Nutritional Guidelines

LESSON 1

ASSIGNMENT 1: NUTRIENTS AND ENERGY REQUIREMENTS

Read this assignment. Then read pages 291–304 in your textbook, *McCurnin's Clinical Textbook for Veterinary Technicians*.

In veterinary medicine, nutrition is one area that affects every pet that comes into the hospital. When looking at the three components that affect the life of an animal—genetics, environment, and nutrition—nutrition is the one factor that the veterinary healthcare team can impact. Proper nutrition and feeding management is the foundation upon which healing and the maintenance of health rests. Research is demonstrating the benefits of feeding the companion animal the right food for its life stage. Pet owners have access to vast educational resources and are subsequently becoming more educated and bringing detailed questions to the healthcare team. This provides an excellent opportunity for the veterinary technician to properly educate clients. Clients often ask veterinary staff about how to choose the best food for their pets. The veterinary technician should be knowledgeable about the nutritional needs of pets at all life stages. Additionally, certain diseases can and should be managed with nutrition, and the veterinary technician plays an important role in this management. The material in this course is aimed at helping you to understand nutrition so you can make better recommendations to your clients.

Nutrients

A *nutrient* is any substance that supports life or provides nourishment to an organism. Nutrients are grouped into categories that aid in understanding their importance and function. Nutrients are divided into two main categories: *energy-producing nutrients,* or *macrominerals*; and *non-energy-producing nutrients*, sometimes referred to as *microminerals*. Nutrients are involved in all basic functions of the body. They act as structural components, are involved in the chemical reactions of metabolism, and transport substances within the

body or out of the body. Nutrients also help to maintain body temperature and supply energy. Each nutrient has different properties, but energy-producing nutrients have a hydro-carbon structure that helps their usage through digestion, metabolism, and transformation. These energy-producing nutrients are stored in the form of *ATP (adenosine triphosphate)*. At the cellular level, ATP is used for metabolism, cellular growth, homeostasis, and rejuvenation of cells. Energy-producing nutrients are proteins, fats, and carbohydrates. While non-energy-producing nutrients—water, vitamins, and minerals—may not be an energy resource, they're involved in numerous tasks throughout the body. Non-energy-producing nutrients are referred to as the "gatekeepers" of metabolism.

Energy-Producing Nutrients

Proteins

Proteins are made up of building blocks called *amino acids*. There are 22 amino acids, which are categorized into *essential* and *nonessential amino acids*. Essential amino acids are required by the body, whereas nonessential amino acids can be synthesized or integrated from other sources. In certain diseases or injuries, the animal may have a higher requirement of specific amino acids. For example, the American Cocker Spaniel has a higher requirement for taurine once diagnosed with cardiomyopathy.

The body requires all 22 amino acids to synthesize a new protein. Dogs require 10 amino acids to meet their biologic needs, and cats require 11. *Taurine* is the essential amino acid required by cats. Dogs have the ability to make taurine from other amino acids, but cats don't. It must be provided in their diet. Cats also require approximately twice as much protein as dogs. These are two differences between the nutritional needs of cats and those of dogs.

Amino acids are used within the body for a wide variety of activities. Proteins are used as structural components of organs and tissues, are responsible for hormone and enzyme production, and are required for the production of red blood cells and antibodies. Once the pet's nutritional requirements have been satisfied, the excess protein can be used for energy.

Protein isn't readily available as an energy source. It's viewed as an "expensive energy" because of the complex process that must occur to convert a hydrocarbon chain into ATP, water, and carbon dioxide. The nitrogen waste product must be excreted through the liver and kidneys.

Unlike fats and carbohydrates, proteins and amino acids aren't stored in the body. If the animal is unable to consume the required levels of amino acids, breakdown of the proteins in the viscera and skeletal muscle occurs. This happens when an animal faces starvation. Once the animal depletes its energy stores, the skeletal muscle and visceral proteins provide amino acids for energy. The breakdown of protein for energy is called *gluconeogenesis*. The patient's muscle mass will decrease over time if nutritional needs aren't met. This explains why *anorectic* patients (those that lack an appetite) must be supported nutritionally. Cats differ greatly from dogs. Gluconeogenesis is the cat's primary method of deriving energy. The cat must consume as much protein as the dog; the process of deriving energy from protein is much more efficient in the cat. It's important to remember that although cats have much higher protein requirements, pet owners shouldn't feed them foods with extremely high protein levels. Providing foods with proper protein levels is more appropriate than following a philosophy of "if a little is good, more is better."

The quantity and proportion of essential amino acids determine the quality, or biologic value, of the protein source. A protein's *biologic value (BV)* refers to the amount of protein that's absorbed by the body after ingestion and the ability of that protein source to be used by the body. The more closely the protein meets the criteria, the higher the quality. If a protein lacks one essential amino acid, its quality is significantly lower. Biologic value is shown as a percentage; 100% demonstrates an ideal protein, while lower figures represent a lower-quality protein. For example, an egg's BV is 100%, liver's is 79%, and whole corn's is 45%. Ground corn is a good source of protein, but whole kernel corn isn't. When corn is ground, the surface area is dramatically increased; the protein source is more available and has a BV of 85%. When a plant protein and a meat protein are combined, the new protein will provide a greater spectrum of amino acids. For example, combining

ground corn and liver has a BV of approximately 92%. In most cases, more than one protein source is used in manufacturing both canned and dry pet foods.

Animals attain protein and amino acids from numerous types of food. Dietary protein is digested in the stomach and intestines to amino acids and peptides. It's then absorbed from the intestines into the bloodstream.

Some dietary protein and amino acids, rather than being absorbed in the intestine, are excreted in feces. This is where the concept of digestibility originates. If the majority of the amino acids are absorbed, the protein is said to be highly digestible. Low digestibility means that a larger proportion of dietary protein is excreted. Proteins can be synthesized in the body from amino acids and other compounds, but protein isn't stored. Every day, protein is lost from the body through *catabolism* (breakdown), metabolic processes, and skin and hair loss, as well as in waste products. Animals therefore need to consume dietary protein regularly to make up for normal losses.

Fats

Lipids, also known as fats, are simple to complex molecules with many functions. These functions include providing and storing energy, making up cell membrane structure, acting as signaling agents and hormones, and forming other important compounds such as cholesterol. Fat also aids in the absorption and usage of fat-soluble vitamins (A, D, E, and K). Fat has two times the energy of protein or carbohydrates. For example, 1 gram of fat has 8.5 kilocalories (kcals) of energy, but 1 gram of protein or carbohydrates has only 3.5 kcals of energy. Thus the amount of fat in a diet has a direct effect on the amount of calories in a food. Fat levels also affect a food's acceptability and palatability.

A basic neutral fat contains a chain of glycerol with three fatty acids attached. This is called a *triglyceride*. The majority of fats and fatty acids can be synthesized in the body from building blocks; however, those fats that can't be synthesized must be supplied in the diet. These are called *essential fatty acids;* linoleic acid and alpha-linolenic acid are required for both dogs and cats, and arachidonic acid is required for cats.

Fatty acids and carbon bonds combine to form fatty acid chains. The length of the carbon atom identifies the fatty acids *as short-chain, medium-chain,* or *long-chain*. Short-chain fatty acids have one to eight carbon atoms, and long-chain fatty acids have 12 to 20+ carbon atoms. Saturation of the fat depends on the number of hydrogen atoms present on every carbon atom. This process varies, but the fatty acid may be saturated, unsaturated, or polyunsaturated. *Omega-3* and *omega-6 fatty acids* are formed based on the position of the double carbon bonds to carbon linkages. Omega-6 (N-6) fatty acids include linoleic acid and arachidonic acid. Omega-3 (N-3) fatty acids include alpha-linolenic acid and eicosapentaenoic acid (EPA). Continuous research is being done to better understand the benefits of N-3 and N-6 fatty acids in clinical medicine.

Fatty acids are the building blocks of fat. For felines, all three essential fatty acids (linoleic, alpha-linolenic, and arachidonic) are required to be added to the diet. Dogs, on the other hand, require only linoleic and alpha-linolenic acid, as they're able to make arachidonic acid from linoleic acid. Large animals don't efficiently convert linoleic to arachidonic acid; therefore arachidonic acid should be considered an essential fatty acid in large animals.

Carbohydrates

Sugars, starches, and fibers make up *carbohydrates*. Sugars and starches are used mainly for energy. Sugars include *monosaccharides* like glucose, *disaccharides* like lactose, and more complex sugar molecules. Simple carbohydrates consist of glucose, sucrose (ordinary table sugar), and fructose (sugar found in fruit). Complex carbohydrates are most often starches, *glycogen* (stored in the body), and certain fibers. Manufacturers of pet foods generally use complex carbohydrates. Dietary carbohydrate is digested to glucose as well as other simple molecules. The intestinal tract is where most dietary carbohydrates are absorbed. Blood glucose levels are regulated by insulin and glucagons from the pancreas. Caution must be taken, however, as excess glucose is stored in the liver and muscle tissue as glycogen, which may be converted to fat for long-term storage.

Fiber

Fibers function differently than sugars and starches. Fiber is commonly classified as a complex carbohydrate, but it differs in that it isn't broken down into sugars. Although technically not a nutrient, variable amounts of fiber are found in foods. Fiber is also known to have positive effects on the health of a pet. There are two types of fiber: soluble and insoluble. *Soluble fiber* provides some calories in the food, but the core function is to improve stool quality. *Insoluble fiber* (such as powdered cellulose) doesn't bring any caloric value to the food, but functions to increase the pet's *satiety*, or feeling of fullness, and to moderate gastrointestinal transit time.

Dogs and cats have only one stomach and lack the enzyme to break down fiber. Yet, animals that possess a *rumen* or *cecum* (e.g., cattle and sheep) are able to use fiber for energy. Carbohydrates are the primary energy source in large animals. Carbohydrate energy sources for large animals include fiber from grasses, sugars, molasses, and growing plants, as well as starches from grains.

Fiber can be a very expensive ingredient and has many different uses in small animal nutrition. Healthcare team members need to understand how each fiber type functions. Placing one fiber type in all foods may not provide the desired outcome. For example, beet pulp is a soluble fiber that functions best in improving stool quality. Peanut hulls are an insoluble fiber that function best in increasing bulk and stool volume and diluting calories. Peanut hulls and powdered cellulose are added to foods to aid in the management of the overweight or obese-prone patient. Consequently, soluble fiber won't necessarily meet the needs of the overweight patient, as many soluble fibers don't provide bulk and satiety. They will, however, add calories to the food.

Water

Water is the most important nutrient, and therefore veterinary technicians must remember to discuss this important nutrient with pet owners. Owners need to be educated to provide clean, fresh water at all time for their pets. Approximately 50 to 70% of human or animal body weight is water. Without an

adequate supply of water, other nutrients can't be carried throughout the body via blood or used in chemical reactions. Water is necessary for temperature regulation, and it provides shape and structure to organs. Water aids in the absorption and metabolism of water-soluble vitamins B and C. The water balance also helps to excrete wastes from the kidneys. *Dehydration* is defined as a decrease in the amount of water present in the body. Greater than a 10% loss of fluids could be life-threatening.

Dogs and cats obtain water daily through drinking and from eating food. Typical dry pet foods contain approximately 10% water, and canned foods contain about 75% water. Therefore, animals tend to drink more water when fed dry compared with wet (canned) diets. Veterinary technicians must discuss the importance of water and the provision of fresh clean water with owners of all species of pets. Although daily minimum water requirements vary in dogs and cats, a rule of thumb is that a milliliter (ml) of water per day is equivalent to the same numbers of kilocalories per day. So, 1 ml of water = 1 kcal and 30 ml of water = 30 kcal.

Many animals consume more water than is minimally required, and the excess water is excreted by the kidneys as urine. Factors that affect the water intake in pets include environment, health status, and as discussed, food type. Large animals derive water from breaking down nutrients, by consuming food, or by drinking water.

Vitamins

Although *vitamins* are required in very small amounts in the body, they're critical to the overall well-being of an animal. Vitamins function as co-factors that participate in many biochemical reactions and metabolic processes. Vitamins are necessary in the diet to avoid vitamin deficiencies in pets. Vitamins are organic molecules found in animal and plant tissues. Differences in vitamin requirements among species have been observed. Dogs and cats can synthesize vitamin C, whereas humans and guinea pigs need to obtain vitamin C from their diet. Vitamins have been given both letter and chemical names.

There are two types of vitamins: *water-soluble vitamins* and *fat-soluble vitamins*. Vitamins are placed in either category based on their solubility and whether they may be stored in the body. Vitamins B and C are water-soluble vitamins that include riboflavin, thiamin, niacin, pyridoxine, pantothenic acid, folic acid, cobalamin, vitamin C, choline, and L-carnitine. Water-soluble vitamins are absorbed in the small intestine, and excess amounts are excreted in the urine. If an animal stops eating, it will become deficient in water-soluble vitamins much sooner than fat-soluble vitamins. Veterinary technicians must monitor these patients closely. Fat-soluble vitamins are absorbed in much the same way as water-soluble vitamins, but are stored mainly in the liver. Because fat-soluble vitamins are stored in the body, the potential exists for the pet to accumulate toxic levels.

Minerals

Minerals are essential in the diet as they're involved in metabolic processes. Minerals fall into two categories: *macrominerals* and *microminerals*. Macrominerals are expressed as a percentage of the food, while microminerals are expressed in parts per million. Macrominerals maintain skeletal structure and promote acid/base balance, clotting factors, nerve conduction, muscle contraction, and many cellular activities. Examples of macrominerals include calcium, phosphorus, magnesium, potassium, sodium, and chloride. Either a deficiency or an excess of minerals can prove detrimental to the pet's health. Although rare, deficiencies can occur, especially if the pet is anorexic or has been starved. Deficiencies may also be seen in pets fed a very poor-quality food. A deficiency might occur if the client is feeding an unbalanced homemade food prepared for the pet. It's imperative that healthcare team members and pet owners consult a board certified nutritionist to assist with the proper formulation of home prepared diets, to reduce the risk of mineral deficiencies or excesses.

Many owners will read the term *ash* on a pet food label. Minerals are inorganic elements that make up ash, which is a term that refers to everything left over in a diet following combustion or heating at high temperatures.

Supplements

We've covered the main categories of nutrients. Additionally, several other compounds can be found in foods that may play a role in nutrition. *Antioxidants* are substances that delay or prevent *oxidation* (change) of other compounds or structures such as cell membranes. Although certain vitamins and minerals serve as antioxidants (e.g., vitamin E, selenium), non-nutrients such as flavonoids and polyphenols can be found in certain plants used in pet food or may be added separately. Carotenoids act both as provitamins (partially converted to vitamin A in the body) and as antioxidants. Carotenoids are typically found in colorful vegetables. Choline is a compound that acts like a B-vitamin, although choline is most often synthesized in the liver as opposed to being a dietary requirement. There are some times when choline can be an essential nutrient. Another vitamin-like compound is L-carnitine, which can be found in animal tissue (meat) and synthesized in the body. L-carnitine is often added to pet food for effects on health—especially in weight management.

Many clients take supplements in their own life and subsequently want to give supplements to their pets. If a vitamin/mineral supplement is given to a pet whose diet contains adequate minerals, the owner may create a vitamin or mineral imbalance in that pet. It's important to understand the dangers of supplementing minerals. Over-supplementation of calcium in a growing puppy will have dramatic negative effects on the skeletal system and may result in a number of developmental orthopedic diseases. Feeding high levels of calcium won't allow that puppy to grow taller. Genetics determine the size of the dog. As discussed prior, macrominerals and microminerals affect the absorption of other minerals. Therefore, if a client supplements one mineral, it undoubtedly will affect many others. Malnutrition as a result of nutrient excess is more common than malnutrition from nutrient deficiencies. However, they can both exist.

Microminerals, also called *trace minerals,* include iron, manganese, copper, and selenium. Companion animals can experience trace-mineral deficiencies. The deficiency can occur either by consuming a food too low in microminerals or by consuming a food that has been supplemented with another mineral that might interfere with absorption of the microminerals.

Nutrients versus Ingredients

Nutrients and ingredients often are confused by pet owners and assumed to mean the same. A *nutrient* is the elemental form of an ingredient. Nutrients are food constituents that help to support life. An *ingredient* is a raw material that, when placed into a food, will provide the appropriate nutrient level. It's the vehicle that provides the nutrients. The formula may use certain ingredients that will provide appropriate levels of proteins, carbohydrates, and fats. For example, if chicken is the first ingredient in a canned food, the nutrients in the chicken are protein, fat, and so on. The chicken is the ingredient; the nutrients are what the body derives from the chicken.

Energy

The main reason food is eaten is to obtain energy. Energy isn't a nutrient by itself, but it's needed to fuel all body functions. When chemical bonds in foods are broken down, energy that can be used in various metabolic processes is released. The amount of food an animal eats in a day is regulated by energy needs in a complex system of feedback mechanisms. In simple terms, animals eat when they're hungry and stop eating when they're full. It's rare to observe obesity in stray or feral dogs and cats. However, in household pets, many factors interfere with normal food intake, leading to excess energy and weight gain. Highly palatable (tasty) foods, free-choice feeding, snacks and treats, and less opportunity for exercise are among the reasons that dogs and cats tend to become overweight.

In the United States, the usual measure of energy is the kilocalorie (abbreviated kcal); in other countries, *kilojoule (kJ)* is used. One calorie is defined as the energy needed to increase the temperature of 1 gram (g) of water from 14.5°C to 15.5°C. Because a calorie is too small a unit to be practical, the term *kilocalorie* is used instead (1 kcal = 1,000 calories) in discussions of nutrition and energy. When speaking with pet owners, it's better to use the term *calories* to mean the same thing as kcal.

When the word *calorie* is used to mean kilocalorie, it's capitalized. *Calorie* means kilocalorie or large calorie, and *calorie* means calorie or small calorie. You'll discover that most nutritionists and textbooks use kcal to be scientifically clear and accurate.

The amount of food that's fed to an animal is established on a calculation of the animal's daily energy requirements. The formula demonstrates how many calories an animal should be fed to maintain its weight in a controlled environment, known as the *resting energy requirement (RER).* If the animal faces additional factors like working, lactation, or growth, a further calculation is required. This constitutes the *daily energy requirement (DER).* Once the calculation is complete, the client will understand how many calories he or she must provide. It's important to realize that the calculation is a starting point. Every pet is an individual and should be evaluated individually; some pets may require more calories, and some may require fewer. The healthcare team can educate clients on how to monitor the pet's weight and body condition by incorporating body condition scoring and body weight assessment.

Calculating Energy Requirements

Resting energy requirement (RER) = 70 [Wt (kg)]$^{0.75}$
Daily energy requirement (Kcals/day) = RER × life-stage factor

Canine Life-Stage Factors

Average adult neutered dog	1.6
Senior (geriatric) dog	1.4
Obesity-prone dog	1.4
Weight loss	1.0
Early gestation	1.8
Late gestation	3.0
Lactation	ad-lib feeding
Growth < 4 mos.	3.0
Growth > 4 mos.	2.0
Light work	2.0
Moderate work	3.0
Heavy work	4.0–8.0

Feline Life-Stage Factors

Average adult neutered cat	1.2
Senior (geriatric) cat	1.1
Obesity-prone cat	1.0
Weight loss	0.8
Early gestation	1.6
Late gestation	2.0
Lactation	ad-lib feeding
Growth	2.5

For Example:

Two-year-old neutered male Golden Retriever
(life-stage factor = 1.6—see above)

Pet weighs 82 lbs (37.2 kg); housed indoors
RER = 70 × [Wt (kg)]$^{0.75}$
RER = 70 × [(37.2)]$^{0.75}$
RER= 1054 kcals

Daily energy requirement (kcals/day) = RER × life-stage factor

1054 × 1.6 = 1686 kcals/day

To calculate RER, you must use a scientific calculator. Enter **37.2,** press the exponent (***x*^{y}**) key, enter **.75,** and press the **=** key. Then multiply by **70.**

Self-Check 1

At the end of each section of *Animal Nutrition, Reproduction, Genetics, and Aging,* you'll be asked to pause and check your understanding of what you've just read by completing a "Self-Check" exercise. Answering these questions will help you review what you've studied so far. Please complete *Self-Check 1* now.

1. *True or False?* Water is the most important nutrient.

2. *True or False?* Iron, manganese, and copper are examples of macrominerals.

3. In the United States, the usual measure of energy is the _____.

4. Cats require _____ (more, less) protein than dogs.

5. Antioxidants are substances that _____ oxidation (breakdown) of other compounds or structures, such as cell membranes.

6. Fat-soluble vitamins are stored in the _____.

Check your answers with those on page 131.

ASSIGNMENT 2: NUTRITIONAL CONSIDERATIONS FOR LIVESTOCK, AVIAN, EXOTIC, AND POCKET PETS

Read this assignment. Then, read pages 339–365; 820–823; 828–832; 833 (Nutrition), 835–836 (Nutrition), and 839, in your textbook, *McCurnin's Clinical Textbook for Veterinary Technicians*.

Large Animal Nutrition

It's essential that technicians have a solid foundation of large animal nutritional knowledge, especially those working in a mixed or large animal practice. Clients with the greatest need for your help may be the backyard farm or the small operation. With any species, it's important to obtain a good history from the client in order to make the best recommendation.

As discussed earlier, nutrients are ingested to support life. Livestock producers and horse owners want to obtain the best results from the nutrients their animals consume, and they want this to occur at an economical rate and with an advantageous financial return. Ingested nutrients may be retained by the animal or excreted in the urine and feces. Those nutrients used by the body help sustain a wide array of body functions, such as homeostasis, replenishment and development of tissues, reproduction, and milk, wool, and meat production.

Maintenance nutrient requirements (MNRs) are the levels of nutrients needed to sustain body weight without gain or loss. The MNR is the minimum level of dietary need; usually a vast percentage of published requirements are higher than this standard. As a general rule, one-half or more of consumed and absorbed nutrients are used to fulfill MNRs. Individual variation results in fluctuation from this standard; be sure to evaluate need against all information to achieve the most accurate results.

Feeding standards are available, listing the quantities of nutrients required by different species for specific life stage and productive purposes (e.g., maintenance, growth, finishing,

lactation, work, and production of wool and eggs). The most widely used feeding standards in the United States are those published by the National Research Council (NRC). These standards are established for beef cattle, dairy cattle, sheep, goats, swine, poultry, and horses.

Digestion is the process of breaking down protein, carbohydrate, and fat into absorbable nutrients. It's accomplished by chemical, enzymatic, microbial, and physical methods. It's essential to remember that it's not the alfalfa, hay, corn, or oats that are used by cells, but rather the digested and absorbed nutrients, such as amino acids, simple sugars, fatty acids, minerals, and vitamins that present at the cellular level. The quality, quantity, and cost of nutrients that can be provided by the feedstuff are of primary importance when ingredients are chosen for feeding farm animals.

Rumen digestion facilitated by microbes has the ability to convert most consumed proteins to peptides and amino acids, many of which are further degraded into ammonia, organic acids, and carbon dioxide. Ammonia released on microbial degradation of feed protein will be removed from the rumen by absorption through the rumen wall or used by micro organisms for synthesis of microbial protein. Microbial protein synthesis by the microorganisms results in a fairly constant supply of protein quality to the lower digestive tract. The protein quality from moderate to poor feed will usually be improved by rumen metabolism, whereas the opposite may occur with high-quality protein feed. Rumen microbes also have the ability to convert nonprotein nitrogen sources into microbial protein. Typical nonprotein nitrogen sources include urea, ammonium salts, ammoniated by-products, and free amino acids and are best used astutely because excessive or unbalanced intake can be toxic. Use of animal protein sources derived from ruminant species isn't allowed in ruminant (i.e., cattle and sheep) foods to prevent the possible transmission of *bovine spongiform encephalopathy (BSE).*

Large animals have different nutritional needs depending on the digestive system. *Nonruminants*, such as swine, require specific amino acids. *Ruminants*, such as cows, sheep, and goats, are capable of synthesizing their own amino acids. Ruminants simply require a source of dietary protein that

can be fermented in the rumen. All ruminants must have a high-quality source of fiber to maintain gastrointestinal function. It's still important to focus on the nutrients in the alfalfa hay, corn, or oats that the large animal may consume, not on the raw ingredient itself. It's important to provide a high quality of feed and manage the quantity offered to maintain good body weight and rates of gain. The client may not realize that the cost of feed represents approximately 50% of the total cost of milk production and 75% of the cost of beef production.

Horses are nonruminant herbivores that require low-fiber, high-protein, and carbohydrate foods. Horses should be fed no more than 50% grain and 50% *forages* (hays). Corn and oats are the most common grains to feed horses; however, if pelleted feeds are used, the owner must ensure that adequate roughage is provided. Assessing the quality of hay is an important aspect of large animal nutrition. Visually inspect the hay. Alfalfa hay should be harvested and cut before it overmatures. The hay should have more leaves than stems and should be green. Two-thirds of the energy and three-quarters of the protein are obtained from the leaves. The stems should be small and flexible, indicating that the hay or grass hasn't been allowed to overmature. It's also important to evaluate the hay for mold, which may make the hay unpalatable and possibly dangerous.

Feedstuff Energy

The largest function of feed is to provide energy for body processes. *Total digestible nutrients (TDNs), gross energy (GE), digestible energy (DE), metabolizable energy (ME),* and *net energy (NE)* are all different measures of feed energy value.

TDNs are a general measure of the nutritive value of a feed. Digestibility coefficients are used to compute the content of TDN. The usefulness of TDN as a measure of feed energy is limited in that it doesn't take into account energy losses in urine, combustible gases, and heat. Discrepancies can be large for forage-based feed because of the tendency to over estimate the energy available for productive purposes. TDN is expressed as a percentage of the ration or in units of weight, not as an actual caloric number.

GE is the total energy potentially available in a feed consumed by an animal. Energy values are expressed in kilocalories (kcal) or megacalories (Mcal) per unit of weight. During digestion and absorption, a portion of the GE escapes the body in the form of undigested food residue in the feces. Subtraction of energy lost in the feces from consumed GE reveals energy that was digested and absorbed, or DE. Measurement of DE uses the same elements as TDN and assigns similar energy values to feed. DE values and TDN are used extensively in horse feed. Energy that's digested and absorbed by the body isn't used with 100% effectiveness due to the fact that some of the absorbed energy is lost in the urine and as combustible gases. Accounting for these energy losses leads to a step beyond DE or TDN known as *ME.* Energy values for ME are often used in swine and poultry feed formulation. One further refinement of this energy scheme involves accounting for heat lost from the body during metabolism of nutrients. NE represents the actual portion of energy available to the animal for use in maintaining body tissues or during pregnancy or lactation. NE values are used extensively in the beef, dairy, and sheep industry.

Feedstuffs

The term *feedstuff* refers to a dietary component that provides some essential nutrient or serves some other function. Feedstuffs may be nonnutritive or nutritive and are classified as forages (roughages), concentrates, by-products, mineral and vitamin supplements, and nonnutritive additives.

Forages are high-fiber feedstuffs that provide few energy-producing nutrients. Protein content present in a forage product depends on the type of plant and stage at harvesting. Protein concentration in plants decreases as a plant matures. In general, alfalfa hay has higher protein levels than grass hay. Other forage products include clover, fescue, timothy hay, corn, and straw. Livestock may be allowed to graze on forage or can be fed harvested forage products.

Concentrates are low-fiber feedstuffs that contain high levels of protein and/or energy. Many feed products are used as energy concentrates, including cereal grains, corn, molasses, and potatoes. By-product feeds include sugar beet pulp, blood, and bone meal. Mineral and vitamin supplements may

contain either individual vitamins or minerals or contain combinations of minerals, with or without vitamins. *Nonnutritive feed additives,* such as hormones and medications, are used to enhance performance and improve livestock health or metabolic status. The use of feed medications is regulated by the Food and Drug Administration.

Nutrition of Companion Birds, Reptiles, and Small Mammals

Nutritional requirements of rabbits, rodents, reptiles, and amphibians vary considerably with the species. Clients often ask veterinary team members for feeding recommendations when they acquire an exotic animal as a pet. Proper feeding will avoid many common problems in these species. Commercially available pelleted diets should be the primary source of nutrients for pet rodents and rabbits.

Avian Nutrition

Nutritional problems encountered in companion birds are often the result of inadequate diets and poor feeding practices. Overall, it's established that nutritional disease is common in pet birds. Although nutritional disease historically has been common, the development and general acceptance of pelleted diets for companion avian species have reduced its occurrence in recent years. Many hospitalized avian patients need nutritional support that may differ from their normal diet. Excessive or inadequate energy intake, imbalance of nutritional supplements, and ingestion of toxic substances (e.g., heavy metal) will create additional challenges for the veterinary professional.

Diet-induced diseases frequently occur in psittacine and passerine bird species as a result of diverse nutrient requirements unknown to the owner. Owner education is of the utmost importance when discussing nutrition with a new avian client. In the past, all-seed diets, seed diets supplemented with fruits and vegetables, and other human foods have been recommended as "the diet" for companion avian species. This recommendation is obsolete and has led to nutritionally induced disease presentations and death of pet birds.

Small birds have high metabolic rates and high energy requirements; therefore, a continuous supply of food should always be available. However, most commercially available seed diets are deficient in certain limiting nutrients such as specific amino acids, vitamins, trace minerals, and macrominerals (e.g., calcium and sodium). Seeds aren't the primary or natural diet of most companion avian species. It's very important that owners are aware of the natural diet of the avian species they're caring for, and that they try to mimic these with commercially available products. Natural diets contain a wide variety of insects, fruits, plant material, and seeds—this is vastly different from the belief that birds need only seed in their diet. Seed diets are composed primarily of sunflower seeds, which are high in fat but low in calcium and vitamin A. Subsequently, diets with a large amount of sunflower seeds often lead to obesity and nutritional deficiencies.

The practice of adding fruits and vegetables presents foods composed primarily of water, carbohydrates, and fiber. Many fruits and vegetables are deficient in protein, vitamins, and minerals needed for many avian species. Birds may select food items based on water and sugar content, texture, color, and taste rather than their nutrient content. This leads to imbalanced nutrient intake, which over time can lead to illness or death.

Captive birds develop nutritional deficiencies by habitually selecting specific food items from a diversified diet. It's important to always ask the owner what the bird is eating and what foods the owner is offering. In most cases, what the owner offers and what the pet ingests are two different diets. Because many malnourished birds often overeat certain food items offered to them, it's unclear whether this is a cause or an effect of malnutrition. Unfortunately, this eating behavior leads to the popular misconception that birds are able to preferentially balance their own diets.

Similar to other species we've discussed, birds have requirements of water, proteins and amino acids, carbohydrates, fats, vitamins, and minerals. Although similar in basic nutritional requirements, it's often the subtle difference in nutrients between species that's important for their health. An important requirement for calcium in the avian diet is similar to that for all animals. Proteins required by companion birds are composed of approximately 20 amino acids.

Food appropriately balanced between carbohydrates, protein, fats, vitamins, minerals, and water is essential for all birds. Companion bird husbandry must address good nutrition at several levels: the daily satisfaction and health of the bird, and long-term contributions to growth, maturation, defense against disease, and reproductive health.

The major benefits of commercially prepared foods (e.g., pelleted diets shown in Figure 1) are nutrient balance and convenience. Manufacturers commonly formulate commercial food using sound scientific principles in accordance with established nutrient recommendations. Although adherence to these recommendations and quality of ingredients may vary among manufacturers, an extruded or pelleted diet supplies all nutrients in a single particle. Such formulations help prevent alteration of nutrient balance by uninformed owners who feed imbalanced seeds or human foods, or by birds that consume different quantities of imbalanced foods that are fed separately.

FIGURE 1—Example of Pelleted Diets for Various Species (Photo courtesy of Kara M. Burns)

It's recommended that a commercially pelleted diet be provided for companion avian species. Pelleted diets have vitamins and minerals incorporated into the product. Supplementation with a high-quality seed mixture, vegetables and to a lesser extent, fruits in measured amounts rounds out the diversified diet. First and foremost, owners should be aware of the natural diet of the particular avian species they're keeping. The natural diet should be followed as closely as possible with commercially available products.

Remember to educate clients on the most important nutrient—water. Water makes up more than 50% of a bird's body weight. Birds don't have sweat glands; therefore, water intake plays an important role in thermoregulation (maintenance of a constant internal body temperature independent of the environmental temperature). Even though some food is high in water content, free water may be required for efficient digestion and absorption of other ingested offerings. Some avian species have an enhanced physiologic ability to extract water from their food. As a general rule, birds should always have access to fresh, clean water. Water should be provided in containers that are easily accessible, but not in a location that will allow feces, feathers, or food particles to accumulate. Water bowls should be attached to the walls of enclosures, near or above food bowls.

Reptiles

It's recommended that the healthcare team always consult a comprehensive reference for feeding guidelines in specific species, as species variations are considerable when speaking of reptiles. Again, husbandry plays a huge role in the health and prevention of nutrition-related disorders. Dietary deficiencies aren't commonly seen in snakes, which eat a whole animal diet; however, a variety of dietary deficiencies are commonly seen in lizards, turtles, and crocodilians. One of the most common is metabolic bone disease, which is caused by inappropriately low calcium intake, low vitamin D_3 intake, or excessive phosphorus intake. This disease may be prevented by feeding a suitable diet and by exposing the animal to ultraviolet (UV) light, either naturally or artificially. It's essential that reptiles, especially lizards, have full-spectrum lighting available during normal daylight hours. Animals with metabolic bone disease must be treated very gently because their bones are subject to pathologic fracture. Vitamin A deficiency is commonly seen in turtles and tortoises and usually manifests as an overgrown beak, palpebral edema, and conjunctivitis.

Many captive lizards are omnivores and will eat mealworms, crickets, grasshoppers, and waxworms. Most insects are calcium deficient; so, to improve the nutritional composition, lizards should be fed a nutritionally supplemented diet. Lizards in the wild are primarily carnivores, eating invertebrate or vertebrate prey. In general, captive lizards require vitamin and mineral

supplementation with an emphasis on a variety of food. Juvenile lizards should be fed one to two times a day, with adults requiring feeding two to three times per week. Most lizards are diurnal and require day feedings and time to bask in natural or ultraviolet light.

Herbivorous lizards, such as the green iguana, require a varied diet to ensure adequate nutritional balance. Recommended diets for herbivores include leafy greens (e.g., romaine lettuce, collard greens), mustard greens, and clover. Vegetables, including green beans, okra, carrots, and squash, are also adequate dietary substances. It's important to note that certain vegetables, such as spinach, cabbage, peas, and potatoes, contain substances that bind calcium and other trace minerals, inhibiting their absorption.

Commercial iguana food is available to provide a base diet for these animals. Commercial diets don't require additional supplementation if the captive lizard is fed a diet based primarily on such purchased food. Homemade diets of vegetables and fruit should always be supplemented with appropriate vitamins and minerals. Technicians can advise lizard owners to purchase a quality reptile vitamin, containing vitamin D_3, to be administered one to two times a week if a good diet is provided. Common iguanas also require protein for normal growth and development. Juvenile iguanas in captivity generally need more protein and calcium than do adults. Common protein sources include dark green leafy vegetables such as collards, turnip greens, kale, bok choy, and broccoli with leaves. Iguanas should never be fed a meat-based diet or any commercial food other than iguana food. Don't feed commercial dog or cat food, as this will cause renal disease and death.

Water should be provided in a bowl for bathing and drinking. Note that some lizards (e.g., chameleons) will drink water only if it's in the form of droplets on plant leaves, similar to dew. Therefore, it's important to spray or mist the animal's enclosure several times a day. In addition, most lizards should be sprayed with water or allowed to bathe to prevent skin problems associated with low humidity.

Small Mammals

Ferrets are strict carnivores, with general dietary requirements of roughly 30% protein and 25% fat. High-fiber diets aren't recommended. Several commercially available ferret-specific diets will provide the proper nutrition for these animals. Although not preferred, if ferret diets aren't available, a high-quality cat food may be used.

In rabbits, dietary requirements vary according to age and purpose. A balanced mixture of timothy grass, grass hay, and vegetables is the recommended diet for most pet rabbits, whereas show and production rabbits typically do better on commercially produced pellets. In general, however, rabbits are herbivores with high fiber requirements. Timothy hay (or other grass) in conjunction with a grass-based pellet as a regulated supplement, is the recommended nutritional regimen for rabbits. Sugary treats shouldn't be fed. "Treats" of fresh greens or other vegetable supplements are encouraged only as occasional rewards. Food items recommended as treats include carrots, small pieces of ripe banana, rice cakes, dry wheat bread, and dandelion leaves. Other components of rabbit nutrition include vitamin supplementation. Vitamin A deficiency can result in infertility and other reproductive complications, central nervous system defects, and increased neonatal mortality. Most fresh commercial grass–based pellets contain adequate vitamin A to prevent such deficiencies; adding a supplement to a diet already fortified with vitamin A can cause toxic complications. Technicians should advise rabbit owners to buy fresh commercial grass hay and commercial grass–based pelleted diets and to monitor the rabbit's appetite.

Guinea pigs are notoriously fastidious eaters. They're herbivores with normal coprophagous behavior. Abrupt changes in feed or feeding systems can result in refusal to eat or drink for extended periods. The recommendation for diet is a grass-based commercial guinea pig pellet and ad libitum grass hay. A high-fiber diet will reduce the incidence of hairball formation. As a result of specific nutrient and vitamin requirements, guinea pigs shouldn't be fed rabbit or any other diet designed for another species. Guinea pigs should be provided hard food diets that promote gnawing because malocclusion can prevent eating

and drinking. Guinea pigs require dietary vitamin C supplementation. Guinea pigs lack an enzyme in glucose to the vitamin C pathway, thus requiring a daily dietary ascorbic acid supplement. Commercially prepared guinea pig diets generally contain minimal vitamin C concentrations, as well as depleted concentrations with a shelf life longer than three months. Vitamin C is highly unstable in the feed, especially when exposed to heat. Use of old feed is one of the primary reasons vitamin C deficiencies are seen. Fresh fruit can be used to supplement commercial diets; to prevent gastrointestinal upset, avoid abrupt changes in diet. Diets supplemented with produce high in ascorbic acid, including spinach, kale, parsley, chicory, bell peppers, and oranges, are recommended.

Self-Check 2

1. Digestion is accomplished by both chemical and _____ methods.

2. *True or False?* Digestion is the process of breaking down protein, carbohydrate, and fat into absorbable nutrients.

3. *True or False?* Ruminants are capable of synthesizing their own amino acids by fermenting them in the rumen.

4. _____ are the primary energy source in livestock foods.

5. *True or False?* In ferrets high-fiber diets aren't recommended.

6. *True or False?* Small birds have high metabolic rates and high energy requirements.

Check your answers with those on page 131.