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COOPERATIVE EXTENSION SERVICE, UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE AND HOME ECONOMICS, AND U. S. DEPARTMENT OF AGRICULTURE COOPERATING. E. F. FROLIK, DEAN; J. L. ADAMS, DIRECTOR

4-H Animal Nutrition

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This manual is designed for you and other older boys and girls (7th grade and up) enrolled in 4-H beef, dairy, sheep and swine projects. The six study lessons in the manual are to be completed during one 4-H Club year.

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LESSON 1 Introducing Animal Nutrition

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

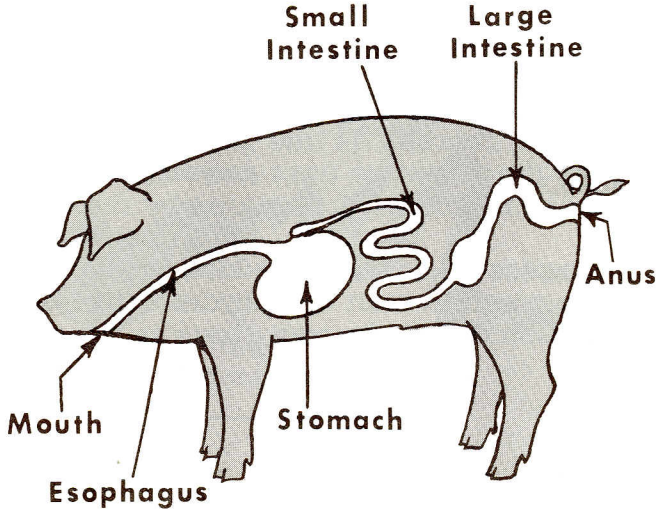
You feed your animal every day. It is something you do automatically, probably without really thinking about what you are doing. You are giving your animal the energy it needs to move around and to fatten. You are giving it needed vitamins and minerals to keep healthy. You are giving it the "building blocks" of protein to grow. In other words, you are giving your animal nutrients. You are part of the world of animal nutrition.

Animal nutrition is a science. It is the science of all the processes which 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 the feed down into very small particles--so small they cannot be seen by the naked eye.

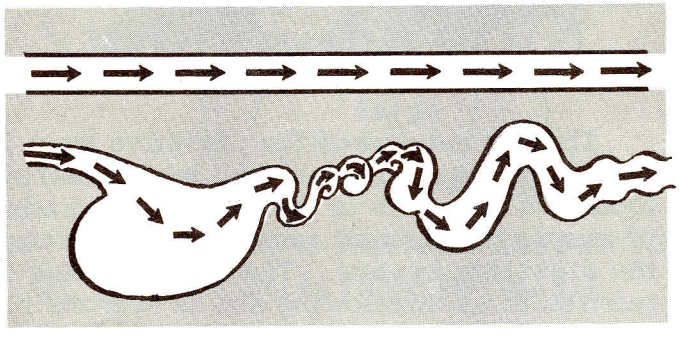
These particles are taken into the blood stream, where they are carried to all parts of the body. Here the particles are "burned" for energy, form body tissue, or are stored as energy in the form of fat.

These first reactions--where the food is broken down--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 as a hollow tube. The digestive tract is like an assembly line; but instead of building something, this factory takes something apart.



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.

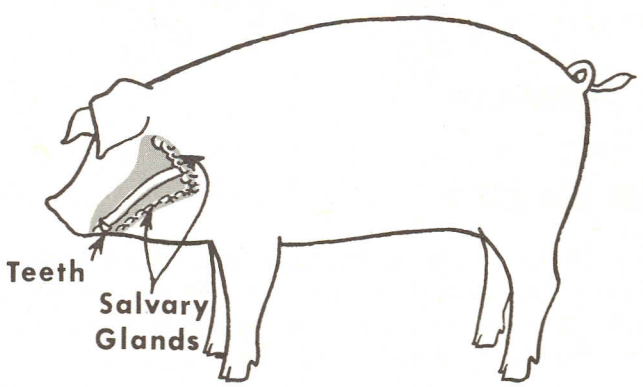
There are four main parts of the digestive tract where chemical reactions take place. In each chamber, different chemicals--digestive juices--are added to the food. These will be explained in detail later.

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 fibers. Pigs are fed grain or other materials low in fiber. The reason for this is that cattle and sheep are able to more efficiently digest fibrous materials than pigs. The differences in their digestive tracts largely explain this.

Through the Digestive Tract

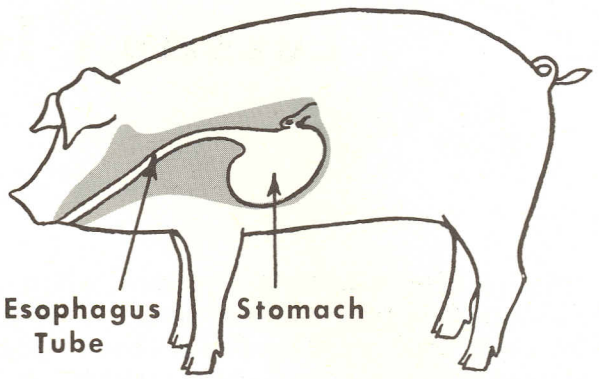
The first part of the tract is the mouth. This, of course, is the place where food enters the digestive tract and where the food is broken into small particles by the teeth.

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.



(1) CARBOHYDRATE (STARCH) BREAKDOWN BEGINS

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 referred to as swallowing and is responsible for moving food from the mouth to the stomach. (This works about like pinching toothpaste out of a tube.)



(2) PROTEIN AND FAT BREAKDOWN BEGINS

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 absorb passes on to the small intestine.

Food from the stomach passes through a valve into 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 continues in the small intestine, where more digestive juices are added. The cells lining the walls of the small intestine produce enzymes that aid digestion as well as absorb the digested feedstuff. In addition, two important glands deposit their juices in the small intestine.

The first of these glands 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 dige them.

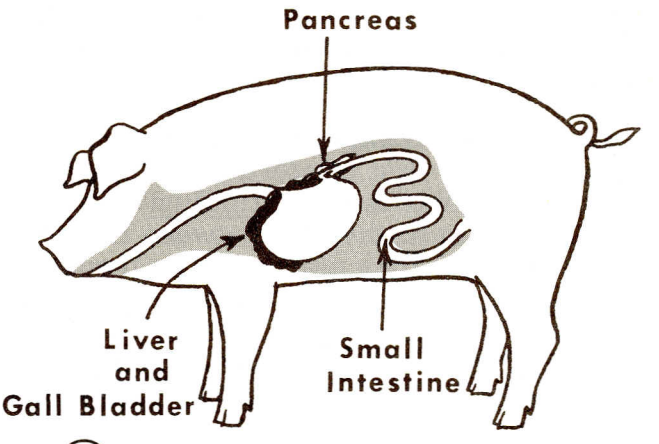
The second gland is the pancreas. Through the pancreatic duct, it delivers several digestive juices to the small intestine. These juices help digest several food components, including carbohydrates, fats and protein. More food nutrients are absorbed from the small intestine than from any other organ.

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

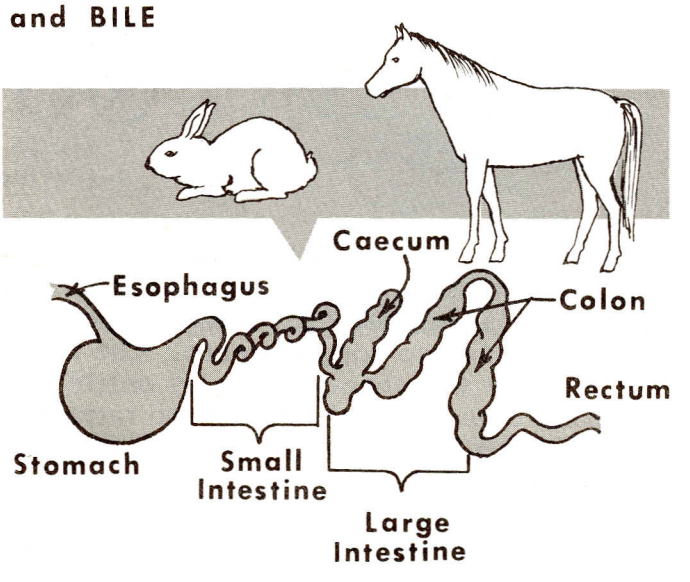
The next part of the digestive tract is the large intestine. It is the fourth major part of the tract. This intestine is shorter but larger than the small intestine. Its main function is to absorb water. It is also the site of some bacterial digestion, as in the caecum. Another job of the large intestine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

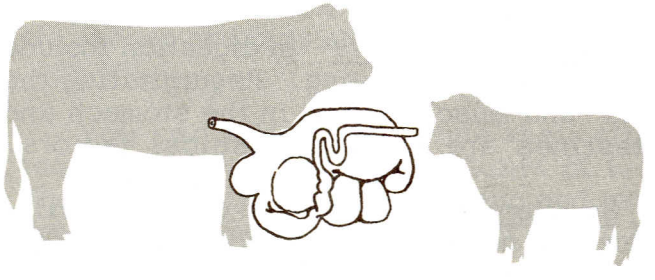
The last part of the digestive tract is the anus. It is simply an opening through which the undigested portion of the feed taken in at the mouth is eliminated.

So this is our "hollow tube." Its main job is to digest and absorb food.



(3) FURTHER BREAKDOWN OF NUTRIENTS BY PANCREATIC ENZYMES and BILE

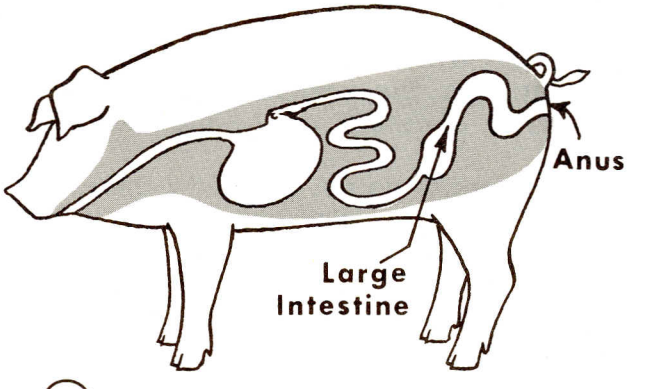




Cattle and Sheep Have Special Stomachs

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

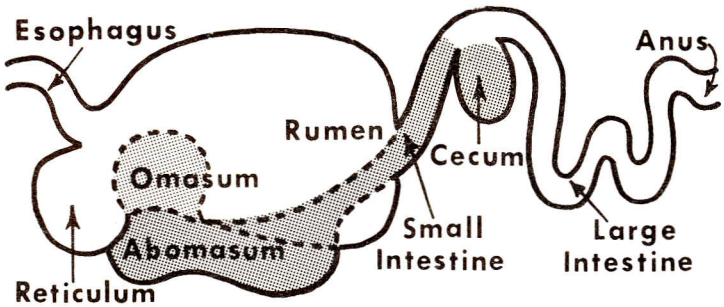
The answer lies in their special kind of stomach.



(4) BACTERIAL ACTION, ABSORPTION OF WATER, COLLECTION OF WASTE

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 or honeycomb. There is no division between the rumen and reitculum. 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.



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. The feeds high in fiber (roughage) eaten by cattle and sheep are 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 up 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 or manyplies. It makes up about 8% of the stomach.

Scientists do not yet know the exact role of the omasum. For one thing, it acts to grind up 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 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.

Nutrition Terms

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

Metabolism--concerns food after it has been digested. It is the changes which 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--are 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--are animals that have one stomach. Pigs and horses are nonruminants.

Enzymes--are digestive juices which act as catalysts. They speed up chemical reactions in digestion.

Mechanical Factors--in digestion include chewing and swallowing. Regurgitating the "cud" and muscle action in the stomach and intestines are other mechanical factors.

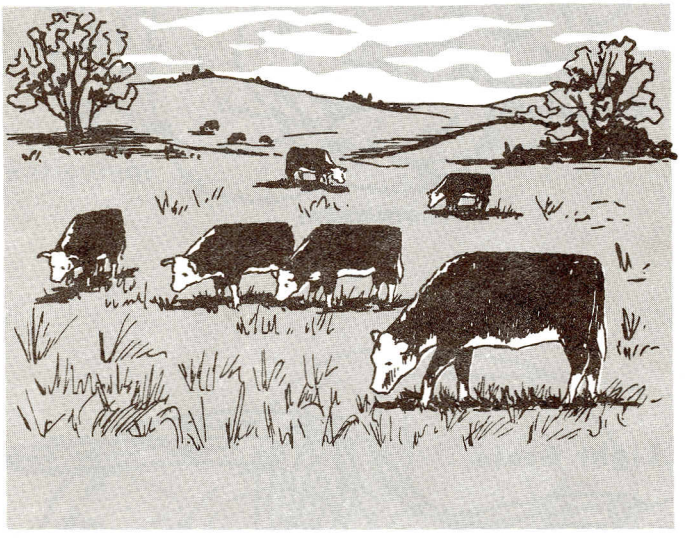
Secretory Factors--have to do with glands. Glands do not act directly in digestion. They secrete enzymes to help digestion.

Chemical Factors--are chemicals that aid digestion. They include both enzymes and other chemicals. Hydrochloric acid is one of the others.

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

LESSON 2 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 cattle, feed is being mixed, ground up, 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 which feed takes through the digestive tract are also important.

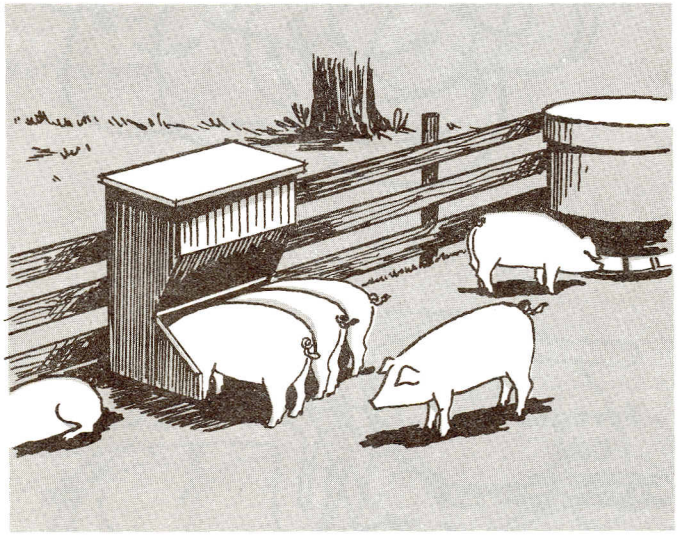
Cattle and sheep are ruminants. Pigs are nonruminants. As a result, the pathways of feed in these animals are different. This, in turn, affects their nutrition.

Pathways in Ruminants

Differences in the digestive tracts of cattle, sheep and pigs are reflected in the ways they eat.

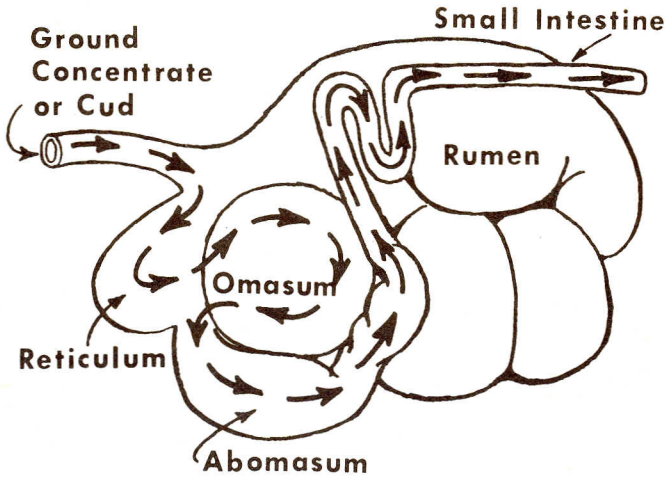
You can watch cattle use their strong tongues to pull in great amounts of feed. They eat rapidly, seldom pausing and hardly bothering to chew. In fact, they eat so hurriedly that they sometimes swallow nails, wire, glass or other debris left around the farm. This is why ruminants sometimes get "hardware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

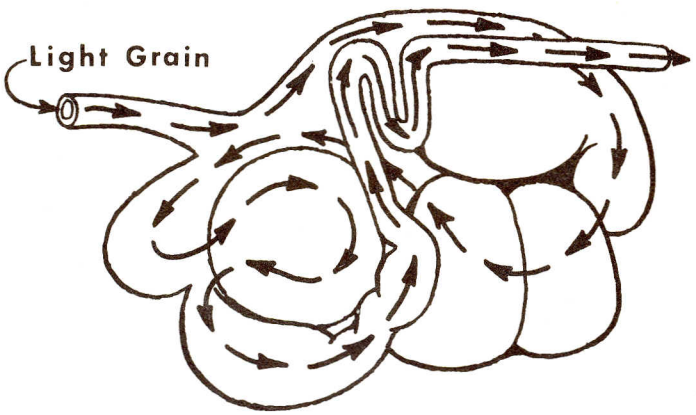
No matter what kind of feed is being eaten, cattle only partially chew it. Only about half the whole-kernel corn eaten by cattle is crushed before it is swallowed. This is why you will often find undigested corn in cattle manure.

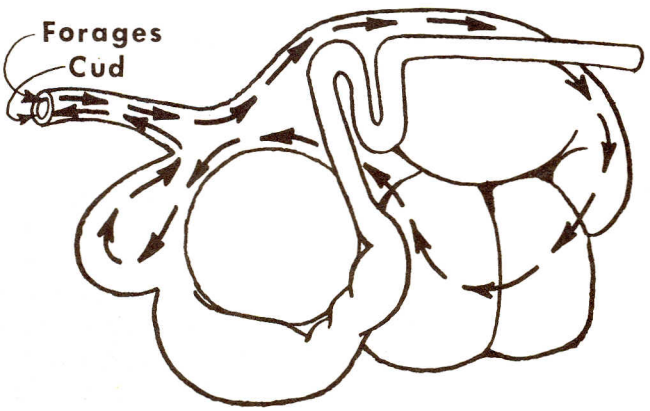


After cattle have taken in enough feed to fill their rumen, they usually find a comfortable spot to lie while they "chew their cud." The feed in the rumen is hardly changed from the form in which it was swallowed except that water has been added. The rumen and reticulum work to prepare the feed for digestion.

THREE POSSIBLE ROUTES OF FEED IN RUMINANTS







The rumen and reticulum act as a holding vat. Feed is stored here for several hours while bacteria digest the feed. 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 of feed it is. There are three possible routes:

1. The most direct route is from the esophagus to the reticulum 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 the reticulum and passes on to the omasum. From there it enters the abomasum.

3. The feed may complete the circuit of the rumen. After entering the reticulum, it 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. But we sometimes overlook mechanical factors. They are also important.

The first mechanical factor is chewing, which is followed by swallowing. In cattle, rumination--the process in which the cud is chewed--comes next.

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.

1. 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.

2. When the reticulum relaxes again, it fills up with feed that has been fermenting in the rumen.

3. Then the reticulum contracts again to trap another supply of food stuffs 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 it 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.

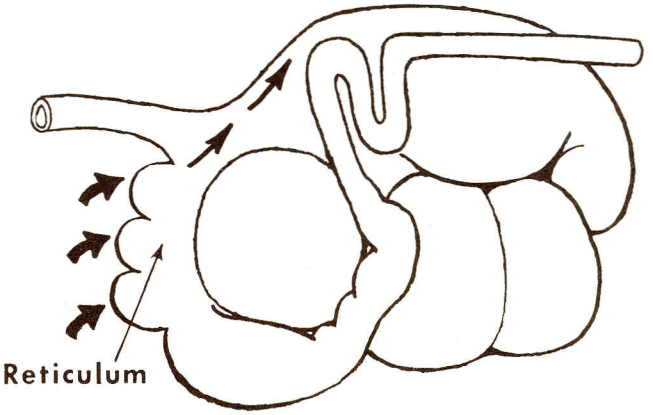
Dry feed, such as grass or hay, must be ruminated. It cannot be digested otherwise. Most of the grains do not appear in the cud. They probably pass straight to the abomasum (true stomach), since they do not require rechewing and do not require long exposure to the more powerful forces of digestion at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

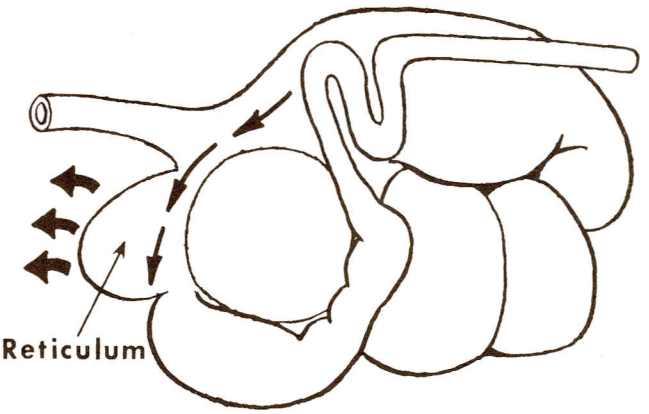
Slow Feed Passage in Cattle

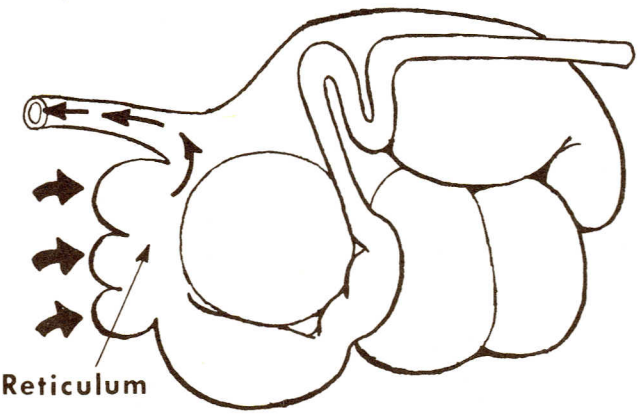
After the cud is rechewed it is reswallowed and passes down the esophagus into the reticulum. Most of it then goes on to the omasum contracts, water is squeezed out while the feed is being forced into the abomasum.

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

IN RUMINATION, THE RETICULUM ACTS AS A PUMP







The appetite of cattle and sheep 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. While ground corn is digested in less than a day, coarse hay may take 4 or 5 days.

Pathways in Nonruminants

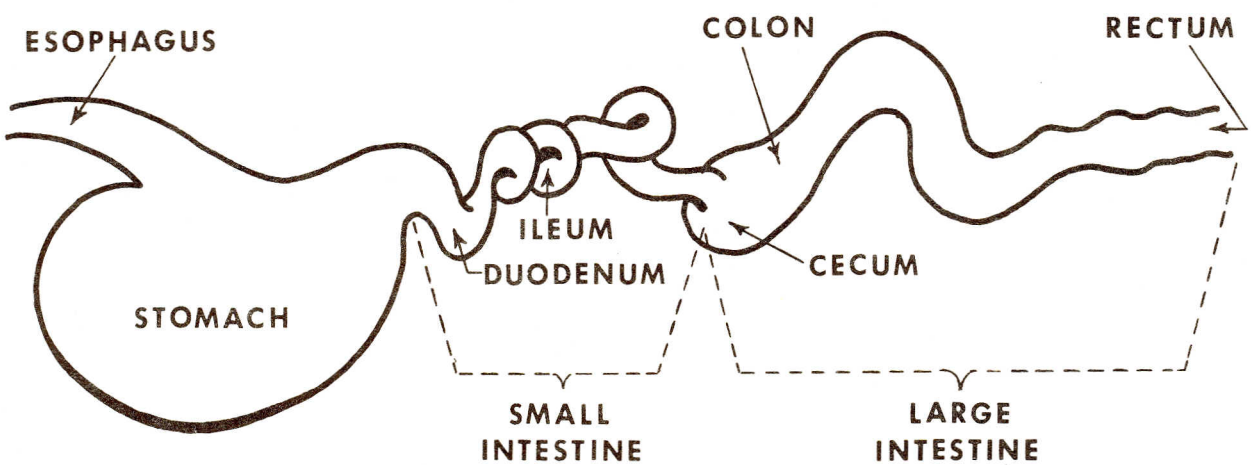
Compared with the time required for some feed to pass through cattle, the 24 hours required for feed to pass through the digestive tract of a pig is short.

Pigs do not have a rumen where feed can be stored while it is digested. Neither 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. Another reason pigs chew and swallow slowly is to get feed mixed with an enzyme in the mouth.

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

From this comparison, we can see why ruminants are well suited for digesting large amounts of roughages. The rumen acts as a storage vat while digestion is carried on by bacteria. Feed passes through the tract slowly. This allows plenty of time for digestion of tough roughages.

DIGESTIVE TRACT OF PIG



LESSON 3 Feed Nutrients

You probably feed your 4-H animal a supplement. If your project is a calf, you feed one kind of supplement. If it is a pig, you feed another kind, and so on.

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.

You know this because you know something about animal nutrition. Animals need many different kinds of nutrients. Different animals need different 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.

In feeding experiments, different feed ingredients are tried. In the laboratory, feeds are analyzed. 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 lamb or steer, fast gains at the least cost are desired.

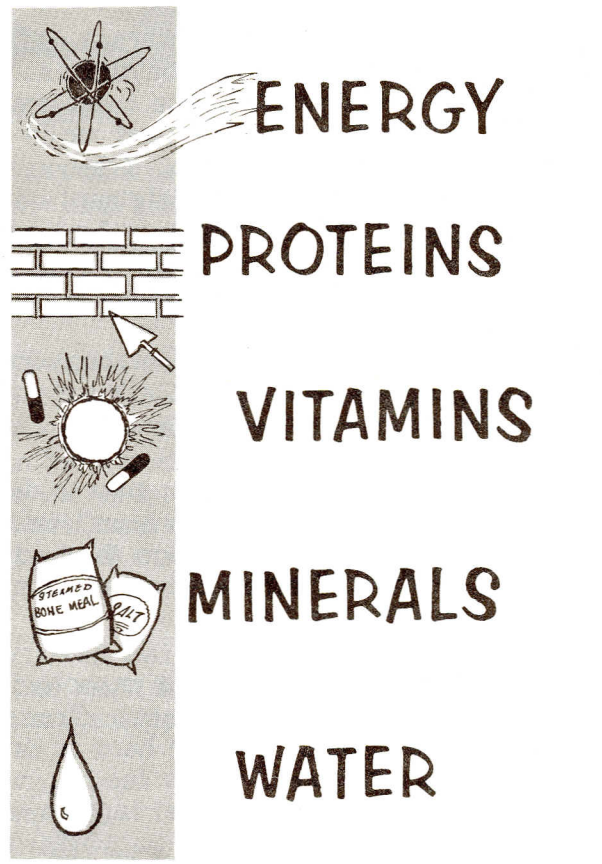
After experiments are conducted, they are checked and rechecked. Then the results are used to make recommendations to farmers. This means more profit for the farmer. It means better, cheaper meat and meat products for everybody.

Kinds of Nutrients

There are many different chemicals in feeds. Animals need some of them in large amounts--others are needed only in 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.

TYPES OF NUTRIENTS

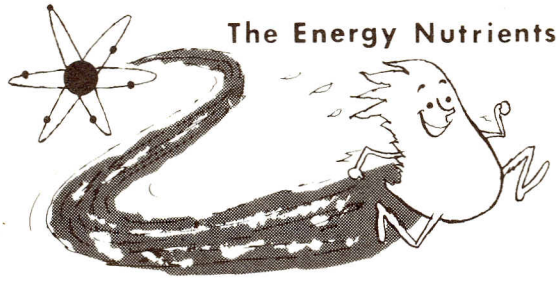


None of these is more important than the others. All are essential. But with the exception of water, the energy nutrients usually make up the greatest bulk of feed.

Energy nutrients are the body's fuel. In fact, they are even 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, a beating heart, breathing, blinking eyes, contractions of the digestive system. At the same time, heat is produced to maintain body warmth.

The Energy Nutrients



The main energy nutrients are carbohydrates. There are many carbohydrates. Even the relatively simple ones are 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. Cellulose is one of the more complex carbohydrates.

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

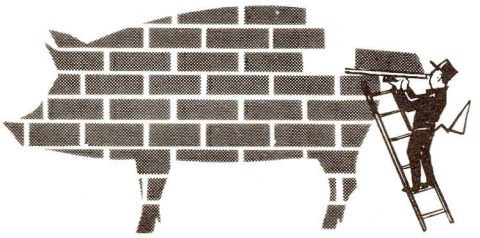
Cellulose is chemically a carbohydrate. It makes up the fiber in plants. Grass has much cellulose. Cellulose is hard to digest. For most animals it has a low feeding value; however, ruminants can digest large amounts of cellulose with the aid of bacteria in the rumen.

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 do carbohydrates. So the energy in fats is more concentrated. Fat has 2.25 times more energy value than carbohydrate.

While carbohydrates and fats supply energy, proteins, supply the material from which body tissue is made. They are the bricks and mortar from which bodies are built.

The Proteins

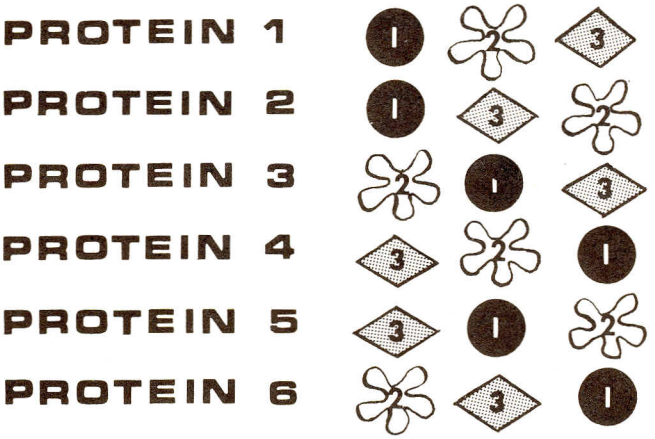


Proteins are highly complex. In addition to carbon, hydrogen and oyxgen, they contain nitrogen. Some proteins also contain sulfur. A few contain phosphorus or iron.

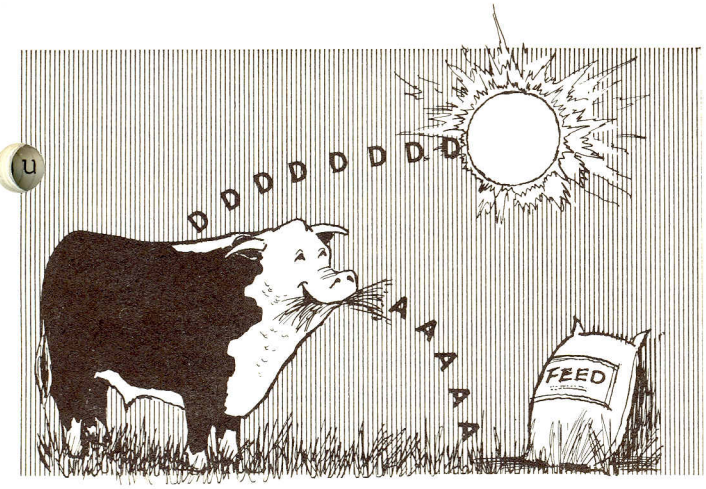
Like carbon, nitrogen can be combined with other chemical elements in different ways. The various combinations result in many different proteins. Each protein is made up of several nitrogen compounds called amino acids. These amino acids are the "building blocks" from which proteins are made. The chemical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

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

No Two Proteins Are Alike Even If Made Of Same Amino Acids



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 or 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 ca 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 are needed in much smaller amounts. Vitamins are such a group.

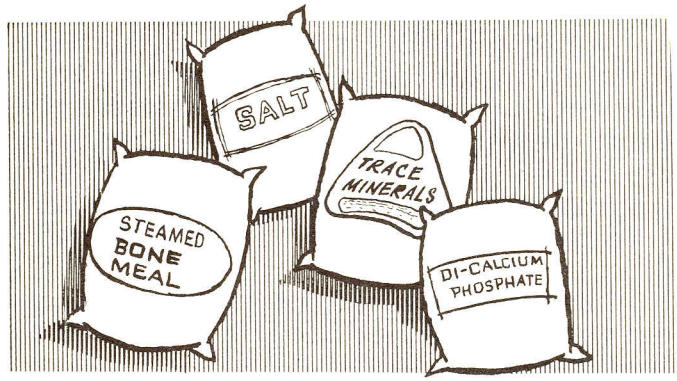
For a long time, people noticed that certain diseases were caused by the lack of certain foods. Then modern science began analyzing the foods. They were found to contain small amounts of certain complex chemicals. Other foods did not contain them.

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 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. Sunshine and sun-cured hay are good sources of Vitamin D.



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

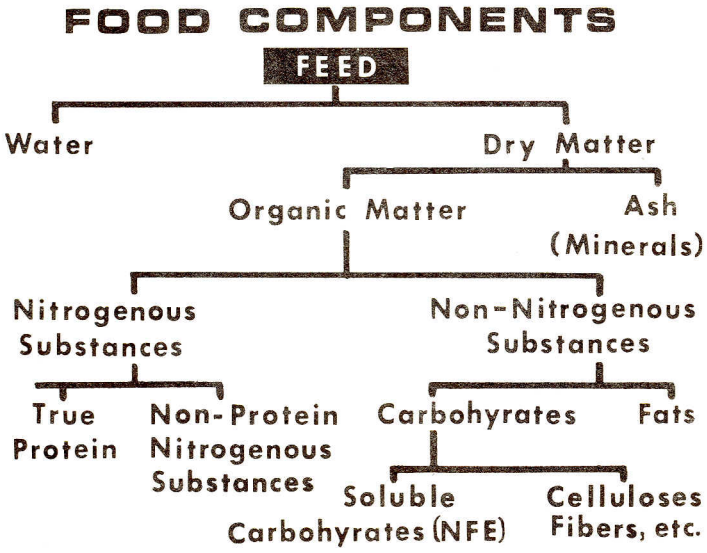
The last item on our list of nutrients is so common that we seldom think of it as a nutrient. But water is the largest single part or nearly all living things. The body of a pig or calf is three-fourths water.

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



Water is one of the nutrients 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-grey 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 which 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 percentage of water, minerals, fat, fiber and protein are added together, the total will be something less than 100 percent. This difference is referred to as the nitrogen-free extract. This extract includes the more soluble carbohydrates, sugars, starch and some cellulose. All of these are readily digested in the digestive tract.

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), we can tell the "energy value" of feed. TDN-total digestible nutrients--is the term used.

LESSON 4 Digestion, Absorption, Metabolism

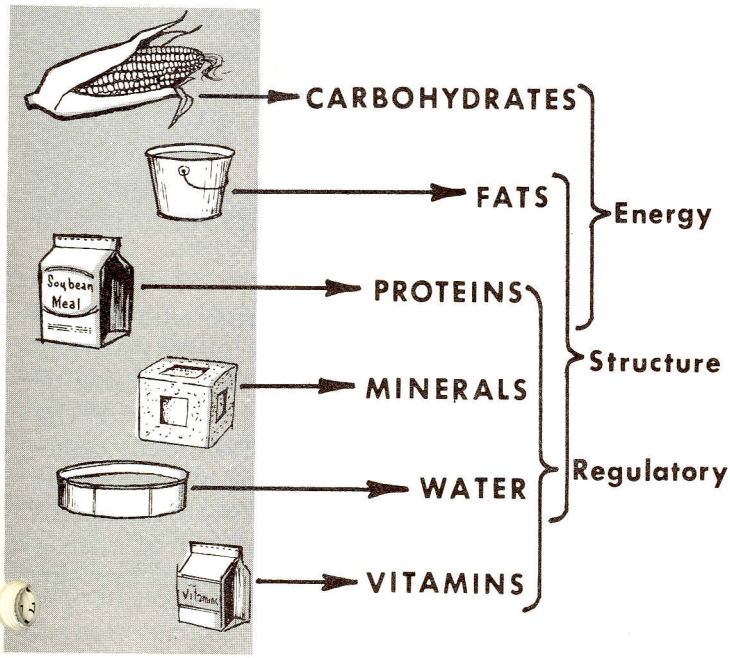
Any of three things can happen to the feed you give your 4-H animal. It can be used for energy or for fattening. It can be used to build body tissue. That which is left over passes through the body as waste.

Of course, feed is not used in the form it is fed. Neither beef or milk is much like hay. Nor is pork or lamb much like corn. Feed must be taken apart before it can be used. Then it is 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 down 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.

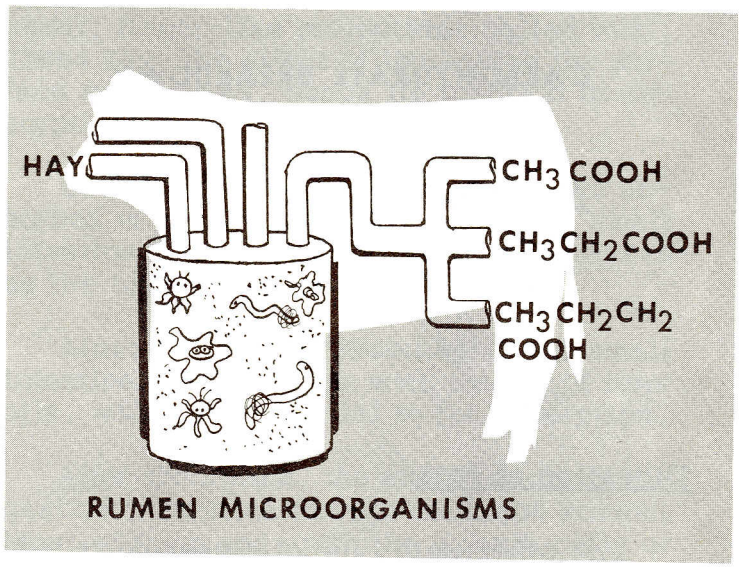
This process of using end products is called metabolism.



Digestion of Carbohydrates

Remember that carbohydrates are energy nutrients. Ruminants usually get most of their carbohydrates from hard-to-digest feed such as grass. Pigs (nonruminant) 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.



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

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

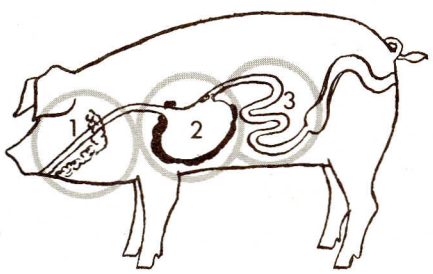
In pigs (nonruminants), carbohydrate digestion begins in the mouth. While the animal chews, saliva is added to the feed. Saliva contains an enzyme called salivary amylase. This enzyme acts on starch by breaking it down into sugars. (A scientist would call these disaccharides, which are a combination 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.

CARBOHYDRATE BREAKDOWN

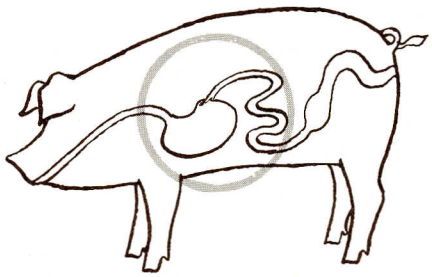


Digestion of Fats

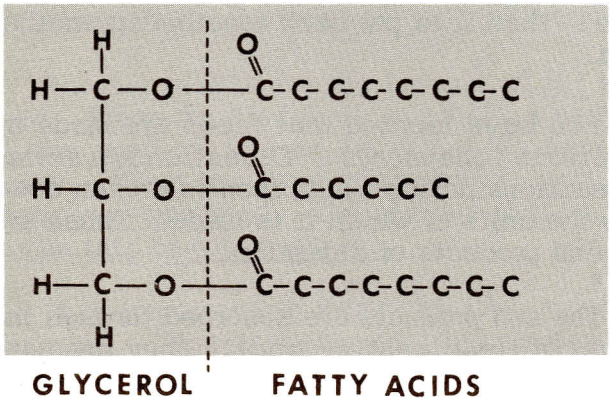
The other main type of digestion is the digestion of fats. These, like carbohydrates, are fuel nutrients. They are made up of fatty acids and glycerol. (These fatty acids are more complex than the short-chain fatty acids in ruminant digestion of carbohydrates.)

Digestion of fat is about the same in cattle, sheep and pigs. In cattle and sheep, fat digestion takes place in the abomasum (true stomach) 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 a similar enzyme-pancreatic lipase.



FAT BREAKDOWN



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

Digestion of Protein

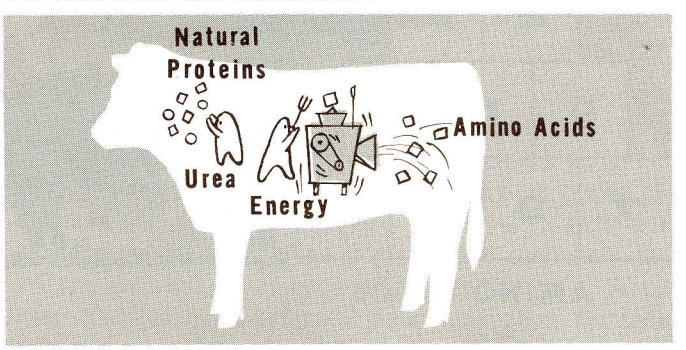
Another nutrient which is digested differently in ruminants and nonruminants is protein.

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 due to the excellent combination of essential amino acids which it contains. During digestion the proteins are broken down 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 chains pass on to the small intestine, where more enzymes are added. These enzymes break down 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--again with the aid of bacteria. Bacteria are small animals and require a certain combination of amino acids to develop their own bodies. These break down 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 and bacteria and ruminants make cattle and sheep 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 or sheep. Cattle and sheep require some source of nitrogen, but they do not have to be fed a specific balance of amino acids. These are called the essential amino acids.

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 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.

Most absorption is from the small intestine. Its surface is covered with millions of small, finger-like projections called villi. These have the effect of increasing the surface many times, hence its function in 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 needed by the cells. Some are used to replace worn-out cells. Some are used to build new body tissue. Some are used for energy. Some are stored for later use.

LESSON 5 Learning About Nutrient Requirements

How did you find out what to feed your 4-H animal? Perhaps it was from your father, your club leader or county extension director. 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.

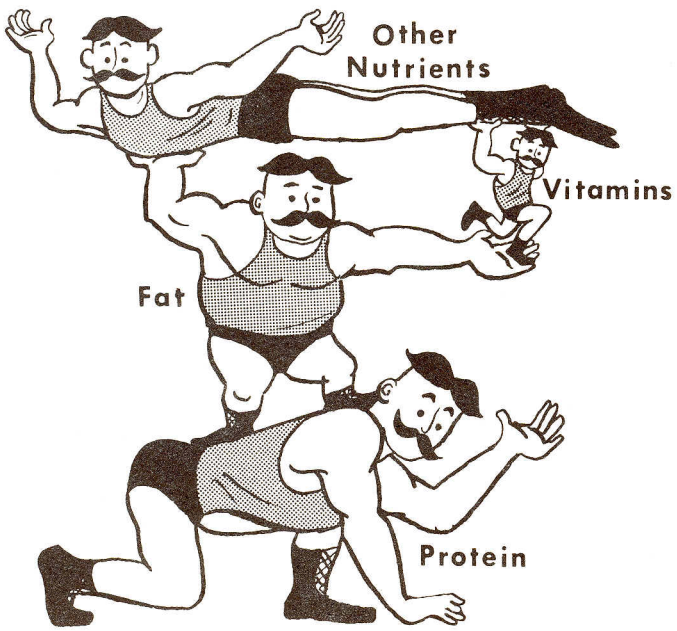
But how do these people know? How do you figure out the right balance of proteins, fats, vitamins and all the other nutrients?

The science of animal nutrition can help you. Scientists have learned what nutrients animals need. They have learned about animals' nutrient requirements.

At least they have learned a lot about nutrient requirements. Scientists are still learning. They constantly search for knowledge which will improve livestock performance.

Underlying the scientists' search for the right nutrients are certain principles. These principles guide scientists in their research. They guide livestock raisers in their feeding programs.

There are four principles you should know.

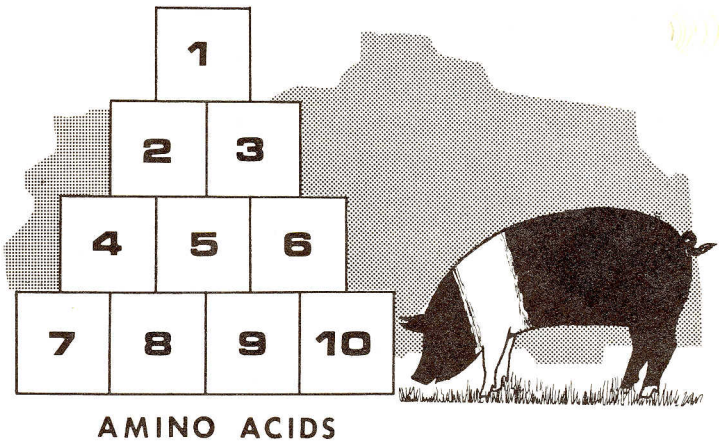


1. Species Differ in Nutrient Requirements

This principle simply says that different kinds of animals need different nutrients.

The digestive tracts of hogs and cattle are different. Their nutrient requirements are also different. You know that the bacteria in the rumen of cattle can manufacture amino acids--the nitrogen building blocks of protein. For this reason, there are no essential amino acid requirements for cattle. Cattle 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 different animals need different nutrients. Take vitamins, for instance. Hogs need at least six of the B vitamins. Cattle do not need any. Bacteria in the rumen can manufacture B vitamins.

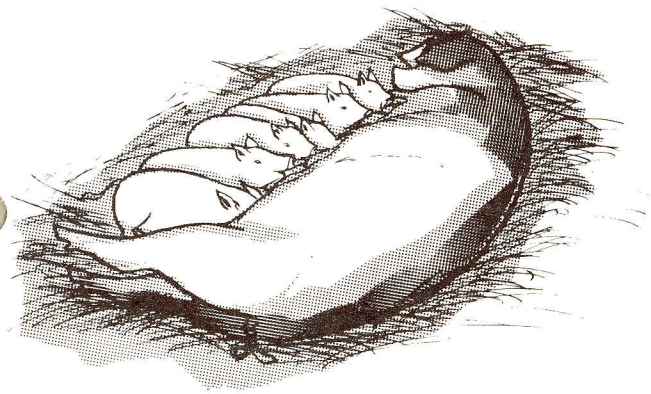
That's how vitamin B12 was discovered. Before its discovery, scientists had guessed it existed. It was often called the "cow manure factor."

Why so? 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 B12.

Later it was discovered that B12 is a by-product when antibotics 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 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 which will help it grow. A grown animal, however, simply needs nutrients to maintain its body. We can see this in the protein content of pig rations. A pig pre-starter contains 18 to 20 percent protein; a starter contains 16 percent; the grower, 14; and the finisher, 10 to 12 percent. Scientists have found these to be the right amounts of protein according to the pig's life cycle.

In cattle, nutrient requirements 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. 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. The nutrient requirements differ according to the desired objective.

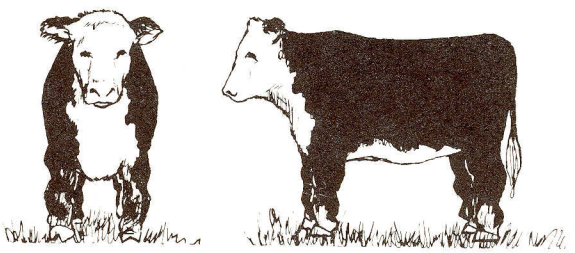
3. Nutrients are Required in Amounts Which Will Promote Maximum Growth or Production and Prevent Nutritional Deficiencies.

We want the best possible production from our animals. We 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 lower 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--they are all needed. And they are needed in the right amounts and in the right proportions.

If an animal does not get enough of a needed nutrient, there is a general deficiency. The result will be 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 his diet. Such deficiencies usually happen by mistake.

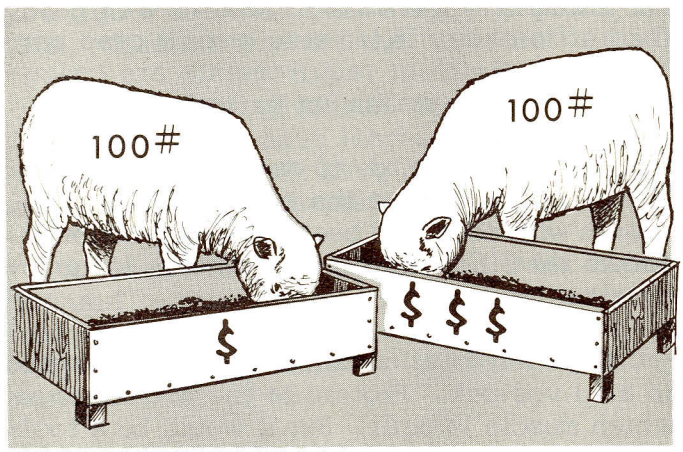


RICKETS
Result of Vitamin D deficient ration

So these are the 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 different 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 sometimes 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 Requirements 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."

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 for each major nutrient of an animal 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, etc.)

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 the daily ration to be made up by each nutrient.

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 ration. When you know the percent of each nutrient, you know the formula for the ration.

Column Headings

In all 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 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, not add to it.

3. Milk Production--The nutrients needed for milk production increase with higher fat content and with level of production.

4. 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.

5. Nutrients--Finally, the tables indicate the amounts of nutrients needed by the animals.

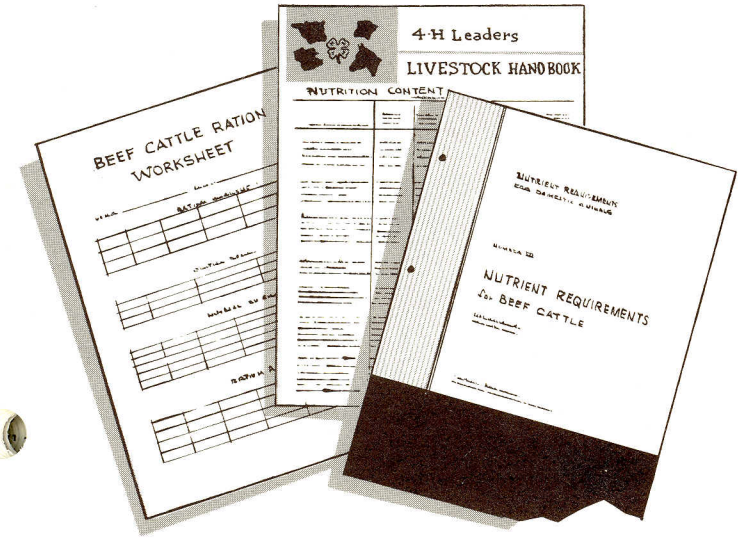
For cattle and sheep, the nutrients given include: total protein; digestible protein; total digestible nutrients (TDN) calcium (Ca); phosphorus (P) carotene; and vitamin A.

The tables for swine include: percent protein, calcium and phosphorus; units of vitamins A and D; micrograms of vitamins B12; and milligrams of riboflavin, pantothenic acid, niacin and choline.

LESSON 6 Using Nutrient Requirement Tables

We can use Nutrient Requirement Tables in at least two ways: (1) to check the ration presently being fed to see if it is 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 doing the multiplying, adding and dividing necessary.



You will note that some nutrients are required in very small amounts. This impresses us with the fact 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.

In this lesson you can become a junior nutritionist (a scientist, if you please.)

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.

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 silage 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 silage containing 70% moisture is 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 (85-90 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 the amounts of the required nutrients. (Use Table No. 1 for beef, 2 for swine, 3 for dairy, and 4 for sheep.

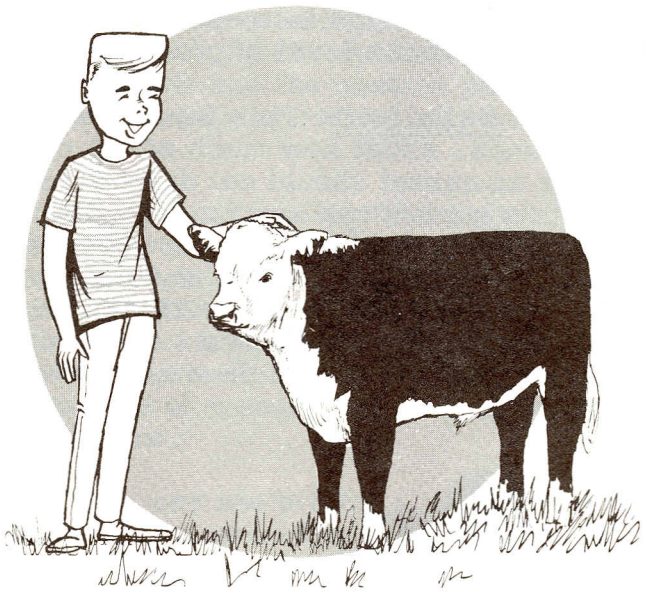
3. List the home-grown, common or natural feedstuffs being fed. Copy the average composition or analysis for all the nutrients opposite each. (Use Table 5 and the worksheet for beef, swine, dairy or sheep).

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. If the requirement is more than that contained in the ration, the ration was



deficient--that is, lacking adequate levels of that nutrient for best growth or performance. The next step would be to find a feed ingredient that was a good source of the deficient nutrient and add enough that the deficiency was erased. In doing this we would have to recalculate the ration to be sure we hadn't put other nutrients out of balance.

The values arrived at 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.

WORKSHEET FOR LESSON 1 INTRODUCING ANIMAL NUTRITION

Section I

1. Which animal, the pig or calf, has a digestive tract more nearly like yours?

2. On which side, the right or left, would you stick a bloated calf? Why?

3. What is the difference between a ruminant and a nonruminant?

4. Do cattle have four stomachs or four compartments of one stomach?

5. The digestive tracts of cattle and pigs are similar from the true stomach on through the tract. (True or False)

6. "Nutrition" and "feeding" mean the same thing. (True or False)

7. There is no particular reason that cattle can utilize more fibrous feed than hogs. (True or False)

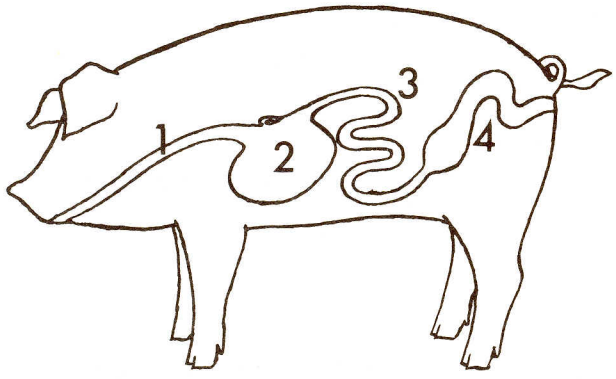
8. The small intestine has (more, fewer) important functions to perform than the large intestine.

9. The digestive systems of horses and rabbits are alike in what respect?

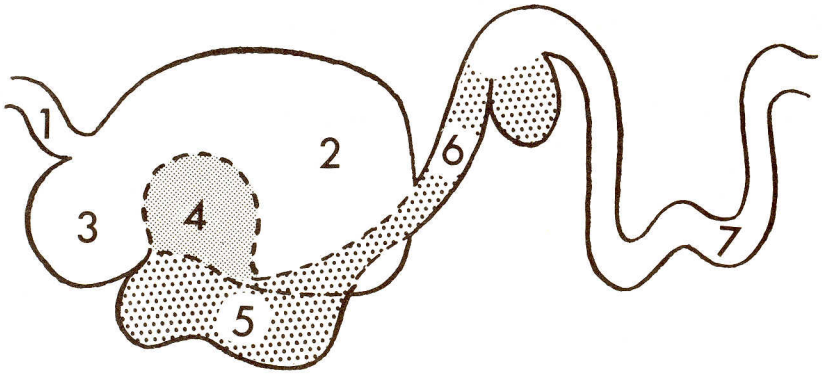
10. Hogs have a more complex digestive tract than cattle. (True or False) Explain.

Section II

Identify the various parts of the digestive tract of a simple stomach animal and a runimant by completing the blanks below.



1. _____
2. _____
3. _____
4. _____



1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

WORKSHEET FOR LESSON 2 PATHWAYS OF FEED

Section I

1. The pig gets hardward disease. (True or False)

2. Feed stays in the digestive tract longer in (cattle or hogs).

3. All feed is rechewed by cattle. (True or False)

4. Cattle chew the cud more on high grain-low roughage rations than on low grain-high roughage. (True or False)

5. Is feed ground for the same reasons for pigs and cattle? (Yes or No)

6. The steer on a fattening ration has a better appetite than one on an all-silage ration. (True or False)

7. What happens when a cow "loses her cud?"

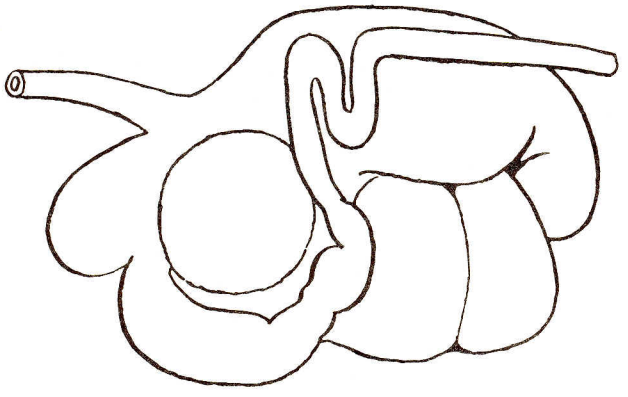
8. Does the pig or cow have the more muscular digestive tract?

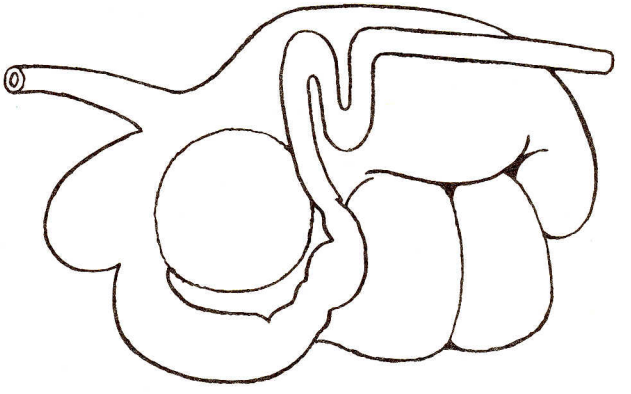
9. Some coarse hay might still be in the digestive tract of a cow as long as (12 hours, 1, 3, 5 days) after it is eaten.

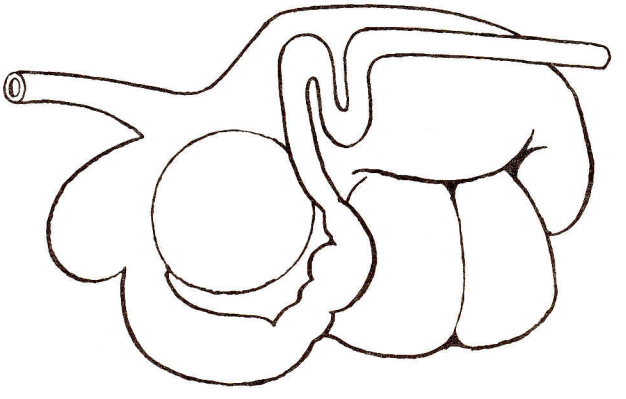
10. Cows and pigs both vomit. (True or False)

Section II

Draw arrows showing the three possible routes of feed in ruminants.







WORKSHEET FOR LESSON 3 FEED NUTRIENTS

Section I

1. Water (is, is not) a nutrient.

2. Antibiotics (are, are not) nutrients.

3. Stilbestrol (is, is not) a nutrient.

4. Supplements must always be fed to all animals. (True or False)

5. The same supplement will be o.k. to feed pigs, cattle and chickens. (True or False)

6. None of the nutrients is more important than the others (True or False).

7. The more water a feed has in it the (greater or less) the feed value as measured by T.D.N.

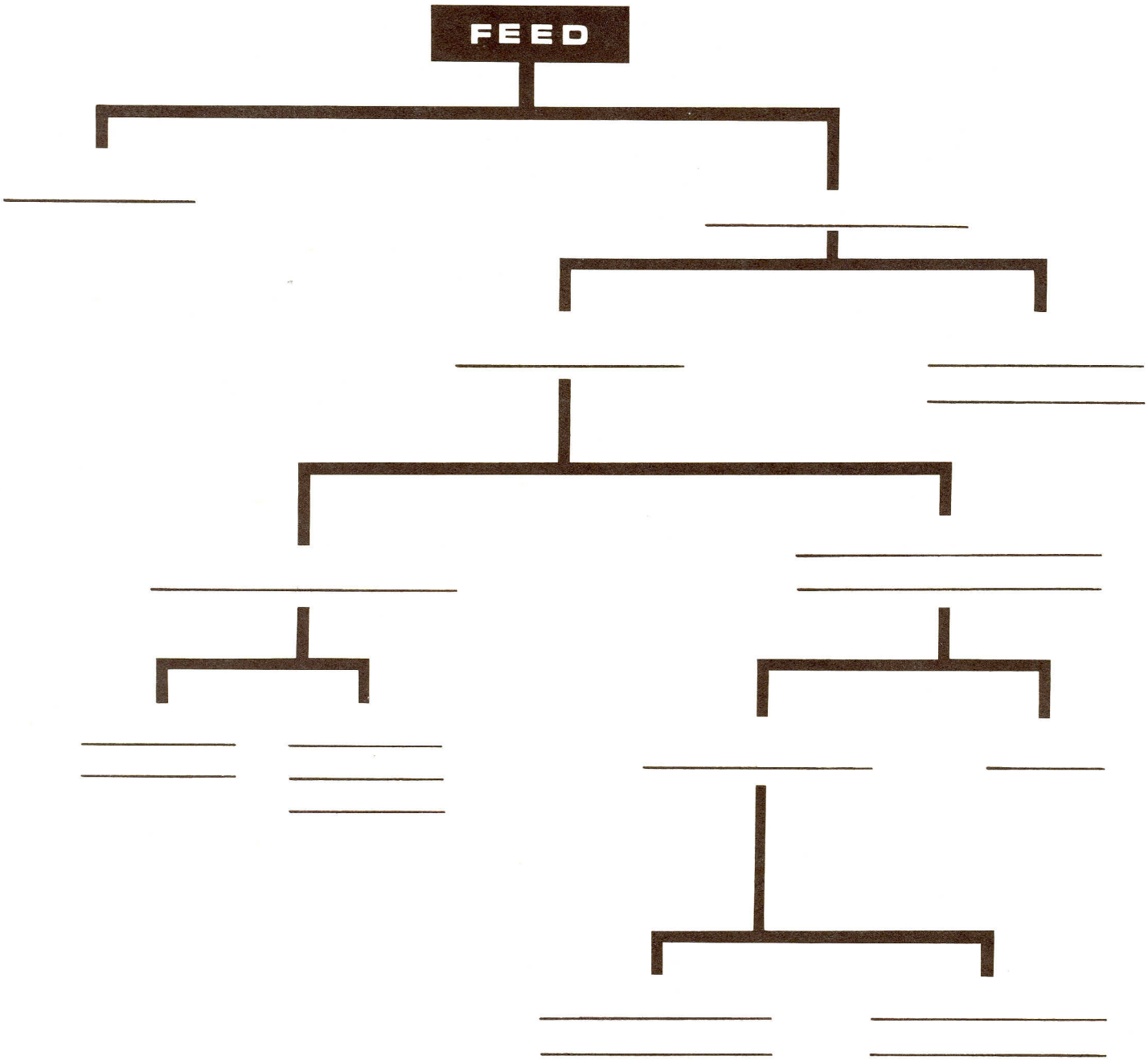
8. An animal that appears healthy but loses weight is probably lacking what class of nutrients?

9. A 5-week-old pig has plenty of corn and water in front of him. What nutrient(s) will likely be lacking?

10. What effect will this have on the pig?

Section II

Complete the following chart by inserting the missing components.



WORKSHEET FOR LESSON 4

DIGESTION, ABSORPTION, METABOLISM

Section I

1. Cattle and swine both produce saliva. Enzyme digestion in (hogs, cattle) starts in the mouth.

2. Bacterial digestion is important in carbohydrate digestion in swine. (True or False)

3. Enzyme digestion is important in carbohydrate digestion in cattle. (True or False)

4. Urea (can, cannot) be fed to hogs.

5. Digestion is similar in pigs and man. (True or False)

6. Cattle must be fed supplements containing the essential amino acids. (True or False)

7. A pig could carry on digestion and absorption of the major nutrients without a stomach. (True or False)

8. A steer has to have fat in the ration to fatten. (True or False)

9. Diseases of the small intestine cause feed to be excreted too rapidly, excreted too slowly, digested poorly, absorbed poorly. (Underline correct answer(s)

10. The liver plays a bigger part in digestion than it does in metabolism (True or False)

WORKSHEET FOR LESSON 5 LEARNING ABOUT NUTRIENT REQUIREMENTS

Section I

1. As pigs increase in weight, the percent protein in the ration should (stay the same, decrease, increase).

2. Vitamin B_{12} is included in all beef supplements. (True or False)

3. A table entitled "nutrient allowances" provides a higher level of nutrients than a table titled "requirements." (True or False)

4. Brood sows would farrow large litters of healthy pigs if fed corn and water. (True or False)

5. Your dairy calf would grow satisfactorily on haylage. (True or False)

6. A livestock feeder can change a feeding program to lower costs if what condition is met?

7. If a calf is fed more protein than he needs, what happens to the excess protein when it is digested?

8. The nutrient requirement tables are not likely to change now for 25 years. (True or False)

9. N.R.C. stands for National Riding Club. (True or False)

10. What is meant by an essential amino acid?

Section II

Complete this section by matching the correct terms and definitions.

1. Crude protein _____
2. Digestible protein _____
3. Ether extract _____
4. Fiber _____
5. Nitrogen-free Extract (NFE) _____
6. Essential Amino Acids _____

A. A term applied to the material that can be dissolved out of a sample of feed heated in ether.

B. Cannot be made in the body from other substances or which cannot be made in sufficient quantity to supply the animal's needs.

C. A measure of all the nitrogen containing compounds in a feed.

D. The hard-to-digest carbohydrate of a feed.

E. Indicates the more easily digested carbohydrate.

F. Tells approximately the amount of true protein in a feed.

WORKSHEET FOR LESSON 6 USING NUTRIENT REQUIREMENT TABLES

1. Where would you go to get information on nutrient requirements?

2. Why bother about figuring nutrient content of rations.

3. What would you need to know about the ration in order to calculate its nutrient content?

4. What is a good reference on nutrient content of feeds?

5. Would you change the ration being fed if the calculated nutrient content was greatly in excess in some one nutrient? If it were deficient in a nutrient?

6. Can you convert pounds to grams and grams to milligrams?

7. If a major nutrient requirement such as protein is being met by feeding a particular ration, can you assume that the rest of the nutrient requirements are being met, too?

8. In the requirement tables, carbohydrates and fats do not appear. Why? Aren't there requirements for these?

9. Do you know what group of nutrients are required by swine and appear in the swine table but not in the beef table? Why?

EXERCISE IN BALANCING BEEF CATTLE RATIONS

Animal_____ Weight_____ Daily Gain_____

Section 1 — Composition of Homegrown Feeds

FEED	Dry matter	Total protein %	T. D. N. %	Calcium %	Phosphorus %	Vit. A equivalent I. U.

Section 2 — Daily Nutrient Requirements of Animal

(Based on air-dry feed containing 90% dry matter)

Daily feed	Lbs. fed	Protein (total) lbs.	T. D. N. lbs.	Calcium gm.	Phosphorus gm.	Vitamin A I. U.

Section 3 — Amount of Nutrients in Feeds Used

FEED	Lbs. fed (air-dry basis)	Protein (total) lbs.	T. D. N. lbs.	Calcium gm.	Phosphorus gm.	Vitamin A I. U.
TOTAL						

Section 4 — Balancing the Ration and Meeting the Requirements

Total from Section 2						
Ration deficiency						
Supplement						
Balanced ration						

TABLE I

DAILY NUTRIENT REQUIREMENTS OF BEEF CATTLE
(Based upon air-dry feed containing 90 percent dry matter)

Body weight	Av. daily gain[1]	Daily feed per animal	Total protein	TDN	Ca.	P	Vitamin A
		Daily nutrients per animal					
lb	lb	lb	lb	lb	gm	gm	IU
FATTENING CALVES FINISHED AS SHORT YEARLINGS							
400	2.3	11.8	1.3	7.8	20	15	8850
600	2.4	16.4	1.8	10.9	20	17	12300
800	2.2	19.4	1.9	12.9	20	18	14600
1000	2.2	23.0	2.3	15.3	21	21	17300
NORMAL GROWTH HEIFERS AND STEERS							
400	1.6	12.2	1.4	6.4	16	11	9200
600	1.4	16.4	1.5	8.2	16	12	12300
800	1.2	19.1	1.6	9.6	16	13	14300
1000	1.0	21.1	1.6	10.6	14	14	15800
WINTERING WEANLING CALVES							
400	1.0	10.5	1.1	5.3	13	10	7900
500	1.0	12.6	1.3	6.3	13	10	9500
600	1.0	14.3	1.3	7.2	13	10	10700
WINTERING PREGNANT HEIFERS							
700	1.5	20.0	1.5	10.0	15	14	20000
900	0.8	18.0	1.4	9.0	13	12	18000
1000	0.5	18.0	1.4	9.0	13	12	18000
WINTERING MATURE PREGNANT COWS							
800	1.5	22.0	1.7	11.0	16	15	22000
1000	0.4	18.0	1.4	9.0	13	12	18000
1200	0.0	18.0	1.4	9.0	13	12	18000
1200	-0.5	17.6	1.3	7.5	13	12	17600

[1]Average daily gain for finishing cattle is based upon cattle receiving stilbestrol. Finishing cattle not receiving stilbestrol gain from 10 to 20% slower than the indicated values.

EXERCISE IN BALANCING SWINE RATIONS

Purpose of Ration (Starter, Grower, Finishing, etc.)_____

Weight of Animal_____

Section 1 — Composition of Homegrown Feeds

FEED	Protein %	Calcium %	Phosphorus %	Vit. A equivalent I. U.	Vit. D I. U.	Fiber %

Section 2 — Nutrient Allowances of Animal

Protein %	Calcium %	Phosphorus %	Zinc (grams)	Iron (grams)	Vitamin A I. U./lb.	Vitamin D I. U./lb.

Section 3 — Amount of Nutrients in Feeds Used

FEED	Protein %	Calcium %	Phosphorus %	Vit. A equivalent I. U.	Vit. D I. U.	Fiber %
TOTAL						

Section 4 — Balancing the Ration and Meeting the Requirements

*						
Ration deficiency						
Addition						
Balanced ration						

* Enter amount required from Section 2 or multiply percent needed by amount of feed being prepared.

TABLE II RECOMMENDED NUTRIENT ALLOWANCES FOR SWINE

	PERCENT OF RATION				AMOUNT PER POUND OF RATION						
	Weight of pig, lbs.	Protein %	Calcium %	Phosphorus %	Vit.A* units/lb.	Vit. D2 units/lb.	Vit.B_{12} mcg./lb.	Riboflavin	Pantothenic acid mg./lb.	Niacin mg./lb.	Choline mg./lb.
BOARS & GILTS											
Developer	200 and up	14	0.70	0.60	2000	300	10	2.0	6	15	400
SOWS											
Pregestation & gestation	-- --	14	0.70	0.55	2500	300	10	2.5	8	15	400
Lactation	-- --	16	0.90	0.70	5000	400	10	2.5	10	20	400
YOUNG PIGS											
Prestarter	up to 12	24	0.70	0.60	2500	450	20	5.0	10	30	500
Starter	12 to 25	18-20	0.70	0.60	2000	400	20	5.0	10	30	450
Grower	25 to 50	16	0.65	0.55	2000	350	10	2.5	6	20	400
OLDER PIGS											
Developer	50 to 125	14	0.60	0.50	1000	250	5	2.0	5	15	300
Finisher	125 to 200	12	0.60	0.50	1000	250	5	2.0	5	15	300

EXERCISE IN BALANCING DAIRY CATTLE RATIONS

Animal_____ Body weight_____

Production: Milk_____ Butterfat test_____

Step 1 **Daily Nutrient Requirement of Animal**

(Based on air-dry feed containing 90% dry matter)

USE	Pounds fed	Protein (Total) lbs.	TDN lbs.	Calcium gm.	Phosphorus gm.	Vitamin A 1000 I. U.
Growth						
Maintenance						
Reproduction						
Production						

Step 2 **Nutrients Provided by Forages**

FEED	Pounds fed	Protein (Total) lbs.	TDN lbs.	Calcium gm.	Phosphorus gm.	Vitamin A 1000 I. U.
Hay						
Silage						
Other						

Step 3 **Nutrients Provided by Grain Mixture**

	Pounds fed	Protein (Total) lbs.	TDN lbs.	Calcium gm.	Phosphorus gm.	Vitamin A 1000 I. U.
Total from Step 1						
Total from Step 2						
Difference— To be provided by grain mix						
Actually provided by grain mix						

TABLE III. DAILY NUTRIENT REQUIREMENTS OF DAIRY CATTLE

(Based on air-dry feed containing 90 percent dry matter)

Normal Growth of Dairy Heifers

Body Weight Lb.	Daily Gain Lb.	Feed Lb.	Total Protein Lb.	Dig. Protein Lb.	TDN Lb.	ENE Therms	Ca. GM.	Phos. GM.	Caro-tene MGM.	Vit. A 1000 I.U.
50	.7	.9	.3	.2	1.1	1.2	2.0	1.5	2.5	1.0
75	.9	1.5	.4	.3	1.7	1.7	2.8	2.1	3.7	1.5
100	1.0	2.2	.6	.4	2.2	2.0	4.0	3.0	5.3	2.1
150	1.3	4.3	.8	.5	3.3	2.8	8.0	6.0	7.8	3.2
200	1.5	6.1	.9	.6	4.2	3.9	9.0	8.0	10.0	4.0
400	1.5	11.0	1.2	.8	6.9	6.0	13.0	12.0	21.0	8.0
600	1.3	15.0	1.5	.9	9.0	7.2	15.0	14.0	31.0	12.0
800	1.2	19.0	1.5	.9	10.1	8.1	16.0	15.0	42.0	17.0
1000	1.2	22.0	1.7	1.0	11.0	9.1	16.0	15.0	50.0	21.0
1200	1.2	22.0	1.7	1.0	11.5	9.5	16.0	15.0	60.0	25.0
Maintenance of Mature Cows										
800	---	12.0	.9	.6	6.2	5.2	10.0	10.0	37.0	15.0
900	---	13.0	1.0	.7	6.8	5.8	11.0	11.0	45.0	17.0
1000	---	14.0	1.1	.7	7.1	6.3	12.0	12.0	48.0	19.0
1200	---	17.0	1.2	.8	8.4	7.4	15.0	15.0	58.0	23.0
1400	---	19.0	1.3	.8	9.2	8.5	17.0	17.0	69.0	27.0
1600	---	21.0	1.5	.9	10.2	9.6	20.0	20.0	80.0	32.0
1800	---	23.0	1.6	1.0	10.8	10.6	23.0	23.0	87.0	35.0
Reproduction (Add to Maintenance last 2 to 3 Months of Gestation)										
900	---	9.0	.9	.6	5.5	4.7	10.0	8.0	22.0	9.0
1200	---	11.0	1.0	.6	6.6	5.1	13.0	11.0	30.0	12.0
1600	---	14.0	1.2	.8	8.0	6.0	16.0	14.0	38.0	15.0

DAILY NUTRIENTS REQUIRED PER POUND OF MILK

Fat Content of Milk %	Total Protein Lbs.	Digestible Protein Lbs.	TDN Lbs.	ENE Therms	Ca. GM.	Phos. GM.
For cows producing more than 77 pounds of milk daily						
3.0	.08	.05	.36	.36	1.3	.9
3.5	.08	.05	.39	.38		
4.0	.09	.05	.42	.40		
4.5	.09	.06	.45	.42		
5.0	.10	.06	.50	.44		
5.5	.10	.07	.50	.46		
For cows producing 44 to 77 pounds of milk daily						
3.0	.07	.05	.32	.34	1.1	.8
3.5	.07	.05	.34	.36		
4.0	.08	.05	.37	.38		
4.5	.08	.05	.39	.40		
5.0	.09	.05	.42	.42		
5.5	.09	.06	.44	.44		
For cows producing less than 44 pounds of milk daily						
3.0	.06	.04	.28	.28	1.0	.7
3.5	.07	.04	.30	.30		
4.0	.07	.05	.33	.32		
4.5	.07	.05	.35	.34		
5.0	.08	.05	.38	.36		
5.5	.08	.05	.40	.38		

EXERCISE IN BALANCING SHEEP RATIONS

Animal_____ Weight_____ Daily Gain_____

Section 1 — Composition of Homegrown Feeds

FEED	Dry matter	Total protein %	T. D. N. %	Calcium %	Phosphorus %	Vit. A equivalent I. U.

Section 2 — Daily Nutrient Requirements of Animal

(Based on air-dry feed containing 90% dry matter)

Daily feed	Lbs. fed	Protein (total) lbs.	T. D. N. lbs.	Calcium gm.	Phosphorus gm.	Vitamin A I. U.

Section 3 — Amount of Nutrients in Feeds Used

FEED	Lbs. fed (air-dry basis)	Protein (total) lbs.	T. D. N. lbs.	Calcium gm.	Phosphorus gm.	Vitamin A I. U.
TOTAL						

Section 4 — Balancing the Ration and Meeting the Requirements

Total from Section 2						
Ration deficiency						
Supplement						
Balanced ration						

TABLE IV

DAILY NUTRIENT REQUIREMENT OF SHEEP
(Based on air-dry feed containing 90 per cent dry matter)

Body weight lb	Gain or loss lb	Feed: Per animal lb	Daily nutrients per animal: Protein lb	TDN lb	Ca. gm	P. gm	Vit. A I. U.
EWES-Non-lactating and First 15 weeks of gestation							
100	0.07	2.6	0.20	1.3	3.2	2.5	965
120	0.07	3.0	0.23	1.5	3.3	2.6	1,156
140	0.07	3.4	0.27	1.7	3.4	2.7	1,350
160	0.07	3.8	0.29	1.9	3.5	2.8	1,542
EWES-Last 6 weeks of gestation							
100	0.37	3.8	0.31	2.0	4.2	3.1	2,316
120	0.37	4.2	0.32	2.2	4.4	3.3	2.775
140	0.37	4.6	0.36	2.4	4.6	3.5	3,240
160	0.37	4.8	0.36	2.5	4.8	3.7	3,702
EWES-First 8-10 weeks of lactation							
100	-0.08	4.6	0.40	2.7	6.2	4.6	2,316
120	-0.08	5.0	0.42	2.9	6.5	4.8	2,775
140	-0.08	5.4	0.45	3.1	6.8	5.0	3,240
160	-0.08	5.6	0.47	3.2	7.1	5.2	3,702
EWES-Last 12-14 weeks of lactation							
100	0.07	3.8	0.31	2.0	4.6	3.4	2,316
120	0.07	4.2	0.32	2.2	4.8	3.6	2,775
140	0.07	4.6	0.34	2.4	5.0	3.8	3,240
160	0.07	4.8	0.36	2.5	5.2	4.0	3,702
EWES-Replacement lambs and yearlings							
60	0.30	2.7	0.29	1.6	2.9	2.6	696
80	0.20	3.2	0.27	1.7	3.0	2.7	926
100	0.14	3.4	0.25	1.7	3.1	2.8	1,158
120	0.07	3.4	0.25	1.7	3.2	2.9	1,388
RAMS-Lambs and yearlings							
80	0.40	3.2	0.31	2.0	3.0	2.7	926
100	0.30	3.7	0.31	2.1	3.1	2.8	1,158
120	0.20	4.2	0.31	2.2	3.2	2.9	1,388
140	0.10	4.6	0.32	2.3	3.3	3.0	1,620
160	0.10	4.8	0.32	2.4	3.4	3.1	1,851
LAMBS-Fattening							
60	0.30	2.7	0.31	1.6	2.9	2.6	580
70	0.40	3.1	0.33	1.9	2.9	2.6	674
80	0.40	3.4	0.35	2.1	3.0	2.7	771
90	0.40	3.8	0.36	2.4	3.0	2.7	868
100	0.35	4.0	0.36	2.6	3.1	2.8	965

Table V.

Average Nutrient Content of Feedstuffs[1]

	Total dry matter %	Protein %	Dig. protein	Total dig. nutrients %	Calcium %	Phosphorus	Carotene mg/lb.	Vit. A IU/lb.	Vit. D IU/lb.	Riboflavin mg/lb.	Pantothenic A. mg/lb.	Niacin mg/lb.	Choline mg/lb	Vit. B12 mcg/lb.
DRY ROUGHAGES														
Alfalfa hay, leafy	90.5	16.0	11.7	51.2	1.31	0.24	20.3	33,000	905	7.7	9.0	18.0	-	-
Alfalfa hay, stemmy	90.5	12.3	8.2	46.3	1.07	0.19	3.3	5,000	-	-	-	-	-	-
Alfalfa-brome hay	89.2	11.8	7.6	47.9	0.77	0.20	6.7	11,000	-	2.9	10.2	11.7	-	-
Corn cobs	90.4	2.3	-	45.7	0.11	0.04	-	-	-	-	-	-	-	-
SILAGES														
Corn, dent, well matured & eared	28.5	2.3	1.3	19.8	0.09	0.07	5.8	9,000	54	-	-	5.7	-	-
Alfalfa, wilted	36.2	6.3	4.3	21.5	0.51	0.12	11.4	19,000	131	-	-	-	-	-
Alfalfa-brome, not wilt	25.0	3.8	2.6	17.0	0.37	0.05	-	34,500	-	-	-	5.7	-	-
CONCENTRATES														
Corn, dent, No. 2	85.0	8.7	6.7	80.1	0.02	0.28	1.3	2,167	-	0.5	2.4	9.8	200	-
Ground ear corn	86.1	7.4	5.4	73.2	0.04	0.22	1.0	1,733	-	0.4	2.0	7.2	160	-
Oats	90.2	12.0	9.4	70.1	0.09	0.33	0.05	83	-	0.5	6.0	6.3	435	-
Barley	89.4	12.7	10.0	77.7	0.06	0.40	0.2	333	-	0.6	3.0	27.2	450	-
Cottonseed meal (45%)	94.3	45.6	37.4	75.1	0.23	1.12	0.1	167	-	2.7	5.5	16.3	1,301	-
Linseed meal (36%)	92.4	36.6	31.5	75.6	0.40	0.86	-	-	-	1.3	-	13.7	557	-
Soybean meal (50%)	91.7	50.4	46.4	79.4	-	-	0.1	167	-	1.4	-	9.8	1,255	-
Feeding limestone	-	-	-	-	38.3	-	-	-	-	-	-	-	-	-
Steamed bonemeal	-	-	-	-	30.0	13.9	-	-	-	-	-	-	-	-

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

[1] Morrison, F. B. Feeds and Feeding. Twenty-second edition. Morrison Publishing Co. Ithaca, N. Y.

OPPORTUNITIES FOR YOU IN ANIMAL SCIENCE

Number and Types of Positions

The farmer is still "making hay while the sun shines" but he's doing it much faster and better, thanks to animal science, defined as "the scientific study of animals and their products, along with the multitude of related businesses and industries."

There are now more than 500 distinct occupations within animal agriculture. You and 499 of your buddies could all graduate at the same time and each could have a different job in animal science.

There are jobs in farming, ranching and production, involving beef cattle, dairy cattle, fur animals, goats, horses, poultry, sheep, swine and what have you.

One of the interesting dimensions of animal science training in recent years on our campus and other campuses is the relatively large number of young people who come to study animal science who have urban or some other non-farm type of background. Our curriculum is developed in such a way so that these young people are prepared to enter the professional world as animal scientists just as effectively as those who come from a rural background.

College Preparation

In regard to the type of college preparation program that is available within the animal science area, at the present time our program has four options--the production option, the science option, the business option and the education option.

One of the options can be heavily oriented to the range management side to give young men special preparation for work in consultation with the managers of grasslands.

While in high school, take plenty of English, chemistry, physics, biology and mathematics.

Demand for Graduates

Recent data concerning last spring's graduates indicate that the demand and salary range for animal science graduates is above the College of Agriculture average.

Supply of Graduates

Although a large percentage of College of Agriculture undergraduates are enrolling in one of the animal science options, the supply of graduates is still below the demand.

General Salary

Salaries for Animal Science graduates are similar to those in other areas. For example, the graduate with a B.S. degree will average $6,000 a year; M.S. degree holders will start at from $7,500-$9,000, and those who have the Ph.D. Degree will make from $10,000 to $13,000.

Challenge

Here is a field in which you can surely attain social, mental, physical and spiritual growth--as well as financial. And don't fail to consider working for a Ph. D. Degree. You'll find your lifetime earnings will more than likely exceed by $100,000 those of a B.S. Degree holder.