1 for beef, Table 2 for swine, and Table 3 for sheep.)

3. List the homegrown, common, or natural feedstuffs being fed. Copy the average composition or analysis for all the nutrients opposite each of them. (Use Table 4.)

4. Weigh the amount of each feedstuff being fed the animal daily. If a complete ration is being fed, then you must know the amount of each feed ingredient in a pound (or ton) of feed.

5. Multiply the percentage composition for each nutrient times the quantity of the feed being fed. Record the result in the appropriate column. Repeat for each nutrient.

6. Add the columns. This gives the total amount of each nutrient contained in the ration being fed.

7. Check this amount against the requirement as taken from Table 1. If the requirement is more than that contained in the ration, we would conclude that the ration was deficient—that is, lacking adequate levels of that nutrient for optimum growth or performance. The next step would be to find a feed ingredient that is a good source of the deficient nutrient and add enough to erase the deficiency. In doing this we would have to recalculate the ration to be sure we hadn't gotten other nutrients out of balance.

   The values obtained by the calculations need to be viewed with some caution. If the feed fed was of lower quality than average, the performance of the animal would be somewhat lower. Therefore, it is common practice for nutritionists to provide more of certain critical nutrients than is actually indicated by the calculations. This is done as insurance against any deficiency or poor performance showing up in the feeding program.

ANIMAL REPRODUCTION

The birth of an animal is the end of a wondrous process. It starts with the merging of two tiny cells—one from the female animal, one from the male. With the joining of these cells, a new animal is conceived.

The cell from the female is called an egg or ovum. The cell from the male is a sperm. The egg and sperm are both sex cells, the very special cells that contain the genetic material an animal inherits from its parents. Two microscopic cells will completely determine the genetic makeup of the offspring. (See the discussion of genes and chromosomes on page 24.)

The production of sex cells is a unique and interesting process. Each of the two sexes has special organs to produce sex cells and carry out the pro-

Table 1. Daily Nutrient Requirements of Beef Cattle
(Based on air-dry feed containing 90 percent dry matter)

Body Weight, lb.	Av. daily gain,[1] lb.	Daily feed per animal, lb.	Total protein, lb.	Digestible protein, lb.	Daily nutrients per animal TDN, lb.	Ca. gm.	P, gm.	Carotene,[2] mg.	Vitamin A, I.U.
Fattening Calves Finished as Short Yearlings									
400	2.3	11.8	1.3	1.0	7.8	20	15	22	8,850
600	2.4	16.4	1.8	1.3	10.9	20	17	31	12,300
800	2.2	19.4	1.9	1.5	12.9	20	18	37	14,600
1,000	2.2	23.0	2.3	1.7	15.3	21	21	44	17,300
Fattening Yearling Cattle									
600	2.6	17.5	1.8	1.3	11.4	20	17	33	13,100
800	2.7	22.3	2.2	1.7	14.5	20	20	42	16,700
1,000	2.6	25.8	2.6	1.9	16.8	23	23	49	19,400
1,100	2.3	25.8	2.6	1.9	16.8	23	23	49	19,400
Wintering Weanling Calves									
400	1.0	10.5	1.1	.7	5.3	13	10	20	7,900
500	1.0	12.6	1.3	.8	6.3	13	10	24	9,500
600	1.0	14.3	1.3	.8	7.2	13	10	27	10,700
Wintering Yearling Cattle									
600	1.0	14.3	1.2	.7	7.2	13	11	27	10,700
800	.7	15.8	1.2	.7	7.9	13	12	30	11,900
900	.5	15.8	1.2	.7	7.9	13	12	30	11,900
Wintering Pregnant Heifers									
700	1.5	20.0	1.5	.9	10.0	15	14	50	20,000
900	.8	18.0	1.4	.8	9.0	13	12	45	18,000
1,000	.5	18.0	1.4	.8	9.0	13	12	45	18,000
Wintering Mature Pregnant Cows									
800	1.5	22.0	1.7	1.0	11.0	16	15	55	22,000
1,000	.4	18.0	1.4	.8	9.0	13	12	45	18,000
1,200	.0	18.0	1.4	.8	9.0	13	12	45	18,000
Normal Growth Heifers and Steers									
400	1.6	12.2	1.4	.9	6.4	16	11	23	9,200
600	1.4	16.4	1.5	.9	8.2	16	12	31	12,300
800	1.2	19.1	1.5	.9	9.6	16	13	36	14,300
1,000	1.0	21.1	1.6	1.0	10.6	14	14	40	15,800

[1]Average daily gain for finishing cattle is based upon cattle receiving stilbestrol. Finishing cattle not receiving stilbestrol gain from 10 to 20 percent slower than the indicated values.
[2] Cattle can use carotene to satisfy their vitamin A requirement. The carotene requirement was calculated from the vitamin A assuming 400 I.U. of vitamin A per mg. of carotene.
Nutrient Requirements of Beef Cattle, National Academy of Sciences–National Research Council–Publication 1137.

Table 2. Recommended Nutrient Allowance for Swine[1]

State of life cycle	Weight of pig, lb.	Percent of ration: Protein, %	Calcium, %	Phosphorus, %	Vitamin A,[2] units/lb.	Vitamin D,[2] units/lb.	Amount per pound of ration: Vitamin B_{12}, units/lb.	Riboflavin, mg./lb.	Pantothenic acid, mg./lb.	Niacin, mg./lb.	Choline, mg./lb.
Boar and Gilt											
Developer	200 to ...	12	.75	.50	2,500	150	6	1.0	5.5	8	370
Sows											
Pregestation and gestation	... ...	12	.75	.50	2,500	150	6	1.0	5.5	8	370
Lactation	... ...	16	.75	.50	2,500	150	6	1.0	5.5	8	370
Young Pigs											
Starter	... to 12	22	.90	.60	1,500	300	9	1.5	7.5	12	600
Creep	12 to 25	20	.90	.60	1,500	300	9	1.5	7.5	12	600
Grower	25 to 50	16	.75	.50	1,750	150	6	1.0	5.5	8	400
Older Pigs											
Finisher	125 to 200	12	.50	.35	950	75	4	.8	5	6	350

[1]The nutrient allowances are suggested for maximum performance not minimum requirements. They are based on research work with natural feedstuffs and found to give satisfactory results.
[2] About 3 times as many units of pro-vitamin A (carotene) are needed as compared with true A.
Source: Illinois Extension Circular 866, "Balancing Swine Rations."

Table 3. Daily Nutrient Requirements of Sheep[1]
(Based on air-dry feed containing 90 percent dry matter)

Body weight, lb.	Gain or loss, lb.	Daily feed per animal, lb.	Daily nutrients per animal: TDN, lb.	Protein, lb.	Ca, gm.[2]	P, gm.	Salt, gm.	Carotene, mg.	Vitamin A, I.U.	Vitamin D, I.U.
Ewes—non-lactating and first 15 weeks of gestation										
100	.07	2.6	1.3	.21	3.2	2.5	9	1.7	935	250
120	.07	3.0	1.5	.24	3.3	2.6	10	2.0	1,100	300
140	.07	3.4	1.7	.27	3.4	2.7	11	2.4	1,320	350
160	.07	3.8	1.9	.30	3.5	2.8	12	2.7	1,485	400
180[3]	.07	4.2	2.1	.33	3.6	2.9	13	3.0	1,650	450
Ewes—last 6 weeks of gestation										
100	.37	3.8	2.0	.32	4.2	3.1	10	5.8	2,320	250
120	.37	4.2	2.2	.34	4.4	3.3	11	6.8	2,720	300
140	.37	4.6	2.4	.36	4.6	3.5	12	7.9	3,160	350
160	.37	4.8	2.5	.37	4.8	3.7	13	9.1	3,640	400
180[3]	.37	5.0	2.6	.38	5.0	3.9	14	10.4	4,160	450
200[3]	.37	5.2	2.7	.39	5.2	4.1	15	11.7	4,680	500
Ewes—first 8-10 weeks of lactation										
100	.08	4.6	2.7	.40	6.2	4.6	11	5.8	2,320	250
120	.08	5.0	2.9	.42	6.5	4.8	12	6.8	2,720	300
140	.08	5.5	3.1	.44	6.8	5.0	13	7.9	3,160	350
160	.08	5.7	3.1	.46	7.1	5.2	14	9.1	3,640	400
180[3]	.08	5.9	3.2	.48	7.4	5.4	15	10.4	4,160	450

Table 3. Continued

Body weight, lb.	Gain or loss, lb.	Daily feed per animal, lb.	Daily nutrients per animal							
			TDN, lb.	Protein, lb.	Ca, gm.[2]	P, gm.	Salt, gm.	Carotene, mg.	Vitamin A, I.U.	Vitamin D, I.U.
Ewes—last 12-14 weeks of lactation										
100	.07	3.8	2.0	.32	4.6	3.4	10	5.8	2,320	250
120	.07	4.2	2.2	.34	4.8	3.6	11	6.8	2,720	300
140	.07	4.6	2.4	.36	5.0	3.8	12	7.9	3,160	350
160	.07	4.8	2.5	.37	5.2	4.0	13	9.1	3,640	400
180[3]	.07	5.0	2.6	.38	5.4	4.2	14	10.4	4,160	450
Ewes—replacement lambs and yearlings										
60	.30	2.7	1.5	.30	2.9	2.6	8	1.7	765	150
80	.20	3.2	1.6	.28	3.0	2.7	9	2.3	1,035	200
100	.14	3.4	1.7	.26	3.1	2.8	10	2.8	1,260	250
120	.07	3.4	1.7	.24	3.2	2.9	11	3.4	1,530	300
140[3]		3.5	1.8	.24	3.3	3.0	12	3.9	1,755	350
160[3]		3.5	1.8	.24	3.4	3.1	13	4.4	1,980	400
Rams—lambs and yearlings										
80	.40	3.2	2.0	.32	3.0	2.7	9	2.3	1,035	200
100	.30	3.7	2.1	.32	3.1	2.8	10	2.8	1,260	250
120	.20	4.2	2.1	.32	3.2	2.9	11	3.4	1,530	300
140	.10	4.6	2.3	.32	3.3	3.0	11	4.0	1,800	350
160	.10	4.8	2.4	.32	3.4	3.1	12	4.5	2,025	400
180[3]		5.0	2.5	.32	3.5	3.2	13	5.0	2,250	450
200[3]		5.2	2.6	.32	3.6	3.3	14	5.5	2,475	500
Lambs—fattening										
60	.35	2.7	1.5	.32	2.9	2.6	8	1.0	550	150
70	.40	3.1	1.8	.34	2.9	2.6	8	1.2	660	175
80	.45	3.4	2.1	.36	3.0	2.7	9	1.4	770	200
90	.45	3.7	2.3	.36	3.0	2.7	9	1.5	825	225
100	.40	3.9	2.4	.36	3.1	2.8	10	1.7	935	250

[1]Nutrient requirements of sheep, subcommittee on sheep nutrition, National Research Council, revised in 1964.
[2] One pound equals 454 grams.
[3]Nutrient requirements for sheep heavier than listed by NRC were determined by extending the NRC recommendations.

Table 4. Average Nutrient Content of Feedstuffs*

	Total dry matter, %	Protein, %	Digestible protein %	Total digestible nutrients, %	Calcium, %	Phosphorus %	Carotene, mg./ lb.	Vitamin A, I.U./lb.	Vitamin D, I.U./lb.	Riboflavin, mg./lb.	Pantothenic A, mg./lb.	Niacin, mg./lb.	Choline, mg./lb.
Dry Roughages													
Alfalfa hay, leafy	90.5	16.0	11.7	51.2	1.31	.24	20.3	33,000	905	7.7	9.0	18.0	– –
Alfalfa hay, stemmy	90.5	12.3	8.2	46.3	1.07	.19	3.3	5,000	– –	– –	– –	– –	– –
Alfalfa-brome hay	89.2	11.8	7.6	47.9	.77	.20	6.7	11,000	– –	2.9	10.2	11.7	– –
Timothy hay, mid-bloom	88.0	7.5	4.1	53.0	.36	.16	21.0	7,000	– –	– –	– –	– –	– –
Timothy hay, late bloom	87.0	6.9	3.4	51.0	.30	.18	– –	4,000	– –	– –	– –	– –	– –
Red clover and hay	88.0	13.1	8.0	51.0	1.42	.19	15.0	34,000	– –	– –	– –	– –	– –
Pea hay	89.3	14.9	10.6	55.1	1.22	.25	10.0	17,000	– –	– –	– –	– –	– –
Grass hay, good quality	90.0	1.4	4.9	47.1	.34	.14	9.3	15,000	– –	– –	– –	– –	– –
Grass hay, mature and weathered	90.0	.1	1.6	41.3	.33	.09	– –	– –	– –	– –	– –	– –	– –
Wheat straw	90.0	3.2	.4	43.0	.15	.07	.9	2,000	– –	– –	– –	– –	– –
Silages													
Corn, dent, well matured, and eared	28.5	2.3	1.3	19.8	.09	.07	5.8	9,000	54	54	54	5.7	– –
Alfalfa, wilted	36.2	6.3	4.3	21.5	.51	.12	11.4	19,000	131	131	131	– –	– –
Alfalfa-brome, not wilted	25.0	3.8	2.6	17.0	.37	.05	– –	34,500	– –	– –	– –	5.7	– –
Concentrates													
Corn, dent, No.2	85.0	8.7	6.7	80.1	.02	.28	1.3	2,167	– –	.5	2.4	9.8	200
Ground ear corn	86.1	7.4	5.4	73.2	.04	.22	1.0	1,733	– –	.4	2.0	7.2	160
Wheat	90.0	11.1	8.3	78.0	.09	.30	– –	– –	– –	.5	5.2	26.8	458
Oats	90.2	12.0	9.4	70.1	.09	.33	.1	83	– –	.5	6.0	6.3	435
Barley	89.4	12.7	10.0	77.7	.06	.40	.2	333	– –	.6	3.0	27.2	450
Cottonseed meal (45%)	94.3	45.6	37.4	75.1	.23	1.12	.1	167	– –	2.7	5.5	16.3	1,301
Linseed meal (36%)	92.4	36.6	31.5	75.6	.40	.86	– –	– –	– –	1.3	– –	13.7	557
Soybean meal (50%)	91.7	50.4	46.4	79.4	– –	– –	.1	167	– –	1.4	– –	9.8	1,255
Feeding limestone	– –	– –	– –	– –	38.30	– –	– –	– –	– –	– –	– –	– –	– –
Steamed bonemeal	– –	– –	– –	– –	30.00	13.90	– –	– –	– –	– –	– –	– –	– –

*Morrison, F.B., Feeds and Feeding, Twenty-second edition, Morrison Publishing Co., Ithaca, N.Y., and Nutrient Requirements of Beef Cattle, Revised Edition, National Academy of Science, National Research Council Publication 1137, 1963.

—indicates nutrient not present in feed or content not known.

cess of reproduction. These are called the reproductive organs.

Male Reproduction Organs

In the male, the two *testicles* are the organs that produce sperm. They also produce a hormone called testosterone. *Hormones* are chemical compounds released into the blood stream (secreted) by glands. They help regulate body functions. Testosterone is the hormone that causes changes in males as they mature. The uneven temper and massive forequarter of a bull are caused by this hormone. A boar's heavy tusk and strong odor are also caused by testosterone.

Each testicle is a mass of tiny tubes. The inner walls of these tubes produce sperm. The thousands of tubes merge at the front edge of the testicle. There, they form a series of larger, tightly coiled tubes where the sperm collect. These make up the *epididymis*. Its function is to store sperm while they mature.

The testicles and epididymides are held in the *scrotum*, the sac-like pouch suspending them from the body. They are outside the body because the testicles must be kept cooler than body temperature to function properly. The scrotum helps regulate their temperature. It relaxes in hot weather, moving the testicles away from the body. In cold weather, it contracts.

From the epididymis, the sperm move through a tube, the *vas deferens*, into the *urethra*. The urethra is the tube that carries urine from the bladder through the penis. The urethra also carries sperm from the junction with the vas deferens to the end of the penis.

Along the urethra are the *accessory glands*. Their names are the *prostate*, the *seminal vesicles*, and *cowpers gland*. They produce fluids that nourish and preserve the sperm. During mating, the accessory glands discharge their fluids into the urethra. This washes the sperm forward through the penis The combined fluid and sperm is called *semen*.

Female Reproductive Organs

Female reproductive organs are quite different from the male's. The female must not only produce sex cells, she must also provide a place for the unborn animal to develop.

The main female organs are the two *ovaries* and *oviducts*, the *uterus*, the *cervix*, and the *vagina*. The ovaries produce the eggs. Each egg is contained in a tiny bubble on an ovary. This bubble is called a *follicle* and is about the size of a pinhead. There are hundreds of follicles on each ovary.

By a process not yet understood, one or more follicles begin to grow while the others remain small. The follicle grows until it is about the size of a pencil eraser. It is filled with a fluid. The egg is suspended in the fluid. Near the time of mating, a hormone causes the follicle to burst.

The fluid gushes out of the follicle carrying the egg with it. The egg is then trapped in a very thin membrane that surrounds the ovary. Shaped like a funnel, this membrane is called the *infundibulum.* The infundibulum narrows into a tube called the *oviduct.* Each oviduct is about the diameter of a wooden match. Its length varies from a few inches to over a foot, depending on the kind of animal.

The oviduct carries the egg to the *uterus* or womb. The largest of the female reproductive organs, the uterus, is where the unborn young (the *fetus*) will develop.

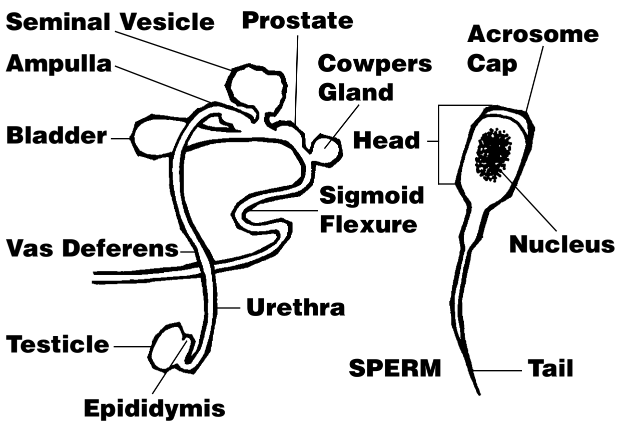
The uterus has a thick wall with heavy layers of muscles. At birth, these muscles will contract with great pressure to force the new animal through the *cervix* and *vagina* (birth canal) and into the world. The lining of the uterus is soft and spongy, containing a vast network of blood vessels. This network of blood vessels provides a "bed" for the fertilized egg to settle into and develop.

How this egg is fertilized is the next part of the reproduction story.

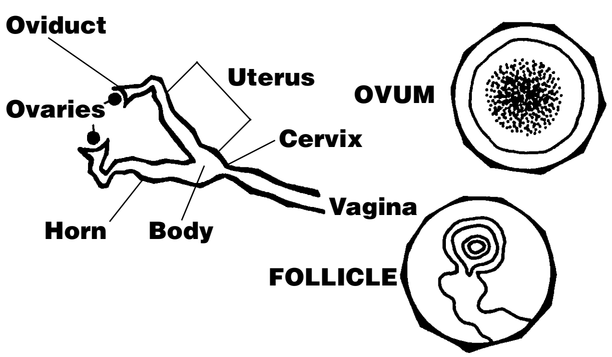
Fertilization

When a gilt, ewe, or heifer is old enough to be bred, it begins to have *estrus periods.* (These are also called "heat" periods.) In cattle, one egg is usually released from one ovary during the estrus

MALE REPRODUCTION ORGANS



FEMALE REPRODUCTION ORGANS



period. In swine, several eggs are released by each ovary at each estrus period. The release of the egg or eggs is called ovulation.

Meanwhile, in the male animal, sperm is continuously produced in enormous numbers. During mating, the bull deposits semen in the vagina of the cow or heifer. With swine, semen is deposited in the cervix of the female.

Mating apparently stimulates the female's uterus to contract and relax several times a minute. This pulsing action forces the semen through the uterus, into the oviducts and the infundibulum. Here, the sperm and egg unite. This is fertilization.

Only one sperm is needed to fertilize each egg. A great many sperm are present, however. A boar, for example, usually deposits about 50 billion sperm during a mating. This large number assures that at least one live sperm will reach every egg. In swine there are several eggs to be fertilized. Each fertilized egg will become one of the pigs of a litter. In cattle, only one egg is usually present. In sheep, two eggs are very common, and occasionally three, four, or five will be present. Sometimes a cow will produce two eggs. If both are fertilized the cow will have twin calves. These two calves would not look alike, however, Each twin would develop from a separate egg and sperm. Identical twins result when a single fertilized egg divides into two at a very early stage.

When examined under a microscope, an egg resembles a chicken egg without a shell. It has a clear fluid on the outside covered by a thin membrane. In the center is a dark mass similar to an egg yolk. This center is the *nucleus*. It is the part of the egg that contains the genetic material.

The sperm has a much different shape. It is much smaller than the egg and is shaped something like a tadpole. It has a head, a middle section, and a tail. The genetic material is contained in the head.

At fertilization a sperm penetrates the outside membrane of the egg and is drawn into the nucleus. At this time, when the sperm enters the nucleus, the complete genetic makeup of the offspring is determined.

The fertilized egg then passes from the infundibulum into the oviduct and finally into the uterus. The soft spongy lining of the uterus traps the fertilized egg at some suitable spot. There the microscopic fertilized egg will grow into a new animal. In cattle, of course, there is usually only one new animal developing. In swine, several eggs develop simultaneously at different spots along the uterus.

Meanwhile, in the empty follicle from which the egg has come, a change begins. The cells lining the follicle change form and multiply very rapidly. Soon there is a solid mass about the size of a grape where the follicle once was. This is called the *corpus luteum.* It produces a hormone called progesterone which prevents other follicles from developing. As long as the fetus is in the uterus, progesterone will be produced.

This is important because it keeps the uterus in perfect condition for the developing fetus. Since no more follicles mature, the mother animal cannot become pregnant again until the fetus is born.

If the egg is not fertilized, the corpus luteum will begin to shrink in about 2 weeks. It will disappear by the end of the third week. The female will then be able to produce another egg and show another estrus. This cycle repeats itself about every 21 days in cattle and swine until the animal becomes pregnant. Sheep exhibit an estrus cycle about every 17 days, but this cycling will not continue throughout the entire year. This will vary from breed to breed and individual to individual. The most common time for cycling of ewes is late summer, fall, and early winter.

Pregnancy and Birth

Pregnancy is the time during which the fetus develops in the uterus. In order for the fetus to develop, a new membrane must form on the uterine wall. A network of membrane and tiny blood vessels begins to take shape shortly after the fetus becomes located in the uterus. This membrane becomes the placenta. Through it the unborn animal is nourished.

Nutrients and oxygen pass from the mother's blood stream through the uterus, into the placenta, and into the fetus. Waste products from the fetus pass into the placenta, through the wall of the uterus, and back into the mother's blood stream. After the animal's birth, the placenta is expelled from the uterus. This is the "afterbirth."

The navel cord, which connects to the fetus's abdomen, links the fetus to the placenta. Two large blood vessels run through the navel cord. One carries nutrients and oxygen from the placenta to the uterus. The other carries waste chemicals from the fetus to the placenta.

The fetus develops gradually. Most of its growth comes in the last one-third of pregnancy. However, most of the vital organs are formed early. The head, nervous system, and blood system develop first. Later, the bones and limbs are formed.

At the proper time the strong muscles of the uterus contract, forcing the new animal through the birth canal and into the world.

Until now, the young animal received nutrients and oxygen from its mother's blood stream. But, at birth the navel cord is broken and the animal must live on its own. The breaking of the navel cord stimulates the animal to breathe. This solves the problem of oxygen. The mother's body has been preparing nutrients for many weeks. The hormones produced during pregnancy have stimulated the milk glands. By the time of birth they are ready to provide milk.

The first milk produced is called colostrum. It is very rich in vitamins and certain minerals the newborn calf, lamb, or pig needs for a good start. For the first 12 to 24 hours it is essential for the new animal to receive colostrum. Then, gradually, the production of colostrum gives way to regular milk.

By the end of a week the new animal has made the major adjustments to its new environment. From here on, the welfare of the young animal is mostly up to its owner. But, nature has given the animal a wonderful beginning in an amazing series of processes.

Glossary

Accessory glands. These glands are located along the urethra of the male. They produce fluids that nourish and preserve sperm.

Birth canal. The birth canal includes the cervix and the vagina of the female. They are the organs through which the unborn animal passes at birth.

Cervix. This is the narrow passage or doorway between the female's vagina and uterus.

Corpus luteum. A solid mass that forms in the follicle after the egg has left. It produces a hormone which helps maintain pregnancy and prevents other follicles from developing while the unborn animal is growing in the uterus.

Epididymis. A mass of tubes connected to the testicle. Its main function is to store sperm.

Estrus. A period in the reproduction cycle of the female when an egg is released from the ovary. The estrus period is commonly called "heat."

Fetus. The unborn animal as it develops in the uterus.

Follicle. A bubble-like structure on the ovary which contains an egg.

Hormone. A body-regulating chemical secreted into the blood stream by a gland.

Infundibulum. The funnel-like membrane that surrounds the ovary. It catches the egg when it is released by the ovary.

Nucleus. The dense center of a cell. It contains the genetic material.

Ovary. A female organ that produces eggs. There are two ovaries.

Oviduct. The tube that carries the egg from the ovary to the uterus.

Ovulation. The time when the follicle bursts and the egg is released.

Ovum. Scientific name for egg.

Placenta. The membrane by which the fetus is attached to the uterus. Nutrients from the mother pass into the placenta and then through the navel cord into the fetus. When the animal is born, the placenta is expelled. It is commonly called the "afterbirth."

Sex cells. The egg and the sperm. They transmit genetic material from the parents to the offspring.

Scrotum. The sac-like pouch that suspends the testicles outside the male body.

Sperm. Male sex cells produced in the testicles.

Semen. Sperm mixed with fluids from the accessory glands.

Testicle. A male gland which produces sperm. There are two testicles.

Urethra. The tube through which both semen and urine pass through the penis of the male.

Uterus. The muscular, spongy organ of the female where the unborn animal develops. It is commonly called the womb.

Vagina. The canal that leads from the uterus to outside the female. Sperm is deposited there by the male, and the fetus passes through the vagina at birth.

Vas deferens. The tube that carries sperm from the epididymis to the urethra in the male.

HOW INHERITANCE WORKS

Two tiny cells are the only links an animal has with its parents. A sperm cell from the sire, an egg cell from the dam—these grow into the new animal.

We know, therefore, that whatever characteristics are inherited from the parents must come from these two cells. Assuming that good care and nutrition are provided, the material in the sperm and egg will determine almost everything about the developing animal—its size, shape, color, even its intelligence.

The study of how characteristics are passed from parents to offspring is the science of genetics. It's easy to see why genetics is important to livestock producers. In trying to understand the mysteries of inheritance, geneticists learn things which are helping to produce better livestock.

Genes and Chromosomes

Inside the cells of animals are certain complex chemical compounds. Geneticists are fairly certain that they are the carriers of inheritance. They are called genes and chromosomes.

Chromosomes are long, thread-like structures, apparently made of protein, large enough to be seen with a microscope. In all body cells, except the sperm and egg, chromosomes exist in pairs.

Each cell contains several different chromosome pairs. Humans have 23 pairs of chromosomes in each of their cells. Here are the number of pairs for farm animals:

Cattle	30	Horses	33
Goats	30	Pigs	19
Sheep	27	Chickens	6

Strung along the chromosomes, somewhat like beads on a string, are genes. Genes are thought to consist of complex molecules. They are chemically linked to the protein of the chromosomes. Genes are too small to be seen with a microscope, but research methods tell us they exist.

Genes are the units of inheritance. It is through genes that characters pass from parents to offspring. Genes are the "brains" of cells. They determine what the cell will be like. This, in turn, determines what the body will be like.

Since chromosomes come in pairs, so do genes. Two genes exist side by side. The total number of genes on a chromosome is not known. There may be several or many, depending on the chromosome.

Genes and chromosomes are able to reproduce themselves in a unique manner.

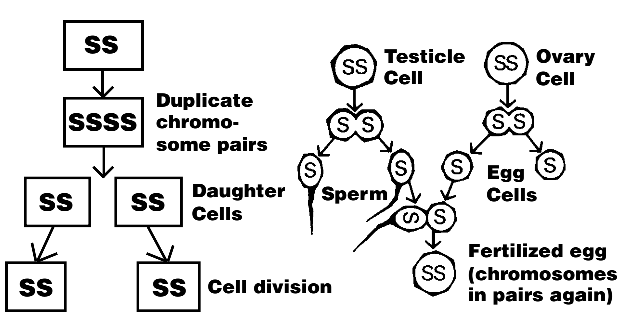
As an animal grows, its cells divide. Before a cell divides, the genes and chromosomes draw chemicals from the nutrients received by the cell. Then through an unknown process, each chromosome duplicates itself. When the cell divides, one member of each duplicated chromosome moves into the new cell. So, the new cell contains exactly the same number and kind of chromosomes as those in the parent cell.

NORMAL CELL DIVISION (Mitosis)

Chromosome pair

REDUCTION DIVISION (Meiosis)

Chromosome pair



Chromosomes in Sex Cells

Genes and chromosomes act somewhat differently when reproductive cells are formed. In the testes of the male and the ovaries of the female, cell division takes another form. This is called reduction division (meiosis).

Instead of each chromosome reproducing itself, the pairs of chromosomes line up like soldiers and one member of each pair moves into one of the two dividing sections of the cell. Sperm cells and egg cells contain only a single chromosome from each original pair of chromosomes. In humans, the sperm and egg cells each contain 23 single chromosomes instead of 23 pairs of chromosomes. An individual can make millions of kinds of reproductive cells, because either chromosome of the pair may move into the reproductive cell. This makes possible millions of different combinations of genes and chromosomes in the reproductive cells of an individual.

When fertilization takes place, the single chromosomes of the sperm unite with the single chromosomes of the egg. Once again, pairs are formed. So, the fertilized egg contains the same number of chromosome pairs as the cells of the parent.

When you consider that the slightest difference in gene makeup would cause a variation in the characteristic of the offspring, it's little wonder that no two people are alike. Except for identical twins, probably no two people in the whole world have exactly the same combinations of genes.

Dominant and Recessive Genes

Most characteristics are determined by several sets of genes. For this reason, it is almost impossible to tell exactly what an unborn animal will be like.

But, there are a few characteristics determined by only one pair of genes. Horns in cattle provide one example. By studying characteristics such as this, we can learn something about how inheritance works.

Consider this problem: A cow that is truly polled (hornless) is bred to a horned bull. Will the calf have horns? It will not. This is because the gene that causes an animal to be polled is dominant over the gene that causes horns to develop.

Let's explain. Let the capital P represent a gene for the polled characteristic. We use a capital P because polled is dominant. Since genes come in pairs, the genotype of the truly polled cow would be PP. Genotype means genetic makeup. The genotype of the horned bull would be pp. The small p indicates the gene is recessive.

In reduction division in the cow's ovaries, the PP genes would separate. Each egg would contain a single P gene. Likewise, each sperm of the bull would contain a single p gene. The other genes which would be present can be ignored in this example.

When the sperm and egg unite, two genes influencing horn development would again be present. The genotype of the calf would then be Pp.

Since the P gene dominates over the recessive p gene, the calf would be polled.

There would be no difference in the phenotype (outward appearance) of the calf and the cow. Both would be polled. But their genotypes would be different. The calf is Pp, the cow PP.

What then would happen if a Pp cow were bred to a horned (pp) bull?

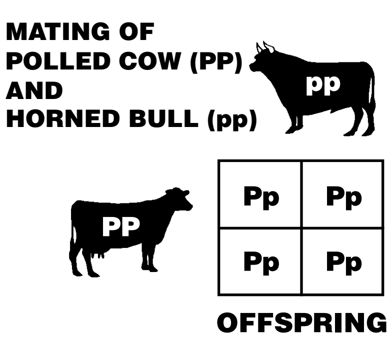
Two possible kinds of eggs would be produced by the Pp cow. Half of her eggs would contain the P gene. Half would contain the p gene. All the sperm would contain the p gene.

In this case, it would be a 50:50 chance whether the p sperm united with a p or a P egg. The genotype of the calf would either be pp or Pp. Thus half the calves from such a mating would be polled and half would be horned.

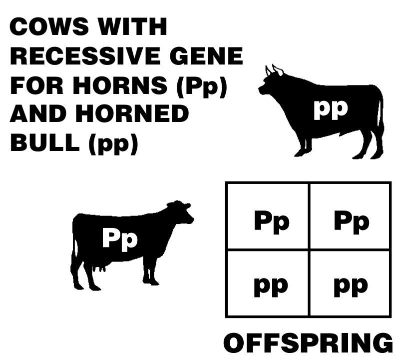
For further understanding, we might figure out what would happen if a Pp cow were bred to a Pp bull. Both the cow and the bull would be polled in appearance. But, both would carry a recessive gene for horns. Half the eggs would contain the P gene. Half would contain the p gene. The same would be true of the sperm.

Chances are 25 percent that a calf would have the PP genotype, 50 percent that it would have a Pp genotype, and 25 percent that it would carry a pp genotype.

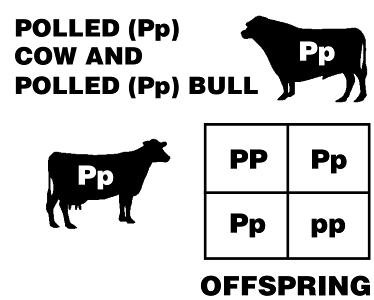
Theoretically, if 100 such matings were made, 75 of the calves would be polled and 25 would have horns. Of the 75 polled calves, 50 would carry a



All calves would be polled with a recessive gene for horns (Pp).



Half the offspring would appear polled (Pp). Half would be horned (pp).



One-fourth of the offspring would be pure polled (PP). One-fourth would be pure horned (pp). One-half would appear polled but would carry the horned recessive gene (Pp).

recessive gene for horns and 25 would be pure polled.

What would happen if a horned cow was bred to a horned bull? In this case, all the eggs and sperm would contain p genes. All calves would be horned.

Another characteristic that is determined by only one pair of genes is the color of Angus cattle. Most Angus are black. They carry a BB genotype. Some black Angus carry a Bb genotype. Red Angus cattle have a bb genotype.

What would be the genotypes of a black bull and black cow which produced a red calf? Could red parents produce a black calf?

Inheritance of Sex

We can use a similar analysis to understand how the sex of an animal is determined.

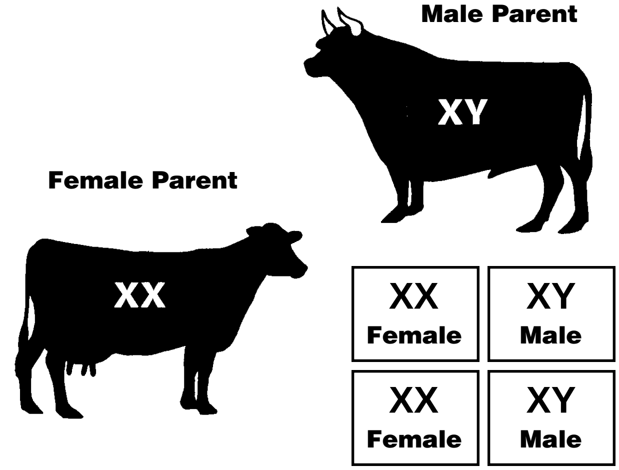
In male mammals (cattle, swine, dogs, cats, and humans) there is one pair of chromosomes that does not exactly match. One is called an x-chromosome. One is called a y-chromosome. The sex genotype of males is therefore xy. The small letters x and y do not mean that either is dominant or recessive. Females have two x-chromosomes. Their sex genotype is xx.

In reduction division in males, half the sperm cells contain an x-chromosome. Half contain a chromosome. All egg cells contain an x-chromosome.

If a sperm with an x-chromosome fertilized the egg, chromosomes in the offspring would be xx. The fertilized egg would develop as a female. If a sperm with a y-chromosome fertilized the egg, the offspring would be xy. It would be a male.

The chances are 50:50 for the offspring to be male or female. That's the reason there are about equal numbers of men and women in the world.

HOW SEX IS DETERMINED



One-half of the offspring would be female and one-half would be male

Complications

So far, we have talked only about how inheritance works in its simplest form. This basic system forms the pattern for all inheritance. Complications arise only where characteristics are influenced by more than one pair of genes.

Most economically important traits, such as conformation, rate of gain, and meatiness, are influenced by many genes. When several chromosomes and hundreds of genes are involved, it is impossible to figure out an animal's complete genotype.

In addition, many genes are not clearly dominant or recessive We can see this in some flowers. In certain kinds of flowers when a red-flowering plant pollinates a white-flowering plant, the flowers on the new plant are pink, instead of red or white. (Does this also explain roan coat color of Shorthorn cattle?) This is called incomplete dominance. When several sets of incompletely dominant genes are at work, the results are pretty hard to figure out. Fortunately for livestock producers, "good" genes seem to be dominant. This helps in improving livestock.

Finally, many things besides the genetic makeup affect an animal. A calf or pig may have the genes which enable it to make fast gains. But, unless it is fed right, it will not produce those good gains. A diseased animal will not perform right no matter what its genetic makeup. An animal with genes for average gains that is properly cared for may do better than an animal with good genes that is *poorly* cared for.

Animal breeding is still a young science. There is still much to be learned, but animal breeding scientists have already discovered much that is helping improve farm animals.

HERITABILITY OF TRAITS

In a certain county there were 50 4-H members in the baby beef project. Each member had two calves. The club committee weighed the calves at the beginning and end of the club year. Average daily gains were calculated for each calf. The best gain was 3 pounds daily The poorest was 1.5 pounds. Why this difference (or variation, as it is called by animal breeding scientists)?

For one thing, the 100 calves were on 50 different farms. Each pair of calves was probably fed a different ration. They were housed in 50 different barns, and 50 different boys and girls cared for them.

These are environmental differences which influenced gains. Each pair of calves was in a different environment. You might say some members were better feeders than others.

But how would you explain this: Not one club member had two calves with the same rate of gain. Even though the two calves were fed alike and housed together, they gained at different rates. We can explain this by genetics. The two calves had different heredity. Each calf inherited different genes which influenced its rate of gain.

Both heredity and environment cause variation in animals. The part of the variation caused by heredity is called heritability. Some traits, such as coat color, are almost completely determined by inheritance. They are high in heritability. Other traits, such as rate of gain, are only partially influenced by heredity. They range from high to low in heritability.

The heredity of an animal is determined when the sperm and egg unite. Anything that later affects the animal is environmental.

High and Low Heritability

In the club members' 100 calves, there was a difference of 1.5 pounds in daily gains between the best and poorest calves. To find out how much of this variation was caused by heredity, we multiply 1.5 pounds by 45 percent. The 45 percent figure has been determined by scientists. It is the heritability of feedlot gains in beef cattle fed under similar conditions.

$$1.5 \times 0.45 = 0.68 \text{ pound}$$

This tells you that an average of 0.68 pound of the variation was probably caused by hereditary differences between the extreme calves. By subtracting 0.68 from 1.5 pounds, you learn that 0.82 pound of the variation was caused by differences in the calves' response to their environment.

Another heritability percentage that is known is that for litter size in hogs. In a herd of gilts, the average litter size is usually eight or nine pigs. That's only an average. Some gilts may give birth to 12 or more pigs, while some may have only two or three.

Can you say that the gilts with small litters definitely inherited a low reproductive rate? Probably not. Scientists have determined that the heritability of litter size is only about 10 percent. This means that 90 percent of the variation in litter size is caused by environmental factors. Perhaps you can name some factors which might cause a small litter size.

Following is a list of heritability estimates for traits in beef cattle, sheep, and hogs. They have been determined by scientists after studying thousands of records.

Traits are usually grouped for convenience into low, medium, or high heritability classes. Low heritability is less than 25 percent; medium is 25 to 50 percent; high includes traits over 50 percent.

Note that traits relating to body structure and physical composition are more heritable than production traits, such as rate of gain and feed efficiency. Traits having to do with reproduction are quite low.

	Hogs	Beef cattle	Sheep
Conformation score	30 %	25 %	–
Number born	10	–	13 %
Weights at weaning	10	30	33
Post-weaning feedlot gains	25	45	71
Feed efficiency	30	40	15
Length of body	60	–	–
Loin eye area	50	65	50
Thickness of fat covering	50	40	–
Percent ham	55	–	–
Percent fat cuts	60	–	
Percent lean cuts	35	–	–
Tenderness	–	60	–
Carcass grade	–	35	–
Yearling body weight	–	–	43
Body type	–	–	12
Clean-fleece weight	–	–	52
Grease-fleece weight	–	–	47
Staple length	–	–	45
Fiber diameter	–	–	57

Using the Principle of Heritability

By selecting for traits, animal breeders improve their herds. The more heritable a trait is, the greater and the quicker will be the improvement.

Let's study two illustrations. Say you are a beef breeder. You want to improve the weaning weights of your calves. You weigh the calves in the fall and adjust the weights to take out the environmental effects of age of dam, sex, and actual age. You find that the average adjusted weight of all calves is 400 pounds.

You decide that you will keep the heaviest heifer and bull calves in the herd. Their average weight is 500 pounds. You plan to use these for herd replacements. How will the offspring of the selected group perform compared with the whole group if no selection had been practiced?

Average weaning weight
of selected calves .... 500 pounds
Average weaning weight
of all calves .... 400 pounds
Difference .... 100 pounds

So, you are aiming for a 100-pound increase in weaning weights. This will not all be transmitted, because you selected calves that were heavy for a mixture of reasons, both hereditary and environmental.

The heritability of weaning weight in beef cattle is 30 percent. Therefore, to find the predicted improvement, we multiply 100 pounds by 30 percent.

Difference x Heritability = Predicted Improvement
100 x 0.30 = 30 pounds

From this we estimate that the average weaning weight of the calves from these selected animals will be 30 pounds higher than the original 400-pound average. They are expected to average 400 + 30 = 430 pounds, assuming equal environmental conditions.

Thirty pounds may not sound like much improvement. But, remember that 30 pounds means about $7.50 more income per calf. Remember, too, that the 30 pounds represents a genetic improvement in the herd. Genetic improvements are permanent, and can be added to generation after generation. The stockperson states it this way: "Each generation stands on the shoulders of the last."

Here's another example using the backfat thickness in hogs. Say you are a commercial swine producer. You sell some hogs, and the buyer reports that the backfat thickness averaged 1.8 inches. You decide that too many hogs are No. 2's and No. 3's. There are not very many No. 1's.

So, you select a boar with 1.2 inches of backfat to sire the next crop of pigs. In order to keep our example from getting too complicated, let us assume that the breeding gilts are unselected and are genetically comparable to the barrows, which averaged 1.8 inches backfat. (Ordinarily, gilts would be selected which have less backfat than the herd average and less than 1.8 inches.)

A boar with 1.2 inches backfat is about 15 percent "leaner" than if he were a market barrow. This is called the sex effect. Therefore, genetically on a barrow basis he has backfat of 1.4 inches (1.2 x 1.15 = 1.4).

You mate the boar that has genes for 1.4 inches backfat to the gilts with genes for 1.8 inches. You can predict the backfat of the offspring and the improvement resulting from this mating.

Average backfat of gilts
selected for breeding .... 1.8 inches
Backfat of boar .... 1.4 inches
Difference......................0.4 inch

The heritability of backfat thickness in swine is 50 percent. But, in this example, you have no improvement in the gilts. Since the boar and gilts each transmit one-half their genes to the offspring, the pigs are expected to get no improvement from their mothers but 0.5 x (-0.4/2 inch) = -0.1 inch from their sire. The average backfat thickness of the next pig crop would be 1.8 minus 0.1 = 1.7 inches. They are better, but still not good enough to have a high percentage of No. 1 carcasses. The heritability of 50 percent is high enough so that you get a big chunk of what you reach for. But the process will have to be continued for several generations, or a better boar used, or some selection practiced in the gilts, to attain the goal of a high percentage of No. 1's.

You reached for 100 pounds added calf weaning weight and got 30 pounds or 30 percent by selecting in both sexes. In the pigs, you reached for 0.4 inch less backfat. We got 0.1 inch less backfat. You could have gotten 0.2 inch or 50 percent if the gilts had been selected with 0.4 percent less backfat than average.

Key Scientific Ideas

From the discussion so far you can pick out four key scientific ideas about genetic improvement.

1. Any animal, at any time, is the product of its heredity and of the environment to which it has been exposed.

   This is why livestock judges cannot accurately tell which animal has the best genes.Good fitting and showmanship will make an animal look better than it really is. A poor job of fitting and showing will make an animal with good genetic makeup appear poorer than it really is.

   Breeders have sometimes been disappointed in the calves or pigs out of a bull or boar that had a good show record. They say he did not "breed like he looked." On the other hand, some pretty average looking bulls or boars have come through as "good breeding sires."

   The advantage of testing programs for bulls and boars is that varying environmental influences are held to a minimum. The differences observed are more nearly caused by genetic makeup. Animals tested or developed under deliberately standardized conditions can be selected with less tendency for environment to mask heredity.

2. Some traits are more heritable than others.

   Heritability estimates for important traits have been determined by scientists. They range from 0 to 100 percent. Knowing the heritability of traits helps breeders know about how much improvement to expect. They can figure when animals are living up to their genetic potential. And, they can more wisely concentrate selection on traits where the most improvement will result.

3. The more highly heritable the trait, the more effective selection for it will be.

   Swine breeders have been amazed at the improvement they have made after about 10 years of selecting for lean, "meat-type" hogs. The percent of lean cuts is a trait with medium to high heritability. When breeders decided to improve this trait, they were able to accomplish much because leanness is largely determined by genes. Boars with genes for leanness transmit them to their offspring. These are a major influence in causing the offspring to be lean. In contrast, breeders could spin their wheels for a lifetime trying to improve a trait with low heritability.

4. Objective measurements for traits give the best indication of genetic merit.

   For example, the best way to evaluate the inherited gaining ability of an animal is to actually weigh the animal. You would weigh the animal at the beginning and at the end of the feeding period, and you would compare its gains to those of animals that were fed and cared for exactly like it. A scale weight is an actual measure of weight. There would be no reason to estimate gaining ability from the "looks" of an animal.

In this case, the "objective measurement" means using actual weights. It also means using a ''fair" test. When a group of animals is fed and cared for exactly alike, you can be sure that the differences in their gaining abilities are mostly caused by heredity, not by environment. Your measurements would be meaningless if the animals being tested were each fed a different ration.

IMPROVING BEEF HERDS

The days of the Texas longhorn are gone. A century ago the trails of the West saw cowboys driving vast range herds to market. It must have been a colorful sight. These were native cattle, the descendants of cattle brought to the New World by the Spanish. It was an exciting era in American agriculture.

Those picturesque longhorns were adapted to the extensive ranching conditions of the 1850's, but longhorns weren't very good eating. And, as time passed, cattle breeders began to discover they could make more profit by using different management practices and by changing their cattle. The native, longhorn cattle were changed to shorter legged, blockier, earlier maturing animals. This was done mostly by using imported British bulls.

You can see that improving beef cattle has long been a goal of breeders. Today, breeders are still improving their animals and they have modern scientific methods to help them. The old-time breeders were mostly trying to change the shape of their cattle. Modern breeders are becoming interested in improving other traits.

If you were a beef breeder, what traits would you try to improve? How would you use a knowledge of genetics to help you? How would you proceed?

Many states have outlined beef breeding programs suited for their areas. They are called Performance Testing, Production Testing, Record of Performance, or On-Farm Testing programs. You should become familiar with your state's program.

Traits to Improve

The first problem in beef improvement is deciding what traits to improve. There are many traits a breeder might select for. Common sense and scientific facts help make the decision.

First, it makes sense to select for those things which will increase profits. These are called "economically important traits " We want low-cost production of desirable beef. A breeder would not increase his or her profits with an improvement plan to get a particular color of cattle. Hair color is not an economically important trait. It would pay, however, to improve feed efficiency.

Next, science tells you that the most improvement can be made by selecting for traits that are transmitted strongly to the offspring (highly heritable). A breeder accomplishes little by trying to improve a trait that has low heritability.

To make real improvement, the fewer traits selected for, the better. The most progress for a trait will be made if all the selection is for that trait. If more than three traits are in the selection program, progress will be slow and limited on each.

In summary, select for economically important traits that are highly heritable. And, select for only a few traits at a time. Let's take a look at some traits and see how they can be improved.

Mothering or Nursing Ability

Scientific study has set the heritability of nursing ability at about 30 percent. This trait is economically important because much of a calf's growth comes between birth and weaning. It is easy to see the importance of this trait. Which cow would you select—one with a 375-pound calf or one with a 525-pound calf beside her at weaning?

The mothering ability of cows can be quite accurately measured. It is done simply by weighing their calves at weaning. The heavier the calf, the better the cow's nursing (milking) ability. This is similar to weighing the milk from a dairy cow to evaluate her milking ability, but is much easier because only one weight is required.

In most beef herds all the calves are weaned at once. They are weighed at this time to check their mothers' nursing abilities. When all the calves are weighed at once, there will be differences in their ages. Also, the sex of the calf and the age of the cow make a difference in figuring mothering ability. In order to make fair comparisons between the calves, their actual weaning weights must be adjusted, taking age and sex factors into account. In statewide improvement programs, these adjustments are usually done by electronic data processing machines. This is often a service to herd owners who participate in organized herd improvement programs.

These adjusted weights are the basis for culling cows from the herd. Cows whose calves have the highest adjusted weights are kept. Cows with the lightest calves are culled. There is no exact line between cows to keep and cows to cull. This is because pasture, range, and management vary with the location.

There are two principles to remember in selecting for nursing ability:

1. Improvement results only when the superior animals are used for breeding and the inferior ones are culled.

2. The environment of animals must be alike if valid comparisons are to be made. It would be unfair to compare weaning weights if some of the calves had been creep fed and others had not.

Growth Rate

Growth rate is another easily measured trait which might be improved. It is 45 percent heritable. Growth rate is important because it is closely related to economy of gain. You would not hesitate in buying a calf that would gain 3 pounds daily instead of a calf that would gain only 2 pounds. It is as simple as that. The better gaining calf will have a lower cost of gain. You will have more pounds of beef to sell for a given amount of feed, or you will be able to finish the calf in a shorter time. All in all, the faster growing calf is more profitable.

You can directly select for growth rate. In the past the selection for growth rate has been done by selecting for conformation traits which were thought to be related to growth. You may have heard a livestock judge say, "This is a growthier heifer." He probably noticed the heifer had long legs or a long body.

Why have breeders relied on eye judgment to select for growth rate? Why have they not used a scale and select for growing ability directly?

Growth rate can be accurately measured. The most common method on farms and ranches is to put bull calves on a feedlot test immediately after weaning. The calves are weighed, then a good ration is full-fed for at least 140 days. At the end of this time the bulls are weighed again. By dividing the amount of gain by the number of days on test, the average daily gain of each bull is figured. Average daily gain is a direct indication of growth rate.

Another way of measuring growth rate is to weigh all calves when they are about 18 months old. The weaning weight is subtracted from this 18-month weight and average daily gain is figured. This kind of measurement may fit into the herd management program, especially for heifers.

Two principles stand out as guides to improve growth rate.

1. There is a great deal of variation in the ability of individual cattle to gain. It is not unusual for bulls from the same herd to vary considerably. The range may be from less than 2 pounds daily to more than 3 pounds.

2. The ability to gain is transmitted from parent to offspring. Therefore, improvement will result if growth rate is selected for. Using sires that have superior gaining ability will improve the gaining ability of the herd.

To select for gaining ability a cattle breeder feedlot tests the bull calves with the *best weaning weights.*

After the feedlot test he or she sells only the superior gaining bulls as breeding bulls. If you buy a bull, choose one with a good daily gain record.

Selecting fast-gaining animals for the breeding herd is doubly important. The two traits of gaining ability and feed efficiency are interrelated. If you improve gaining ability, you improve feed efficiency and you improve your herd.

Feed Efficiency

Feed efficiency is a ratio of the amount of feed needed to produce a unit of weight gain. In beef cattle it is about 40 percent heritable. A tested bull that converts 6 pounds of feed into a pound of gain has higher feed efficiency than one that eats 10 pounds of feed to make a pound gain. Feed efficiency ratios are like golf scores, low ones are best.

On a farm or ranch it is almost impossible to keep track of exactly how much each animal eats. So it is impossible to measure feed efficiency. Fortunately, feed efficiency can be selected for indirectly by selecting for rate of gain. Scientists have found a high correlation between rate of gain and feed efficiency.

Feed efficiency can be measured directly at a bull testing station. Each bull is fed separately and accurate feed consumption records on each one can be kept.

Conformation

The final item considered in a selection program is conformation. Conformation scores are 25 to 40 percent heritable, depending on the age when taken.

When we speak of conformation, we mean those traits that contribute to carcass desirability and structural soundness. Remember that performance traits, such as growth rate, should be measured and selected for directly—not through conformation traits.

The important conformation items are structural soundness and beefiness. We look for structural traits which suggest a healthy, long-lived animal, such as correct skeletal structure. In beefiness we are looking for muscling, the thickness of the flesh. Special attention is paid to the regions of the high-priced cuts—back, loin, rump, and round. We also want a satisfactory finish at a relatively young age, but animals that develop fat at the expense of muscling must be avoided, too.

Science is trying to find new tools to measure fat and muscling in live beef cattle. The near future will probably see such tools. For the present, breeders should use the best current eye appraisal methods for evaluating the major items of conformation. Some kind of scoring system is usually used to evaluate conformation. Scores are given at weaning and again at the end of the feedlot test. A scoring system may be simple or it may involve detailed individual scores for each major conformation item.

Most performance testing programs include a method for comparing the conformation of live animals. In many programs, each animal is given an overall index.

Conformation is used in the selection program to guard against producing the "wrong" kind of cattle. For instance, a cow may be a good milker, but her skeletal structure may be too weak for her to have many calves.

As an additional selection tool, progressive breeders are beginning to use carcass evaluation of some of their animals. They use carcass cutout information in addition to the visual items that can be seen in live animals. Such things as depth of fat, area of rib eye, percent hindquarters, and color of meat are considered in evaluating carcasses.

IMPROVING A SWINE HERD

Production in almost any herd of hogs can be improved. A producer can often boost his or her profits by upgrading his or her nutrition, management, health, or marketing programs. This will improve the litters being raised now. But, there is another kind of improvement that is more lasting. A breeding and selection program will improve the genes of a herd. This is permanent improvement.

In previous lessons you learned a few principles of genetics. Through the selection programs, these principles are put to work on the farm.

Take a herd of average crossbred sows, for instance. How would you use a knowledge of genetics to begin improving your market hogs and to upgrade the breeding stocks?

First, you might consult someone who has received training from an animal breeding scientist. Your county Extension agent would be a good choice. Most states have a proven selection program to follow. Your county Extension agent would know about it.

Let's take a look at a typical improvement program. In it you can see genetic principles being applied. There are usually seven steps involved.

1. Identify each sow and each of her pigs at farrowing. This is usually done by ear notching.

   The scientific principle here is that pigs from the same litter will have different genes. The best individuals are selected from the best litters. So you must identify each individual animal.

2. Start a written record when each sow farrows. The record need not be fancy. A simple farrowing record is shown on page 36. The information includes the sow's number, the sex and ear notch number of each pig in the litter, the farrowing date, the sire, the number of live and dead pigs farrowed, and some notes on the mothering ability of the sow. Special notes can be made of vaccinations, changes in rations, and so forth.

   Good written records are a must for any improvement program. A hog producer cannot possibly remember everything. Any good farmer, businessman, or scientist is a good record keeper.

3. Weigh each pig at weaning and at about 154 days old (5 months). Of course, it would be hard to weigh every pig when it is exactly 154 days old. You can weigh several litters at the same time.

   These weights are used to compare the growth rates of the pigs. The heavier the pig, the better its growth rate. In choosing replacement gilts, you select those with the highest 154-day weights (other traits being equal). In a well-managed herd, about 180 pounds is the lowest weight you should choose. In any case, choose only from the top one-half of the gilts. You can also use 154-day weights if you plan to keep some of the old sows. You would keep the sows that raised the most pigs and whose pigs had the highest 154-day weights.

   Two scientific ideas are involved in step 3. (1) Remember that breeders select for economically important traits. And, they select for traits with heritability that is medium or higher. The ability to make fast gains is very important in swine. Rate of gain has a medium heritability. (2) In selecting for traits, accurate, objective measures should be used. Do not guess the 154-day weights of pigs. Actually weigh them using an accurate scale.

4. Probe the gilts that have qualified on weight. Probing measures the fat thickness over the pig's back. You have probably seen this done or demonstrated. Probe measurements are taken at three points on the back. The "backfat thickness" is the average of the three probes. (The average is their sum divided by three.)

   The gilts will have different weights when they are probed. Gilts with the least backfat are the ones to choose for the breeding herd. Gilts with more than 1.3 inches of backfat are usually not chosen. If this standard can't be met, particular emphasis should be given meatiness in the choice of a boar.

   Step 4 also has two scientific bases. (1) Research proves that the backfat probe is a good way to predict meatiness in live pigs. For hogs of equal weight, the greater the probe measurement, the less lean cuts. The lower the probe, the more lean. Meatiness has much economic importance. When you select gilts with low backfat, you are indirectly selecting for meatiness. (2) All gilts in a herd usually have the same environment. They are fed, housed, and managed alike. Therefore, differences in their backfat must be caused to a considerable extent by differences in their genes. Since genes are passed on to the offspring, gilts with low backfat that are used for breeding will pass on the important trait of meatiness.

5. Examine the fast-gaining, low-probing gilts for physical defects. Count the teats on the underline, and appraise the general soundness of the mammary (milk-producing) system. Also, appraise the soundness of the feet and legs. Finally, evaluate the gilts for conformation. Pay special attention to *muscling* in the *ham* and *loin*. Look for reasonable length of side, a trim jowl, and feminine head. Reject gilts that have defects or that definitely lack ham, loin, or length.

   There is a scientific principle here, too. Some traits can be accurately appraised with the eye. Some cannot. Number of teats and physical defects can be "eyeballed" satisfactorily. Use eye appraisal only for traits for which it is suited. Use more accurate measures, such as scales and the probe, for traits for which they are suited.

6. Get as much market information as you can on the barrows and market gilts you sell. Ask the buyer to give you carcass grade, backfat, and length on at least one truckload of your hogs. On all hogs, get an estimate of the percentages of No. 1's, 2's, and 3's. The national average is about 35 percent no. 1's. If 50 percent or more of the hogs you market grade No. 1 and they have good ham and loin development, you are producing meat-type hogs. If you are marketing a lower percentage of No. 1's, you should concentrate (put selection pressure) on increasing meatiness.

   Enter a market hog show which has a carcass contest. This will give you more detailed carcass information on a selected sample of your hogs. Two such shows are presently held in Washington. Ask your county agent for details. In many carcass contests each hog carcass must meet certification standards. The standards are 1.6 inches or less backfat, 29 inches body length, and 4 square inches or more of loin eye. In many contests the trimmed hams and loins are weighed. Then the percentage of ham and loin in the carcass is calculated. The hog with the highest percentage of ham and loin is the winner.

   Carcass evaluation involves much science—both animal science and the science of economics. Economists who do "consumer preference" studies report that pork has lost some consumer demand. This simply means that people are less willing to buy pork. The apparent reason is too much fat in the pork. Hog raisers are increasing consumer demand by producing more lean pork. Lean pork has excellent nutritional value and ranks high on a "repeat business" scale.

   Carcass and live grade information tells hog producers whether their animals are satisfactory. With this information they can better plan their breeding programs. (Meatiness can be improved most by using meaty breeding stock.)

   Meat scientists have the tools for evaluating hog carcasses. For example, they have found ham and loin percentage is a good indicator of total lean cuts.

7. Study the records on your gilts and decide what traits need improvement the most. Then buy a boar with an outstanding overall record (index), but with very strong score in the traits your herd is weakest in.

   Buy the breed of boar that best fits a planned rotational crossbreeding program. There are two good places to buy boars. One is a boar testing station and the other, a herd owner who has participated in testing or in breed improvement programs. In either case, you have actual performance records to guide your decisions.

The scientific principles for these suggestions are:

1. In each herd, certain traits need more improvement than others. Your 154-day weight records might show a need to improve rate of gain most. Backfat probe records might show a need to buy a boar with very low backfat. If your guilt were too short, you would buy a boar with exceptional length. You would not ignore overall merit, however.

2. Once again, actual records are the best measure of genetic merit. Boar testing stations give factual records on gaining ability and backfat thickness. Often, information on the feed efficiency of a group of pigs closely related to the boar is also available and carcass information on a litter mate may be given.

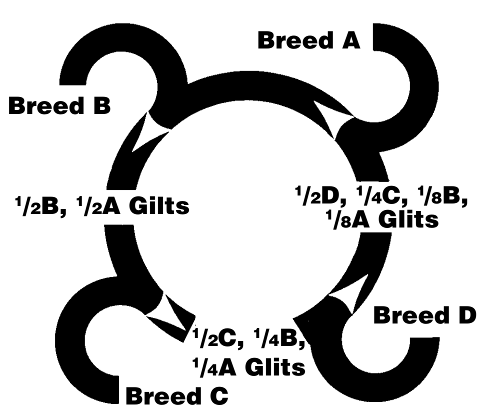
   Breeders who have taken part in testing station and breed certification programs often have gain records and probe data on their boars. They may also have carcass cutout information on half brothers or sisters of boars.

3. Crossbreeding gives "hybrid vigor" (heterosis) in hogs. In other words, pigs from parents of two different breeds are more "vigorous" than purebreds. Certain traits can be improved more quickly in crossbreeds than in purebreds.

   Most modern commercial hogs are crossbred. Swine raisers have found that crossbreeding gives them improvement in one or more of the important traits. These may include litter size, birth weight, livability, mothering ability, growth rate, and disease resistance.

   Usually two or three breeds are used in cross breeding. They are used in a definite order. The outstanding characteristics of several breeds can be obtained in the crossbred pig. If good seed stock boars are used, and care is exercised in selecting the gilts, a high level of performance will be maintained. You won't find a tendency for the crossbred stock to deteriorate or "run out." It isn't likely that every mating will be perfectly successful. That is expecting too much, even with the best breeding program. But, consistently high-level performance can be maintained and corrective procedures can be made in selecting replacement boars and gilts if minor faults appear.

A ROTATIONAL BREEDING PROGRAM



The Procedure for Conducting a Swine Improvement Program

I. Records Kept
   A. Birth
      1. Litter size, litter weight at birth, sex, individual birth weight.
      2. This information is tabulated on the farrowing record sheet for each litter. The farrowing record sheet can be the basis for your entire swine herd improvement program. Any records on feed consumption, carcass data, or final disposal can be recorded in the "Notes" space.
   B. Weaning
      1. Individual weaning weight, number weaned, litter weaning weight.
      2. This information is tabulated on the same farrowing record sheet as mentioned above.

II. First Selection at Weaning Time
   A. Remove small litters from consideration. Outstanding pigs from small litters are not kept.
      1. Only pigs from uniform, large, healthy litters are considered.
      2. Exception: When the number of replacement gilts needed is greater than 1/4 the number in the sow herd, a few gilts may have to be kept which otherwise would go to slaughter.
      3. Remove from consideration such obvious defects as swirls, hernia, cryptorchidism, inverted nipples, crooked legs, and ear blindness.
      4. Between this selection and 200 pounds, check litter records and be familiar with how pigs are doing

FARROWING RECORD

Date Litter Farrowed ____

Number of Pigs Farrowed ____ Live ____ Boars ____ Sows ____ Dead ____

Sire of Litter ____

Dam of Litter ____

Pig's Number	Birth Wt. within 24 hrs.	56-Day Weight Date	154-Day Weight Date	Notes

so final selections can be more meaningful.

B. Selection at this stage emphasized litter performance.

III. Selection at 154-day weights or market time weights
   A. Considerations
      1. Weight for age (Individual)
      2. Birth weight, both individual and litter average.
      3. Weaning weight, both individual and litter average.
      4. Sort pigs conforming to your ideal.
      5. Check production history of dams of these prospective replacements. Sort and rank again.
      6. Consider backfat probe, carcass measurements, and feed efficiency records.
      7. Then get down to the fine points of stock judging to make the final selection.
   B. General considerations on judging
      1. Know the conformation of the dam of each prospective replacement. If the pig doesn't conform to, or excel the type of the dam, kick it out of consideration. Here is a place you might want to try mating the sow to another boar.
      2. It isn't possible to expect succeeding litters from the same sow sired by the same boar to be equal in quality. (Segregation and recombination of genes each mating.) However, such litters are more apt to approach quality than would litters from different boars and the same sow.
      3. Like only tends to beget like.
      4. As long as a sow's production is satisfactory, don't cull her until a replacement has been proved. This is especially true of a purebred production.
      5. Hang on to proved boars as long as possible.

IMPROVING SHEEP FLOCKS

Management is the key to a highly productive and profitable sheep operation. Too many flocks never have a chance to be profitable because they are used merely as scavengers of the fence rows and are given little management consideration.

A summary of the production records of 113 Illinois flocks indicates that six factors are required in order to maximize flock returns: (1) all ewes should lamb, (2) a high percentage of multiple births is required, (3) lamb death losses must be kept low, (4) lambs must be marketed at desirable weights and at the time of year when prices are highest, (5) heavy-shearing ewes are essential, and (6) wool must be marketed in a desirable condition and at the highest possible price per pound.

To continually improve a sheep flock, select breeding stock with care, keep and make use of complete flock production records, carry out a sound management program, and keep current up-to-date on new things taking place in the sheep industry.

Selection of Breeding Stock

Selecting good breeding stock to start or expand your flock is an extremely important part of livestock management. This is just as true for a commercial flock as it is for a purebred flock. The greatest consideration should be given to the selection of the ram, for it is through the use of good stud rams that the most rapid progress can be made in flock improvement.

The following is a list of criteria to use in selecting breeding stock.

1. Growthiness (size for age)

   Select rapid-gaining individuals that meet your other standards. Rapid-gaining animals usually make the most efficient use of feed and can be marketed at a younger age. A slow-growing lamb is not so profitable as a fast-growing lamb. Set a goal of having twin lambs weigh at least 85 pounds and single lambs weigh at least 95 pounds at 120 days of age (if creep fed). Then select breeding stock with the gaining ability to produce such lambs.

2. Soundness

   a. Feet and legs. When feet are well trimmed, the sheep should be able to stand squarely on them. Select individuals that have short, strong pasterns and straight legs with plenty of width between them. Crooked legs and weak pasterns can decrease an animal's ability to move and perform normally, and therefore decrease its years of reproductive usefulness.

b. Mouth. Check the sheep's mouth to determine age, condition of the eight incisors, and any jaw malformations, such as monkey mouth or parrot mouth.

c. Udder. If ewes have produced at least one lamb crop, check their udders to be sure that both teats are present and functional and that there are no lumps or hard areas.

d. Testicles. Check the ram to be sure both testicles are present, fully descended, sound, and of equal size.

3. Conformation

a. Wide chest.
b. Smooth shoulders.
c. Fullness through heart area and spring of ribs.
d. Long and deep body.
e. Wide and straight top.
f. Long, wide, and level rump.
g. Deep, thick, and full leg of lamb or mutton.
h. Overall balance (blending together of body parts).

4. Condition of birth (single or twin)

Select as your first choice, in both ewes and rams, individuals from multiple births. Even though the heritability of multiple births is low, progress can be made in increasing lambing percentage by selecting for twinning. A good set of twins is more profitable than a good single lamb.

5. Previous performance

When buying stock, get as much performance information as possible—such things as weight at 90 or 120 days and weight at one year of age. Find out about the performance of their progeny, if any. Also, check the performance of sires and dams.

6. Substance (amount of bone)

Select heavy-boned sheep. In general, heavy-boned sheep do better than fine-boned animals.

7. Wool

Select heavy-shearing sheep that have dense, uniform, high-quality fleeces, free of dark fibers. This factor is often overlooked in sheep selection, but wool makes a sizable contribution to a sheep enterprise.

8. Age

Select younger ewes because they have more productive years ahead. Ewes usually reach peak productivity at four to six years old. The age of the ram will determine how many ewes he can service. A ram lamb can be used on about 15 ewes, a yearling ram on 25 to 35, and an aged ram on 35 to 45. Usually, however, three rams are used for every 100 ewes in the breeding flock.

9. Sex character

Ewes should be feminine in appearance and rams masculine in appearance. Masculine rams are generally more rugged, active, and aggressive than rams that lack this quality.

10. Breed type

Breed type is a very important consideration in purebred livestock. Without breed type we lose breed identity, because breed type constitutes the characteristics which distinguish one breed from another. Even though breed type is important, do not get carried away with it to the point that you forget all else. It needs to be appraised along with the factors discussed above.

Production Records

Production records, if well kept, can be useful tools to both commercial and purebred flock owners. They help measure flock productivity, identify high- and low-producing ewes, show differences in gaining ability of the lambs, and aid in evaluating ram performance. They are a valuable supplement to what can be seen with the naked eye.

The records can be quite simple and do not have to be in great detail. The following information should be included on the record: ewe number, date lambed, number and sex of lambs born, sire of lambs, age and weight of lambs weaned, and fleece weight of the ewe. Any additional information that you desire could also be included. (See sample records on page 40.)

Without some sort of production records it is difficult to measure progress in flock improvement. Such factors as weaning weights, fleece weights, lambing percentage, and percent of death loss are very important and have a direct effect on the income and profit from the enterprise. Tables 5 and 6 point out the large differences in ewe productivity and lamb gains that can exist within a flock. This information was taken from the production records of a flock containing 105 ewes. All male lambs were castrated at 10 days and all lambs were weaned at 90 days of age.

Table 5. Pounds of Lamb Weaned at 90 Days From High- and Low-Producing Ewes

Ewes raising singles		Ewes raising twins	
High	Low	High	Low
87.1	44.6	148.2	77.7
85.5	46.9	143.1	86.6
84.2	47.5	142.7	92.2

Table 6. Daily Gain From 0 to 90 Days (Weaning) for Fast- and Slow-Growing Lambs

Single Lambs		Twin Lambs	
High	Low	High	Low
.81	.35	.73	.22
.80	.38	.70	.31
.79	.42	.70	.32

If you wish to start your flock on a production testing program, you can obtain assistance from your county Extension agent. The *Individual Ewe Production Record*, C0096, is available from the Bulletin Office, PO Box 645912, Washington State University, Pullman, WA 99164-5912, will provide information necessary to start this program.

More sheep breeders each year are becoming interested in obtaining carcass information in addition to their production records. Enter your lambs in carcass shows if you have an opportunity. It is important to know how desirable the carcasses are from lambs you are producing.

The trend in the sheep industry, as in beef and swine, is an ever-increasing demand for production of a meat-type animal. The high degree of finish to which livestock have been fattened in the past is no longer tolerated. The housewife wants less waste fat on the meat she buys. Extremely fat animals are not economical to produce because it requires about $2^1/4$ times as much energy to produce a pound of fat as to produce a pound of muscle and bone.

What is meat-type lamb? Our present concept is that it is an efficient, rapid-gaining individual that produces a highly desirable carcass containing a minimum amount of fat and a maximum amount of muscle, especially in the leg and loin areas. To be more specific, it is best to have lambs that weigh at least 90 pounds at 120 days of age, yield in excess of 50 percent when slaughtered, carry no less than 0.10 inch and no more than 0.30 inch of subcutaneous fat, and have at least 2.5 square inches of loin eye.

Keeping Up-to-Date

In order to keep up with changes in the sheep industry, read the sheep articles in leading farm magazines and subscribe to a sheep magazine. Send for new sheep bulletins whenever they become available. Attending county or statewide sheep days, county sheep schools, or other similar events is also a good way of receiving current information. Take an active part in your state or local sheep association, and if you raise purebred sheep become active in your state breed association.

SCIENCE AND ANIMAL HEALTH

Ask a livestock producer what his or her biggest problem is. He or she will probably say disease.

SHED RECORD

Owner or Ranch ______________________ Address ______________________

Weaning Dates __________ __________ __________ Shearing Date ______________________

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ewe No.	Lamb Ident. No.	Date Lambed	Ram Bred to	Birth Wt.	Sex	Type		Weaning		Wt. Adj. to _____ Days	Rearing Adj. Factor	Final Adj. Wt.	Ewe Fleece Wt.	Remarks
						Birth	Rearing	Date	Wt.					

You can understand his or her feelings. You worry about the health of your own 4-H project animals because disease would hurt your chances to make a profit. Your efforts to do well at an achievement show might be ruined.

Multiply your small project by the thousands of livestock producers in America. This gives you an idea of the seriousness of disease to the livestock industry.

Livestock diseases are of tremendous economic importance. The problem is important enough for state and federal governments to spend millions of dollars on disease research. Governments also pass laws to control or eradicate diseases.

In addition, entire industries are devoted to developing, manufacturing, and selling animal health products. They make drugs, antibiotics, insecticides, disinfectants, sanitation devices, and many other products. A profession—veterinary medicine—dedicates itself to preventing and controlling animal diseases.

Those working with animal health have made great strides. They now know enough to prevent, control, or eliminate most diseases. It is estimated that at least three-fourths of the losses from death and lowered production could be prevented if known health practices were followed. The remaining one-fourth cannot always be prevented because we do not yet know enough about their causes.

The scientists who work in animal health have discovered certain practices that farmers and ranchers can use to prevent disease. They are commonsense ideas with good scientific principles behind them. Let's take a look at some of the practices and their scientific bases.

1. Isolate animals for 3 or 4 weeks before adding them to your herd. This applies to new animals. It also goes for animals that have been part of the herd, but have been taken away and exposed to other animals (animals taken to shows, for instance).

   The scientific basis for this recommendation is:

   Diseases are transmitted by close association or direct contact of animals. Infected animals coming into a herd could transmit the disease to the entire herd.

   Disease losses can be kept low if the disease affects only a few animals instead of the entire herd. Isolation helps keep disease outbreaks confined to a few animals.

   The incubation period (the time it takes disease to show up) of most diseases is less than 30 days. If animals do not "break" with a disease in 3 or 4 weeks of isolation, chances are that they are free of highly contagious diseases.

   Isolation allows the farmer to better observe new animals for symptoms of disease and it permits animals to adjust to their new environment with less "stress" than if they were immediately put with the herd.

2. Put a planned immunization program into effect.

   The scientific basis for this recommendation is:

   Contagious diseases are caused by microorganisms, mostly bacteria and viruses. But animals can develop defenses against many microorganisms. These defenses are the antibodies in the blood.

   Vaccines cause animals to build up their antibody defenses against possible invasion by microorganisms. Each vaccine protects the animal from a specific disease.

   A *planned* immunization program does not leave the protection of the animals to chance. Even when there is a vaccine for a disease, vaccination must take place *before* an animal is exposed to the disease. Vaccination in most cases *after* exposure would not give the animal a chance to build its defenses. The animal would become sick and losses would occur.

   Planning a total immunization program with your veterinarian is the most scientific way to prevent the diseases for which there are vaccines. Planning involves doing, too. Unless the animals are actually vaccinated on time with the right vaccine and by the best method, the animals will not be immune.

3. Provide clean, healthful surroundings for your animals.

   The scientific basis for this recommendation is:

   Disease organisms often grow in organic waste that has not been cleaned up. Removing the source (reservoir) of the disease organism lessens the chances of disease.

   As animals' environment is improved, their performance will improve. Clean, healthful surroundings promote better performance because of less stress from disease. The animal's bodies are not constantly fighting disease.

   The most dangerous source of disease is a diseased animal itself. Diseased animals should be quarantined from the herd. The pens and yards where they have been should be thoroughly cleaned. This is to prevent the spread of the disease.

4. Rations must be nutritionally adequate.

   The scientific basis for this recommendation is:

   Some diseases are caused by deficiencies of certain nutrients. No microorganism is involved. Various deficiencies can cause body abnormalities, infertility, abortion, and many less noticeable, but very serious malfunctions.

   Animals have more disease resistance if their rations are adequate. An animal's general well-being depends largely on its nutrition. The better the nutrition, the better the body defenses against diseases will be. Remember the best nutrition does not necessarily mean the most fattening ration.

   Rations can cause health problems other than deficiencies and increased susceptibility to disease. Over-feeding can cause problems. For example, an overly fitted beef heifer will sometimes be infertile simply because she has been fed more than she needs. Her reproductive tract could be said to be in unnatural or "unhealthy" condition.

5. Keep visitors, dogs, other animals, and birds out of the livestock lot and houses.

   The scientific basis for this recommendation is:

   Diseases are transmitted in many ways. They may be carried on the boots, shoes, and clothing of people; by the feet, hair, and feces of birds and other animals.

   As the traffic in and out of livestock lots is reduced, so are the chances of transmitting disease.

   Disease can be carried from livestock lots as well as to them. A good livestock person wants to prevent his or her animals from infecting others just as he or she wants to stop others from infecting his or her own animals.

6. Get an accurate diagnosis of the disease problem.

   The scientific basis for this recommendation is:

   Correct diagnosis of the disease is necessary before it can be treated. The symptoms of several diseases may be very similar. A wrong diagnosis would result in the wrong treatment and loss would result.

   A diagnosis requires much specialized knowledge and many procedures. Veterinarians have this knowledge and can accurately identify most diseases. Many veterinarians have their own laboratories. In addition, they are backed by state diagnostic laboratories and the laboratories of commercial drug companies. Veterinarians rely on these laboratories to help diagnose difficult cases. They know it takes skilled scientists to identify a disease.

7. Consult your veterinarian. Together, map a disease prevention program.

   The scientific basis for this recommendation is:

   Preventing disease is more effective than treating animals after they become sick.

Your local veterinarian is best qualified to help outline a disease control program. He or she is trained in his or her field and knows the disease problems on neighboring farms.

If you consult your veterinarian regularly, he or she will know the history of your herd in case of a disease outbreak and be in a better position to make an accurate diagnosis.

Disease prevention will probably be more effective when the herd owner and the veterinarian work together in all phases of the herd health program so your livestock will make you more money.

LEARNING ABOUT MEAT

As a raiser of beef, pork, or lamb in your 4-H project, you are part of a huge industry. The livestock industry provides about 100 pounds of beef, 65 pounds of pork, and 5 pounds of lamb for every person in the United States each year. American farmers sell over $11 billion worth of livestock annually.

But, farmers are only a part of the industry. There are people who process the meat. There are wholesalers who distribute carcasses to retail stores and restaurants. There are truck drivers and railroads who transport it. There are retailers who cut the meat and sell it to the public.

More than 14 million tons of red meat (beef, pork, and lamb) are raised, processed, and sold annually. All this is because Americans like meat and they eat more of it than people of most other countries.

With such a huge industry, it isn't surprising that livestock producers are interested in the "meat end" of their livestock business. They want to produce the kind of meat people want to buy. Modern breeding, management, and marketing programs are all geared to producing animals that will yield the quality and quantity of meat most desired by consumers.

Beef Cattle

A 1,000-pound choice steer will yield about 600 pounds of carcass. There are 400 pounds of hide, legs, feet, head, internal organs, and stomach con tents. These are called by-products and they have a much lower value than meat. The packer saves or sells as many of the by-products as possible to help pay the cost at slaughtering and processing.

The carcass itself will also yield various products, each with a different value. People usually buy cuts of beef, not the whole carcass. Since they like some cuts better than others, they are willing to pay more for them. The high value retail cuts come from the rib, loin, and round. The lower value cuts are from the chuck, plate, brisket, flank, and shanks.

The retailer usually buys "sides" of beef (half a carcass). He or she may also buy additional wholesale cuts to meet the needs of customers. He or she then makes *retail cuts* from the side of beef or the wholesale cut. Assuming the steer weighs 1,000 pounds, the carcass will weigh about 600 pounds. So, each side is about 300 pounds. What retail cuts will be made from this side? An actual cutting test at the University of Illinois Meats Laboratory on 242 Good-Choice carcasses gives this information in Table 7.

Table 7. Average Amount of Salable Retail Cuts from a 1,000-Pound Choice Line Steer or Its 600-Pound Carcass

Trimmed retail cut[1]	Weight in Pounds	Percent carcass	Percent live
T-bone, porterhouse, and club steaks	33.6	5.6	3.36
Sirloin steaks	33.6	5.6	3.36
Rib roast or steak	35.4	5.9	3.54
Sirloin tip steak	15.6	2.6	1.56
Top round steak	27.0	4.5	2.70
Bottom round steak	30.6	5.1	3.06
Rump roast	16.2	2.7	1.62
Flank steak	3.0	.5	.30
Chuck arm pot roast	25.8	4.3	2.58
Chuck blade pot roast	61.8	10.3	6.18
Heel of round pot roast	10.8	1.8	1.08
Stew meat	27.0	4.5	2.70
Ground beef	81.6	13.6	8.16
Total salable meat	**402.0**	**67.0**	**40.20**
Carcass fat and bone waste	**198.0**	**33.0**	**19.80**

[1]To figure the retail value of each type of cut, multiply the retail selling price (get this in your local store) by the weight of the cuts. Add the values of all cuts to get the total retail value of your steer. To get the farm-to-consumer mark-up, subtract the live value of your steer at current market prices from the total retail value.

You can see that a 1,000-pound steer has only 33.6 pounds of T-bone, porterhouse, and club steaks. On the other hand, there are 198 pounds of bone and fat waste.

Hogs

A hog carcass weighs much less than a live animal. A 215-pound market hog will yield about a 150-pound pork carcass. There are 65 pounds of hair, feet, legs, head, internal organs, and contents. (See Table 8.)

The handling of pork, however, is different from beef or lamb. Most beef and lamb is sold as fresh meat. The belly, ham, picnic, and boston butt are often smoked and cured. The loin is usually sold fresh.

Another difference is that the pork trade uses the term lean cuts. These cuts are the ham, loin, picnic, and boston butt. The picnic and boston butt come from the shoulder. The four lean cuts plus the belly (uncured bacon) are called primal cuts. The preferred, high-value cuts are the ham and loin.

When the belly, boston butt, and picnic are cured and smoked, their value increases. This is especially true of bacon.

You can decide how cuts of pork rank in value. Simply ask yourself which cuts you like best. Check the prices of different cuts in newspaper advertisements. The higher priced the cut is, the more desired it is.

Lambs

The dressed lamb carcass weighs much less than the live lamb. A 100-pound choice shorn lamb yields a carcass weighing about 50 pounds. The remainder of the live weight is made up of pelt, blood, feet, head, and internal organs and contents. The forms of sale and distribution of lamb parallel that of beef more closely than pork. In general, the retailer buys lamb carcasses, though he or she may buy hindsaddles or foresaddles (rear half and front half of the carcass). On rare occasions he or she may purchase additional wholesale cuts to satisfy customer's needs.

As is true for all meats, the most desired cuts are more highly priced than those that are less desirable. The loin rack (rib), and leg are high-value cuts and the shoulder, breast, flank, shank, and neck are less valuable per pound. (See Table 9.)

Table 8. Salable Retail Cuts from a 215-Pound Choice Hog or Its 150-Pound Carcass

Trimmed retail cut[1]	Weight in Pounds	Percent	
		carcass	live
Ham	28.4	18.9	13.2
Loin	22.1	14.7	10.2
Picnic	12.2	8.1	5.7
Boston butt	10.3	6.9	4.7
Bellies	28.0	18.7	13.0
Spareribs	4.7	3.1	2.3
Lard	26.9	17.9	12.5
Pork fat	1.1	.7	.5
Trimmings	6.9	4.6	3.2
Miscellaneous	8.8	5.9	4.0
Total salable meat	**149.4**	**99.5**	**79.3**
Carcass fat and bone waste	**65.6**	**43.0**	**30.5**

[1]To determine the retail value of each type of cut, multiply the retail selling price (get this in your local store) by the weight of the cuts. Add the values of all cuts to get the total retail value of your hog. To get the farm-to-consumer mark-up, subtract the live value of your hog at current market prices from the total retail value.

Table 9. Average Amount of Salable Retail Cuts from a 100-Pound Choice Lamb or Its 50-Pound Carcass

Trimmed retail cut[1]	Weight in Pounds	Percent	
		carcass	live
Loin chops	5.2	10.4	5.2
Rib (rack) chops	3.9	7.9	3.9
Leg roast (American style)	12.2	24.3	12.1
Shoulder roast (square cut)	12.0	24.1	12.0
Ground lamb or lamb stew	5.0	10.0	5.0
Neck slices	1.0	2.0	1.0
Lamb shanks	1.3	2.6	1.3
Total salable meat	**40.6**	**81.3**	**40.5**
Carcass fat and bone waste	**9.3**	**18.7**	**9.3**

[1]To figure the retail value of each type of cut, multiply the retail selling price (get this in your local store) by the weight of the cuts. Add the values of all cuts to get the total retail value of your lamb. To get the farm-to-consumer mark-up, subtract the live value of your lamb at current market prices from the total retail value.

The points to remember about meat value are:

1. Only part of the live steer or hog is salable meat. One pound of beef at the meat counter requires about 2.25 pounds liveweight. Likewise, a pound of salable pork requires about 2.13 pounds of live hog. A pound of salable lamb requires about 2.46 pounds of live lamb.

2. Some cuts are more desired than others. Hence, they are more valued and higher priced than others.

CARCASS STANDARDS

Another important part of the meat end of the livestock industry is to know what kind of animals to produce. There are generally accepted standards for carcasses. They serve as guidelines to livestock producers.

Beef

There are five considerations in beef standards. They are carcass weight, fat covering and internal body cavity fats, rib eye area, meat quality, and conformation.

Weight of carcass. In recent years, 500- to 700-pound beef carcasses have brought the best prices. Therefore, it makes sense to produce cattle whose carcass yields are within these weights. Some beef cattle breeding improvement programs include a carcass feature. These programs give preference to cattle that make 1.5 pounds of carcass weight per day of age. This is to assure gaining ability as well as carcass desirability.

Fat covering. Too much outside fat lowers the value of cattle. A steer should have less than 0.1 inch of fat covering per 100 pounds of carcass weight. This is measured over the rib eye at a cut between the twelfth and thirteenth rib. Carcasses with less than 0.1 inch of fat per 100 pounds are preferred if the quality is of Choice grade. In addition to excess outside fat or "rind,'' a carcass may also have much kidney and pelvic fat. Together, these lower the amount of salable retail meat in a carcass. The amount of fat indicates the cutability of beef carcasses.

Rib eye area. A rib eye area of 2 square inches per 100 pounds of carcass weight is preferred. Rib eye is relatively easy to measure on a carcass. It indicates the amount of muscling in the highest value cuts—the rib and loin.

Quality of meat. Bright-colored, fine-textured muscle with at least a moderate amount of marbling is preferred. The cut surface of the rib eye is used to judge quality. The desired quality is equivalent to USDA Choice grade. It is judged by eye appraisal. A carcass from a young animal is preferred. "Youth" is indicated by red, porous bone.

Conformation. Conformation has to do with the shape of the carcass—its length and width, its muscling in the high-value regions. Conformation is also measured by eye appraisal. It is used to indicate muscling.

Cattlemen are still searching for more scientific ways to measure and judge carcass quality and conformation. Beef carcass evaluation is not as standardized as in pork.

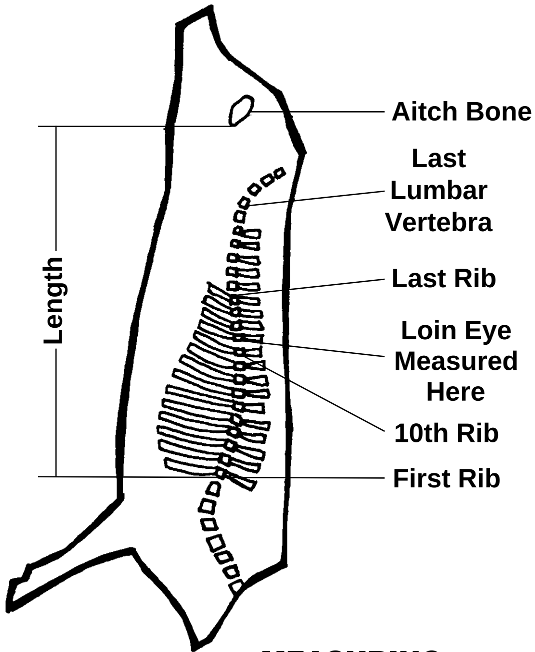
Pork

Pork carcass evaluation is relatively easy. The high-value cuts—ham and loin—are cut and trimmed as part of the regular packing house procedure. It is easy to "catch" these cuts, weigh them, and figure the ham and loin percentage.

This is commonly done in pork carcass evaluation. The higher the percentage of ham and loin, the better the carcass. It is not uncommon for good hog carcasses to yield 40 percent or more of the carcass weight in ham and loin.

Other standards have also been set for pork carcasses. These standards are now generally accepted for breed certification programs and minimum requirements in carcass shows. They include:

Carcass length. A carcass length of at least 29 inches is the accepted standard. There is little scientific proof that carcass length is related to carcass value or cutout. Still, reasonable length in



MEASURING PORK CARCASSES

breeding stock may be desirable for efficient reproduction. There appears to be no sound basis for giving extra credit if the carcass is over 29 inches long. Length is measured from the fore edge of the first rib to the aitchbone.

Grade and backfat thickness. The accepted standard for hog carcasses is U.S. No. 1 grade. This grade is largely determined by the thickness of the backfat. A No. 1 pig of average market weight must have less than 1.6 inches backfat. More than 1.6 inches backfat makes the carcass less desirable.

Loin eye area. Four square inches of loin eye is the minimum for certification by breed associations. Hog breeders believe this is very important, because small loin eye size has been blamed for some of the loss of consumer desire for pork. Carcasses with a loin eye area of 4 square inches or more will be meaty carcasses with good ham and loin percentages. Hog breeders like to see loin eye areas of 6 and 7 inches, and a few are found in the present hog population. Loin eye is measured after the loin has been cut at the tenth rib.

Quality. Pork carcass quality has come to mean a high percentage of ham and loin. However, "quality" to someone buying pork means meat that is firm, not soft or watery. Quality pork also has uniform color and some marbling. Marbling means small flecks of fat in the lean tissue.

Simply weighing the hams and loins after they have been uniformly cut and trimmed allows good appraisal of swine carcasses. For example:

	Carcass 1	**Carcass 2**
Weight	150 lb.	150 lb.
Ham weight	34	28
Loin weight	26	23
Percent ham and loin	40	34
	Very Good	Unacceptable

Lambs

There are five major considerations in lamb carcass evaluation: carcass weight, fat covering and internal body cavity fats, rib eye area, meat quality, and conformation.

Weight of carcass. At the present time, a 45- to 60-pound carcass brings the highest price. Heavier lambs are generally fatter and therefore yield a lower percentage of salable meat.

Fat covering and internal body cavity fats. There is a very high inverse relationship between the fatness of the carcass and its yield of salable retail cuts. There is, however, a need for the carcass to be uniformly covered with a thin cover of fat in order to prevent excessive dehydration and meat discoloration. Most lambs need 0.10 inch of fat cover at the twelfth rib to insure such protection, but should certainly have no more than 0.30 inch of fat. Internal body cavity fats should represent less than 3 percent of the carcass weight.

Rib eye area. This is the cross-sectional surface area of the major loin muscle at the twelfth rib. A 50-pound lamb carcass should have at least 2 square inches of rib eye area. The larger the rib eye, the more total muscle in the carcass. In addition, a larger rib eye results in much more attractive and appealing rib and loin chops.

Quality of meat. Lambs meeting the requirements for the UDSA grade of Choice or better satisfy a broader segment of the market than the lower quality lambs. Such lambs must be young, well shaped, and reasonably well finished. The meat should be bright in color, firm, fine textured, and show some marbling.

Conformation. Conformation is a subjective appraisal of the relative amount of lean and its distribution in high-value areas. It is a judgment of the shape of the carcass—its length, width, and fullness of muscling.

There are, at the present time, no universally accepted carcass standards for lamb as there are for pork.

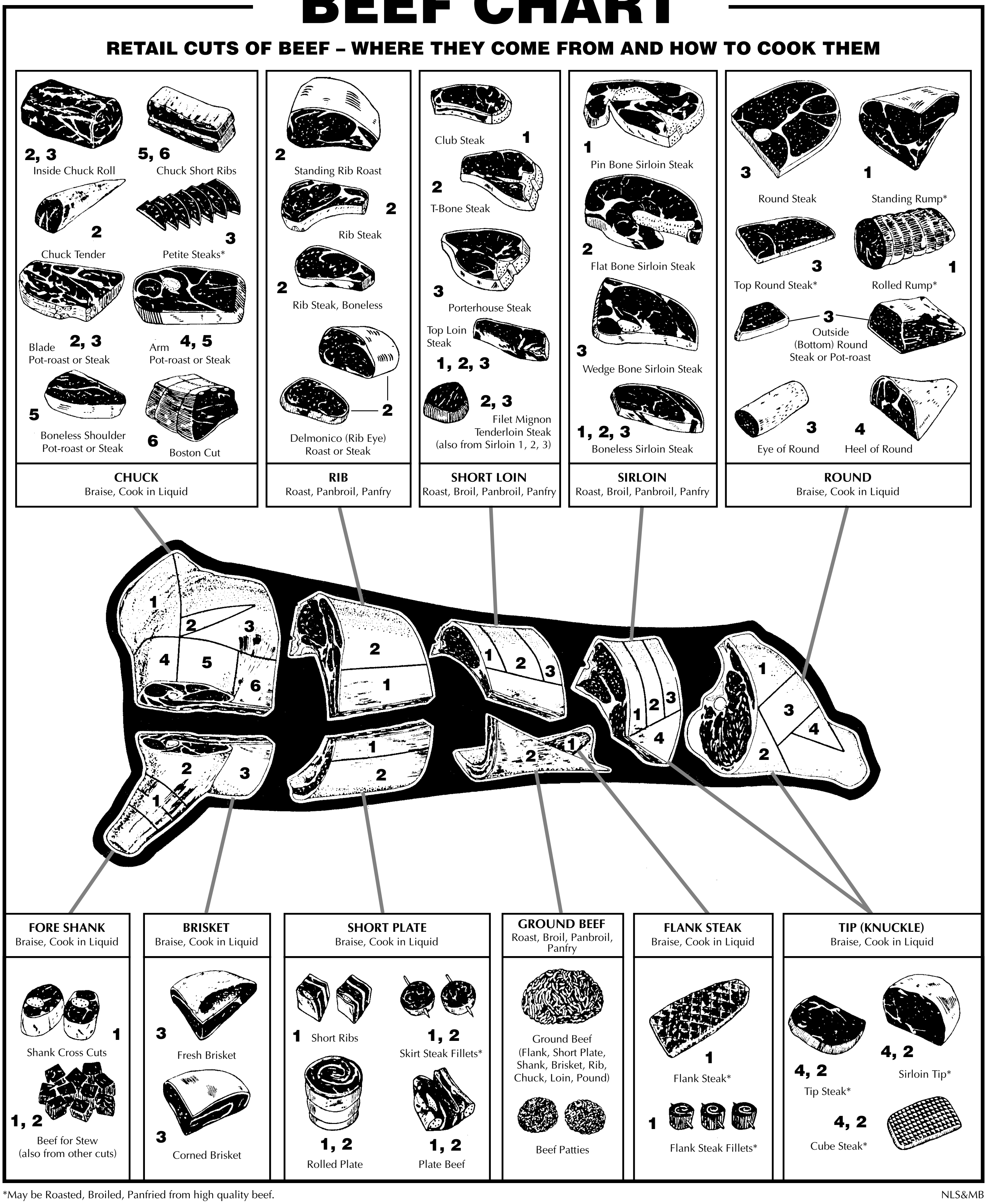
Key Points about Meat Carcasses

1. You must know what is desirable in a carcass before you can improve the live meat animal.

2. Cattle, lamb, and hog carcasses are evaluated differently.

Present carcass evaluation procedures are a direct application of the findings of meat scientists. Their research work is being used to guide other animal scientists working on the production of meat animals. Together these scientists are making a major contribution to the improvement of meat animals. There is still much to learn about meat. 4-H members can begin to learn more about meats, too. This lesson is only a start.

BEEF CHART

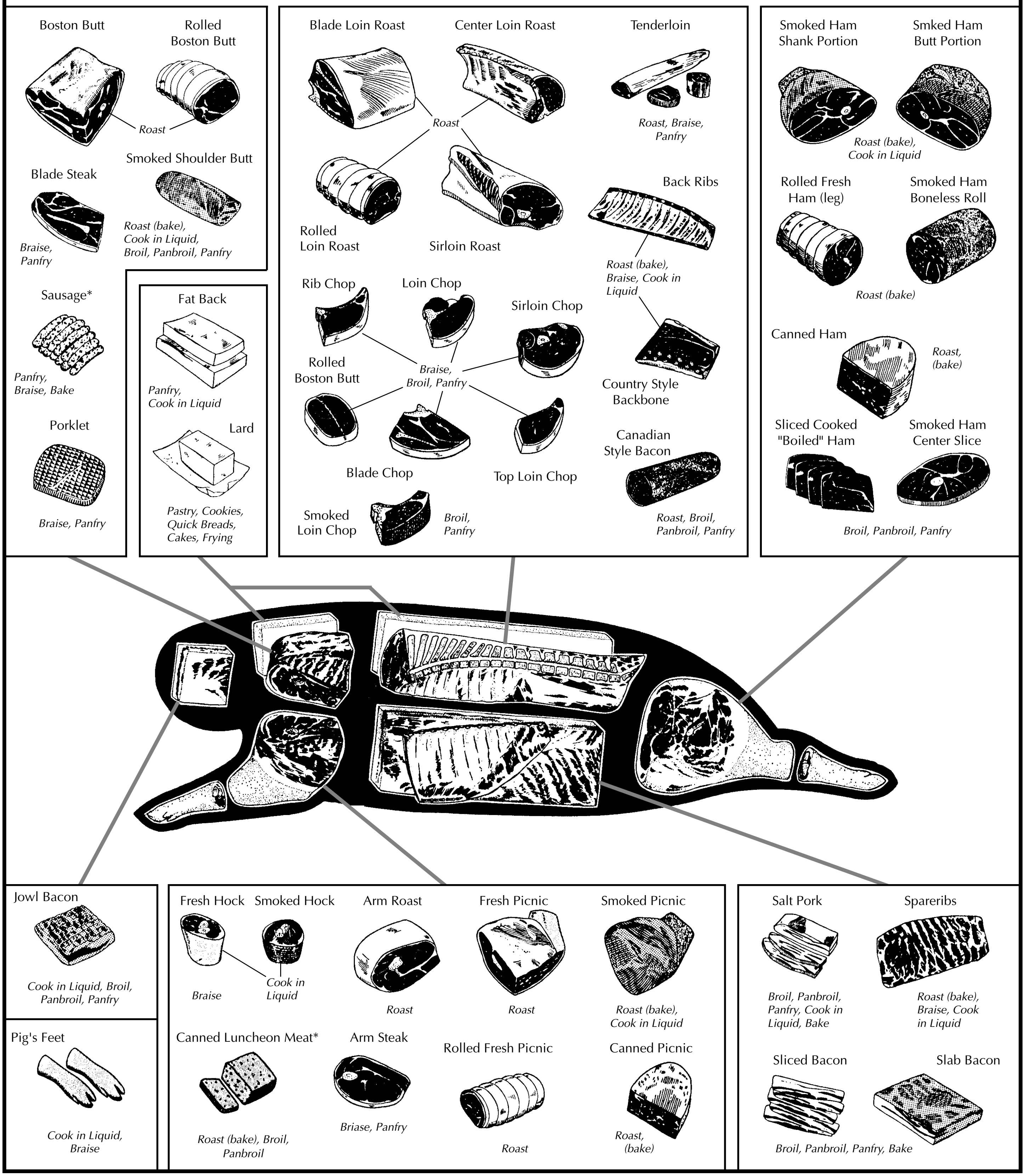


*May be Roasted, Broiled, Panfried from high quality beef.

NLS&MB

PORK CHART

RETAIL CUTS OF PORK – WHERE THEY COME FROM AND HOW TO COOK THEM

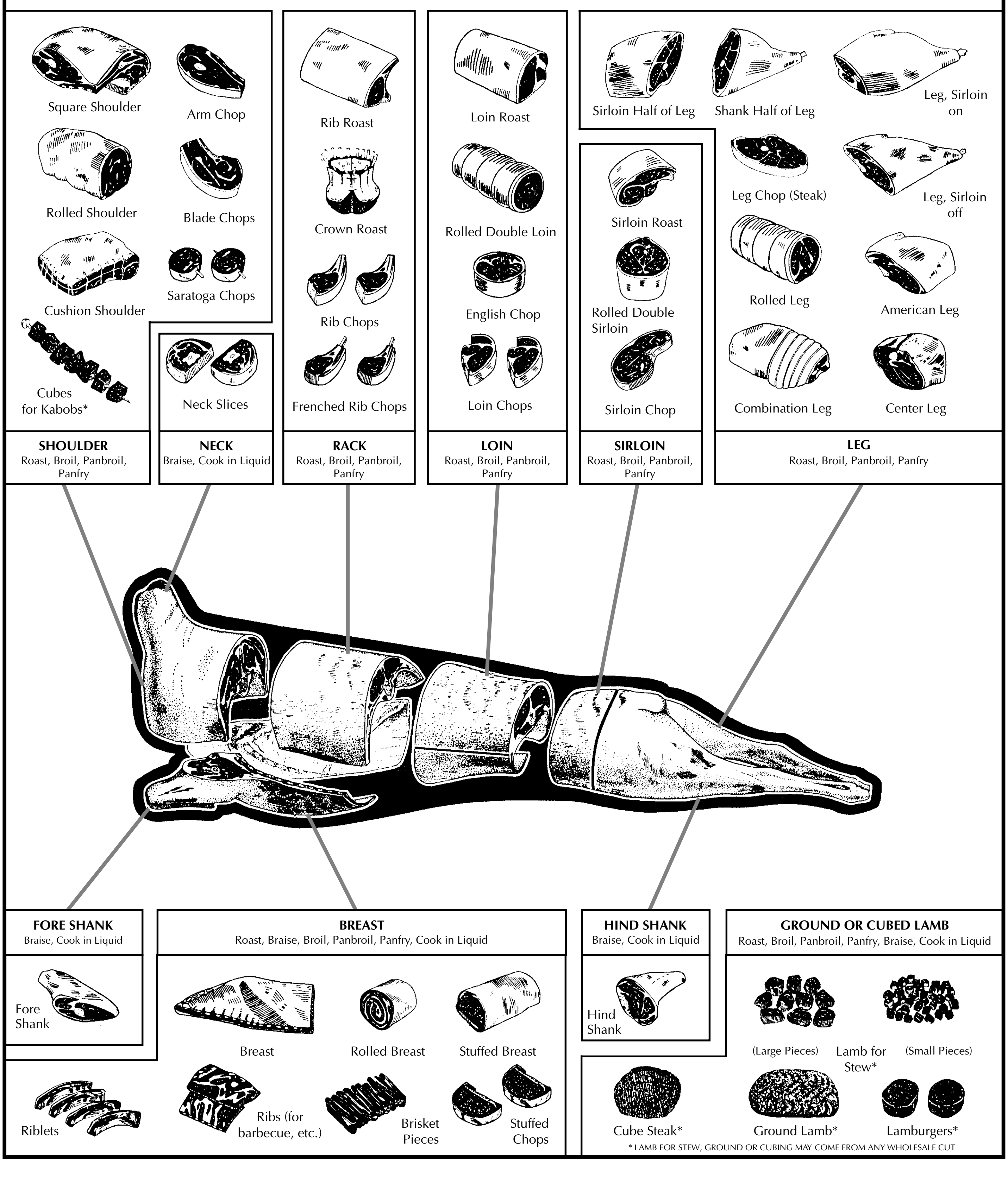


*These items may come from several areas of the pork side.

NLS&MB

LAMB CHART

RETAIL CUTS OF LAMB – WHERE THEY COME FROM AND HOW TO COOK THEM



Issued by Washington State University Cooperative Extension and the U.S. Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. Cooperative Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, color, gender, national origin, religion, age, disability, and sexual orientation. Evidence of noncompliance may be reported through your local Cooperative Extension office. Reprinted August 1997. Subject code 810. C.

EM3125

More boys and girls belong to 4-H than any other youth group.