PURINA Institute

Advancing Science for Pet Health

Purina Institute Handbook of

CANINE AND FELINE WELL-PET NUTRITION

A Reference Guide to Nutritional Management of Healthy Dogs and Cats

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INTRODUCTION

Nutrition impacts every aspect of a pet's life. It is a source of all the essential nutrients the body needs for growing, thriving, and protecting against and proactively reducing disease. Nutrition also brings the pet pleasure, positively reinforces the human-animal bond, and helps owners express love to their pets.

As we continue to recognize the integral role that pets play in our lives, it is essential to acknowledge the importance of proper nutrition in ensuring their health and longevity. Pets have transcended their role as mere companions. They have become cherished family members, and responsible pet owners strive to provide them with the best care possible. When it comes to nutrition, it is not easy, especially for a first-time pet parent, to navigate between pet food trends and the multiple channels of information available. It is difficult for pet owners to know which nutritional solutions are the most appropriate and what is right for a particular pet.

In the current labyrinth of information, veterinary health care professionals are the most trusted resource on nutrition for pet owners. Complete and balanced nutrition tailored to the specific needs of pets—considering their life stage, changing metabolic requirements, environmental factors, and living conditions—is fundamental to their growth, development, resistance to infections, overall health, behavior, and happiness. In contrast, incomplete, unbalanced diets, which pet owners sometimes use with the best intentions in mind, can lead to serious health issues. These include food-borne illnesses, skin disorders, digestive problems, and weakened immune function. Therefore, it is very important to reinforce the importance of everyday well-pet nutrition to all pet owners.

In this regard, the Purina Institute, a global professional organization, plays a pivotal role by sharing leading-edge research and evidence-based information from the global scientific community. This empowers the entire veterinary health care team to prioritize nutrition in discussions with pet owners, ultimately enhancing the well-being and longevity of pets.

We believe that science is more powerful when shared. To support this mission, we have collaborated with world-renowned experts in pet health and nutrition to create a comprehensive resource. The new *Purina Institute Handbook of Canine and Feline Well-Pet Nutrition* is designed to assist veterinary professionals in efforts to unlock the power of nutrition, helping pets live better, longer lives.

Thank you for your commitment to improving pet health through nutrition. Together, we can make a significant impact on the well-being of our beloved companions.

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EDITORS' NOTE

In a 2023 survey, 96% of pet owners said they trust their veterinarian for pet nutrition advice. However, the survey showed only 22% of veterinary professionals have proactive conversations about nutrition at most visits.[1] Veterinary teams managing healthy dogs and cats face a unique set of challenges. With so much information—and misinformation—freely available, it was our goal to create a practical and reliable resource on nutrition to help the veterinary health care team, including veterinarians, veterinary technicians or nurses, and students, manage healthy dogs and cats with nutrition and have constructive nutrition conversations with pet owners.

The *Purina Institute Handbook of Canine and Feline Well-Pet Nutrition* was created to help veterinary health care professionals make nutritional recommendations for healthy dogs and cats and confidently answer common pet owner questions about nutrition. Nutrition is a topic that should be addressed at every veterinary visit. From pre-weaning puppies and kittens to senior dogs and cats, nutrition plays an important role in pet health and in proactively supporting each body system before common health issues even start.

Most of the acronyms used are defined in the chapters. Acronyms that are used repeatedly throughout the book may not be defined in all chapters. Key examples are listed below and these, along with other commonly used terms, are defined in further detail in the glossary at the end of the book.

- AAFCO – Association of American Feed Control Officials
- BCS – body condition score
- BW – body weight
- Ca:P – calcium-to-phosphorus ratio
- DHA – docosahexaenoic acid
- EPA – eicosapentaenoic acid
- FEDIAF – Fédération Européenne de l'Industrie des Aliments pour Animaux Familiers or European Pet Food Industry Federation
- MCS – muscle condition score
- MER – maintenance energy requirements
- NRC – National Research Council
- RER – resting energy requirements

The chapters in this book are meant to stand alone, so veterinary health care professionals can reference one or two chapters at a time without needing to consult other chapters. Some of the chapters contain links to other chapters for easy navigation. Additional information on well-pet nutrition and other topics may also be found at CentreSquare (purinainstitute.com/centresquare or via the QR code). Resources on nutritional management of common conditions can be found in the *Purina Institute Handbook of Canine and Feline Clinical Nutrition*, available for free in eight languages at purinainstitute.com/sign-up.

We are very grateful to our authors. A total of 61 contributors representing 22 different countries supported this project. This book was a team effort and was created with the intention of being a valuable and comprehensive resource on well-pet nutrition for veterinary health care professionals worldwide. We hope the information facilitates nutrition conversations and enables veterinary professionals to help dogs and cats live longer, healthier lives.

Best wishes,

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REFERENCE

1. Nutrition Recommendations Study, June 2023, among 210 Pet Owners and 200 Veterinary Professionals in the United States

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MACRONUTRIENTS IN SMALL ANIMAL NUTRITION

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KEY TAKEAWAYS

- Proteins, fats, and carbohydrates form the dynamic trio necessary for providing energy and supporting vital bodily functions, which is critical in fueling growth and establishing the foundation of overall pet health.
- In health, the body primarily relies on carbohydrates and fats for energy, resorting to proteins in times of scarcity, where excessive reliance can lead to health complications.
- Selecting diets that consider individual species needs, life stages, and specific health conditions is crucial for ensuring optimal nutrition.

INTRODUCTION

Macronutrients—protein, fat, and carbohydrates—are consumed in large (macro) quantities by animals to supply energy as adenosine triphosphate (ATP) while serving as the building blocks for bodily structures and functions. These macronutrients interact through metabolic pathways, enabling the body to finely regulate its composition based on dietary intake and energy needs.[1-3] This metabolic flexibility ensures that animals adapt to various dietary conditions and physiological demands. Grasping these core principles empowers veterinary professionals and pet owners to select diets that promote optimal health and longevity.

ENERGY PRIORITIZATION AND METABOLISM (FIGURE 1)

Meeting energy needs is the body's primary concern, first through carbohydrates (glucose) and fats (fatty acids and glycerol), which are metabolized in the mitochondria to produce ATP.[1,3,4] In times of energy deficits, certain amino acids can be converted into glucose or enter the tricarboxylic acid (TCA) cycle to generate ATP, which is crucial during periods when carbohydrates and fats are scarce.[2,5] However, relying on protein for energy can lead to a reduction in muscle tissue (LBM: lean body mass) and protein reserves, resulting in muscle wasting, immune dysfunction, and increased morbidity and mortality.[1,6] Conversely, excessive intake of any macronutrient results in the conversion of surplus energy into fat stores, contributing to obesity in both dogs and cats, as the body does not distinguish between macronutrients in terms of energy source when provided in excess.

ENERGY MEASUREMENT: METABOLIZABLE ENERGY (ME)

Energy from food is expressed as metabolizable energy (ME), which quantifies the energy available to the body after accounting for losses through feces and urine.[1] It is typically measured in kilocalories (kcal or Cal) or joules (J), where 1 kcal equals 4184 J. Specifically, 1 kcal is defined as the energy required to raise the temperature of 1 kilogram of water by 1 degree Celsius. Atwater factors estimate energy content in standard food sources at approximately 4 kcal per gram (kcal/g) for proteins and carbohydrates and 9 kcal/g for fat. For most dry and wet pet foods, which have lower digestibility compared to uncooked foods, modified Atwater factors estimate metabolizable energy at about 3.5 kcal/g for protein and carbohydrates and around 8.5 kcal/g for fat.[1]

PROTEIN: ESSENTIAL FOR BODY FUNCTION AND ENERGY

Protein is undoubtedly the most critical macronutrient in the nutrition of both dogs and cats, serving as the primary source of amino acids and nitrogen for various physiological functions. When energy-rich nutrients, such as fats and carbohydrates, are plentiful, absorbed amino acids contribute to the body's amino acid pool stored in lean body mass (LBM), crucial for synthesizing new proteins required for biological functions. Loss of LBM, often seen in conditions such as starvation, cachexia (loss due to illness), and sarcopenia (loss

due to aging), is linked to increased morbidity and mortality, independent of underlying diseases or age.[1,6]

Vital functions of proteins[1,2]

- **Structural proteins** (e.g., collagen, keratin): Provide structural support to cells and tissues
- **Functional proteins** (e.g., enzymes, transporters): Execute biochemical tasks
- **Storage proteins** (e.g., hemosiderin): Serve as nutrient reservoirs
- **Transport proteins** (e.g., hemoglobin, albumin): Distribute substances throughout the body
- **Defense proteins** (e.g., globulins, fibrinogens): Guard against pathogens
- **Regulatory proteins** (e.g., hormones): Modulate physiological processes

Protein and amino acid requirements

Distinct protein and amino acid requirements span different life stages for dogs and cats, with minimum protein needs or guidelines established by organizations like the NRC, AAFCO, and FEDIAF (**Table 1**).[1,7,8] The NRC also sets a "recommended allowance (RA)" to address the uncertain bioavailability of nutrients. Research suggests that while these requirements may support nitrogen balance, they may inadequately sustain protein turnover and LBM.[9] Therefore, they should not be regarded as optimal levels. Protein needs diverge significantly based on dietary amino acid concentration, ratio, digestibility, and individual pet responses, yielding varied protein values across different pet food brands and products.[10,11]

Growth, reproduction, and tissue development

Protein needs surge during growth, tissue development, and immune system maturation, making higher protein diets especially beneficial for growing, pregnant, and lactating animals, as well as for those recovering from illness.

Additionally, to preserve muscle mass during active weight loss,[12,13] weight management diets typically have a higher protein-to-calorie ratio.

Senior animals

Contrary to common beliefs that restricting protein protects renal function, healthy senior dogs and cats may actually require up to 50% more protein than younger adults to combat sarcopenia.[14,15] Recommended protein intake is approximately 4 grams per kilogram of body weight for senior dogs and roughly 5.2 g/kg for senior cats,[14] indicating a need for a higher amount of protein as they age unless kidney disease necessitates restrictions. High-quality, easily digestible protein is vital in senior diets, as these animals often face challenges related to sarcopenia and reduced ability to synthesize endogenous protein.[14]

COMMUNICATION TIP

Pets have needs for protein, fat, and carbohydrates. Understanding these nutrients empowers veterinary professionals to recommend diets that promote optimal health and longevity.

Cats

As obligate carnivores, cats have significantly higher protein needs than dogs because they maintain a constant state of gluconeogenesis to meet their energy demands.[16] Additionally, cats cannot readily downregulate protein catabolic enzymes, even during starvation, which means their bodies continue to break down muscle protein for fuel. This leads to a rapid depletion of LBM and nitrogen. Consequently, energy deficits pose a greater threat to their health, significantly increasing the risk of muscle wasting and reduced metabolic function.

Essential amino acids for dogs and cats include:[1,7,8,16]

- Arginine
- Histidine
- Isoleucine
- Leucine
- Lysine
- Methionine – spared by cystine
- Phenylalanine – spared by tyrosine
- Threonine
- Tryptophan
- Valine
- + Taurine – only for cats

High-quality protein sources, such as eggs and poultry, provide essential amino acids in optimal amounts and ratios, including limiting amino acids like lysine, tryptophan, and methionine.

Notable amino acids

Arginine

Arginine is a key component of the urea cycle, converting toxic ammonia into urea for urinary excretion. Cats, in particular, exist in a constant catabolic state for protein and cannot synthesize sufficient amounts of arginine, making dietary arginine essential for their survival. Even a single protein-containing meal devoid of arginine can lead to hyperammonemia, potentially resulting in fatality.[16,17]

Glutamine

Like arginine, glutamine plays a crucial role in the urea cycle as a transporter of nitrogen and ammonia. It also serves as an important energy source for cells in the gastrointestinal tract (enterocytes) and the immune system (lymphocytes), making it a "conditionally essential" amino acid during critical illness.

Taurine

Taurine, a β-sulfonic amino acid, is not incorporated into proteins but is crucial for numerous physiological functions, including supporting vision, cardiac health, and reproduction. Taurine deficiency has been linked to diet-related dilated cardiomyopathy (DCM) in both cats and dogs,[18,19] as well as central retinal degeneration in cats. It is an essential amino acid for cats, who lack the enzyme needed to convert cysteine into taurine.[19]

Tryptophan

Tryptophan serves as a precursor to serotonin, the neurotransmitter associated with feelings of well-being and relaxation. It is often added to pet foods for its calming effects.

FAT: A HIGH-ENERGY MACRONUTRIENT

Dietary fats, primarily consisting of triglycerides, act as concentrated energy sources while providing essential polyunsaturated fatty acids (PUFAs).[4,20] These fats aid in the absorption of fat-soluble vitamins and enhance food palatability.[21] Besides energy provision, PUFAs fulfill critical structural roles in cell membranes and serve as precursors for various cell mediators and hormones involved in regulatory and signaling processes.[4,20]

Vital functions of fats[4,20]

- **Structural fats** (e.g., phospholipids, cholesterol): Form cell membranes, providing structural integrity and fluidity
- **Regulatory fats** (e.g., eicosanoids, steroid hormones): Influence physiological processes including inflammation, immune response, blood clotting, metabolism, and reproduction
- **Functional fats** (e.g., provitamins like carotenoids): Serve biological roles
- **Digestive fats** (e.g., bile acids): Facilitate digestion and the absorption of dietary fats

Fat and fatty acid requirements

Fat is the most energy-dense macronutrient, delivering more than twice the energy of proteins or carbohydrates. This characteristic makes it an excellent energy source for animals with high metabolic demands, such as growing pets, pregnant or lactating females (**Table 1**), and athletic animals. However, overconsumption can lead to obesity.

Cats, as obligate carnivores, can tolerate higher levels of fat compared to dogs (**Table 1**). Since there are no standardized guidelines for optimal fat requirements for dogs and cats, these should be tailored to each individual's weight and health status.

Common signs of fat and fatty acid deficiencies include dry skin and hair loss, while excessive intake is associated with obesity, hyperlipidemia, and gastrointestinal issues in fat-intolerant individuals.[4] Additionally, high levels of dietary fat can lead to rancidity, decreasing food palatability and producing harmful free radicals, underscoring the importance of incorporating sufficient antioxidants into pet diets.

Essential fatty acids for dogs and cats include:

- Linoleic acid (LA)
- Arachidonic acid (AA) – only for cats[16]
- Eicosapentaenoic acid (EPA) + docosahexaenoic acid (DHA)[22] – for growth and reproduction

Notable fats

PUFAs

Omega-6 and omega-3 polyunsaturated fatty acids compete for the same enzymes necessary for their conversion into eicosanoids, such as prostaglandins (PGs) and leukotrienes (LTs), which are key inflammatory mediators (**Figure 1**). The more

Table 1. Comparison of established requirements versus categorization based on macronutrient composition in pet diets. Adapted from Churchill and Eirmann (2021) and Hill and Dzanis (2024).[12,13] There are no defined values for low, moderate, and high ranges for protein and fat for dog and cat diets.

	Established requirements or recommended amounts for pet food (in grams/100 kcal)			Diets (in grams/100 kcal)			
	AAFCO Minimum	FEDIAF Minimum	NRC Recommended Allowance	Very low	Low	Moderate	High
Protein, Dog							
Adult	4.5	4.5 or 5.2*	2.5	< 3.0	3.0–6.0	6.0–9.0	> 9.0
Growth	5.6	6.3 (< 14 weeks old) 5.0 (≥ 14 weeks old)	5.6 (< 14 weeks old) 4.4 (≥ 14 weeks old)				
Reproduction	5.6	5.3	5.0				
Protein, Cat							
Adult	6.5	6.3 or 8.3*	5		< 7.0	7.0–10.0	> 10.0
Growth	7.5	7	5.6				
Reproduction	7.5	7.5	5.3				
Fat, Dog							
Adult	1.4	1.4	1.4	< 2.5	2.5–3.5	3.5–5.0	> 5.0
Growth & reproduction	2.1	2.1	2.1				
Fat, Cat							
Adult	2.3	2.3	2.3		< 3.0	3.0–5.0	> 5.0
Growth & reproduction	2.3	2.3	2.3				

*Minimum values based on an average daily energy intake of either 95 kcal/kg$^{0.75}$ or 110 kcal/kg$^{0.75}$ (dogs), or 75 kcal/kg$^{0.67}$ or 100 kcal/kg$^{0.67}$ (cats).

inflammatory 2-series PGs and 4-series LTs derive from arachidonic acid (AA), while eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) promote the production of the less inflammatory 3-series PGs and 5-series LTs. Balancing these fatty acids in the diet can help modulate inflammatory responses.[4,20,22]

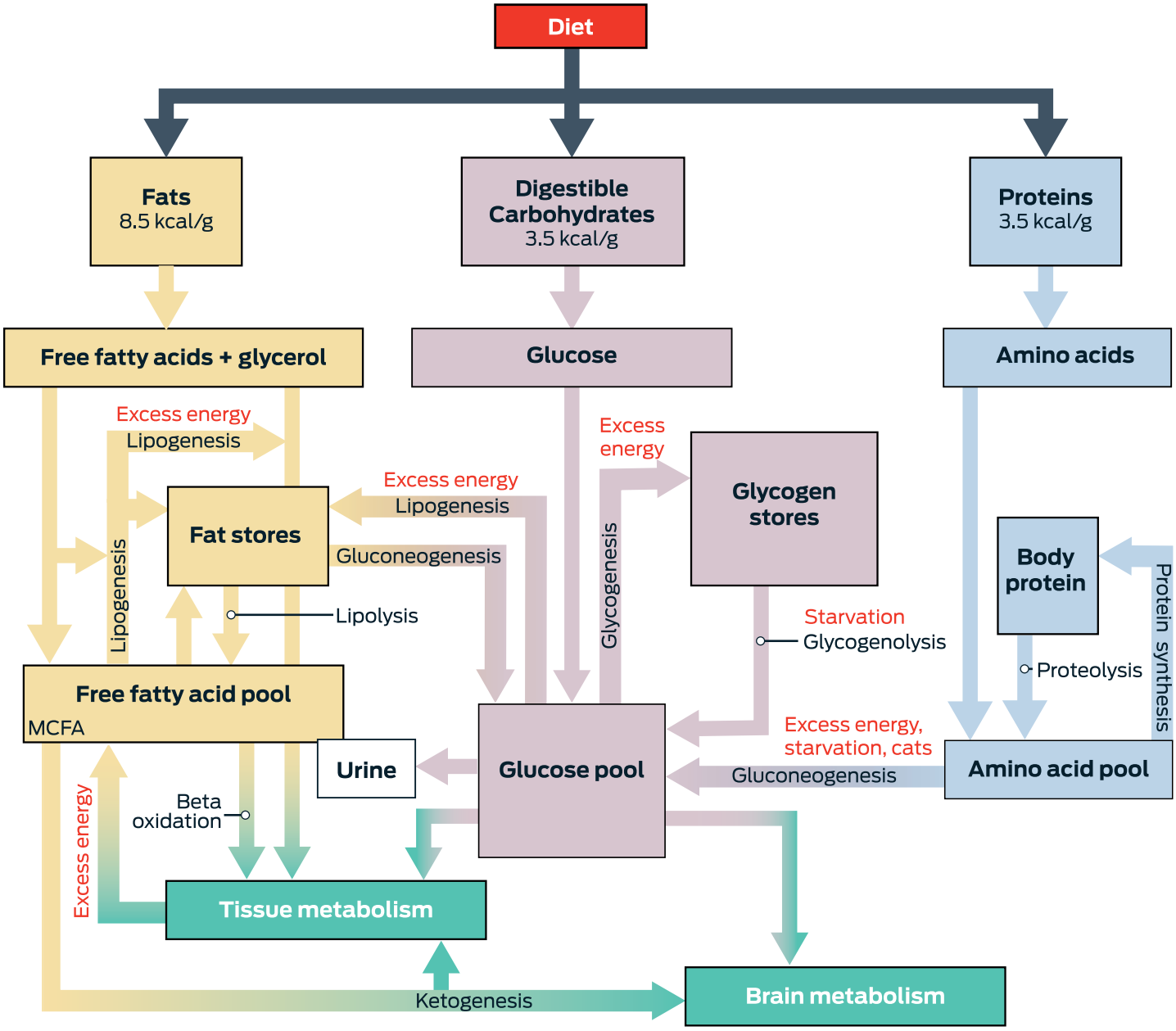
n-6 FAs

- **LA:** Abundant in corn, walnut, safflower, and sunflower oil.
- **AA:** Primarily found in animal fats. Essential for cats due to their limited ability to convert LA to AA.

n-3 FAs

- **EPA and DHA:** Sourced from marine oils such as fish, krill, and algae, these fatty acids are recognized for their anti-inflammatory properties and overall health benefits, including support for osteoarthritis, dermatitis, gastrointestinal diseases, cardiovascular issues, and certain cancers.[22-25] They may also enhance cognitive function[26,27] and help mitigate hyperlipidemia. Some nutritionists advocate for specific n-6 FA to n-3 FA ratios to address health issues rather than fixed dosages. Excessive n-3 FA intake may lead to altered platelet function, gastrointestinal disturbances,[28,29] impaired wound healing, lipid peroxidation, nutrient excesses, weight gain, and negative impacts on immune function and glycemic control.[30,31]
- **Alpha-Linolenic Acid (ALA):** Found in flaxseed oil, ALA can be converted to EPA and DHA; this conversion is inefficient in dogs and nearly impossible in cats, highlighting the necessity for direct dietary sources of marine oils.[20]

Figure 1. Metabolic fuel flow and storage. The diagram illustrates the energy metabolism of dietary carbohydrates, fats, and proteins while highlighting their interactions within the body. Dietary carbohydrates contribute to this system by supplying a glucose pool that fuels the brain and other tissues; excess glucose is either stored as glycogen through glycogenesis or converted into fat. Dietary fats are broken down into free fatty acids and glycerol, which can provide energy through beta-oxidation, be converted into glucose via gluconeogenesis, or be stored in adipose tissue. Additionally, ketone bodies derived from medium-chain fatty acids (MCFAs) serve as an alternative fuel source when glucose metabolism is compromised. Dietary proteins provide the amino acid pool essential for new protein synthesis and the maintenance of lean body mass. The body regulates stable glucose levels (euglycemia) through dietary carbohydrates and metabolic processes such as glycogenolysis and gluconeogenesis, ensuring a continuous energy supply for the brain and other vital tissues.



Medium-Chain Triglycerides (MCT)

Found in coconut oil and some vegetable oils, MCTs can be absorbed directly into the portal blood system, bypassing the lymphatic system. This unique characteristic has drawn interest in MCTs as an alternative energy source for dogs with fat intolerance (e.g., lymphangiectasia).[29] MCTs also supply medium-chain fatty acids, such as octanoic and decanoic acid, which are metabolized into ketone bodies.[4] These ketone bodies can cross the blood-brain barrier, offering alternative energy for conditions like epilepsy and cognitive dysfunction, where glucose metabolism may be compromised.[32] MCTs may also promote neural health by exerting antioxidant effects, enhancing mitochondrial function, and delivering neuroprotective properties.[1]

CARBOHYDRATES: NON-ESSENTIAL BUT BENEFICIAL

Dietary carbohydrates for dogs and cats primarily consist of complex carbohydrates, such as polysaccharides (starches and dietary fibers) and oligosaccharides. Starches contain α-glycosidic bonds that are enzymatically broken down in the gut into simple carbohydrates, such as glucose, a readily available source of ATP.[3,33] Dietary fibers, composed of β-glycosidic bonds, remain undigested in monogastric animals and do not directly supply calories. They are often included in pet foods to aid in weight control, manage hairballs, and promote gut health.

Vital functions of carbohydrates

- Provide energy and dietary fibers[34]

Carbohydrate requirements

Healthy adult dogs and cats do not have a dietary requirement for carbohydrates, as glucose can be synthesized from other macronutrients. However, during periods of increased energy demand—such as growth, gestation, or lactation—carbohydrates may become conditionally essential as they provide readily utilizable energy to spare other macronutrients essential for growth and development. Moreover, when dietary fat or protein needs to be restricted for medical reasons, carbohydrates can serve as a valuable alternative energy source.

Cats

As strict carnivores, cats lack sweet taste receptors and have a more limited ability to process carbohydrates compared to dogs. They do not produce salivary amylase and generate significantly lower levels of pancreatic amylase. Additionally, their liver has reduced glucokinase activity, an enzyme involved in the first step of glycolysis. Nevertheless, research shows that cats can utilize processed starches and demonstrate metabolic flexibility to enhance carbohydrate metabolism, enabling protein sparing—provided their diet includes at least 4 g of protein per 100 kcal. However, their carbohydrate intake should not exceed 40–50% of total calories (or 11 g to 14 g/100 kcal) to ensure optimal protein and fat consumption.[35,36]

Contrary to common belief, high-carbohydrate diets are not linked to diabetes, obesity, or pathological hyperglycemia. Such diets may be higher in dietary fiber and lower in fat, potentially supporting weight management and regulating digestible carbohydrate absorption.[35]

Notable carbohydrates

Dietary fibers

As non-digestible carbohydrates, they remain within the gastrointestinal tract unchanged and physically alter the ingesta through unique bulking, water-soluble, or water-binding abilities.[33] These characteristics help modulate digesta transit time and nutrient absorption and regulate appetite. Additionally, certain fibers, such as prebiotics, are selectively fermented by beneficial colonic microbes, discouraging pathogenic bacterial growth and promoting colonocyte health by the microbial synthesis of short-chain fatty acids (SCFAs).[37,38]

Their physiological effects depend on properties such as fermentability, viscosity, and solubility. Generally, soluble fibers are more fermentable and viscous, providing a myriad of health benefits. Conversely, insoluble dietary fibers are less fermentable but effectively increase fecal mass or create a sense of fullness by bulking and binding water.

Beneficial health effects of fibers

- **Weight management:** Both soluble and insoluble dietary fibers add bulk to food with minimal calories, promoting satiety and reducing energy intake.[39]
- **Bowel regulation:** Fibers increase fecal size and facilitate normal peristalsis, aiding in the prevention and treatment of constipation. Soluble fibers may also bind to excess water in the gastrointestinal tract in patients with diarrhea.[37,38]

- **Nutrient absorption modulation:** Fibers may interfere with enzymatic digestion and absorption of nutrients, such as starches, protein, and minerals, by forming viscous gels around the ingesta and modulating gastrointestinal transit time. This characteristic can be advantageous for managing postprandial glycemia.[40,41]

However, these physiological effects are not uniform; fiber type and dosing should be adjusted based on the individual response of each patient.

Commonly used dietary fibers[33]

- **Inulin, oligosaccharides, mucilages, gum:** Soluble, fermentable fibers beneficial for gut health; gum is additionally used as a thickening agent in pet foods.
- **Psyllium, pea fiber:** Supports digestive health through a mixture of both soluble and insoluble fibers.
- **Cellulose, hemicellulose:** Insoluble, slowly fermentable fibers that enhance fecal bulk and promote peristalsis.
- **Bran, hulls, and beet pulp:** Rich in insoluble fibers that support bowel regularity.

WATER

Though water does not provide energy, it is an indispensable macronutrient, constituting 60% of an adult animal's body weight.[1] Within the body, water dissolves and transports substances and is essential for hydrolysis and dehydration reactions involved in macronutrient metabolism. It also plays a critical role in temperature regulation by distributing heat.

Pets acquire water from drinking, food, and metabolic processes. The daily recommended intake is about 60 ml/kg for healthy dogs and cats or an amount (ml) that corresponds to their Maintenance Energy Requirement (MER),[1,42] varying with activity and life stage. Dry pet foods contain approximately 3–11% moisture, while canned foods have 60–87% moisture,[43] impacting drinking behavior when switching diets.[42]

High-moisture foods are typically more palatable to dogs and cats[43] and can also support weight management efforts by increasing satiety levels without increasing calorie intake.

SUMMARY

Macronutrient metabolism in dogs and cats intricately shapes their dietary requirements, profoundly impacting overall health and disease management. Veterinary professionals must tailor nutritional recommendations based on species-specific needs, energy demands, and individual health conditions. By understanding the unique metabolic pathways of proteins, fats, and carbohydrates and their properties, veterinarians can deliver insightful dietary guidance that ultimately enhances pet health and longevity.

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MICRONUTRIENTS IN SMALL ANIMAL NUTRITION

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KEY TAKEAWAYS

- Micronutrients support the immune system and play key roles in many other systems, such as bone health and cellular metabolism.
- Providing a complete and balanced diet that contains all essential nutrients is vitally important for all life stages.
- The importance of micronutrients is often underestimated, especially the trace elements.

INTRODUCTION TO MICRONUTRIENTS IN DOGS AND CATS

Micronutrients are essential components of a balanced diet for dogs and cats, playing critical roles in various physiological processes and can be divided into two main categories, vitamins and minerals.[1-3] This chapter aims to provide an overview of key micronutrients, focusing on fat-soluble vitamins, important B vitamins, calcium, and phosphorus. Sources of micronutrients are found in **Box 1** and the health impacts resulting from a diet deficient in micronutrients are found in **Box 2**.

1. **Vitamins:** Organic compounds essential for growth, metabolism, and general health. Vitamins are further classified into two groups:

   Fat-Soluble Vitamins: Include vitamins A, D, E, and K. These are stored in the body's fatty tissues and liver and can be utilized as needed.

   Water-Soluble Vitamins: Include vitamin C and B vitamins (B1, B2, B3, B5, B6, B7, B9, and B12). Vitamin C is not essential for adult dogs and cats. The B vitamins are not stored in the body and need to be supplied regularly through the diet. Some can be synthesized by microbiota in the large intestines and absorbed with water.

2. **Minerals:** Inorganic elements that are essential for various physiological functions. Minerals are divided into two categories:

   Macrominerals: These are needed in larger amounts and include calcium, phosphorus, potassium, sodium, and magnesium.

   Trace Minerals: These are required in smaller amounts and include the essential elements iron, zinc, copper, manganese, iodine, and selenium.

Box 1. Which foods provide micronutrients?

Micronutrients can be found in complete and balanced pet food but require supplementation to home-cooked diets.

Animal Sources: Animal-based ingredients are excellent sources of many B vitamins, fat-soluble vitamins (especially vitamin A), and minerals. In addition, micronutrients are more bioavailable or abundant in animal products. For instance, vitamin B12 is found naturally almost exclusively in animal products like meat, fish, eggs, and dairy. Iron from animal sources (heme iron) is also more easily absorbed than iron from plants.

Plant Sources: Fruits, vegetables, legumes, nuts, and seeds also include some vitamins and minerals, but mainly water-soluble rather than fat-soluble vitamins. The exception is vitamin E, which can be found in large quantities in grain seedlings. Leafy greens are rich in folate and contain some magnesium, and whole grains provide zinc and iron, however not in sufficient amounts to meet the requirements of dogs and cats. Vitamin C can be found in citrus fruits, but dogs and cats can produce vitamin C in their liver. Vitamin C needs to be added to the diet in patients with liver disease, and it is also used as an antioxidant in pet food.

WHAT IS THE GENERAL ROLE OF MICRONUTRIENTS IN SMALL ANIMAL NUTRITION?

Micronutrients play a variety of crucial roles in the body of small animals:

1. **Immune Function:** Micronutrients such as vitamins A, C, D, and E, and minerals including zinc and selenium are vital for supporting the immune system. Vitamins A, C, and E and selenium have antioxidant properties, protecting cells from oxidative damage, and boost immune cells, while vitamin D helps regulate immune responses and reduce inflammation. Zinc is important for the growth and function of immune cells.[4]

2. **Bone and Dental Health:** Calcium, phosphorus, and vitamin D are essential for maintaining strong bones and preventing disorders like osteomalacia. Calcium and phosphorus are the primary components of bone tissue, while vitamin D facilitates their absorption and utilization.

3. **Energy Production:** B vitamins (thiamine (B1), riboflavin (B2), niacin, pantothenic acid (B5), pyridoxine (B6), biotin (B7), folate (B9), and cobalamin (B12)) and minerals like magnesium and phosphorus are crucial for converting components of the feedstuffs into energy. B vitamins act as coenzymes in metabolic processes that break down proteins, fats, and carbohydrates.[5]

4. **Cognitive Function:** Vitamins E, B6, B12, and folate (B9) are important for maintaining cognitive function and reducing the risk of age-related cognitive decline. They are involved in nerve signaling, antioxidant defense, and the production of neurotransmitters.[6,7]

5. **Heart Health:** Micronutrients like potassium, magnesium, antioxidants (such as vitamins C and E), and omega-3 fatty acids contribute to heart health by reducing inflammation, regulating blood pressure, and preventing oxidative damage to blood vessels.[8]

6. **Skin and Coat Health:** Zinc, omega-3 fatty acids, and vitamins A and E contribute to healthy skin and a shiny coat.

OVERVIEW OF KEY MICRONUTRIENTS IN SMALL ANIMAL NUTRITION

Fat-soluble vitamins

Fat-soluble vitamins include vitamins A, D, E, and K. These vitamins are absorbed with dietary fats and stored in the body's fatty tissues and liver.

Vitamin A (retinol)
Function: Vitamin A is crucial for vision, immune function, and skin health. It plays a role in the maintenance of epithelial tissues and is involved in the synthesis of rhodopsin, a pigment in the retina essential for low-light vision. Retinol is the active form of vitamin A. While some species convert beta-carotene to retinol, cats lack the needed intestinal enzyme and require retinol in their diet.

Vitamin D (cholecalciferol)
Function: Important for calcium and phosphorus metabolism, promoting bone health and immune function. It enhances intestinal absorption of calcium and is not synthesized in the skin upon exposure to sunlight by dogs and cats. It needs to be supplemented in home-cooked diets. Due to a narrow safety range, avoid excessive dietary vitamin D.

Vitamin E (tocopherol)
Function: Acts as a potent antioxidant, protecting cell membranes from oxidative damage. Also plays a role in immune function, cell proliferation, and skin health.[9] It is often added to pet food as an antioxidant and can help prevent food spoilage during storage.

Vitamin K
Function: Essential for blood coagulation and bone metabolism. Involved in the synthesis of proteins required for blood clotting and bone health. A dietary source is usually not required for dogs and cats, as the intestinal microbiota can produce sufficient vitamin K.

Important B vitamins

B vitamins are a group of eight water-soluble vitamins involved in energy production, metabolism, and the synthesis of neurotransmitters and red blood cells. All B vitamins are typically supplemented in both commercial pet food and home-cooked diets.

Vitamin B1 (thiamine)
Function: Essential for carbohydrate metabolism and the proper functioning of the nervous system.

Vitamin B2 (riboflavin)
Function: Plays a key role in energy production and the metabolism of fats, drugs, and steroids.

Box 2. Common micronutrient deficiencies and their health impacts

Micronutrient deficiencies can lead to significant health issues in small animals:

- **Iron:** Deficiency can cause anemia, leading to fatigue, weakness, pale mucous membranes, and impaired cognitive and immune function.
- **Vitamin D:** Deficiency can result in bone disorders like rickets in puppies and kittens and osteomalacia in adult animals. Muscle weakness and pain due to impaired calcium absorption can also occur. It is also possible for dogs and cats to consume excess vitamin D.
- **Vitamin A:** Vitamin A is essential for vision, and deficiency can lead to night blindness and other vision impairments. A lack of vitamin A may cause skin problems and poor coat condition due to its role in maintaining epithelial tissues. Reduced immune function can occur, and there is an increased risk of infectious diseases. It is also possible for dogs and cats to consume excess vitamin A.
- **Iodine:** Insufficient iodine intake can cause thyroid dysfunction, leading to conditions like goiter and hypothyroidism.
- **Folate:** Deficiency can cause fatigue, weakness, and megaloblastic anemia and, in pregnant animals, increase the risk of developmental problems in the offspring.
- **Vitamin B12:** Its deficiency can cause anemia, leading to weakness and lethargy. Additionally neurological symptoms can occur including weakness and difficulty in walking.
- **Vitamin B1:** Thiamine deficiency can lead to neurological problems, including ataxia (loss of coordination) and seizures. In addition, weight loss and poor appetite may occur due to the impact on metabolism. Cats are particularly susceptible to thiamine deficiency.
- **Vitamin E:** A deficiency leads to muscle degeneration (nutritional myopathy) and weakness. In breeding animals, low vitamin E levels can affect fertility and reproduction, and can impair immune function, leading to increased risk for diseases. Vitamin E deficiency can also result in pansteatitis in cats.
- **Copper:** A deficiency in dogs and cats leads to anemia, impaired immune function, neurological issues, and connective tissue disorders including joint and skin issues.
- **Zinc:** Low zinc levels in the diet lead to dermatitis, impaired immune response, poor growth, and neurological symptoms.

Vitamin B3 (niacin)

Function: Important for DNA repair, energy production, and the synthesis of cholesterol and fatty acids. Higher requirement in cats (cats cannot produce niacin from tryptophan).

Vitamin B9 (folate)

Function: Essential for DNA synthesis and repair, and critical during periods of rapid growth, especially during gestation.

Vitamin B12 (cobalamin)

Function: Important for red blood cell formation, neurological function, and DNA synthesis. Needs to be supplemented in vegetarian and vegan diets.

KEY MINERALS

Calcium

Function: Calcium is essential for bone and tooth formation, muscle contraction, nerve transmission, and blood clotting. Approximately 99% of the body's calcium is stored in bones and teeth, where it provides structural support. A source of calcium such as bone meal or an inorganic mineral supplement needs to be included in commercial pet food or in home-cooked diets to provide sufficient calcium.

Phosphorus

Function: Phosphorus is crucial for the formation of bones and teeth, energy production (as part of ATP), and the synthesis of nucleic acids and cell membranes. It also plays a role in buffering systems that maintain acid-base balance in the body.

Magnesium

Function: Magnesium is essential as a cofactor for over 300 enzymes, including those for the synthesis of DNA, RNA, and protein, and in the metabolism of carbohydrates (energy production). In addition, magnesium is important for muscle and nerve function, bone health (structural development), and for the regulation of calcium and potassium levels.

Sodium

Function: Sodium is essential for maintaining the balance of fluids in the body. It helps regulate the distribution of water between the intracellular and extracellular compartments, ensuring proper hydration and preventing dehydration. It contributes to acid-base balance. In dogs and cats with cardiac disease, low-to-moderate dietary sodium intake can help reduce sodium and water retention, thereby reducing congestion and improving heart function. It is important for fluid balance, osmotic balance, and blood pressure regulation via the kidneys through the renin-angiotensin system.

Zinc

Function: Zinc is critical for the normal development and function of cells mediating innate immunity, neutrophils and natural killer cells. Zinc is also used for DNA synthesis, wound healing, and as a cofactor for many enzymes including those in carbohydrate, protein, and fat metabolism.

Copper

Function: Copper is important for the absorption, storage, and metabolism of iron, which is crucial for the formation of erythrocytes, has an antioxidant function and is necessary for the formation of collagen and elastin (connective tissue). It is involved in nerve function and ATP production in glucose metabolism.

THE CALCIUM TO PHOSPHORUS RATIO: IMPORTANCE FOR GROWTH IN DOGS AND CATS

Of the 12 essential minerals, calcium and phosphorus play the largest role in canine and feline health. The calcium to phosphorus (Ca:P) ratio is highly important in pet nutrition, particularly for growing dogs and cats. This ratio plays a vital role in skeletal development, overall health, and the prevention of nutritional deficiencies or imbalances.

COMMUNICATION TIP

Ensuring that pets receive a complete and balanced diet containing all essential vitamins and minerals in the proper amounts and proportions is crucial for maintaining their overall health.

Recommended calcium to phosphorus ratios

For growing dogs and cats, the recommended Ca:P ratio is typically around 1.1:1 to 1.6:1. This means that for every part of phosphorus, there should be 1.1 to 1.6 parts of calcium. However, this ratio can vary based on the specific life stage and dietary needs of the animal.[10]

Puppies and Kittens: During growth phases, the need for calcium is particularly high to support the development of bones and teeth. A balanced ratio helps to ensure that the skeletal system develops properly.

Adult Dogs and Cats: Adult animals still require a balanced Ca:P ratio, but the emphasis on calcium is less critical compared to growing animals. It is still recommended to have at least a ratio of 1:1.

Importance of calcium and phosphorus

1. **Bone Development:** Calcium and phosphorus are essential for the formation and maintenance of bones. They work together to form hydroxyapatite, the mineral complex that gives bones their strength and rigidity. An imbalance, particularly a deficiency in calcium relative to phosphorus, can lead to skeletal deformities and conditions such as osteochondrosis and rickets (in dogs) or osteodystrophy (in cats).

2. **Nutritional Balance:** A proper Ca:P ratio ensures that both minerals are bioavailable and can be effectively utilized by the body. If the ratio is too high in phosphorus, it can lead to calcium depletion, resulting in weakened bones and increased risk of fractures.

3. **Growth Rates:** Rapid but controlled growth in puppies and kittens requires adequate calcium for developing bones. An improper ratio can hinder

growth rates or lead to developmental orthopedic diseases (DOD), which can affect the animal's quality of life and longevity.

4. **Hormonal Regulation:** Calcium and phosphorus are regulated by hormones, including parathyroid hormone (PTH) and calcitonin. An imbalance in these minerals can disrupt hormonal regulation, leading to further complications in metabolism and health.

Consequences of imbalance of Ca and P

Calcium Deficiency: Low calcium concentrations in the diet can lead to metabolic bone disease. In young animals, soft, weak bones can occur, and osteoporosis occurs in adults (loss of bone density), resulting in an increased risk of fractures.

Phosphorus Deficiency: Low phosphorus concentration in the diet is extremely uncommon in dogs and cats, but leads to skeletal deformities in young animals. It can also cause anemia, cardiac issues, neurological signs, anemia, and metabolic acidosis.

Excess Phosphorus: High phosphorus concentrations in the diet can lead to:

- Secondary hyperparathyroidism, where the body compensates for low calcium by increasing PTH, which can cause bone resorption, poor bone mineralization, and growth abnormalities.
- Kidney disease (especially in cats, depending on the phosphorus source).

Excess Calcium: An overly high calcium intake can also be problematic, especially in growing dogs, leading to:

- Hypercalcemia (high blood calcium levels), which can cause kidney calcification and other health problems.
- Potential to interfere with the absorption of other essential minerals, e.g., iron.

Maintaining an appropriate calcium to phosphorus ratio is essential for healthy growth and development of dogs and cats. Proper nutrition during the growth phase is crucial to prevent skeletal abnormalities and ensure long-term health. When selecting a diet for puppies and kittens, it is vital to consider this ratio to promote optimal growth and prevent potential health issues.

REASONS TO ADJUST MICRONUTRIENT INTAKE IN HEALTHY DOGS AND CATS

1. **Puppies and Kittens:** During the rapid growth phases of puppies and kittens, their nutritional needs change significantly. Increased but appropriate calcium and phosphorus amounts in pet food are crucial for developing strong bones and teeth. Inadequate intake can lead to developmental orthopedic diseases (DOD), such as hip dysplasia and rickets.

2. **Adult and Senior Pets:** Aging animals should be supplemented with increased levels of antioxidants such as Vitamin E.

3. **Dietary Changes:** When transitioning pets to a new diet, it is crucial to ensure that the new diet meets all micronutrient requirements. Home-cooked diets, in particular, can be deficient in essential vitamins and minerals if not properly formulated. Feeding a diet that is not complete and balanced can lead to potential deficiencies in certain micronutrients, necessitating adjustments or supplementation to maintain overall health.

4. **Environmental Factors:** The nutrient content of pet food can be influenced by geographical factors such as soil quality and agricultural practices. Pets living in areas with low-quality soils may require additional supplementation of certain micronutrients. Highly active pets or those living in extreme climates may require additional micronutrients to support their energy needs and specific environmental challenges.

5. **Pregnancy and Lactation:** Pregnant and lactating pets have increased nutritional needs to support fetal development and milk production. Adjustments in micronutrient intake, particularly calcium, phosphorus, and certain B vitamins, are essential during this period.

CONCLUSION

Adjusting micronutrient intake is vital for maintaining the health and well-being of pets throughout their lives. Factors such as growth stages, specific health conditions, dietary changes, and reproductive status all necessitate careful consideration of micronutrient needs. Micronutrients support a wide range of

physiological functions, from immune support and bone health to energy production and cognitive function. Ensuring that pets receive a complete and balanced diet containing all essential vitamins and minerals in the proper amounts and proportions is crucial for maintaining their overall health and preventing deficiencies or excesses. By understanding the roles and sources of micronutrients, veterinarians can make informed recommendations for their patients' nutrition and well-being.

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PRACTICAL TOOL: NUTRIENTS IN PET FOOD

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While owners may evaluate a pet food based on the ingredient list, what the body requires is the nutrients provided by those ingredients. In addition to water, nutrients include protein, fats, carbohydrates, minerals, and vitamins. All essential nutrients have a minimum requirement, and some, for example, calcium, also have a maximum or a safe upper limit.

ESTABLISHING NUTRIENT REQUIREMENTS

For commercial pet foods there are two sets of commonly used nutrient requirements or recommendations. One has been developed by the AAFCO[1] and one by FEDIAF.[2] Both provide nutrient requirement tables for adult maintenance, growth, and reproduction.

AAFCO is made up of feed control officials who work along with the pet food industry to provide guidelines for nutritional adequacy and adoption of pet food regulations, although they are not an enforcement agency. Most of North America and much of Australasia use the AAFCO nutritional guidelines.

FEDIAF is the trade body representing the European pet food industry who similarly develops nutritional guidelines working with the non-industry pet nutrition specialists of their Scientific Advisory Board. European countries, among others, use the FEDIAF guidelines, but FEDIAF is not an enforcement agency and their use by pet food manufacturers is voluntary.

The guidelines set up by AAFCO and FEDIAF are based on the National Research Council publication, Nutrient Requirements of Dogs and Cats (NRC).[3] Many of the NRC minimum requirements are based on purified diets and/or highly available nutrients which do not reflect the nutrient availability of most ingredients used in commercial pet foods. AAFCO provides recommended nutrient concentrations for pet foods. FEDIAF also similarly, although not identically for all nutrients, adjusts the minimum recommended levels to ensure adequate nutrient intake. For both organizations, companies must make allowances for nutrient losses during processing and storage to meet the nutrient requirements.

AAFCO and FEDIAF have maximum levels or safe upper limits for some nutrients which, based on scientific data, have not been associated with adverse effects in healthy cats and dogs. In addition, FEDIAF has legal total maximum levels for some nutrients if they are added as a nutritional additive (e.g., trace elements such as copper, and vitamin D). The legal maximums apply to all life stages and species. They do not imply a known safe upper limit and do not apply if the nutrient comes exclusively from the feed ingredients.

Diets that meet all essential nutrient requirements for a specific life stage without exceeding the maximum concentration are considered "complete" (FEDIAF) or "complete and balanced" (AAFCO) for that life stage. These terms mean that all essential nutrients are present in the diet in the proper proportions, and the food can be the sole source of nutrition for the individual.

Box 1. Nutrient composition on pet food labels[1,4]

In a complete or complete and balanced pet food, the nutrients the package label must state are:

- Crude protein or protein
- Crude fat or fat
- Crude fiber
- Crude ash or incinerated residue or inorganic matter (i.e., minerals) (FEDIAF only)
- Moisture (always required for AAFCO; FEDIAF requires if >14%)
- The concentration of other nutrients must be declared if claims are made on the label, and may also be declared voluntarily

The mandatory nutrients are reported as percentages (grams of nutrient/100 grams of food) on an "as fed" basis.

DETERMINING IF A DIET MEETS NUTRIENT REQUIREMENTS

Determination of the nutrient quantities in a diet is usually initially performed by formulation, i.e, using a computer program. This requires knowledge of the nutrient concentrations of each ingredient and the diet as a whole and comparing those with the nutritional recommendations for the species and life stage. If a product is labeled as a complete pet food without specification of a life stage, it is assumed to be complete for all life stages and should be formulated for the more stringent levels recommended for the growth and reproduction life stage.

Pet food in Europe will meet the needs for at least one life stage if it is labeled "complete." For countries following AAFCO guidelines, it is imperative to look at the nutritional adequacy statement to determine if the pet food is complete and balanced. Pet food can be determined to be complete and balanced if it meets the AAFCO profiles ("formulated to meet"), if an AAFCO feeding trial has been performed ("animal feeding tests substantiate"), or if a similar product in the same product family has undergone an AAFCO feeding trial (the "family rule"). AAFCO has protocols for these types of feeding trials for adult dogs and cats, puppies and kittens, and reproducing bitches and queens. Companies may also do longer feeding trials, as well as trials for digestibility, palatability, urinary analysis, microbiome effects and other purposes.

NUTRIENT EXPRESSIONS USED IN PET FOODS

Determining the amount of a nutrient is useful if you are comparing pet foods, for example, diets for a growing puppy or kitten or to recommend a therapeutic (dietetic) diet for disorders like pancreatitis or chronic kidney disease. Nutrients can be expressed on a basis of as fed, dry matter, or on an energy basis.

As fed basis

An as fed basis for a nutrient is a percentage of the nutrient as it is fed to the pet. The total percentage for the food includes the moisture or water in the food. This is what is included on the pet food label. As fed values are difficult to use for comparison as they are affected by moisture content and the energy density of the food.

Dry matter basis

To compare foods on a dry matter basis (DMB) the water is mathematically removed from the amount of the nutrients. Dry matter is the component of food that is not water (moisture). This allows for a more direct comparison, e.g., between the percentage of a nutrient in a wet food with a high moisture content with a dry food with a lower moisture content. Nutrient composition on a DMB is often provided by companies and is also listed in the FEDIAF and AAFCO guidelines.

$$\text{DMB} = \frac{(\text{percent of the nutrient [protein, fat, etc.]})}{(100\% - \%\ \text{moisture})}$$

As an example, if the moisture is 80%, the dry matter is 20%. If protein on an as fed basis (i.e., on the label) is 10%, the protein on DMB is 10/20 x 100 or 50%.

A dry food will have a higher nutrient percentage on the label (as fed basis) compared to a wet food. The moisture may or may not be stated on the label. If it is not stated, 10% is often used as an estimate.

Energy or calorie basis

While dry matter is useful for comparing nutrients, animals are fed and consume foods by calorie content, so comparing nutrients by a given number of calories is more precise because it includes the effects of water and the caloric density (calories per unit of weight) of the food. Pet foods can vary considerably in their caloric density, with wet products ranging from 600 to 1500 kcal/kg and dry foods ranging from 3000 kcal/kg to more than 4000 kcal/kg. A pet eating a higher calorie pet food will eat less food to meet its energy needs, and therefore will also consume lower amounts of other nutrients. Nutrients are usually stated as units (e.g., grams or milligrams) per 100 or 1000 kcal (calories).

Percent metabolizable energy

The calorie distribution can also be used for comparing pet foods. This is the percentage of calories provided by the energy-containing macronutrients, i.e., fat, protein, and carbohydrates. For example, the total calories of a diet may be made up by 30% protein, 20% fat, and 50% carbohydrates. As fat contains about 2.25 times the calories per gram compared to that of protein or carbohydrate, the calorie percentages of the nutrients (kcal of nutrient/100 kcal of diet) will not be the same as the actual amount or weight of these nutrients, which would be the as fed amounts (grams of nutrient/100 grams of diet).

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NUTRITIONAL SUPPORT OF PEDIATRIC DOGS AND CATS

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KEY TAKEAWAYS

- The neonatal period of cats and dogs is the first 2 weeks of their life, with the first week considered the most critical for survival.
- Newborn puppies and kittens must receive colostrum immediately after birth.
- The goal of feeding puppies and kittens is to ensure they develop into healthy adults.
- Energy and key nutrients are critical to healthy development in pediatric puppies and kittens.

Growth is a complex process involving interactions between genetics, nutrition, and other environmental influences. Nutrition plays a role in the health and development of neonatal kittens and puppies, and directly affects the immune system, body composition, growth rate, and skeletal development. Diet and feeding management are perhaps the most important factors that influence health and disease.

The specific objectives of a pediatric feeding plan are to achieve healthy growth, optimize development, minimize disease risk factors, and achieve optimal health. Additionally, the veterinary team wants to optimize trainability, support immune function, and minimize obesity and developmental orthopedic disease. This chapter will focus on puppies and kittens through weaning. Puppy growth and kitten growth post-weaning are covered elsewhere. The goal of feeding puppies and kittens is to ensure they develop into healthy adults.

NEONATES

The neonatal period of cats and dogs is the first 2 weeks of their life, with the first week considered the most critical for survival.[1,2] Due to high rates of morbidity and mortality, the neonatal period in dogs and cats remains a major challenge for veterinary teams, breeders, and pet owners. Newborn puppies and kittens are physiologically immature, with low percentages of body fat: 1–2% as compared to 12–35% in adult dogs and cats. This immaturity is termed altricial, meaning they are completely dependent on their mother for survival.[1,3] If they are orphaned, that care will depend on their foster parents until they are mature enough to start caring for themselves.

The canine and feline neonatal period is a critical time due to 1) the adjustment of the neonate to the extrauterine environment, and 2) the neonate preparing for greater autonomy post-weaning.[2] During this timeframe, nutrition plays a pivotal role, aiding proper health during the early stages of life as well as long-term effects. Inadequate nutrition or inability of the gastrointestinal tract to digest and absorb nutrients can influence growth and health status, and may lead to premature death. Additionally, nutrition and feeding are influential factors in socialization.[2]

The first nutritional concern for newborns is that they receive colostrum immediately after birth. Colostrum is milk produced by the mother during the first 24–72 hours after parturition. Colostrum provides nutrients, water, growth factors, digestive enzymes, and maternal antibodies.[4-6] Most of the antibodies and other factors transmitted through the colostrum are in the form of large proteins. These are absorbed across the intestinal barrier, conferring passive immunity to the neonate.[1] The neonate's ability to absorb these large proteins across the intestinal barrier remains only for the first 24–72 hours of life. Continuation of colostrum after this period provides no additional immunity to the neonate. Additionally, it is important to remember the neonate can only receive protection from diseases for which the mother has been vaccinated or has contracted and developed natural immunity. This passive immunity will help protect the

neonate until the weaning period and is considered gone by ~16 weeks of age.[1,4]

All components of colostrum are vital to the survival of the newborn. The micronutrient content of colostrum also has been found to effectively contribute to puppies' and kittens' health and growth.[2] The key differences between colostrum and milk are the water content and nutrient composition.[1] The water content of colostrum is lower than that of milk. Thus, it is sticky and has a concentrated appearance as compared with milk. The water content found in milk will gradually increase from day 1 to day 3.[1,4,5] Additionally, lactose concentration in colostrum is lower than in milk, and protein and fat concentrations are higher.

Energy content found in milk also increases throughout lactation.[1,4] Neonates do not develop ample glycogen reserves until after the first few days of nursing. This lack of glycogen reserves results in the neonate needing to be nursed or fed frequently, sometimes as often as every 2 hours for the first week or so of life.

The second important concern for newborn kittens and puppies is the inability to maintain body temperature. Neonates are unable to thermoregulate and must be kept in an environment that is 85–90 °F during the first week of life, and 80–85 °F during the second week. Those unable to keep warm may become hypothermic, which will result in being unable to feed, and if tube fed, unable to digest the food. This failure to feed may result in rejection by the bitch or queen.[1,4-6] The best source of warmth is the mother. After 6 days the neonates are able to shiver but are still very susceptible to becoming chilled. Keeping the environment warm and avoiding drafts is extremely important during the first few weeks of life.

ORPHANED KITTENS AND PUPPIES

Kittens and puppies are typically raised without incident by their mother and weaned to an appropriate growth diet. However, with orphaned neonates, other feeding approaches are required. If a nursing queen or bitch is available, it is preferable to try to foster the orphaned offspring with her. Orphaned neonates have the same requirements as neonates that have a mother; they still need adequate, frequent nutrition and warmth. If a foster mother is not available, kittens and puppies can be hand-raised. Very young or debilitated neonates can be raised by hand through tube feeding, with bottle feeding in older and healthier neonates. Bottle feeding is safest and easiest but can be time consuming, especially with multiple neonates. With training from the veterinary team, tube feeding can be mastered by most if needed to deliver nutrition.[7]

Cow's and goat's milk do not contain as much fat, protein, calcium, or calories as milk from queens and bitches and therefore should be avoided.[4,6] Recommendations for feeding vary but typically range from 13–18 ml/100 g body weight (using a formula with a caloric density of approximately 1 kcal/ml) to commence and then gradually increasing as the orphan gains weight.[1,4,7] Every feeding should be followed with anogenital stimulation by using a cotton swab or warm cloth to encourage urination and defecation.

The ratio of casein:whey in milk also differs among species. Casein is the solid protein found in milk, while whey is the liquid protein found in milk. The amount of casein in milk may affect protein digestion, mineral utilization, and the amino acid composition of the milk. The casein:whey ratio for cats is 60:40, while the ratio for dogs is 70:30.[1,4] Canine milk contains almost twice as much protein compared to cow's milk. It also provides branched-chain amino acids and high levels of arginine and lysine.

When feeding orphans, it is recommended that a commercial puppy or kitten milk replacer be used, as many home-prepared formulas are not adequate to meet the needs of a growing puppy or kitten.

Frequent reassessment of the feeding plan should be done, evaluating the overall health, appearance, activity level, hydration status, and weight gain of the orphans. For kittens, the expected weight gain would be ~15–20 g/day,[6] and puppies, 4 g/d/kg of anticipated adult weight.[7] Excessive whimpering or vocalization may be an indication of discomfort or hunger and would warrant reassessment of the feeding plan. Low birth weight and failure to gain weight are correlated with poor survivability. See **Table 1** for standard birth weights for kittens and puppies.

In the first 24 hours of life, puppies and kittens may lose a small amount of weight due to slight dehydration and initial defecation.[9] Puppies and kittens should gain weight daily, doubling birth weight by 7–10 days of age. Research has shown that puppies who lost >10% of their birth weight within the first 2 days of life were much less likely to survive until weaning compared to puppies who maintained or gained weight in that time.[9] Thus, it

Table 1. Standard mean birth weights[4,5,8,9]

Species	Birth weight in grams
Kittens	90–120
Toy breed puppies	100–200
Medium breed puppies	250–350
Large breed puppies	350–500
Giant breed puppies	600–700

is important for veterinary healthcare team members to weigh all neonates at birth, at 12 hours, and at 24 hours of life. After 24 hours the neonates should be weighed daily, with accurate records documenting consistent weight gain and any changes in body weight.

The AAFCO and FEDIAF do not provide detailed guidelines for testing milk replacers. Therefore, it is recommended that manufacturers' information related to nutrient composition, nutritional integrity, and feeding efficacy be obtained, as this information will be helpful in choosing the best milk replacer.[1] It is important to remember even the best milk replacer cannot provide the neonate with the antibodies found in colostrum; thus extra care must be taken to maintain a clean environment and prevent transmission of disease.[1,4] It is imperative that the feeding equipment (e.g., bottles, nipples, tubes) is/are cleaned and disinfected between feedings. The milk replacer itself should be made fresh or refrigerated between feedings to decrease the incidence of bacterial contamination. When feeding, refrigerated milk replacer should be gently warmed to room temperature. When milk replacer needs to be reconstituted, only the volume of milk replacer that will be consumed within a 24-hour period should be made. Milk replacer not used at that feeding should be stored in the refrigerator.[4]

KEY NUTRIENTS

Water

Water is the most important nutrient in all stages of life; however, hydration status can be difficult to assess in neonatal puppies and kittens. Neonates have less subcutaneous fat, making skin turgor/tenting a less accurate indicator of hydration status in pediatric animals. Puppies and kittens with light pigmentation that are well-hydrated typically display deep pink coloration of the ventrum, muzzle, and oral mucous membranes.[9] Dehydration may lead to a darker pink/red, but this measure is very subjective. Dehydrated neonates may have dry oral and ocular mucous membranes; however, veterinary teams should be cautious when assessing oral mucous membranes in neonates that have recently nursed as milk on the mucous membranes will make them feel slick, which may be mistaken for normal hydration. Normal urine in neonates is dilute with no discernible color.[9] Thus, any yellow color is suggestive of dehydration.

Puppies and kittens have a relatively high water intake. A typical neonatal puppy needs ~130–220 ml/kg body weight per day and a neonatal kitten needs ~4.4–6.5 ml water/oz. body weight.[5,6,9] Orphaned puppies and kittens should receive ~0.2 ml/g to ensure success in feeding. Water should be given until 180 ml/kg body weight is reached if the milk replacer doesn't provide this much water at the recommended dilution.

Energy

Queen's and bitch's milk are extremely digestible with energy digestibility >95%. The high digestibility of the mother's milk maximizes its usage and helps kittens and puppies survive the critical first weeks. Canine milk is high in energy and provides about 146 kcal GE/100 g of milk. The average energy intake for puppies is about 240 kcal/kg body weight/day during the first 4 weeks of life.[6]

Kittens less than 1 week old will eat a volume equal to 10–15% of their body weight as milk (or properly formulated milk replacer) per day and a volume equal to 20–25% of their body weight per day between weeks 1 to 4.[5]

Protein

The protein digestibility of bitch's milk is very high, with nitrogen retention ~90% during the first week. Canine milk also contains more than twice as much protein per 100 ml than cow's milk (7.5% vs. 3.3%).[6] Also found are high levels of arginine, lysine, and branched-chain amino acids. When assessing and formulating milk replacers, this nutrient profile needs to be considered. This profile also reflects the enormous anabolic activity of puppies at this young age. If milk replacer is used, it is important to meet protein requirements.

The minimum protein requirement of nursing kittens has not been established although it is assumed to be similar to that for weaned kittens, ~18–20% DM. The protein content of queen's milk ranges from 33–44% DM.[5]

It is essential for commercial milk replacers to have adequate protein and essential amino acid content. Arginine and histidine levels in the formula are of particular importance, as a deficiency of these amino acids may lead to cataract development in neonates and contribute to anorexia and poor growth.

Taurine

Taurine is essential for normal growth and development of kittens. Queen's milk supplies about 300 mg taurine per liter.[10,11] Queens fed low-taurine foods have substantially lower milk taurine levels, which may impair normal growth and development of the neonate. Cow's milk is a poor source of taurine; therefore, if the owner uses homemade milk replacers based on cow's milk, it must be supplemented with taurine (30 mg taurine/100 ml milk replacer).[5]

Fat

Milk fat is an important source of energy and essential fatty acids for nursing kittens. The makeup of the queen's diet influences the quality and quantity of milk fat, which translates into fat composition of the neonatal kitten. Throughout the lactation period, an increase in the fat content of queen's milk is noted. Average fat concentrations are typically 28% DM. Queen's milk provides the essential fatty acids linoleic and arachidonic acid at 1.4 g and 0.05 g/1000 kcal, respectively. Docosahexaenoic acid (DHA) is also essential for normal neural and retinal development and function in kittens and the queen's milk DHA concentrations are reflective of her dietary intake. The recommended DM level of DHA plus eicosapentaenoic acid (EPA) for kittens after weaning is 0.025 g/1000 kcal with EPA not exceeding 60% of the total DHA plus EPA. These levels are said to be suitable for neonatal orphan formulas as well.[10]

Canine milk should contain ≥9 g fat/100 g of milk.[6] Bitch's milk contains a high percentage of unsaturated fatty acids and is rich in linoleic acid. Milk fat and fatty acid composition are highly variable components of milk and often reflect dietary intake of the bitch. The fatty acid composition of milk may be influenced by the type of dietary fat fed in conjunction with the fatty acid profile of endogenous fat deposits.

Retinal function of young dogs improved when foods containing long-chain omega-3 (n-3) polyunsaturated fatty acids were fed during gestation and lactation.[11] EPA should not exceed 60% of the total amount of DHA plus EPA; subsequently, DHA needs to be at least 40% of the total DHA plus EPA. Linoleic acid is required for normal growth. The linoleic acid content of bitch's milk is 4.9% DM. DHA has also been shown to improve learning in dogs.[12]

Carbohydrate

Lactose concentration of queen's milk is 4 g/100 g,[5] but no requirements for carbohydrates have been established for nursing kittens. The amount of lactose in the queen's milk increases after the transition from colostrum to milk. It is imperative that the veterinary team educate owners that overfeeding cow's milk can lead to diarrhea, bloating, and abdominal discomfort in kittens due to bacterial metabolism of undigested lactose in the large intestine. Thus, they should be advised to limit the quantities given and to terminate feeding cow's milk if intolerance occurs.

Lactose concentration in bitch's milk is 3.3 g/100 g, ~30% lower than cow's milk. The primary carbohydrate in milk is lactose. Lactose should be the main carbohydrate source during the first weeks of the canine neonate's life to avoid diarrhea. Pancreatic amylase activity is insignificant at 4 weeks of age and low at 8 weeks; conversely, intestinal lactase activity is greater until about 4 months of age.[5]

Calcium and phosphorus

In feline colostrum, calcium concentrations are low. However, calcium concentrations increase through mid to late lactation. Hence, calcium requirements are limited in early stages and increase with bone mineralization and growth. Milk phosphorus concentrations do not vary to the same extent. On day 1 of lactation calcium:phosphorus ratios increase from a low of 0.4:1 to 0.8:1 to approximately 1:1 between week 1 to 3 of lactation.[5,13]

In canine milk, calcium levels are very high in colostrum and after 2 to 3 days begin to decrease. Throughout the lactation period, the calcium content again increases. The calcium:phosphorus ratio remains consistent around 1.3:1. Calcium and phosphorus levels in milk are similar among canine breeds.

WEANING KITTENS

Weaning is a gradual process that begins when kittens are 3–4 weeks old through 6–9 weeks of age. Kittens begin to eat solid foods around 3–4 weeks, although the queen's milk is still ~95% of their caloric intake. Kittens

are eating nearly 30% of their caloric requirement as solid food with the remaining 70% from the queen's milk by 5–6 weeks.[4,5,14] A gradual increase of solid food continues until the kittens are no longer nursing from the queen. Most kittens are weaned by 6 weeks of age; however, some purebred kittens may not be weaned until ~8 weeks of age.

As the neonates' food intake increases, the queen's milk production decreases. By 6 weeks of age, most kittens are obtaining their full nutrition from their food and not from the queen (nutritional weaning).[1] Although little milk is being produced by the queen and little nutrition is obtained by kittens, some queens may continue to nurse their young past the 6-week timeframe. It is believed that the psychological and emotional benefits of suckling may be as important as the nutritional benefits in animals older than 5 weeks of age. Because of this, complete weaning (behavioral weaning) should not be done until kittens are at least 7–8 weeks of age.[1,15]

Weaning can be a stressful event in the kitten's life. Transition to independent feeding, greater environmental exposure, and waning maternal antibodies result in reduced immune defense. These factors contribute to increased morbidity and mortality in the postweaning period. Proper nutrition and husbandry can significantly reduce these events.

Recommended nutrient allowances for weanling kittens are similar to those for lactating queens and for growing kittens postweaning. Energy requirements for weanling kittens are between 200–250 kcal/kg body weight.[5] Kittens' stomach volumes are small; thus, feeding energy-dense foods is prudent as it aids in meeting the higher energy needs of weanling kittens without exceeding gastric capacity.

Weaning can be encouraged either by mixing a commercial food specifically made and tested for growth or all life stages with warm water or milk replacer into a soft gruel.[1,5] At this age, kittens lap at but do not prehend food. It is imperative for the veterinary team to remember that cow's milk should not be used to make the gruel, as the lactose level is too high and may contribute to diarrhea. This gruel should be provided in a shallow dish, with the kittens allowed free access several times per day. Remove the gruel after 20–30 minutes to discourage bacterial growth. A homemade weaning formula is not recommended due to the unknown nutrient content, which could lead to nutrient, vitamin, and mineral imbalances as well as unknown caloric density. Initially, food intake will be minimal; however, by 5–6 weeks of age the deciduous teeth will have begun to erupt, facilitating chewing of the dry food.

COMMUNICATION TIP

The canine and feline neonatal period is a critical time period, during which nutrition plays a pivotal role. Nutrition can impact both the short-term and long-term health of a neonatal pet.

The food should be highly digestible and complete and balanced for growth and reproduction. The weaning process will be less stressful if kittens are initially offered the same food that will be fed after weaning. Using the same food assists the transition and helps avoid gastrointestinal upset that may occur with food change. Food and water should be easily accessible and offered in broad, shallow pans. Food should be replenished 3 to 4 times daily. Washing pans between feedings is recommended.

The pet owner is encouraged to monitor physical appearance, activity, stool quality, and food intake daily. Weekly, kittens should be weighed and their body condition assessed. Kittens should continue to grow at ~100 g/week. Gender differences in growth rate may become evident as female kittens are often smaller than males. Kittens should demonstrate increasing activity and social and exploratory behavior. Crying in neonates and older weanling kittens is indicative of distress (cold, hunger, pain, disease, isolation, etc.). Owners should be encouraged to practice good cattery husbandry and monitor kittens closely for disease.

WEANING PUPPIES

The weaning of puppies is a gradual progression with two distinct phases. The first phase begins when puppies start eating solid food between 3 and 4 weeks of age, when deciduous teeth begin to erupt.[1,6,16] This is especially important when the dam has a large litter. Milk production will gradually decrease as the puppies' intake of solid food increases, which makes the second phase, known as complete weaning, less stressful.

It should be noted that some dams could continue to produce large quantities of milk, thus increasing the risk of mammary congestion when the puppies are completely separated. To aid in reducing mammary gland engorgement, it is recommended to limit food intake for a 24-hour period while puppies are being weaned, as this will reduce nutrients available for milk production.[6] When the decision is made to separate the puppies from the mother, all puppies should be taken away simultaneously.

Weanling puppies should be encouraged to start eating solid food as soon as possible as this helps to:

- reduce reliance on the mother.
- reduce the nutritional burden on the mother.
- make complete weaning less stressful.

Frequently, puppies will accidentally contact the dam's food (during play and exploration) and start eating small amounts little by little. At 3 weeks of age, puppies can be offered gruel to stimulate food intake. Gruels can be put together by blending canned growth/reproduction-type food with an equal amount of warm water. Alternatively, 1 part of dry food can be ground and mixed with 3 parts of warm water. The food used to make the gruel should be highly digestible, contain at least 6.7–8.0 g/100 kcal protein, and have an energy content of ~4.0 kcal ME/gram.[6,17] The dam should be eating a good quality food that is complete and balanced for growth and reproduction. Remind owners that puppies should be monitored for vomiting and diarrhea during this period. If gastrointestinal disturbances do occur, gruel can be made from a highly digestible food intended for dietary management of diarrhea and complete and balanced for growth with a minimum of 6.5 g/100 kcal protein. With the increase in the puppies' solid food, the water content in the gruel can be gradually decreased. By 5 weeks of age the dam's milk production begins to decline, but the puppies should be eating enough solid food at this time.

Puppies can be separated from their mother for short periods of time beginning around 3 weeks of age. The time away from the dam should be increased to ~4 hours a day by around 6 weeks of age. As weaning should be completed between 6 and 7 weeks of age, puppies can be removed from the dam. It is recommended to keep the puppy on the same food after weaning, to help reduce stress and the risk of diarrhea.

SUMMARY

Nutrition plays a role in the health and development of growing kittens and puppies and directly affects the immune system, body composition, growth rate, and skeletal development. Diet is both manageable and perhaps the most important factor that influences health and disease. It is important for the veterinary team to remember that the goal of a feeding plan for kittens and puppies is to create a healthy adult. The specific objectives of a proper neonate feeding plan are to achieve healthy growth, optimize development, minimize risk factors for disease, and achieve optimal health.

Table 2. Important considerations for the neonate's first 48 hours of life[4,6,9]

Key factors	Kittens	Puppies
Ensure colostrum intake	Within 12 hours of birth	Within 24 hours of birth
Environmental temperature	33.3–35.5 °C (92–96 °F)	35.5 ± 0.8 °C (96 ± 1.4 °F)
Birth weight	90–120 g	Breed dependent: 100 g for toy breed to 600 g for giant breed
Daily weight gain	10–13 g/day	5–10% BW gain 1st week
Heart rate	>220 beats/min	230–240 beats/min
Respiration rate	15–35 breaths/min	15–35 breaths/min
Water intake	4.4–6.5 ml water/oz. BW	130–220 ml water/kg BW/day

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NUTRITIONAL SUPPORT OF HEALTHY GROWTH IN PUPPIES

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KEY TAKEAWAYS

- A feeding plan for growing dogs should involve the veterinary health care team, who can recommend the most appropriate diet based on the specific needs of different puppies and consider the characteristics of the family the dog will be joining.
- Puppies need an adequate intake of energy and nutrients to support healthy growth. Both excesses and deficiencies—particularly of energy and calcium, especially in large and giant breeds—can result in osteoarticular malformations.
- Creating a growth chart is the most reliable way to evaluate the growth process and establish safe and healthy feeding management during development.

NUTRITION PLAYS AN ESSENTIAL ROLE IN THE HEALTHY GROWTH OF PUPPIES

The growth phase is a period of physiological demand essential for the development of organic tissues, occurring within an ideal timeframe until adulthood. Its characteristics vary according to breed and the animal's body conformation.[1] Nutrition during this life stage is a key factor in ensuring healthy development, relying on optimal energy intake for growth combined with a well-balanced nutrient profile, and is essential for the proper maturation of musculoskeletal, visceral, and central nervous system tissues.[2]

Energy intake is particularly important, as it regulates the growth rate—growth is accelerated when the energy supply is excessive, and development is delayed when the energy intake is insufficient. Daily energy regulation helps to achieve an ideal body composition, avoiding excessive accumulation of adipose tissue or deficits in lean mass development. Inadequate musculoskeletal development may lead to bone fragility and reduced mineral density—conversely, excessive mineral deposition or growth rate may increase the risk of osteoarticular disturbances.[3,4] Large breed puppies, especially in the first months of life, may exhibit a high rate of daily tissue accretion with higher growth rates compared to other breeds. This rapid growth makes them particularly susceptible to osteoarticular disturbances, requiring careful control of the diet's nutritional composition and the amount of food provided.[5]

One of pet owners' most common concerns when introducing a weaned puppy into the household is, "Can I provide food at will?" The answer is clear—growing dogs should receive controlled portions rather than *ad libitum* access to food. The next question that often arises is, "How much food should be provided?" This directly depends on the animal's energy requirements for healthy development and maintenance of ideal body condition, and the energy content of the diet. To ensure adequate intake of essential nutrients, the energy content of the diet must be compatible with the puppy's energy requirements, so that when energy needs are met, all essential nutrients are also consumed in the correct amounts. Additionally, pet owners frequently have concerns about which type of diet to adopt (whether commercial or home-cooked), feeding schedules, and whether additional supplementation to the daily food intake is necessary. These topics will be explored throughout this chapter.

KEY CONSIDERATIONS FOR DEVELOPING AN EFFECTIVE FEEDING PLAN

When introducing new puppies into a family, factors such as puppy body weight (BW), breed, and growth stage serve as key starting points in developing a specific nutritional plan. Due to differences in body surface area, conformation, activity levels, housing environment, and humanization of companion animals

living with humans, energy and nutritional intake can vary significantly across individuals and breeds.[6,7]

Large and giant dog breeds (LGB, with mature BW over 25 kg) require a longer period to reach adulthood, typically between 18 and 24 months,[6] whereas small and medium dog breeds (SMB, with mature BW under 25 kg) usually reach their adult BW around 12 months.[8] Although the growth rate of LGB is slower and takes longer to complete, their daily tissue accretion is quantitatively very high, with some breeds gaining more than 230 g per day.[9] Additionally, LGB have a higher genetic predisposition to develop orthopedic diseases.[10] This pathological process can occur earlier, have a higher incidence, or become more severe if food composition and nutritional management are inadequate.[1,11]

It is essential to emphasize that regardless of the type of food—whether commercial dry, semi-moist, or wet, or home-cooked—all essential nutrients required for dogs must be present in adequate amounts for the specific life stage, avoiding both excesses and deficiencies in the formulation.[12] In this regard, it is particularly challenging to balance homemade diets during growth and they should only be recommended under the supervision of a qualified veterinarian properly certified in nutrition. Owners often make daily ingredient measurements subjectively and might make substitutions, inclusions, or exclusions, increasing the risk of altering nutrient proportions. Additionally, mineral and vitamin supplementation, which is crucial for a properly balanced homemade diet, may not always be palatable and can be considered expensive by owners, leading to its potential omission from the diet.[13]

Moreover, offering treats during growth—often used for training purposes—should be done cautiously and be planned, ensuring they do not exceed 10% of the puppy's total daily caloric intake. Low-calorie options should be prioritized in both homemade treats and commercial products.[14] Portioning the total daily food and using it as an alternative training reward can be an effective strategy to prevent any disruption to the overall caloric or nutrient intake.

Owners often have questions about supplements, particularly those aimed at promoting vitality, health, and skin and coat quality. The general rule is that if the food is complete and balanced, nutritional supplements are not necessary. The exception may be the use of nutraceuticals—which are designed to modulate gut or overall health, immunity, or other specific functions—when based on scientifically proven products and used correctly. However, uncontrolled nutrient supplementation in an already balanced diet is not only unnecessary but can also be harmful. These products are often highly concentrated, and even a small amount can result in excessive intake with a risk of nutrient oversupply.[15] A suggested workflow to establish a nutrition plan for healthy growth is illustrated in **Figure 1**.

COMMUNICATION TIP

Proper nutrition during growth is a key factor in ensuring healthy development, relies on optimal energy intake combined with a well-balanced nutrient profile, and is essential for the proper maturation of musculoskeletal, visceral, and central nervous system tissues.

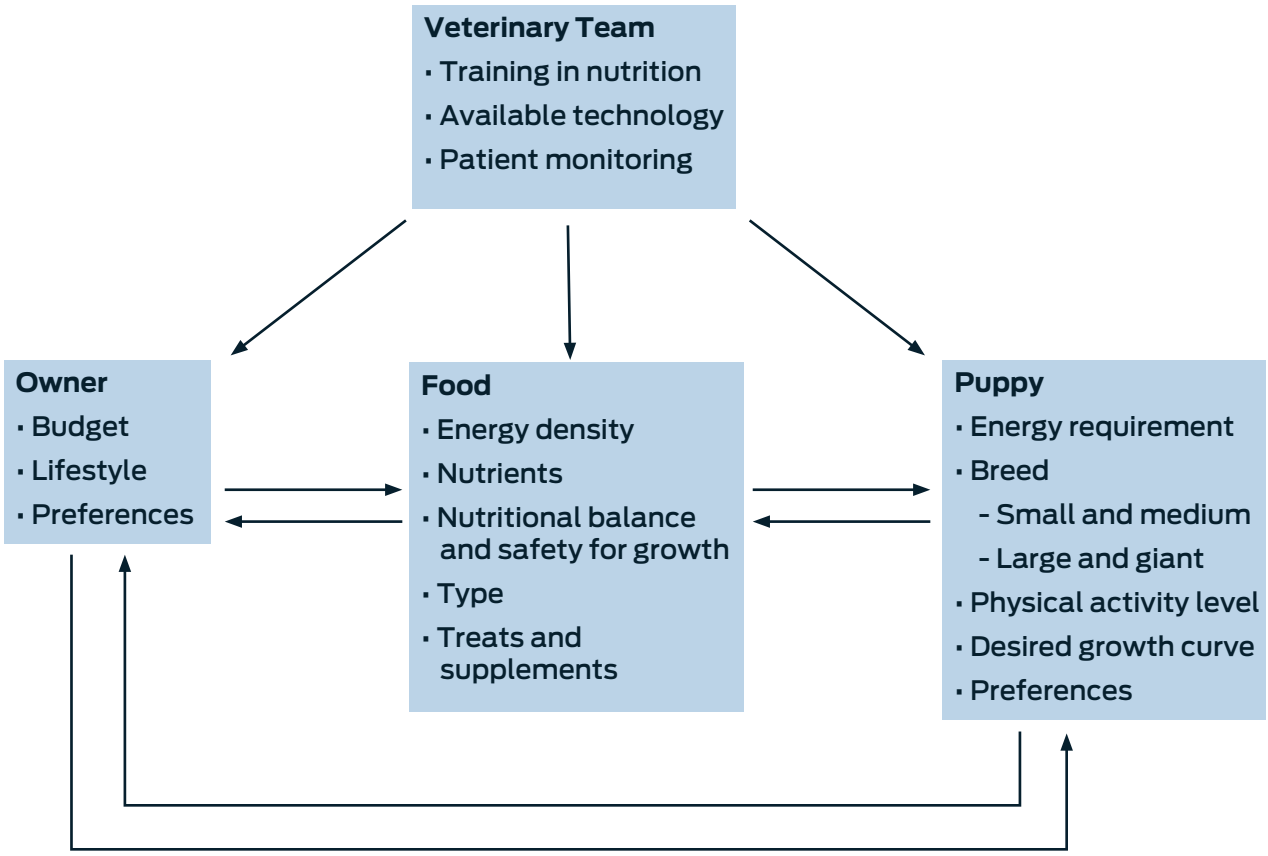
ENERGY REQUIREMENTS FOR POST-WEANING GROWTH

The energy requirement fluctuates throughout neonatal and post-weaning phases, gradually decreasing until adulthood, when it stabilizes at maintenance level.[11] There is limited consistent data on energy requirements for growth during the end of the neonatal phase until approximately the eighth week of life. After this period, energy needs can be estimated using predictive equations based on the puppy's current weight and anticipated adult weight.[12,16]

The equation proposed by NRC (2006) appears to overestimate the actual energy requirement of SMB by up to 20%.[12] The equation proposed by Klein (2019) seems to be closer to actual values;[16] however, it may still exhibit consistent deviations for some individuals (**Table 1**). For Great Danes, an additional 25% of the previously calculated energy requirement is recommended.[17]

While these equations are useful, it is essential to treat them as starting points, making regular adjustments biweekly or monthly based on individual growth

Figure 1. Suggested workflow with key considerations for developing a feeding plan



curves. Exponential growth is evident until a puppy reaches 50% of its estimated adult BW, after which growth gradually slows down in the following weeks until adulthood. Predictive equations for estimating growth curves from the eighth week to one year of age are available.[18] While these general equations are useful, more specific growth charts, based on more precise BW intervals and sex, can also be found.[19,20] For these calculations, the puppy's weight at 12 weeks of age may be considered the starting point.[7] Although male and female puppies have similar BW at birth, males generally present with higher BW in the following weeks and in adulthood due to the physiological effects of male sex hormones.[4,7] Finally, it is important to note that while these tools are practical and easy to implement, they are not free from errors and must be used with discretion and care.

KEY NUTRIENTS FOR POST-WEANING GROWTH

Healthy growth in puppies requires at least 42 essential nutrients.[12] Their proper concentration in the diet depends on the food's energy density and the individual's energy requirements, which together determine the amount of food and nutrient intake. Bioavailability is also a critical factor, influenced by ingredient quality, food processing methods, and food stability throughout its shelf life. Determining nutrient bioavailability in puppies is challenging, as their digestive and metabolic systems are still maturing.[2]

Food energy

The energy density of food can serve as the starting point for product selection. In LGB where the risk of rapid, unhealthy growth is a greater concern, products with moderate energy density, equal to or below 3.7 kcal/g of dry matter (DM), associated with controlled portion feeding, are recommended. There is more flexibility in selecting food energy content for SMB, basing it on individual preferences, intake behavior, and growth curves.

Protein

The protein requirement for growth does not differ between breeds and sizes.[4] Studies in giant breed dogs have shown that normal or high levels of crude protein (CP) did not impact growth, provided energy intake remained consistent.[21] More important than CP itself, dogs require 10 essential amino acids for growth,

along with cysteine and tyrosine in combination with methionine and phenylalanine, respectively. Because of this, the information on CP content on labels is insufficient to assess the quality of protein nutrition in puppies. Given the actual energy intake during growth, the values proposed by FEDIAF (2024) seem more appropriate to ensure adequate amino acid consumption: 25% (6.25 g/100 kcal) of CP in early growth (< 14 weeks of age); 20% (5 g/100 kcal) of CP in late growth (> 14 weeks of age).[18]

Fat and essential fatty acids

Fats provide energy for growth and supply essential polyunsaturated fatty acids, which are necessary for maintaining the integrity of cell membranes and epithelial barriers, developing neuronal tissue, forming the retina to ensure proper vision, and supporting the development of immune and inflammatory responses.[2,22] To meet these needs, puppy food should contain at least 8.5% total fat (2.12 g/100 kcal), with specific recommendations for individual fatty acids: 1.3% linoleic acid, 0.03% arachidonic acid, 0.08% linolenic acid, and 0.05% for the sum of eicosapentaenoic and docosahexaenoic acids.[18] This highlights the importance of including specialized fat sources in puppy diets, such as fish oil, fish meal, or algae derivatives.

Calcium, phosphorus, and vitamin D

Osteoarticular formation and growth are key aspects of healthy development. Excessive energy supply must be avoided, especially in LGB, as a rapid growth rate can disrupt endochondral ossification, increasing the risk of osteochondrosis and osteochondritis. These conditions may result in asynchronous bone growth and joint malformations, severely compromising the puppy's health and well-being.[23]

Calcium, phosphorus, and vitamin D are strictly regulated in the body by a sophisticated endocrine system.[1] During growth, puppies are more vulnerable to imbalances of these substances, requiring their intake to fall within an ideal range.[3] Additionally, it has been demonstrated that LGB puppies metabolize and regulate calcium and vitamin D differently from SMB puppies.[24] Higher passive intestinal calcium absorption and elevated levels of growth hormone make LGB puppies more susceptible to osteomegaly when exposed to excessive calcium intake. This condition is characterized by increased bone density or mass and altered endochondral ossification.[25] Differences in metabolizing vitamin D have also been reported in some LGB puppies, making them more susceptible to vitamin D excess. This can lead to excessive calcitonin secretion, disturbances in bone remodeling, growth plate enlargement, and altered endochondral ossification.[24,25] The opposite scenario—low calcium, phosphorus, and vitamin D intake—equally affects puppies of all breeds and sizes, leading to reduced bone density, lameness, difficulty walking, and spontaneous fractures caused by nutritional hyperparathyroidism. Additionally, the total phosphorus content and its ratio to calcium are also critically important factors when formulating a balanced diet for growing puppies.[26] To

Table 1. Suggested equations to estimate energy requirements and growth curves for puppies

Reference	Puppy feature	Reference energy requirement (kcal/day) to growth
NRC (2006)[12]	All dogs	$130 \times BW^{0.75} \times 3.2 \times [Ln^{(-0.87 \times p)} - 0.1]$
Klein et al. (2019)[16]	8 weeks to 12 months	$[254.1–135.0 \times (BW_a/BW_m)] \times BW^{0.75}$
	Weight at 12 weeks (kg)	**Growth Curve**
FEDIAF (2024)[18]	≤ 7	% of expected mature BW = 36.92×Ln (age in weeks) – 43.57
	> 7–15	% of expected mature BW = 36.86×Ln (age in weeks) – 48.22
	> 15–27.5	% of expected mature BW = 39.88×Ln (age in weeks) – 60.70
	> 27.5–47.5	% of expected mature BW = 36.96×Ln (age in weeks) – 56.18
	> 47.5	% of expected mature BW = 36.61×Ln (age in weeks) – 62.39

find the recommendations for calcium, phosphorus, and vitamin D in growing puppies, readers can refer to the FEDIAF (2024) guidelines, which include specific recommendations for SMB and LGB puppies.[18]

FEEDING MANAGEMENT

Effective feeding management involves selecting appropriate food, controlling portion sizes, and establishing a consistent feeding schedule. Portion-controlled feeding is especially important during growth, as it helps regulate food intake to support a healthy growth curve. The success of this feeding strategy requires owners to understand the approach well and commit to an individualized nutritional plan. It is best that puppies are fed multiple small meals per day—typically starting with three to four meals and gradually transitioning to two meals as they grow. The number of meals may vary based on the puppy's feeding attitudes, as well as the owner's availability and preferences.

MONITORING AND REASSESSMENT

Regular monitoring and reassessments are essential to ensure optimal growth. Every two to four weeks, body growth (body weight) should be evaluated and compared to the puppy's target growth curve. This can be done at home or at a veterinary clinic. These reassessments are crucial, as equations for estimating energy requirements may provide inaccurate estimates, and there is significant variation in energy needs among individuals and breeds.

During these evaluations, BW, body condition score, muscle mass score, skin and coat condition, and overall behavior should be assessed. A growth curve should be charted, maintained, and updated regularly. Detecting faster or slower growth rates will signal the need for immediate adjustments in the amount or type of food provided to maintain healthy growth.

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PRACTICAL TOOL: NUTRITION FOR LARGE BREED PUPPIES

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Large breed puppies have unique nutritional needs, although the definition of a "large breed" can be controversial. Many veterinarians consider puppies that have an expected adult weight over 25 kg (55 pounds) to be "large breed"; however, AAFCO recommends feeding large breed puppy foods to puppies that have an expected adult weight of over 70 pounds (32 kg).[1] In contrast, FEDIAF recommends feeding large breed puppy foods to puppies with an expected adult weight of over 15 kg (33 pounds).[2] Large breed puppy foods are often labeled for puppies with an expected adult weight over 25 kg (55 pounds).[3] Giant breed puppies can be considered separately from large breed puppies when their anticipated adult weight is over 45 kg or 100 pounds. However, neither AAFCO nor FEDIAF makes this distinction between large breed and giant breed.[3]

Large breed puppy foods typically have a larger kibble size than other puppy diets to ease prehension and promote dental health.[4] Puppy food should be provided until the puppy is fully grown because of the increased demand for nutrients throughout the growth phase. Large breed puppies grow until about 18 months, whereas giant breed puppies grow until about 24 months. Growth charts can be helpful to determine when growth is completed.[3] Diets formulated for large breed puppies usually meet the strictest nutrient requirements for large and giant breed puppies. Calcium and phosphorus are particularly controlled in large breed puppy food, as imbalances of these nutrients will result in irreversible skeletal deformities.[5] All puppies need eicosapentaenoic acid and docosahexaenoic acid (EPA and DHA) for brain and retina development, so these should be present in large breed puppy foods.[2]

The energy density of large breed puppy diets varies, as large breed puppies can have variable energy requirements. For example, Newfoundland puppies have lower energy requirements, whereas Great Dane puppies have higher energy requirements than other puppies.[6] Furthermore, energy demands are high after weaning and decline thereafter, with spay and neuter surgery significantly lowering energy requirements.[3,7] On top of that, much individual variability of energy requirements exists, necessitating adjusting feeding amounts for each individual.[8] Maintaining an ideal body condition is important to prevent overweight and obesity and comorbidities later in life, such as orthopedic disease.[7] Feeding amounts should be adjusted based on growth charts and, more importantly, BCS.[9] Veterinarians should consider teaching pet owners to assess BCS. Owners should check body weight and BCS in large breed puppies every 2 weeks. While body weight is expected to gradually increase in puppies, the owner should alert the veterinary team if there are any decreases or large increases in body weight, or any changes in BCS.

Table 1. Factors to consider when selecting a diet for large breed puppies

Nutrient	Amount relative to adult maintenance requirements	Amount relative to small and medium breed puppies' needs	Recommended amount in dry matter basis (per 100 grams dry matter)	Recommended amount in calorie content basis (per 100 kcal)
Energy Density	Higher	Variable	≥ 350 kcal	n/a
Protein	Higher	Similar	> 25 grams	> 6.25 grams
Calcium	Higher and more tightly controlled	More tightly controlled	1.20-1.60 grams	0.30-0.40 grams
Phosphorus	Higher and more tightly controlled	Similar	1.00-1.60 grams	0.25-0.40 grams
Ca:P	More tightly controlled	More tightly controlled	1:1 - 1.6:1	1:1 - 1.6:1
EPA + DHA	Higher	Similar	> 0.05 grams	> 0.013 grams

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PRACTICAL TOOL: NUTRITIONAL CONSIDERATIONS FOR SMALL AND TOY BREED DOGS

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It is important to consider the specific nutritional needs of small (6–10 kg) and toy breed dogs (< 6 kg), as there are physiological differences that impact their growth, development, and lifelong health. This table provides an overview of the unique nutritional needs of small and toy breed dogs.

Table 1. Factors to consider when selecting a diet for small and toy breed puppies

Consideration	Physiological differences in small and toy breed dogs	Nutritional modification and rationale
Metabolic rate and energy needs	Small dogs have a lower basal metabolic rate but a higher mass-specific metabolic rate than larger dogs.[1]	May require a higher energy density food to help small dogs consume enough calories from the food provided. Adjustments in caloric intake may be needed based on individual metabolic differences.
Nutrient density	In addition to higher mass-specific metabolic rates, small and toy breed dogs tend to have smaller stomachs relative to body size than larger dogs.	Requires higher concentrations of nutrients (such as protein and micronutrients) to ensure that nutrient requirements are met despite smaller food intake.
Digestive physiology	High levels of some ingredients, such as cellulose, may excessively limit colonic fermentation, potentially leading to constipation in smaller dogs.[2]	Fermentative activities should be promoted in small and toy breed dogs. Limit ingredients that could reduce colonic fermentation. Selecting highly digestible ingredients and higher proportions of fermentable fibers is recommended.[2] In addition, using blends of different fibers in a diet can support gut health.
Body and muscle condition	Although many small and toy breed dogs require more energy- and nutrient-dense foods than their larger counterparts, it is important for them to maintain ideal body and muscle condition. Small and toy breed dogs are predisposed to gaining excessive weight. For example, since they require relatively small amounts of food, it is easy for owners to accidentally overfeed these patients. Many of these dogs also get limited exercise.	Monitor individuals to maintain a lean, healthy body and muscle condition. Intervene early if excessive body weight is noted. The energy intake from snacks or treats should not exceed 10% of the pet's total daily calories.
Feeding for growth	Puppies should be fed a complete and balanced growth diet until they reach full skeletal maturity. In small and toy breed dogs, skeletal maturity may be reached as early as 9 months of age.	After skeletal maturity is reached, a complete and balanced adult maintenance diet can be chosen. Individual variation in metabolism should be considered for puppies and adult dogs. Feed to maintain normal growth and a lean, healthy body condition.
Dental health	Small and toy breed dogs are prone to dental disease due to small mouth size and crowded teeth. They may also have difficulty eating large kibbles.	Smaller kibbles can be easier to chew. Dental-specific diets help to reduce plaque and calculus formation. Tooth brushing is also recommended.

Table 1. *Continued*

Consideration	Physiological differences in small and toy breed dogs	Nutritional modification and rationale
Skin and coat health	Small and toy breed dogs are predisposed to developing skin conditions such as atopic dermatitis and chronic skin infections.[3]	Some small dogs may benefit from complete and balanced diets with higher levels of skin-nourishing nutrients such as vitamin A, essential fatty acids, and high-quality protein. These nutrients, often found in higher proportions in diets formulated for small and toy breed dogs, may help promote healthy skin and a shiny coat.
Blood glucose regulation	There is an increased risk of hypoglycemia, especially in puppies and toy breeds, due to limited glycogen storage.	Frequent, small meals at regular intervals can help maintain stable blood glucose levels. Dietary carbohydrate intake should be maintained at a consistent level and any dietary transitions should be gradual.

ADDITIONAL CONSIDERATIONS

- **Importance of consulting a qualified veterinary nutritionist or Board Certified Veterinary Nutritionist.** Some small and toy breed dog owners may wish to home-cook meals for their dogs. If a recipe has not been formulated by a qualified or board certified veterinary nutritionist, it is typically unbalanced.[4] Owners wishing to home-cook should be referred for a consultation.

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NUTRITIONAL SUPPORT OF ADULT DOGS

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KEY TAKEAWAYS

- To build an individualized feeding plan, a dog's needs should be recognized/established/evaluated and integrated with owner constraints or preferences.
- Complete and balanced diets are necessary. A well-balanced diet for adult dogs should provide more than 40 essential nutrients, including amino acids, fatty acids, fiber, vitamins, and minerals.
- Proper portion control and consistent feeding schedules help prevent obesity and ensure adequate nutrient intake.

ESSENTIAL ROLE OF NUTRITION IN QUALITY OF LIFE AND OVERALL HEALTH

Adequate nutrition is a cornerstone for optimal health, well-being, and longevity in adult dogs. Owners must understand that, while dogs share their families' daily routines and enjoy close interactions with humans, they are a distinct species. This means that dogs have unique nutritional needs that owners must understand and meet.

Providing dogs with a large amount of treats such as biscuits, or imposing human cultural dietary values is neither an expression of affection nor a healthy practice. Instead, it demonstrates a misunderstanding of their nutritional needs and puts pets at risk of malnutrition, most notably obesity—which can severely impact their well-being, quality of life, and longevity.[1,2] This highlights the importance of veterinarians' involvement in guiding proper dietary management for dogs, and working alongside owners to discuss and establish the best food choices and feeding strategies tailored to each dog's needs.

KEY CONSIDERATIONS FOR DEVELOPING A FEEDING PLAN

Developing a feeding plan includes assessing the dog's specific requirements and the owner's preferences and constraints, selecting appropriate food options to ensure safety and quality, and regularly reassessing to improve the plan as needed (**Figure 1**).

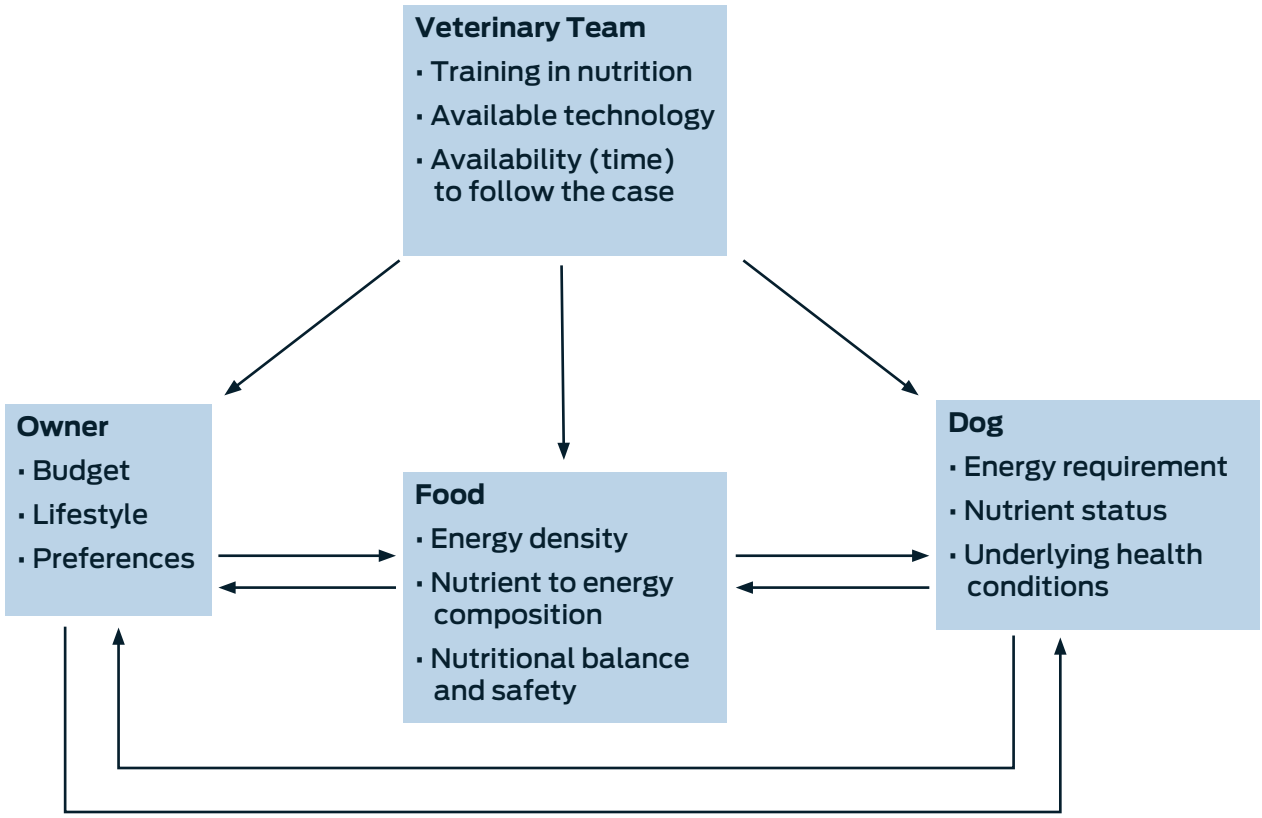
Proper nutrition can be achieved through various food types, provided the product is complete, safe, and nutritionally balanced for dogs. Options may differ in cost, practicality, and safety. While veterinarians trained in veterinary nutrition can effectively design homemade or unconventional diets, the most cost-effective, convenient, and reliable way to provide dogs with all essential nutrients—adult dogs require over forty—is through commercial products from reputable companies with the necessary expertise and technology. The primary types of commercial pet food include dry diets (kibble), semi-moist food, and wet products. Dry diets are often favored as the main source of nutrition due to their higher caloric density per unit, convenience, cost-effectiveness, and potential benefits for oral health by helping reduce calculus accumulation. However, all these food types, whether used individually or in combination, can provide adequate nutrition when properly balanced.

During food type selection, questions should be asked to better understand the owner's perspective in the following areas:

- **Budget:** What is the owner's financial capacity for food and feeding solutions?
- **Lifestyle:** What is the owner's availability to prepare or administer food?
- **Preferences:** Does the owner have personal or cultural dietary preferences, and how can these be balanced with the dog's nutritional requirements?

Owners must also recognize that the daily amount of food offered and the feeding schedule are equally critical factors in ensuring proper nutrition. Adequate nutrition is only achieved when the right food is provided in

Figure 1. Workflow with key considerations for developing a feeding plan



the right quantity. Therefore, veterinarians should guide owners in determining the appropriate amount of food. Veterinary professionals can use the feeding guidelines on the packaging as a guide and adjust for the individual animal, or energy requirements can be calculated and then adjusted from there.

Additionally, it is necessary to thoroughly discuss supplements, treats, and human foods or table scraps to balance the owner's preferences and expectations with the dog's health and nutritional needs. Owners often overlook the excessive calorie intake from snacks or human food, which poses a significant health risk and can substantially contribute to obesity.[2,3] Treats may also contribute excessive nutrients which can potentially cause health problems.

Commercial diets are generally formulated with safe nutrient margins; however, dogs may face a risk of nutrient imbalance when snacks or extra food make up more than 10% of the daily caloric intake. Rather than forbidding snacks, working with the owner to strategically incorporate them into the dog's feeding plan and creating a balanced, enjoyable, and healthy feeding routine is recommended.

SPECIFIC REQUIREMENTS OF EACH DOG

Understanding a dog's individual nutritional needs requires considering factors such as age, breed, size, activity level, health status, reproductive status, and any medical conditions. The maintenance phase in feeding is established when a dog reaches its mature size and does not undergo significant physiological demands, such as intense physical activity. The primary objective during this stage is to provide a complete and balanced diet that meets the dog's energy and essential nutrient requirements while supporting the pet's lifestyle and maintaining an ideal body condition.

Assessing a dog's nutritional status also guides the veterinarian in selecting the appropriate nutrient composition for the diet. This evaluation includes, at minimum, determining the BCS, MCS, and assessing the skin and coat condition.[4] These evaluations are an integral part of a physical exam and veterinarians can consult various resources for their application.[5]

Overweight or obese dogs (BCS > 7 on a 9-point scale)[6] are best managed with a low-energy, low-fat, high-fiber

diet, whereas underweight dogs (BCS < 3) may require a high-energy, high-fat, low-fiber diet. Low MCS indicates the need for a more comprehensive clinical evaluation to rule out underlying diseases. Additionally, these dogs require a diet rich in protein, energy, vitamins, and minerals, with high palatability to help restore muscle mass reserves. Poor or compromised skin and coat condition may suggest underlying health issues affecting nutrient balance or indicate an inadequately formulated diet, one that is unbalanced or deficient in nutrients. In such cases, a nutrient-dense, highly palatable diet is necessary to ensure sufficient intake of essential amino acids, fatty acids, minerals, and vitamins, all of which are directly linked to hair and skin homeostasis.[7]

Dental and oral health should always be evaluated. In older dogs, periodontal disease and tooth mobility, pain, and loss can significantly impact food apprehension, swallowing, and overall intake. Regular oral examinations are essential, and the most appropriate food type should be selected considering the dog's oral health status to ensure proper nutrition and ease of eating.

HOW TO ESTIMATE ENERGY REQUIREMENTS AND INTEGRATE THEM IN THE FEEDING PLAN

Healthy adult dogs regulate their food intake based on their daily energy requirements. Therefore, the caloric content determines the amount consumed rather than the volume of food itself. This underscores the importance of selecting diets with appropriate nutrient ratios relative to the dog's energy intake. Otherwise, a dog may consume enough calories but fail to meet its essential nutrient requirements, leading to potential deficiencies. Due to this, FEDIAF[8] has proposed separate nutrient allowances for dogs with low and normal energy requirements, providing a valuable resource for balancing and selecting appropriate diets.

The challenge is that dogs exhibit an unparalleled diversity in body weight and size, along with varying temperaments and housing conditions that influence their levels of physical activity. As a result, energy requirements are more accurately aligned with metabolic body weight ($BW^{0.75}$) rather than directly correlating with body weight. Individual MER can vary widely, ranging from 85 to 220 kcal/kg $BW^{0.75}$/day. This variability reflects the influence of multiple factors, including breed, age, activity level, neutering status, environmental conditions, and body composition.[9]

COMMUNICATION TIP

Owners must understand that, while dogs share their families' daily routines and enjoy close interactions with humans, they are a distinct species. This means that dogs have unique nutritional needs that owners must understand and meet.

Food amounts must be determined based on energy requirements and energy density of the diet. Dogs with high energy needs consume more calories and larger food portions and can be fed diets with standard nutrient levels, as outlined by AAFCO.[10] Conversely, dogs with low energy needs consume fewer calories and smaller food portions. To prevent deficiencies, they require diets with lower caloric density but enriched with essential nutrients, which are defined in FEDIAF but not AAFCO.[8]

Table 1 provides general guidelines for selecting the appropriate food composition based on expected energy requirements. These recommendations serve as a reference for choosing a diet. Still, patient-specific recommendations should be flexible to accommodate the specific needs of both dog and owner, as well as the veterinarian's professional perspective.

PROTEIN IN ADULT DOG NUTRITION

Protein content in commercial diets for adult dogs can vary significantly (15%–60%, dry matter basis [DM], or 3.6–15 g/100 kcal). The dietary requirement for protein is primarily based on the need for essential amino acids rather than total crude protein. As a result, crude protein levels on labels do not provide much meaningful nutritional information. Once the amino acid requirements are satisfied, additional protein does not necessarily provide further physiological benefits. Excess protein is metabolized by the liver, with the by-products excreted via the kidneys.

The minimum crude protein recommendation depends on the amount of food consumed and the protein

quality (essential amino acid balance and digestibility). The NRC (2006) recommends protein intake of 3.28 g/kg $BW^{0.75}$/day,[9] but FEDIAF (2024) suggests 4.95 g/kg $BW^{0.75}$/day for healthy adult dogs fed commercial diets with at least 80% crude protein digestibility.[8]

FATS AND ESSENTIAL FATTY ACIDS

Fats serve as a concentrated energy source, facilitate the absorption of fat-soluble vitamins (A, D, E, K), and increase diet palatability. Essential fatty acids (EFAs), such as linoleic and α-linolenic acids, are indispensable for dogs due to their inability to synthesize these compounds, which play key roles in maintaining cell membrane integrity and supporting eicosanoid, prostaglandin, and leukotriene production.[11] Linoleic acid deficiency can result in dermatological issues, including skin hyperproliferation and increased transdermal water loss.

The minimum fat requirement for adult dogs is 5.5% on DM (1.37 g/100 kcal), including at least 1.53% linoleic acid (0.38 g/100 kcal).[8] Fat content in commercial foods can vary significantly depending on energy density, palatability, and the product's targeted population. Low-energy-dense products may contain less than 12% fat (3 g/100 kcal), while high-energy-dense foods may contain more than 18% fat (4.5 g/100 kcal).

CARBOHYDRATES IN ADULT DOG DIETS

Starch is the primary digestible carbohydrate in prepared diets and is efficiently utilized by dogs as an energy source. The type and amount of starch in commercial diets can vary significantly, ranging from 10% to 65% on DM, and may include ingredients such as cereals, tubers, and pulses. These sources are safe for dogs and play an important role in balancing the overall energy content, as well as the ratio of protein, fat, and other essential nutrients in the diet.

Fiber contributes to reducing energy density and digestibility, also promoting satiety. Fiber is essential to gut physiology, influencing microbiota composition and formation of fermentation products, which ultimately impact overall health. Diets containing up to 4% crude fiber on DM (1 g/100 kcal) are generally adequate, while higher fiber levels (> 6% on DM, or 1.5 g/100 kcal) can be particularly beneficial for dogs prone to obesity.

FEEDING MANAGEMENT

Effective feeding management involves selecting the appropriate food, controlling portion sizes, and establishing a consistent feeding schedule. While some dogs are able to self-regulate their food intake on an *ad libitum* basis, many tend to overconsume, increasing their risk of obesity and related health complications.

Portion-controlled feeding allows for precise monitoring of calorie and nutrient intake, making it easier to detect any deviations, such as low or excessive consumption, which could signal underlying medical issues. It also helps maintain control over body condition, supporting the maintenance of healthy body weight. However, portion-controlled feeding requires a higher level of owner commitment, as it involves food preparation, weighing or measuring, and a consistent feeding schedule. Success depends on the owner's understanding of the approach's importance and their dedication to following individualized nutritional plans.

Dogs have a large capacity to store food in their stomachs,[12] which allows many to adapt well to a single meal per day. However, some owners may feel that this is inadequate for the dog's behavior and welfare, preferring to divide the daily amount into two or more meals. Some dogs, particularly those with difficulty eating or prone to being underweight, may not adapt well to a single meal per day. In such cases, offering multiple small meals throughout the day is preferable.

When transitioning between diets with different energy densities or consistencies, it is recommended to make gradual changes over a period of three to seven days to minimize digestive disturbances. Snacks and table scraps should make up no more than 10% of the daily caloric intake and should ideally complement the nutritional profile of the main diet.

MONITORING AND REASSESSMENT

Regular monitoring and reassessments are essential for maintaining optimal nutrition in adult dogs, although their frequency may vary depending on the dog's condition. During these evaluations, body weight, BCS, MCS, and skin and coat condition should be assessed, along with overall attitude, behavior, and diet acceptance. The owner's feeding practices should

Table 1. Suggested criteria to select a diet composition for adult dog maintenance based on expected energy requirements

	Low energy requirement	Normal to high energy requirement
Conditions associated	Old age (> 7 yo), neutering, low level of exercise, obesity, hypothyroidism, specific breeds	Young age, intact, normal to high level of exercise, underweight, some diseases, specific breeds
Suggested range of calories per day	75–95 kcal/kg $BW^{0.75}$/day (approximately 1–1.4 x RER)	> 110 kcal/kg $BW^{0.75}$/day (>1.6 x RER)
Suggested food characteristics	Moderate to low energy (< 3.6 kcal/g as-fed) for dry diets	Normal to high energy (> 3.8 kcal/g as-fed) for dry diets
	Amino acids and proteins in higher amounts [> 21% crude protein on dry matter basis (5.2 g/100 kcal)]	Amino acids and proteins at least at maintenance amounts [> 18% crude protein on dry matter basis (4.5 g/100 kcal)]
	Moderate in fat [< 14%, dry matter basis (3.5 g/100 kcal)]	Fat concentrations may vary
	Vitamins and minerals corrected for low food intake (higher levels)	Vitamins and minerals at maintenance amounts
	Supplemented in fiber [> 4% crude fiber on dry matter basis (1 g/100 kcal)]	Fiber in amount necessary for intestinal health [< 3% crude fiber on dry matter basis (0.7 g/100 kcal)]

also be reviewed and corrected if needed. Routine blood work is advisable as abnormalities may need to be addressed with modifications to the nutrition plan.

Checking in with the owner in the first weeks of implementing a new diet or feeding plan can be beneficial to monitor the dog's body weight and food intake. Diet acceptance may not always be optimal and energy requirement estimations may vary considerably between individuals. Errors in estimating energy needs can be minimized when based on actual food intake history instead of estimated by equations. If detailed information on all consumed foods is collected during dietary assessment, the veterinarian can assess the dog's energy intake with higher accuracy. However, when this is not possible or practical, it is essential to remember that individual dogs may deviate significantly from predictive equation estimations as well as from packaging feeding guidelines. Any unintended changes in body weight require adjustments of either food quantity or its composition.

CONCLUSION

Optimized nutrition for adult dogs requires an individualized approach that accounts for variations in energy and nutrient requirements. A well-balanced diet should provide adequate levels of 12 essential amino acids and protein, two essential fatty acids and fats, 12 minerals, and 13 vitamins, ensuring the right balance between essential nutrients and available energy. Additionally, digestible carbohydrates and fiber are important for macronutrient balance and intestinal health, while also helping to achieve an energy density that meets the dog's metabolic demands.

Maintaining an ideal body condition helps prevent obesity-related risks and promote longevity. Achieving this requires portion-controlled feeding and the owner's compliance with the feeding plan, which should be emphasized during consultations. Effective communication with pet owners is key to bridging the gap between evidence-based recommendations and their practical implementation.

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NUTRITIONAL SUPPORT OF SENIOR DOGS

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KEY TAKEAWAYS

- Individual assessment of each dog's nutritional status is important as senior dogs are a heterogeneous group with significant differences in their energy requirements and health status.
- Delaying sarcopenia and frailty in senior dogs can be achieved through adequate nutrition (protein and energy intake). Careful monitoring of BCS and MCS is warranted so that nutritional intervention can be made promptly.
- Nutritional interventions, MCTs, omega-3 fatty acids (EPA and DHA), and antioxidant blends have a positive impact on cognitive dysfunction syndrome in older dogs.

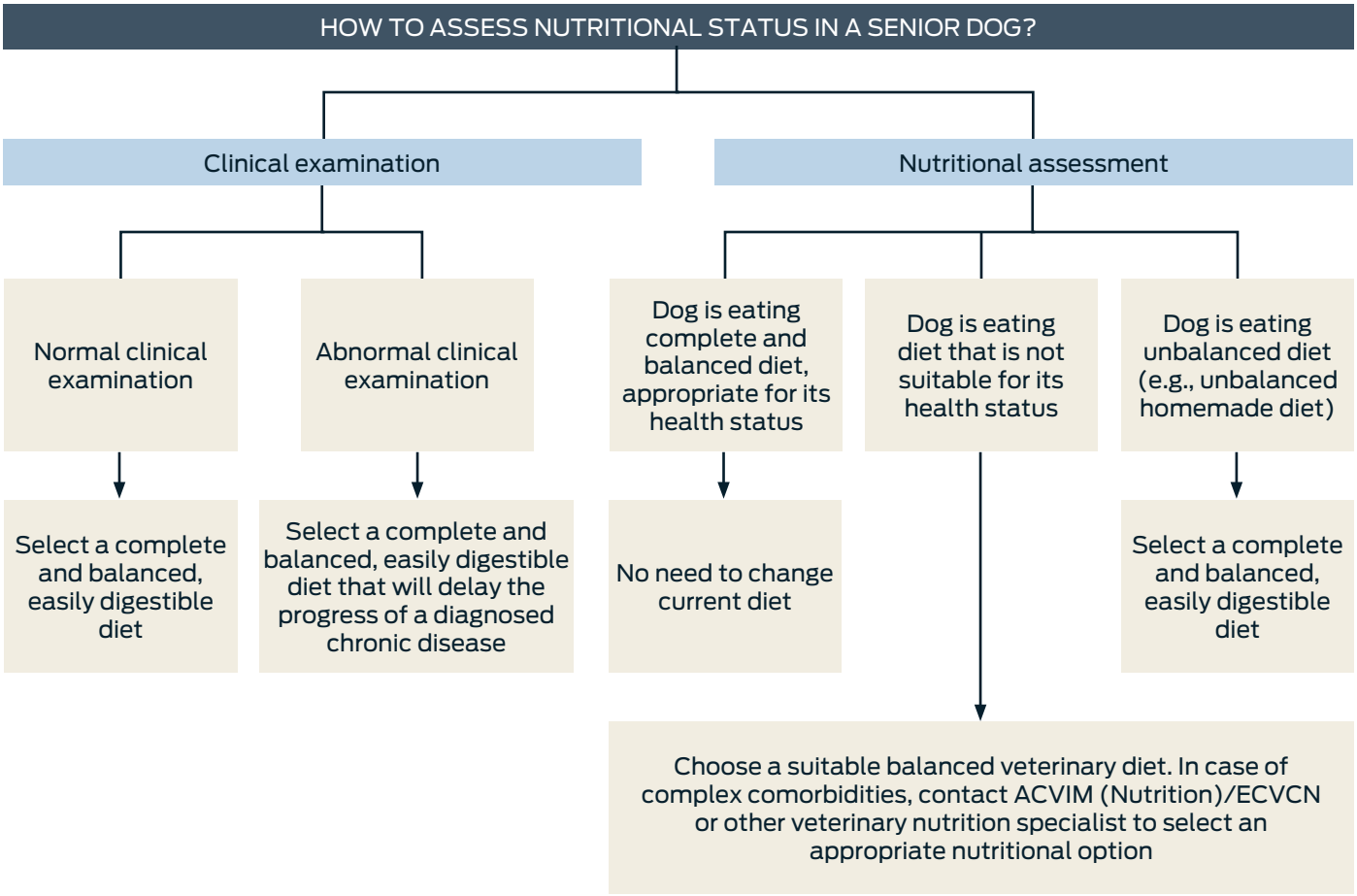
VARIATION AMONG SENIOR DIETS AND DIFFERENT REQUIREMENTS BASED ON THE INDIVIDUAL DOG

The senior stage in dogs is not precisely defined, as there are considerable differences between life expectancies depending on breed. Breed size is known to correlate negatively with expected life span.[1,2] Moreover, different aging rates can occur within a breed due to genetic and environmental influences over the course of a lifetime. Therefore, the senior phase of life in dogs is considered the most physiologically diverse. There are currently no published nutritional guidelines for the "senior" life stage. The nutritional requirements of senior dogs are not specifically defined according to current NRC,[3] FEDIAF,[4] or AAFCO dietary recommendations. Nevertheless, the nutritional composition of the diet can be adjusted to better meet the challenges of aged pets. This ultimately leads to great variability in the composition of diets marketed for senior dogs. Therefore, a critical evaluation and selection of diets based on the individual dog and its requirements are warranted. A careful evaluation of the diet based on digestibility, energy density, protein and fat content, dietary fiber content, eicosapentaenoic (EPA) and docosahexaenoic (DHA) fatty acid (FA) concentration, omega-3 to omega-6 FA ratio, phosphorus, and the addition of antioxidant blends and/or medium-chain triglycerides (MCTs) should be made (**Figure 1**).

MAINTAINING IDEAL BODY CONDITION AND CHANGES IN ENERGY REQUIREMENTS

When evaluating nutritional status, it is important to consider the energy intake of the individual dog, which ultimately determines nutrient intake. The maintenance energy requirement (MER) in senior dogs decreases by approximately 25% or more.[5,6] MER is estimated at 95 kcal/$BW^{0.75}$ for dogs older than 7 years.[4] However, this does not apply to all seniors, as individual energy requirements vary greatly in older dogs and can range from 80 to 120 kcal/$BW^{0.75}$. Therefore, energy intake should be individualized, as some senior pets would benefit from a more nutrient-dense diet, while others that are prone to obesity would benefit from a less calorie-dense diet balanced to promote a healthy weight or weight loss. In the case of unintentional weight loss, a timely assessment of nutritional status by evaluating BCS, MCS, body weight, and energy intake would raise concern even before clinical signs of chronic disease [e.g., neoplasia, chronic kidney disease (CKD)] are present. Similarly, unintentional weight gain combined with reduced mobility could indicate the presence of osteoarthritis or could be a sign of hypothyroidism. White adipose tissue primarily stores triglycerides as a source of energy and protects the organs. However, it also plays an important role in metabolism as an endocrine organ and releases various factors known as adipokines.[7] In a state of obesity, where white adipose tissue accumulates in excess, it contributes to a chronic state of mild inflammation and oxidative stress.[8] In senior patients, who are often found to have chronic impairment in various organ systems, obesity would ultimately pose a significant risk of exacerbating inflammation.[9] Therefore, it is of utmost importance to implement an appropriate weight loss protocol in

Figure 1. How to assess the nutritional status of a senior dog based on clinical examination and nutritional history



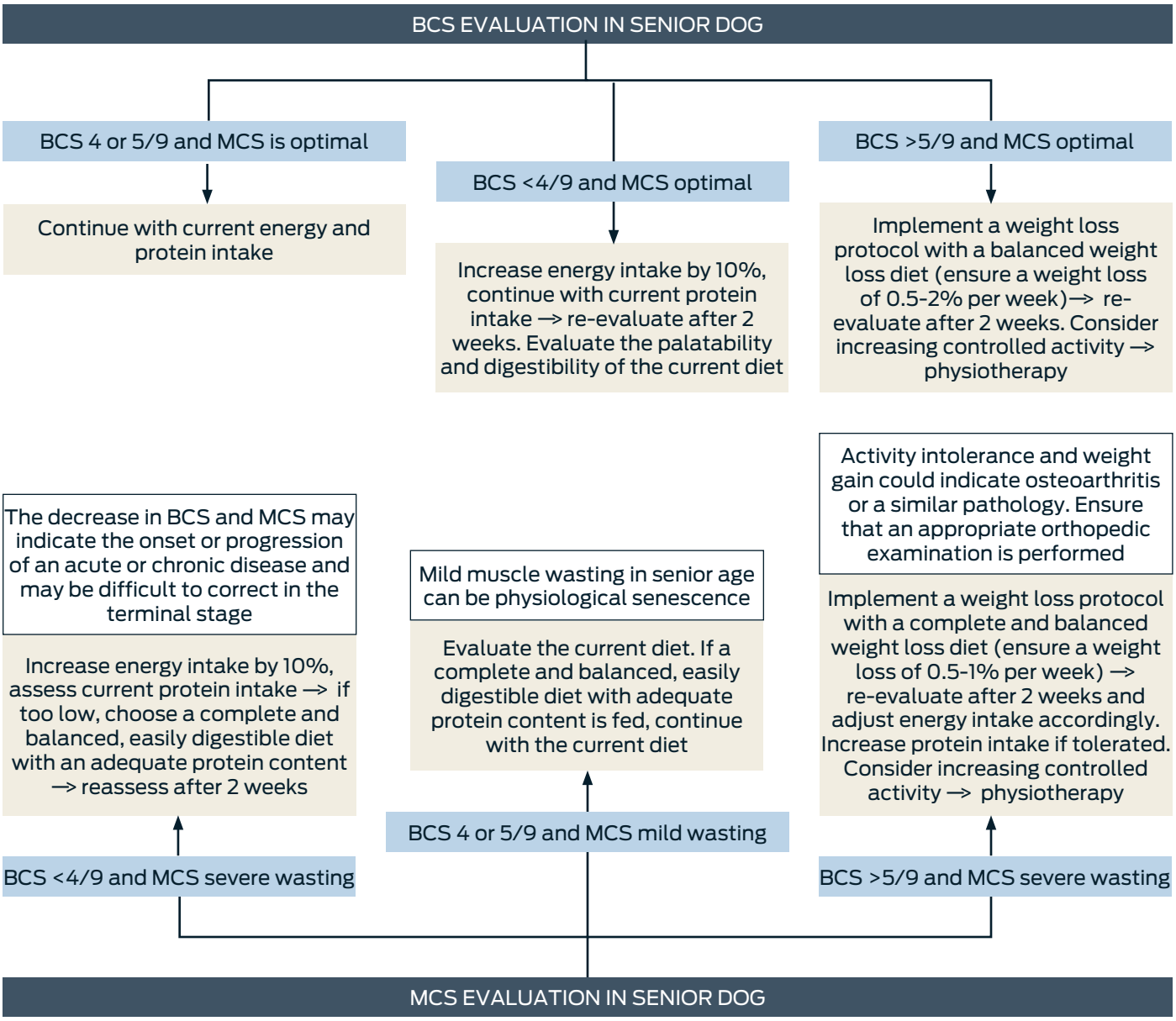
overweight or obese patients and adjust it to maintain optimal lean muscle mass and increase activity. In the case of concomitant activity intolerance (e.g., due to osteoarthritis), physiotherapy protocols (underwater treadmill) integrated into the weight loss protocol are important to maintain compliance and achieve optimal results. Excess adipose tissue ultimately shortens the lifespan of pets as it exacerbates the risk of dyslipidemia and insulin resistance and impacts the cardiovascular, renal, and skeletal systems, leading to various pathologies and associated complications.[10,11] In addition to closely monitoring weight and BCS, it is important to assess MCS, to delay age-related frailty (**Figure 2**).

PROTEIN

Protein is another nutrient of interest, yet protein requirements for senior dogs are not well defined. Some important points related to protein intake should be considered in the nutritional evaluation of a senior pet: the age-related loss of lean body mass, also known as sarcopenia, and the presence of a chronic disease that requires the restriction of protein intake. Aging leads to significant changes in body composition.[12] Senior dogs lose their lean body mass as they age, and a significant loss of lean body mass is associated with higher rates of morbidity and mortality.[12] A decrease in taste and smell acuity correlates with the fact that senior dogs become pickier in food selection, leading to a decrease in appetite and overall nutrient intake.[13] A decrease in protein and energy intake can ultimately lead to protein malnutrition, which increases the rate of lean muscle mass loss and sarcopenia. Protein malnutrition is detrimental to wound healing and leads to impaired immune response and, in more exacerbated cases, hypoalbuminemia and ascites.[14] Regular health checks, in addition to follow-up of weight, BCS, and MCS, are necessary to respond in a timely manner to changes influenced by nutritional interventions that can be treated, minimized, or prevented.

The causes of sarcopenia are considered multifactorial. Diet, type and amount of activity, metabolism, genetic factors, and disease all play a crucial role in its development. However, research in pets is still

Figure 2. Nutritional interventions based on BCS and MCS assessment. Body Condition Score (BCS) according to a 9-point scale; Muscle Condition Score (MCS) (normal muscle mass, mild, moderate, or severe muscle loss).



insufficient.[15] Another term used to describe the effects of aging is frailty. It is defined as a decline in immune function associated with a loss of muscle mass and loss of physiologic reserves, leading to decreased resilience to stressors.[16] As muscles age, hypoplasia and decreased metabolic function lead to atrophy and accumulation of intramyocellular lipids, resulting in damage and abnormalities in muscle tissue.[17] The onset of frailty and sarcopenia can be delayed in dogs with optimal BCS and activity.[12] Both the quality and digestibility of protein in the diet are important. Daily protein intake should not be below the recommendation of 5.2 g/100 kcal[4] for healthy senior dogs with an average MER of 95 kcal/$BW^{0.75}$. In case of a higher MER of 110 kcal/$BW^{0.75}$, the minimum recommendation for protein intake is 4.5 g/100 kcal.[4]

The reduction of protein intake in senior pets is justified in certain chronic diseases alongside other nutritional interventions, namely in the case of CKD IRIS > 1, protein-losing nephropathy, and chronic liver disease. In senior pets with chronic disease, it is important to monitor MCS because aging muscles also become more resistant to anabolic signaling and less effective at suppressing catabolic muscle breakdown; therefore, maximal protein synthesis is eventually unable to overcome the shift toward muscle loss.[18] In practice, we often see that older pets with marked sarcopenia and

cachexia respond poorly to nutritional interventions. Therefore, delaying the onset of sarcopenia and/or cachexia and carefully monitoring BCS and MCS are essential in senior pets.

RELEVANCE OF LONG-CHAIN FATTY ACIDS IN SENIOR PETS' NUTRITION

Supplementing diets with EPA and DHA from fish or algae oil is very beneficial in senior pets. Arachidonic acid (AA, omega-6) is the precursor of mediators known for their pro-inflammatory effects, while EPA and DHA (omega-3) produce mediators of decreased inflammatory potency. Therefore, omega-3 FA derived from marine sources are used in well-pet diets as well as in veterinary diets targeting conditions associated with chronic inflammation (obesity, osteoarthritis, CKD, etc.). In addition, EPA and DHA are known to lower circulating triglyceride levels. Both EPA and DHA have an anabolic effect on muscle and may improve muscle function and cachexia scores in dogs with heart failure secondary to DCM.[19,20]

MCTs FOR SENIORS

The aging process involves marked changes in the brain due to a high rate of oxidative damage, reduced antioxidant potential, and impaired regeneration of neural tissue, leading to cognitive dysfunction syndrome (CDS) in the senior dog population.[21] It is estimated that 28–68% of senior dogs suffer from CDS, which manifests as attention deficit, a decreased ability to solve problems, altered sleep habits, and undesirable behaviors such as pacing and vocalization.[22] Medium-chain triglycerides (MCTs) serve as nutritional interventions that aim to increase alternative energy sources in the form of ketone bodies (acetoacetate, acetone, and beta-hydroxybutyrate). MCTs consist of saturated C6, C8, C10, and C12 fatty acids and do not require bile salts for digestion. They are rapidly and efficiently absorbed through the intestinal mucosa, and the majority of absorbed MCTs are then transported directly through the portal vein to the liver, bypassing the lymph system, where they are converted into ketone bodies regardless of the amount of macronutrients in the diet.[23,24] Elevated blood levels of ketone bodies can increase the metabolism of ketone bodies in the brain and serve as an alternative energy source to compensate for deficits in cerebral glucose metabolism. This increases the brain's energy supply and helps to maintain or improve brain function.[25] Ketone bodies are rapidly converted into glucose precursors through the interaction of astrocytes and glial cells with neurons.[26] MCTs may also improve brain mitochondrial activity and reduce the amount of amyloid precursor protein in the brain.[27] Supplementation with 1.74 g/100 kcal (97% caprylic acid and 3% capric acid) in a complete and balanced diet led to significant improvement of CDS signs.[28] Additionally, in a long-term study, aged dogs supplemented with MCT (1.27 g/100 kcal) showed significantly better performance on most cognitive test protocols.[29] Differences were also found in terms of task difficulty, with the more difficult task showing a greater effect of supplementation. These results suggest that long-term MCT supplementation may have a cognitive-enhancing effect in aged pets and delay their cognitive decline. These results support the hypothesis that MCT supplementation may improve brain function in aged dogs by providing the brain with an alternative energy source.

In addition, long-chain polyunsaturated FA also showed benefits in improving cognitive abilities in senior dogs in cognitive tests of visual-spatial memory. The proposed pathway is the role of DHA in the production of phosphatidylserine in the neuronal membrane, where it plays a crucial role in the activation of signaling pathways.[30]

COMMUNICATION TIP

Regular assessment of a senior dog's nutritional status ensures the nutritional composition of the diet is tailored to the dog's individual needs and health status.

ANTIOXIDANTS IN SENIOR DIETS

Antioxidants in senior diets act as mitochondrial cofactors and increase cellular endogenous antioxidant upregulation.[31] Oxidative stress and chronic inflammation may contribute to sarcopenia, as signaling pathways can be activated or deactivated by oxidative stress and inflammation.[32] Antioxidants showed variable results when researched in senior dog trials.[33] Namely, polyphenols from grape and blueberry extracts did not significantly improve memory in dogs after prolonged use.[34] Nevertheless, polyphenols used as blends together with other nutraceuticals

such as arginine, L-carnitine, and B vitamins showed consistently positive effects.[35-38] In addition, EPA and DHA in combination with CoQ10, also known as ubiquinone, a powerful antioxidant that plays a crucial role in cellular energy metabolism, showed promising results in senior dogs with CDS.[39] Nevertheless, it is a challenge to determine the benefits of individual dietary supplements in studies in which several dietary changes are made simultaneously. The results should therefore be critically reviewed.

DIGESTIBILITY CHANGES IN SENIOR DOGS

The aging process leads to a decline in cell function and to the phenomenon defined as “senescence," the inability of cells to proliferate, which is irreversible and eventually leads to a progressive loss of regenerative and protective mechanisms, resulting in a deterioration of organ function.[40] Changes associated with aging include changes in body composition, metabolic rate, and gut microbiota. Additionally, there are physiological changes associated with aging and intestinal morphology. In dogs, the intestinal villus surface area decreases with age, as does the height of the jejunal and ileal villi.[41] Decrease in the production of hydrochloric acid and bile secretion as well as changes in the activity of the salivary glands, liver, and pancreas, are correlated with aging.[42] The composition of the microbiome and the production of short-chain fatty acids in aged dogs showed a variety of changes, albeit on a small scale.[43] Interestingly, there are no findings indicating a marked decrease in digestive efficiency in senior dogs despite the morphologic alterations, suggesting that changes associated with aging in dogs may not have clinical significance. Moreover, aging was associated with preserved nutrient digestibility and digestive capacity in healthy aged dogs when fed low-energy high-fiber diets (up to 10.81 g/100 kcal TDF).[44] Nevertheless, senior dogs may benefit from a diet with higher protein digestibility due to increased protein turnover, sarcopenia, frailty, and senescence.[45]

PHOSPHORUS IN SENIOR DIETS

Phosphorus in pet foods can be found in organic and inorganic forms. Inorganic phosphorus salts are added to diets for various purposes: to meet phosphorus requirements; as additives for water-binding purposes, preservation, texture, color, and/or palatability; and/or as an agent in periodontal disease prevention. Soluble or inorganic forms of phosphorus are potentially more harmful compared to organic phosphorus.[46] The amount and source of inorganic phosphorus salts in the diet have a significant impact on phosphorus homeostasis, which could pose a risk for renal and skeletal health over a prolonged period of time.[47] Nevertheless, it can be difficult to assess the phosphorus content in the diet, as pet food manufacturers are not obliged to declare the phosphorus content. They also do not differentiate between different phosphorus sources, solubility, or bioavailability of phosphorus. Furthermore, it is important to note that the negative effects in healthy adults have only been demonstrated in cats. While the same risks could also apply to dogs, there is not enough data to make a well-founded statement as of yet.

POTENTIAL HEALTH CONCERNS OF SENIOR DOGS AND HOW THESE CAN BE ADDRESSED WITH NUTRITION

Regular assessment of nutritional factors during the senior dog’s life stage is recommended to better support the individual senior dog. For dogs that are seniors but are clinically healthy and have no significant pathologies, the focus should be on life-stage support. However, because senior diets vary significantly in nutrient composition, an individualized nutritional approach is required (**Figure 1**). Chronic pathologies that may require nutritional intervention and are more common in senior dogs include CKD,[48] neoplasia,[49] osteoarthritis,[50] and periodontal disease.[51]

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NUTRITIONAL SUPPORT OF SPORTING AND WORKING DOGS

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KEY TAKEAWAYS

- Match a working dog's nutrition to the activity type and duration of the work performed, including periods of reduced workload. The duration of exercise guides the macronutrient profile to support performance, recovery, and overall health.
- Proper hydration and fluid balance are crucial for maintaining thermoregulation, enhancing performance, and promoting recovery. Pre-, during, and post-exercise hydration strategies are crucial for maintaining optimal performance and health.
- Environmental factors can alter metabolic demands and impact hydration, appetite, and nutrient requirements.

UNIQUE ENERGY AND NUTRIENT REQUIREMENTS OF SPORTING AND WORKING DOGS

The nutritional demands of working and sporting dogs require a diet optimized for high energy expenditure, muscle maintenance, and physical resilience. Protein, particularly from highly digestible animal sources, is paramount for muscle repair and development, and provides essential amino acids crucial for active dogs. Fats serve as a principal energy source, especially for endurance activities, and support cellular function and the absorption of fat-soluble vitamins. Carbohydrates provide a readily available energy source, particularly for high-intensity activities, and are vital in replenishing glycogen stores. A balanced intake of dietary vitamins and minerals is essential for various physiological functions, including immune support, bone health, and energy production, with electrolytes being particularly important for dogs working in high heat conditions.[1] Adequate hydration is paramount, as water loss through panting necessitates regular access to fresh water.

These distinctive energy and nutrient requirements of canine athletes and working dogs are based on the type of exercise, length of exercise, ambient conditions, and the individual dog. Energy demands vary considerably, with sprinting dogs requiring short bursts of intense energy fueled by carbohydrates, while endurance dogs rely on sustained energy from fats.[2] Consequently, nutritional strategies must be tailored to the specific activity type, breed, age, and environmental conditions. Specific considerations, such as nutrient timing for endurance dogs and rapid glycogen replenishment for sprinting dogs, further emphasize the need for individualized feeding plans. This highlights the importance of consulting with a veterinarian or a board-certified or qualified veterinary nutritionist to create a customized feeding plan, enhance performance, and ensure proper hydration.

TYPE AND AMOUNT OF WORK AFFECT NUTRIENT NEEDS

The duration and type of work significantly influence the nutritional requirements of working dogs by the level of physiological demands and determine the energy substrates used. These factors, in turn, affect the necessary intake of macronutrients, micronutrients, and water to sustain optimal performance, recovery, and overall health.

Canine athletes are categorized into loosely defined groups based on the distance traveled and duration of their activities. Distance can be extremely varied, even within the same sport or discipline. Duration exists on a continuum, ranging from sprinting and short-distance efforts to middle-distance and long-distance activities. For instance, a competitive agility dog typically sprints for less than two minutes, a field retriever may complete tests involving land and water retrieval for five to 20 minutes, while a sled dog participating in a long-distance race may run up to 100 miles per day. During intense initial exercise, animals

Table 1. Energy utilization based on duration of exercise

Time required	Energy production	Canine sports and working dog activity examples	Energy substrates used (in order of priority)
< 1 minute	Phosphocreatine system and anaerobic glycolysis	Agility Flyball Police K9 work	Muscle glycogen
< 2 minutes	Anaerobic glycolysis	Agility Flyball Nosework Sight hound racing Lure coursing	Muscle glycogen Carbohydrate
20–30 minutes	Carbohydrate oxidation	Hunt test Field trial Herding, competitive Sprint mushing Pile/rubble work Tracking	Carbohydrate Fat
> 30 minutes	Fat oxidation	Sprint mushing Middle- and long-distance mushing Herding, field work* Search and rescue Hunting, field work* Tracking	Fat Carbohydrate Protein

* denotes dogs working in field conditions, which are typically longer in duration, not competition work

use the phosphocreatine system for immediate ATP. Glycogenolysis then fuels sprinting and intermediate activity. Sustained glycolysis leads to lactic acid buildup and pH changes. For longer exercise (30 minutes–2 hours), carbohydrate oxidation via the citric acid cycle is initially dependent on glycogen. In prolonged endurance exercise (greater than 2 hours), when glycogen is depleted, protein oxidation occurs, limiting oxygen consumption. Fatty acid oxidation increases after 30 minutes and becomes the main fuel for sustained low to moderate intensity exercise, enabling prolonged activity greater than 2 hours.

Based on this combination of distance, time, and activities, a proposed way of looking at energy needs in sporting and working dogs would be by time (**Table 1**). As noted in the "Strength-endurance continuum" presented by Zink and Van Dyke, shorter distance canine sports and working activities require greater strength and less endurance, whereas long distance mushing still requires strength but greater endurance.[3]

Time, or duration of work, is an equalizing factor that allows dog handlers to look at nutrients in general terms to feed appropriate diets to their sporting and working dogs.

Maintenance or higher carbohydrate intake may benefit dogs engaged in short, intense, intermittent work by supporting glycogen storage and rapid energy availability. For endurance dogs, while fat is the primary energy source, an adequate carbohydrate intake ensures sufficient glycogen stores are replaced for sustained activity and prevents premature fatigue. Continuing research is investigating how endurance sled dogs sustain their metabolism for several hours during submaximal exercise, primarily with a dietary intake of fat while utilizing glucose as an energy substrate.[4]

Extended duration, or endurance, work necessitates a higher fat intake to meet the substantial energy demands and enhance metabolic adaptations for

fat utilization. The quality of fat, including omega-3 fatty acids, also plays a role in reducing inflammation associated with prolonged activity.[5] While consistently important for all working dogs for muscle maintenance and repair, the specific requirements of protein increase during periods of very prolonged exertion or during intense training phases to support muscle adaptation and prevent overtraining syndromes.[6]

INFLUENCE OF ENVIRONMENTAL FACTORS ON NUTRITIONAL REQUIREMENTS OF CANINE ATHLETES AND WORKING DOGS

Environmental factors, particularly ambient temperature and humidity, exert significant physiological demands on canine athletes and working dogs, directly impacting their energy expenditure, hydration status, and electrolyte balance. This can have a significant influence on their nutritional requirements.

Heat stress

Exposure to high ambient temperatures necessitates increased thermoregulatory efforts in canines, primarily through panting, an evaporative cooling mechanism. This physiological response elevates metabolic rate and consequently increases energy expenditure. Studies have demonstrated a positive correlation between ambient temperature and caloric requirements in working dogs.[7]

In addition to an increased energy expenditure, panting leads to significant water loss, increasing the risk of dehydration, which can result in hypovolemia and impair cardiovascular function, thermoregulation, and performance. High humidity exacerbates heat stress by reducing the efficiency of evaporative cooling, further increasing the risk of hyperthermia, dehydration, and heat-related illness. Exercise combined with evaporative cooling via panting results in physiological changes such as tachypnea, tachycardia, hyperthermia, lactic acidosis, respiratory alkalosis, and hypocapnia.

A decrease in appetite may also be seen in hot environments, posing a challenge to meet the increased energy and nutrient demands. Offering palatable, calorie-dense food options and adjusting feeding schedules to cooler times of the day may be beneficial.

COMMUNICATION TIP

Sporting and working dogs have unique nutritional needs based on their activity level, workload, and environment.

Cold stress

In contrast, exposure to cold or subfreezing temperatures necessitates an increase in metabolic heat production to maintain core body temperature. This thermogenic response also significantly elevates energy requirements. The magnitude of this increase is influenced by factors such as coat insulation, breed, activity level, and environmental conditions such as wind chill.[8] Diets with higher fat content can provide a concentrated source of energy to meet these increased caloric demands. Protein can also contribute to metabolic heat production through thermogenesis.[9]

While dehydration may be less obvious in cold weather, it is still a concern. Increased respiratory water loss due to cold, dry air and a potentially reduced drive to drink cold water can lead to inadequate hydration. Ensuring access to palatable, non-frozen water is critical. In cold and subzero temperatures, this means stopping the activity and offering water since it will likely freeze if left out.

Altitude stress

Working or competing at high altitudes presents a unique set of physiological challenges. The primary concern is the reduced partial pressure of oxygen (hypoxia), which can lead to several adaptations and increased metabolic demands. The body's initial response to hypoxia stimulates increased respiratory and heart rates, elevating energy expenditure even at rest. Over a matter of days, erythropoiesis further increases metabolic demands. Hypoxia can shift the metabolic substrate utilization, potentially increasing reliance on carbohydrates. This may influence the optimal macronutrient composition of the diet.

An increased respiratory rate in dry, high-altitude air can lead to greater insensible water loss, increasing the risk of dehydration. Ensuring adequate fluid intake is paramount. Some dogs may experience a temporary decrease in appetite upon arrival at high altitude, which can complicate meeting their energy needs.

Nutritional strategies for humans working at altitude may involve a slightly higher carbohydrate content in the diet and meticulous attention to hydration. Ideally, gradual acclimatization can occur along with essential careful monitoring of the dog's condition.

Wind stress

Wind can significantly influence the actual temperature experienced by a mammal, particularly in cold weather. It increases convective heat loss, making the perceived temperature much lower than the actual ambient temperature. This necessitates greater metabolic heat production to maintain core body temperature, thus increasing energy requirements.[10] Dogs with shorter coats are more susceptible to the effects of wind chill. In dry environments, wind can also enhance evaporative water loss from the respiratory tract, contributing to dehydration. In windy conditions, especially in cold weather, providing adequate insulation, such as dog coats, and ensuring sufficient caloric intake are important nutritional considerations.[11]

Sunlight and UV radiation stress

Exposure to intense sunlight and ultraviolet (UV) radiation can have indirect effects on nutritional needs and overall health. Direct sun exposure increases body temperature and leads to greater evaporative water loss through panting. Prolonged exposure to intense sunlight, especially when combined with high temperatures and humidity, significantly increases the risk of heat-related illnesses, requiring immediate intervention and potentially affecting subsequent nutritional management during recovery. Providing shade and ensuring adequate hydration are crucial in sunny conditions.

Air quality

Exposure to poor air quality, including pollutants, smoke, and allergens, can indirectly influence nutritional requirements by impairing respiratory function and elevating oxidative stress. Pollutant exposure promotes the production of reactive oxygen species, thereby increasing the body's demand for antioxidant nutrients such as vitamin E and vitamin C.[12] Impaired respiratory function may also elevate the energy cost of breathing. Although direct nutritional strategies to counteract poor air quality are limited, providing a diet rich in antioxidants may help alleviate some of the associated negative effects. Notably, Alaskan husky sled dogs have been shown to be valuable animal models for studying the impact of air quality on physiological function.[12]

WATER INTAKE AND HYDRATION STRATEGIES FOR CANINE ATHLETES AND WORKING DOGS

Maintaining adequate hydration is vital for physiological functions and optimal performance of canine athletes and working dogs. Dehydration can impair thermoregulation, reduce cardiovascular efficiency, increase the risk of injury, and diminish overall work capacity. Understanding the factors influencing water requirements and implementing effective hydration strategies are crucial for these active animals.[13]

Several factors contribute to the water needs of athletic and working dogs. Activity level and intensity primarily influence water needs since exercise increases metabolic heat production and evaporative water loss through panting. Secondly, environmental conditions play a crucial role in dictating water needs. The greater the ambient temperature and humidity, the greater the fluid losses with exercise. Diet has a significant impact on hydration, with dogs on dry kibble requiring more free water compared to those on a moist diet. Electrolyte status and osmotic load of the diet can also affect an individual's overall water balance. Ultimately, individual physiological factors, such as age, breed, body size, and metabolic rate, can influence water requirements. Larger dogs will obviously have greater water needs, while smaller dogs may have higher metabolic rates based on body surface area.

Monitoring and assessing hydration status in this population of dogs is essential before, during, and after exercise. Relying on a dog's thirst drive and voluntary water intake may not suffice to maintain optimal hydration. Several methods can be employed in the exercising or work environment to evaluate hydration status (**Box 1**). Familiarizing oneself with a dog's specific assessment parameters and changes during dehydration is crucial.

Hydration strategies for optimal performance can mitigate the risks of dehydration, reluctance to work, and heat-related illness. Pre-exercise hydration is extremely important, and providing free choice access to plain water in the hours leading up to activity is recommended. During exercise, small amounts of water

Box 1. Assessment of hydration status

- **Clinical signs of hydration status to assess with exercise and work**
  - Dry, tacky mucous membranes
  - Capillary refill time (CRT) > 2 seconds – indicates a minimum of 5% dehydration
  - Decreased skin turgor
  - Sunken eyes
  - Tachycardia
- **Objective parameters to assess hydration status**
  - Body weight – a decrease of > 2% indicates dehydration
  - Urine specific gravity – can be affected by renal function and diet
  - Total plasma protein
  - Hematocrit
  - Serum osmolality

can be given frequently to help offset fluid losses, such as 1/8 to 1/2 cup at a time. The method of administration, palatability, and temperature of the water may influence a dog's voluntary intake. Hydration can be achieved in the field using a squirt-type water bottle or a collapsible lightweight bowl. It is worthwhile to practice prior to using and allow time for the dog to acclimate to this method of offering water. Research on electrolyte supplementation in dogs during exercise is limited and shows no definitive evidence that electrolyte supplementation is needed in dogs. It is believed that because dogs primarily pant to cool themselves, their electrolyte losses are not comparable to those seen in other species that cool through sweating. One study showed that consuming electrolyte-enriched fluids before exercise could help dogs maintain lower peak body core temperatures during work. However, data from the same study showed that consuming electrolyte-enriched water in tracking dogs in hot and humid environments had no effect on blood electrolyte values, pre and post exercise.[14]

Effective post exercise rehydration is important for the recovery of canine athletes, facilitating the restoration of fluid balance affected by physical exertion. Exercise-induced dehydration, primarily due to evaporative heat loss via panting and a small amount of sweating, can lead to a cascade of physiological impairments, including reduced blood volume, increased cardiovascular load, and impaired thermoregulation. Therefore, timely and adequate fluid replacement is essential for optimizing recovery and subsequent performance.

The primary goal of post exercise rehydration is to restore euhydration by replacing fluid deficits in the most efficient manner possible. Consideration of the volume, composition, and timing of fluid intake can affect a dog's intake. Providing fresh water immediately after exercise encourages voluntary fluid intake. The temperature of the water may influence palatability for some dogs. Initiating rehydration as soon as possible after exercise helps expedite recovery. Smaller, frequent amounts may be more effective than a large volume at once in promoting fluid retention and minimizing vomiting. Offering small frequent amounts (1–2 cups) for the first 15 to 30 minutes, followed by free choice water may help avoid this.

The volume needed for rehydration depends on the magnitude of fluid losses during exercise, which can be estimated by monitoring body weight changes. In humans, a general guideline is to replace approximately 1.5 times the estimated fluid deficit following intense exercise, and the ingestion of glucose with fluids can enhance both fluid absorption and glycogen resynthesis. Including glucose post exercise to facilitate glycogen replacement is ideal for subsequent bouts of exercise. Research has shown that immediate post-exercise supplementation with a 1.5 g/kg body weight of a glucose polymer solution in sled dogs during the first four hours of recovery results in an increased glucose concentration, which subsequently facilitates a more rapid muscle glycogen repletion compared to dogs that do not receive supplements.[15] Therefore, immediate glucose supplementation post exercise (1.5 g/kg) may enhance recovery between exercise sessions for dogs competing in multiple events on the same day or over consecutive days. Practically, offering a dilute glucose solution alongside plain water post exercise is one strategy; another is offering the glucose solution mixed in a low volume of water, followed by plain water. This allows for both efficient rehydration and glycogen replenishment. The palatability of the solution should also be considered to encourage voluntary intake.

Observing clinical signs of hydration (e.g., mucous membrane moisture, skin turgor) and monitoring post-exercise body weight can help assess the effectiveness

of the rehydration strategy. Testing these techniques before an event may provide a healthier dog and a competitive edge.

NUTRITION DURING THE OFF-SEASON

The off-season for canine athletes requires a strategic adjustment in dietary intake to facilitate physiological recovery and attain or maintain an ideal body condition. A primary consideration is the reduction of caloric intake, considering the decreased energy expenditure associated with lower training volumes and competition demands. This adjustment is important for preventing excessive weight gain, which can negatively impact future performance and overall health.

While overall caloric intake is reduced, maintaining adequate protein intake remains vital for muscle repair and preservation during periods of lower activity.[16] The proportion of carbohydrates in the diet may be moderately decreased, reflecting the reduced need for rapid glycogen replenishment; however, extreme lowering or complete elimination is not recommended, particularly if the canine athlete remains moderately active.[17] Fat intake should be carefully managed to contribute to overall caloric balance while ensuring sufficient essential fatty acids for coat health and other physiological functions.[5]

Regular monitoring of BCS throughout the off-season is important for guiding dietary adjustments. As in training periods, handlers should still aim for a BCS of 4 or 5/9. Individualized nutritional plans developed in consultation with a sports medicine veterinarian or a qualified veterinary nutritionist are helpful, considering breed-specific metabolic rates, age, off-season activity levels, and any underlying health conditions. Maintaining the same or a similar diet in the off-season as during training and competition periods is achievable with careful practices.

SUMMARY

Sporting and working dogs have unique nutritional needs based on their activity level, workload, and environment. During periods of intense training or competition, these dogs benefit from a performance diet higher in fat and protein to meet energy demands and support muscle maintenance. Conversely, during the off-season or low-activity times, a maintenance diet with fewer calories but enough protein is more suitable to prevent weight gain and help recovery.

Macronutrient needs differ depending on the type of athletic activity. Sprint-type canine athletes, such as agility dogs or those in lure coursing, require more carbohydrates to support quick energy bursts and to quickly restore glycogen stores. In contrast, endurance dogs—like sled dogs, herding breeds, or hunting dogs—depend on fat as their primary energy source. A diet rich in fat, especially omega-3 fatty acids, helps meet sustained energy needs and may reduce inflammation linked to prolonged activity. Hydration is critically important for all canine athletes. Providing regular access to fresh water before, during, and after activity is extremely important.

Environmental factors also influence nutritional needs. In hot, humid weather as well as cold weather climates, dogs use more energy for thermoregulation and may experience reduced appetite. Providing calorie-dense, highly palatable food and ensuring proper hydration is helpful. Higher altitude, wind, and poor air quality may also affect energy expenditure and hydration.

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NUTRITIONAL SUPPORT OF REPRODUCING AND LACTATING DOGS

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KEY TAKEAWAYS

- Dogs should be in ideal nutritional status and body condition (BCS 5/9) before breeding.
- Due to exponential intrauterine growth of the puppies, the energy demand of the bitch increases after the fifth week of gestation.
- During lactation, energy demand depends on the number of puppies, reaching up to 4 x MER in large litters.

As breeding pets can be a rather emotional endeavor, providing dog owners with evidence-based information on the unique nutritional requirements of their dogs is important to prevent them from relying on myth or anecdotal evidence. Commercial complete and balanced diets specifically for reproduction or all life stages fulfill the nutritional needs for gestation and lactation,[1,2] and homemade diets have a high risk of being unbalanced and are not recommended.[3,4] The primary goal of feeding reproducing animals is to create optimal conditions throughout the reproductive process, ensuring high reproductive performance and optimizing the litter size as well as the puppies' survival and growth.

Aims of feeding reproductive dogs include:

- Optimizing ovulation rate as well as sperm quality.
- Promoting optimal placenta function and best conditions for implantation of the embryo(s).
- Providing an optimum nutrient supply during gestation, allowing the best possible development of the fetuses during the intrauterine phase and allowing the bitch to build up body reserves.
- Avoiding negative effects on parturition (e.g., bradytocia or problems of widening of the birth canal), thus best enabling the bitch to deliver the puppies.
- Ensuring the bitch has the best nutritional support in order to produce high-quality colostrum and milk, furthering the development of the puppies.
- Supporting the puppies during the transition process when switching from milk to additional food and later on promoting the weaning process.

FEEDING THE BITCH BEFORE CONCEPTION

Bitches should have an ideal body condition (BCS 5/9) before breeding, as being either obese or underweight may negatively impact reproductive performance.[1,2] Malnourished bitches show a higher risk for delivering puppies with reduced birth weight, which increases their risk of developing hypoglycemia and lowers survival rates.[3,4] Additionally, underweight puppies are at higher risk of developing obesity later in life.[5] Obesity may also impair reproductive performance of dogs[1,6] by prolonging the intervals between estrous cycles, reducing ovulation rate resulting in small litter size, and increasing the risk of dystocia. The resulting prolonged labor causes additional stress for both puppies and bitch. Furthermore, obesity leads to a decrease in milk production. Aside from optimizing BCS before breeding season, there are no specific nutritional requirements for a female dog during her heat cycle. While "flushing feeding" (feeding higher amounts of food before conception to stimulate ovulation rate) is commonly used in other multiparous species and is recommended by some breeders and veterinarians, there is currently no scientific evidence to support its benefit in dogs.

GESTATION IN DOGS

Like all mammals, the pregnant bitch and fetuses are in a positive energy and nitrogen balance throughout gestation. Gestation lasts about 65 days in dogs[7] (58–71 days) and is divided into trimesters. The number of puppies is quite variable, being affected by many factors.[1,4,6,8]

INTRAUTERINE GROWTH OF PUPPIES AND NUTRITIONAL NEEDS OF THE BITCH

The fertilized egg cells reach the uterus 10 days after conception.[8] During the first three weeks, embryos are nourished via embryotrophe. They are quite sensitive to disturbances, especially extreme feeding imbalances. After placentation (day 20 post coitus), nutrient supply occurs via blood vessels of the placenta. Intrauterine growth follows an exponential pattern, resulting in a relatively low nutritional demand of the bitch for early gestation. During this period, the dietary requirements of the pregnant bitch do not significantly differ from those of a young adult dog.[9] Nutrient requirements increase markedly after the fifth week of gestation as the growth rate of fetuses is rapidly increasing.[10] The increase of energy requirements ranges between 30–60% of MER depending on litter size (small litter: 1.3 x MER, large litter: 1.6 x MER,[6,11-13] or 2.5–3.0 x RER). Undersupply of energy may result in lower vitality of the newborn and higher risk of mortality,[2,9,14] because of lower glycogen storage. As the fetus relies on glucose exclusively as an energy source, the diet fed during gestation should supply at least 20% of energy from carbohydrates. Although bitches have no specific carbohydrate requirement, their protein requirement increases[15,16] to ensure sufficient gluconeogenesis from amino acids when carbohydrate-free diets are fed.[15] Furthermore, milk has a higher lactose content when the diet for lactating bitches contains at least 10–20% of energy from carbohydrates.[15]

PRACTICAL FEEDING DURING GESTATION

Increasing energy intake by 10–15% each week beginning in the fifth week of gestation until partum[17,18] results in an overall energy surplus of about 40–60% compared to MER, meeting the demands of the pregnant bitch. However, individual adjustments may be necessary. A transition to a reproduction/growth diet is recommended at the end of the fifth gestation week. In any event, it is possible to use these diets during the entire reproductive cycle[2] to avoid any changes in diet, which may be important in bitches with nutrition sensitivity. Additional feeding of calcium additives or food rich in calcium (e.g., milk products) is not recommended if the bitch is fed a commercial diet designed to support gestation and lactation[2] as calcium might become excessive and therefore harmful.[19]

Box 1. Nutrients of special interest during reproduction

- **Protein**

  Protein requirements increase (24.6 g/kg $BW^{0.75}$)[12] during late gestation and lactation due to the development of the placenta, fetuses, and mammary tissue, as well as milk production. During the first trimester there is no additional protein requirement due to the low growth rate of the fetuses. One way to assess the protein supply is to measure the protein content in blood serum of the bitch, which should be above 55 g/L.[11]

- **Fat**

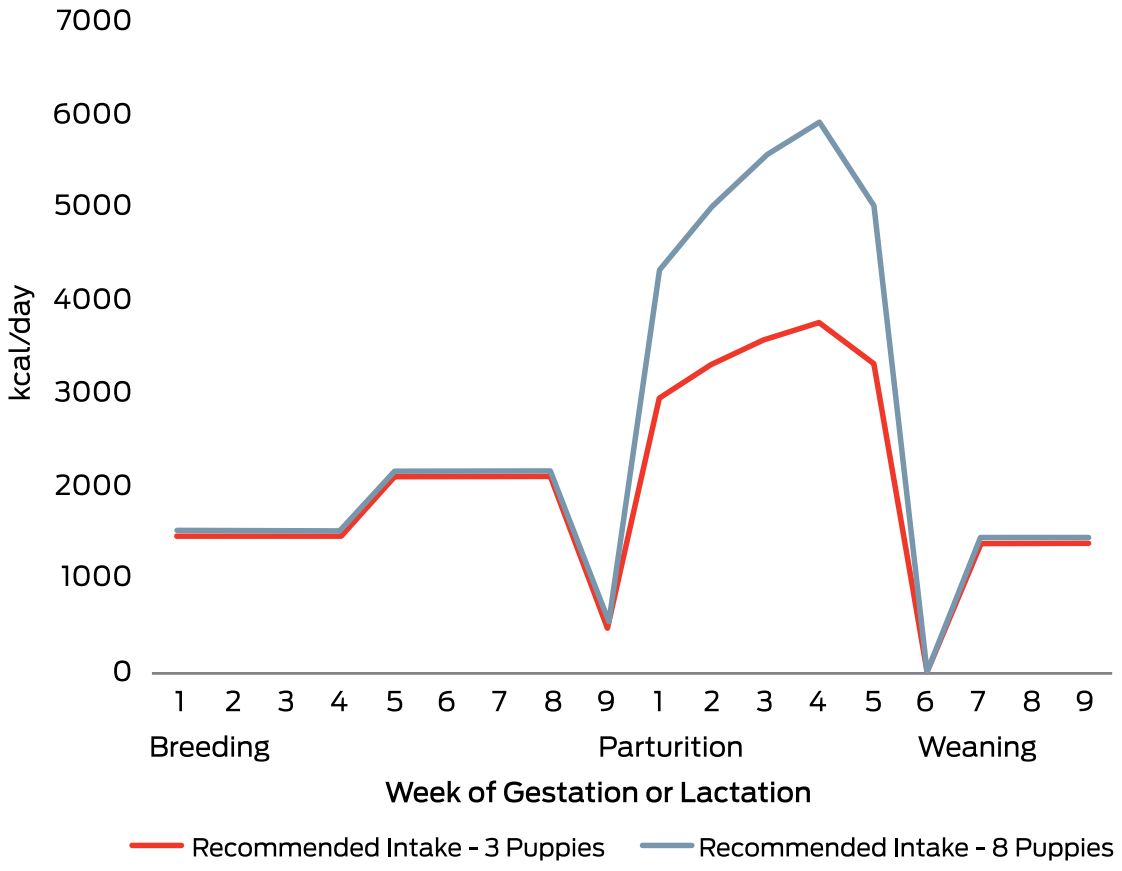
  Fat is important in diets of breeding dogs because of its high energy density, but also regarding supply of essential fatty acids. Omega-3 fatty acids have a positive effect on neural development of the fetus, so fish oil or algae oil are recommended to be included in the diet for reproduction.

- **Minerals and vitamins**

  Maternal metabolism can compensate for many disbalances, and an unbalanced intake of calcium and phosphorus has no direct impact on the intrauterine development of puppies. Deficiencies in iodine or selenium may not be compensated, resulting in goiter or muscular weakness, respectively.[11] Scarce supply of vitamin A and vitamin E will not affect fetal development in most cases, but concentration of these vitamins in colostrum will be quite low.[11] On the other hand, massive oversupply with vitamin A and vitamin D (feeding high amounts of liver) can result in malformations. When using high amounts of unsaturated fatty acids in the diet, additional vitamin E is needed.

Monitoring weight and adjusting food intake is essential as underfeeding can result in embryo loss, abnormal fetal development, spontaneous abortion or stillbirth, small litter sizes, and low birth weight of puppies. Conversely, overfeeding has negative effects as well. While feeding two meals per day is adequate in most cases, for some bitches (giant breed, very large

Figure 1. Recommendations for energy supply for a 25 kg dog based on litter size[13]



number of puppies) a more frequent feeding or free-choice feeding is necessary, especially at the end of gestation and into lactation.[6,11]

WEIGHT DEVELOPMENT OF THE BITCH DURING GESTATION

The bitch should not lose any weight or decrease BCS during gestation. By the end of pregnancy, a healthy, well-nourished bitch is expected to gain around 10–15% of her prebreeding weight.[18]

PERIPARTAL FEEDING

Obstipation may occur in the final stages of gestation. Fiber supplements such as psyllium or wheat dextrin may be used as a laxative. In very severe cases sodium sulfate can be used.[11]

On the day of partum, most bitches naturally refuse food, which constitutes normal physiological behavior. While giving birth, the bitch should have unrestricted access to water. Consuming the placentas is physiological—consumption should only be restricted in very large litters. A liquid diet (highly digestible diet mixed with water) should be fed postpartum to compensate for the significant fluid losses, after which the reproduction or all-life-stages diet should be reintroduced.[11]

LACTATION

From the nutritional perspective, lactation poses significantly greater challenges than gestation (**Figure 1**), as energy requirement increases up to 2 to 4 times (depending on litter size), peaking around the third to fifth week postpartum.[18,20-23] Additional energy demand accounts for 0.25 MER per puppy (e.g., 4 puppies: 2 x MER; 8 puppies: 3 x MER).[13] The estimated energy requirement of nursing puppies is directly proportional to their weight.[14] Litters with a smaller total weight have a smaller total energy requirement and therefore put a lower demand on the lactating bitch,[24,25] requiring the bitch to produce only a moderate amount of milk.[24] In large litters of large breed puppies, growth rates might be affected by insufficient milk production and/or intake.[25] As the water demand of lactating bitches is very high, the water supply should be considered as well. Fresh water should be available at all times.

Milk yield

Milk yield depends on the state of lactation and the size of the breed as well as the number of puppies[21,22,25] and varies between 2.5–6.6% of BW during the third and fourth weeks.[11,21] The larger the litter size, the higher the milk yield,[22] but not in a linear manner. As soon as the puppies are ingesting additional food and are nursing less, milk production is reduced.[11]

Milk composition

Colostrum

As in other species, the colostrum is characterized by high content of albumin and globulin.[26] The immunological quality of colostrum differs on an individual basis.[27] Immunoglobulin G is most important,[27,28] accounting for 60–75% of the immunoglobulins, around 20 g/L. The immunoglobulin concentration drops markedly, by 50% within 24 hours after partum.[28,29] Puppies depend on the antibodies provided by colostrum, but these antibodies can only be absorbed during the first 12–16 hours of life.[13] Earlier consumption improves the absorption rate.[29]

Mature milk

The composition of bitch milk is quite constant.[21,30-32] The milk is characterized by a high content of protein, consisting of 70% casein and 30% whey protein, and low lactose content.[11] Overall, 60% of energy is delivered by fat, 30% from protein, and 10% from lactose. The amino acid pattern of milk protein differs markedly compared to cow's milk, as the amount of lysine is lower, but the content of sulfur-containing amino acids is higher. The milk fat consists mainly (2/3) of unsaturated fatty acids, while short-chain fatty acids are missing.[11] Fat composition (e.g., linolenic acid and alpha-linolenic acid) is affected by the fatty acid composition of the diet, while EPA and DHA are not affected.[33] The calcium and phosphorus levels are much higher compared to cow's milk.[31] Furthermore, the trace mineral content is quite high as well.[31]

Weight development of the bitch

During lactation, weight loss should not exceed 5–10% of prebreeding weight. Especially in bitches of large breeds with large litter size, this may pose a challenge and diets with high energy density (>4,000 kcal/kg) are recommended.[11]

Practical aspects

After partum, compared to pregnancy, food intake capacity increases. However, depending on litter size, high-energy-density food is needed.[11,24,25] A highly digestible puppy diet is suitable for feeding the bitch during lactation. Most bitches (apart from those with small litters) should be fed ad libitum or small multiple meals per day to ensure adequate energy intake. Repeated measurements of body condition allow for precise adjustments of the feeding amounts. Food allowance should be reduced at the start of the weaning process. Vomiting by the bitch during the third or fourth week of lactation can be a physiological process to give the offspring access to pre-digested food.[11]

COMMUNICATION TIP

Commercial complete and balanced diets specifically for reproduction or all life stages fulfill the nutritional needs for gestation and lactation, and homemade diets have a high risk of being unbalanced and are not recommended unless they have been prepared by a qualified specialist in veterinary nutrition, such as a board certified veterinary nutritionist.

Weaning

The weaning process, combined with a reduction in the amount of food (25% compared to prebreeding), results in a fast stop of milk production in the bitch. During the following 4 to 5 days, the amount of food should be increased step by step to normal pregestation levels.[11]

FEEDING OF THE MALE REPRODUCTIVE DOG

An ideal body condition score should also be targeted for the male dog. Compared to other species, studies on the impact of diet on sperm quality in dogs are rare. Of special interest are the trace minerals, iodine, selenium, and zinc, as well as vitamin A, vitamin E, and linoleic acid. Recent studies[34,35] showed better motility of sperm when antioxidants were added to the diet and higher testosterone levels in blood when salmon oil was fed.[34,35] In any case of low reproductive performance, the diet of the male dog should be examined by a specialist, especially in cases of homemade diets or BARF rations, which are often unbalanced.[36] All

substances with a negative impact, like mycotoxins or heavy metals, should be avoided; a diet from a high-quality manufacturer should be selected. It may take 2 to 3 months after dietary adjustments before any improvements in sperm quality are observed, as this corresponds to the duration of spermatogenesis.

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NUTRITIONAL SUPPORT OF HEALTHY GROWTH IN KITTENS

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KEY TAKEAWAYS

- Most kittens are fully weaned by 6–8 weeks of age and reach adult body weight by 10–12 months of age.
- Spaying or neutering at an early age does not affect growth rate, but caloric requirements decrease by approximately 10–25% after spay and neuter surgery.
- Feeding practices during the post-weaning period may increase tendency for obesity unless carefully monitored and adjusted.
- Kittens should be exposed to a variety of food flavors and textures to help prevent neophobia, along with play-associated feeding practices to prevent weight gain.

Although kittens develop growth-associated orthopedic disease less frequently than dogs, optimal nutrition during the growth phase is essential for healthy outcomes. Nutritional excesses and deficiencies can occur in kittens at any stage of growth, thus careful attention needs to be given to the overall macro- and micronutrient content of kitten diets, as well as ensuring appropriate calories are fed.

Despite the kitten life stage being defined as birth to one year,[1,2] it is more practical to consider the nutritional requirements of kittens in three different stages of growth: nursing, weaning, post-weaning. This chapter focuses on the post-weaning period, which cats enter by 6–8 weeks of age, a time at which feeding habits[3] and practices become established. Feeding a complete and balanced diet and maintaining ideal BCS is essential because feeding an inappropriate diet or excess calories can lead to later problems such as obesity.

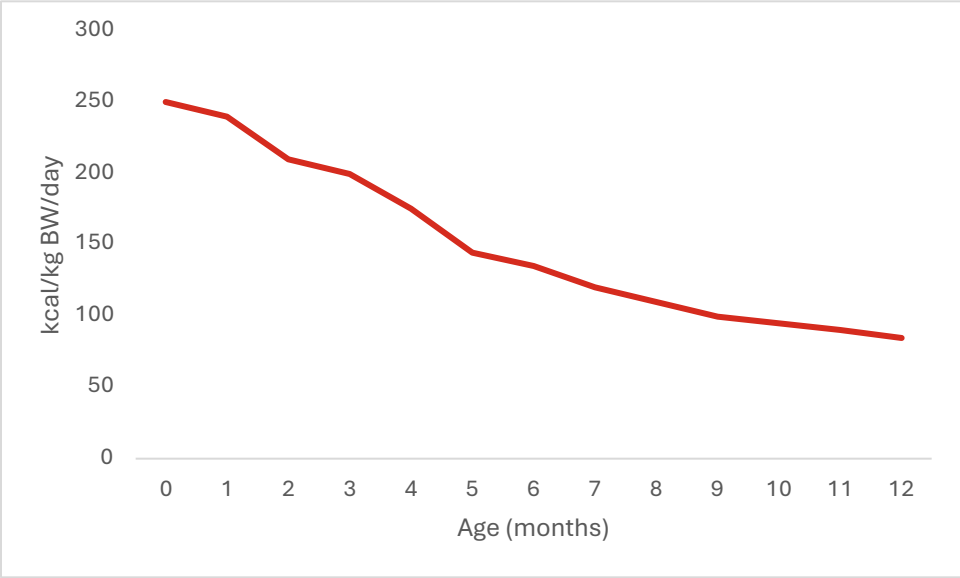
GROWTH RATE AND ENERGY REQUIREMENTS

By the time kittens are 6 months of age, they have typically reached 50–70% adult body weight and subsequently have a declining energy requirement as their growth slows (**Figure 1**).[2,4] For body weight, kittens should continue to gain 100 grams/week until they reach 20 weeks (5 months) of age. There is minimal breed variation in this growth rate, but males tend to be larger than females. After 5 months, they gain 11–20 grams/day (higher end for males) until they reach adult body weight at around 10 months of age. This equates to an average daily energy requirement for growth of 4.0–5.0 kcal metabolizable energy [ME]/g body weight, or roughly 2–3 x resting energy requirement [RER] throughout the growth period.[2,4]

Spaying and neutering does not impact growth rate but does decrease energy requirements.[5-8] Weight gain associated with spaying or neutering is typically attributed to an increased food intake that peaks around 8 weeks following gonadectomy and persists for 18 weeks post surgery.[6] Food intake should therefore be decreased by at least 10–15% after neutering, which takes growth and decreased energy requirements into account. However, body weight, BCS, and caloric intake, including treats, should still be closely monitored and adjusted for individual animals. The age of spay or neuter surgery does not appear to impact the predisposition for weight gain overall, provided calorie intake is appropriate.[5]

Due to the increased voluntary food intake observed following neutering, free access feeding may lead to increased body weight and body fat. One of the major contributors to life-time obesity in cats is a high rate of growth as a kitten, as well as neutering. Maintaining a healthy lean body weight is essential to reduce incidence of metabolic diseases such as diabetes mellitus or conditions such as osteoarthritis. It is important to note that along with the declining energy requirement, average activity of kittens declines between 19–52 weeks,[8] likely reflecting a decrease in

Figure 1. Daily energy requirements in growing kittens from birth (0) to 12 months of age



play behavior. This further increases the concern for obesity developing during this phase.

Individual monitoring of body weight and BCS is recommended to guide feeding practices, but most kittens between 12 and 24 weeks old do well with feeding 3–4 times daily, then decreasing to twice daily until 52 weeks of age. Transition from ad libitum or free access feeding during the weaning period to dedicated meal feeding post-weaning should be done gradually to ensure no adjustment issues develop, such as rapid consumption or overeating at meal times.[9] Additionally, the use of play (prey-associated) feeding practices may encourage activity and reduce risk of obesity.

MACRONUTRIENT REQUIREMENTS

Overall dietary protein requirement for kittens is nearly twice that of adult dogs. Total dietary protein requirements for growing kittens decrease over time, although they have similar essential amino acid requirements on a calorie basis as adult cats. The Association of American Feed Control Officials (AAFCO) minimum recommended amount of protein for kitten growth is > 7.5 grams/100 kcal (30% on dry matter basis), and FEDIAF guidelines recommend > 7.0 grams/100 kcal (28% on dry matter basis) (**Table 1**).[10,11] Kittens require a portion of this to be derived from animal protein. Excessive dietary protein content may decrease growth rate.[4] In addition to being essential for muscle and skeletal growth, protein enhances development of a normal immune system and impacts all body function development.

Kittens are tolerant to a high fat content in diets, and fat is essential in the growth period for cellular (neural) health, absorption of fat-soluble vitamins, and as an energy source. The AAFCO and FEDIAF minimums for kitten growth are 2.25 grams fat/100 kcal. Most kitten diets are higher than this in fat, with a concentration of 3–4 grams/100 kcal or more, and thus kitten food is often very energy dense (> 4 kcal/g on dry matter basis).[2,4] A diet with lower energy density may be necessary for spayed and neutered kittens, and calorie intake should be carefully adjusted if excessive weight gain is present. Poor quality diets may lead to diarrhea and should be avoided. They may especially cause gastrointestinal signs during transition periods. Inclusion of docosahexaenoic acid (DHA), ideally derived from fish or algal sources, is considered necessary for cognition, retinal, and neural development. The most rapid period of neural (brain) development in kittens is from 8–28 weeks, highlighting the importance of adequate nutritional value during this period.[12]

Carbohydrates are not required if there are glucogenic amino acids in the diet, but kittens are able to digest starch from cereal grains.[13] Carbohydrates can supply readily available energy for growth when highly digestible sources are provided.[4] Poor quality (i.e., poorly digestible carbohydrates or other poorly digestible nutrients) can lead to diarrhea and abdominal bloating.

Table 1. AAFCO and FEDIAF minimums for kittens and adult cats in grams/100 kcal[10,11]

	Kitten, AAFCO	Kitten, FEDIAF	Adult cat, AAFCO grams/100 kcal	Adult cat, FEDIAF 100 x $BW^{0.67}$ grams/100 kcal	Adult cat, FEDIAF 75 x $BW^{0.67}$ grams/100 kcal
Protein	7.50	7.00	6.50	6.25	8.33
Fat	>2.25	2.25	2.25	2.25	2.25
Calcium	0.250	0.250	0.15	0.100	0.133
Phosphorus	0.200	0.210	0.125	0.064	0.085
Sodium	0.050	0.040	0.050	0.019	0.025
Chloride	0.075	0.060	0.075	0.029	0.039
Potassium	0.150	0.150	0.150	0.150	0.200
Magnesium	0.200	0.013	0.010	0.010	0.013
Taurine	0.050 (wet) 0.025 (dry)	0.063 (wet) 0.025 (dry)	0.050 (wet) 0.025 (dry)	0.050 (wet) 0.025 (dry)	0.067 (wet) 0.033 (dry)

OTHER DIETARY CONSIDERATIONS

Diets that acidify urinary pH to < 6.2 should not be fed to kittens in the weaning or post-weaning phase. Kittens that have urinary pH < 6.0 grow more slowly, have increased urinary potassium loss and poor bone mineralization.[2,4] Therefore, diets that acidify urine should be avoided.

Kittens require an appropriate calcium and phosphorus content. Nutritional secondary hyperparathyroidism is still reported in kittens fed an all-meat diet.[14] Early recognition of this problem and switching to a diet providing calcium and phosphorus above their minimum requirement with a calcium-phosphorus ratio of 1.2–2:1 typically resolves all associated clinical signs.

As well as musculoskeletal growth and neural development, the post-weaning period is a critical stage in developing an adequate immune system and gastrointestinal (GI) microbiota.[12] The GI microbiota is an integral part of systemic health and immunity; thus it makes sense that optimizing development of a healthy microbial ecosystem during growth will lead to enhanced health outcomes as an adult. One study in puppies supplemented daily with *Enterococcus faecium* SF68 (now *Enterococcus lactis* SF68) from weaning showed enhancement of some immune functions.[15] Kittens fed the same probiotic had reduced incidence of diarrhea and a significantly lower number of days with diarrhea during the first year of life.[16] However, a later study showed no difference in survival in orphaned kittens (≥ 4 weeks old) with diarrhea when given this same probiotic.[17]

Bovine colostrum provides immunoglobulins as well as bioactive factors (e.g., lactoferrin) that are thought to promote nutrient absorption by colonic bacteria and contribute to the overall health of the GI microbiome.[18] Improved immune and gut function has been reported in kittens fed a diet containing 0.1% dried bovine colostrum.[18]

As kittens in the growth period have small stomach capacity, food digestibility should be high (> 80% total digestibility). Kittens do not require milk (from any source) after 6–8 weeks of age.

Cats in the wild typically hunt and eat small prey many (10–20) times a day, rather than ingesting one large meal, with kittens exhibiting this hunting behavior from an early age.[3] Introduction of kittens to food-based interactive play is ideal to assuage their prey drive, and to expend energy that may prevent weight gain.[2]

Adult cats are renowned for being fussy eaters, and it is possible that feeding practices as kittens may influence this characteristic.[19,20] In an early study, domesticated cats showed a tendency to choose to eat a new food rather than one typically fed, which is a concept called neophilia (or the novelty effect).[21] However, the opposite concept, neophobia, has also been reported, where the cat turns down novel flavors or textures.[17] If

COMMUNICATION TIP

Nutritional excesses and deficiencies can occur in kittens at any stage of growth, thus careful attention needs to be given to the overall macro- and micronutrient content of kitten diets, as well as ensuring appropriate calories are fed.

the food is not palatable, or has been associated with a negative experience (e.g., vomiting), then the cat's response may be different than expected. Additionally, perceived palatability in cats raised on identical diets may not be consistent, suggesting individual differences in preference.[20] Cats prefer to ingest food at body temperature, not too hot and not too cold.

Taking these requirements into consideration, it is generally considered preferable to feed a complete and balanced diet labeled for kitten growth, including wet and/or dry food, rather than to adjust or manipulate an inadequate diet or to feed a home-cooked diet. A variety of textures and flavors should be offered to kittens to help prevent aversion to food types later in life.

CONCLUSION

Although kittens may not have the same risk of developmental orthopedic disease as puppies, it is still essential to feed a complete and balanced diet for kitten growth. It is also important to ensure that essential amino acid and protein requirements are met with a highly digestible diet. One of the most important considerations during the post-weaning period is to avoid excessive weight gain and development of obesity, especially following gonadectomy. Alteration of feeding practices and energy density of food may be required, tailored to the individual animal. It is recommended that treats form < 10% of a kitten's daily caloric intake.

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NUTRITIONAL SUPPORT OF ADULT CATS

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KEY TAKEAWAYS

- Optimal nutrition allows adult cats to be in their best health, and includes maintaining an ideal body condition, selecting an appropriate diet, and meeting the cat's needs from a feeding management perspective.
- Changing the way the cat's food is offered can help meet their predatory instincts and hunting desires, while continuing to provide appropriate nutrition and calories.
- Considerations for proactive nutrition for adult cats include preventing obesity, ensuring adequate hydration, and promoting dental health.

Domestic cats are referred to as "obligate carnivores" because of their specific gastrointestinal anatomy, digestive physiology, and metabolism that allow maximal use of a carnivorous (animal protein-based) diet.[1,2] There are several key nutrients adult cats need to be in their best health. In addition to meeting the nutritional needs of adult cats, it is important to meet their needs from a feeding management perspective and to maintain an ideal BCS.

GASTROINTESTINAL ANATOMY AND DIGESTIVE PHYSIOLOGY

Gastrointestinal anatomy

Anatomic adaptations of the gastrointestinal tract of the domestic cat to its carnivorous diet include well-developed canine teeth for ripping and shearing meat, shorter intestinal length than omnivores as they are not dependent on fermentation of plant material for nutrients, and the decreased capacity of the proximal stomach to expand for storage as cats eat small meals frequently.[3]

Digestive physiology

The lack of α-amylase enzyme in saliva that initiates starch digestion, low average pH of the stomach at 2.5, reduced pancreatic amylase, and limited activity of intestinal disaccharidases support reliance on protein digestion more than carbohydrates to derive energy from food via gluconeogenesis.[4,5] Enterocytes possess greater villus height to increase absorption in the cat's relatively short digestive tract compared to dogs. Cats have reduced digestive enzyme capacity compared to dogs, and their limited monosaccharide transport system does not easily adapt to abrupt changes in dietary carbohydrate intake.[6,7]

NUTRIENT METABOLISM AND KEY NUTRIENTS FOR CATS

Protein

Normal adult cats have a higher protein requirement than other adult non-carnivore species with specific metabolic needs for arginine, taurine, methionine, and cysteine.[1,6] The diet must provide a total of 11 essential amino acids (arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, taurine, threonine, tryptophan, and valine),[8,9] and within these there are two amino acids (arginine and taurine) of particular metabolic importance,[10] which if deficient can lead to severe illness and even death.

Arginine

Cats cannot synthesize sufficient arginine from citrulline and ornithine to support its role of elimination of ammonia in the form of urea. Experimental data has shown that cats that consume high protein meals deficient in arginine will become hyperammonemic within 2 hours and may die from ammonia toxicity if this amino acid remains deficient.[11,12]

Taurine

Taurine is a sulfur-containing ß-amino acid that is widely distributed among numerous tissues, is used for bile acid conjugation to form bile salts in dietary fat digestion and absorption, and functions as a neurotransmitter and neuromodulator. Taurine exists in free form and does not form part of proteins. Taurine

Table 1. Energy requirements for adult cats are impacted by many factors.[30,31] Cats should always be monitored for weight loss or weight gain and changes in BCS when MER is calculated.

Physiological status	MER factor	Additional notes
Active spayed/neutered cats	1.2	
Intact active cats	1.4–1.6	· If cat has outdoor access, the amount fed at home may need to be decreased
Indoor, spayed/neutered, less active cats	1.0	· Prone to weight gain due to inactivity
Overweight or obese cats or obese-prone cats	0.8	· May require long-term feeding below RER

is necessary for integrity and function of several tissues and organs such as the brain, retina, and cardiac muscle.[9,13] Deficiency of taurine in cats occurs because they cannot synthesize enough taurine from cysteine and results in blindness, reproductive dysfunction, and dilated cardiomyopathy.[14]

Fats

Dietary fat is important as a concentrated source of energy[6,8] that can be divided into roles as facilitative or functional. Facilitative fat adds palatability and texture to foods, while functional fat delivers essential fatty acids[15] that are not otherwise synthesized but are necessary for adult maintenance.[16] The omega-6 essential fatty acid arachidonic acid (AA) (20:4n6) must come from the diet as cats lack sufficient delta-6-desaturase enzyme activity to synthesize AA from linoleic acid (18:2n6).[15] The omega-3 long chain polyunsaturated fatty acids, eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids, are recommended for adult maintenance, but there is no dietary requirement.[6,15]

Carbohydrates

There is no absolute dietary requirement for carbohydrates when compared with protein and fats for adult cats. Adult cats are in a constant state of gluconeogenesis from glucogenic amino acids, lactic acid, and glycerol, and have high levels of hepatic hexokinase activity for glucose metabolism.[4,5]

There is a need to have a constant and ready supply of glucose or glucose precursors for continued support of central nervous system activity, so in times of high energy expenditure, it may be beneficial to supply dietary carbohydrates as an energy source to decrease the need to derive glucose from lipid and protein precursors.[9] Early research suggested that cats have a poor adaptation to use of dietary carbohydrates,[17,18] but adult feline maintenance diets have typically included dietary carbohydrates (both soluble carbohydrates and fiber) that have been shown to be well tolerated and digested.[7,19,20] One recent study revealed changes in the gut microbiome and metabolome with improved gastrointestinal health in response to inclusion of dietary fermentable fiber in feline diets.[21]

Vitamins

The water-soluble vitamins niacin (B3) and pyridoxine (B6) are required either because of decreased enzymatic conversion (B3 from tryptophan) or increased usage (high transaminase activity requiring B6), respectively. Cats lack sufficient intestinal dioxygenase enzyme activity[22] to meet the requirement for retinol (A) from conversion of plant sources of beta-carotene. Domestic cats either cannot sufficiently convert or do not possess adequate stores[23] of 7-dehydrocholesterol in the skin to meet the requirement for cholecalciferol (D) using UV-light. Animal protein provides a source of both vitamins A and D to meet the dietary requirements for adult cats.[1,24]

Water

Cats evolved from desert Felidae predators who obtained water from ingesting prey that comprised about 60–70% water. The water content of commercial foods ranges from 8–10% in dry kibble diets to about 75–80% in wet foods. Cats eating dry diets must consume more water to stay hydrated. The urine of cats is more concentrated than that of dogs, noted clinically as urine specific gravity > 1.035–1.040 in the normal adult cat, indicating their ability to conserve body water.[25] The recommendations for water intake for adult cats are suggested at 1.5 to 2 mL of water/gram of dry matter (DM) consumed, which could be met with 1 mL water/kcal ME for dry food or wet food at 78 to 82% moisture.[24]

Box 1. Key concerns of pet owners

- **Is the current diet the best choice for my cat?**

  There are some basic guidelines for any diet that make it appropriate for feeding.[34] All diets should be complete and balanced, correctly labeled, and possess a nutritional adequacy statement for the pet's life stage in keeping with guidelines and recommendations such as from AAFCO or FEDIAF.

- **Cats are carnivores so why do diets include carbohydrates and fats?**

  Pet cats have been integrated into the human lifestyle and intimate environment, allowing the evolution of the feline intestinal microbiota to utilize some carbohydrates via fermentation to produce a healthy colonic environment. This adaptation to use dietary carbohydrates, inclusive of fiber, results in digestion and utilization of carbohydrates in cats[40] to support overall health and stool quality.

- **How many treats am I allowed to offer per day?**

  The general rule recommended by WSAVA[35] and AAHA[41,42] for treat allotment is no more than 10% of the daily calorie intake (MER). Any food or snack that is not complete and balanced is considered a treat and may include fruits, vegetables, components of the cat's main diet, commercial or homemade treats, table scraps or human food, supplements, and dental chews. The main goal of restricting treats to no more than 10% of MER is to prevent weight gain and nutrient imbalances while still providing variety and enrichment through food as treats.

- **There are numerous supplements available to ensure my cat is healthy long term. How do I know if a supplement is right for my cat?**

  Pet owners can seek the guidance of a veterinarian or veterinary nutrition specialist to research products to determine suitability for the cat.[43]

FEEDING MANAGEMENT STRATEGIES

Feeding pets in general can be divided into 3 basic approaches:[26]

i. Free choice or *ad libitum* – Food is left available continuously throughout the day and night, so the pet chooses its time and amount to eat.

ii. Time-restricted meal – Food is offered at specific times of the day and left available for the pet to eat within a time limit. Once the time limit is reached, the food is removed until the next scheduled feeding.

iii. Portion-controlled or meal feeding – Offering a specific amount of food at specific times to deliver nutrients and calories as calculated for that pet.

Cats are predators with innate and constant desire to hunt. The drive is so strong that they will leave an existing meal to engage in hunting activity that is only successful about one third of the time. While there is no data about how meal feeding specifically alters feline health, this known predatory desire should be considered when designing a feeding plan for cats. A cat that is meal-fed will still have the instinct to hunt with normal feeding behavior driving the typical consumption of 8–16 small meals/day.[27] The recommendation is to mimic the hunting activity of cats by providing puzzle feeders and foraging toys, and by changing feeding toys to offer variety. Simulated hunting experiences such as hiding food and offering frequent small meals in vertical and/or multiple locations allow isolated feeding. The amount of food offered per day and night as cats are regular and frequent eaters in these different ways should be monitored to prevent over-conditioning or obesity.

Other aspects of feeding adult cats include food format, odor, and taste.[28,29] An adult cat familiar with one texture or format of food may avoid the new food (neophobia). Kittens and young adult cats should be exposed to a variety of food types and formats to allow for easier diet changes when necessary.

ENERGY REQUIREMENTS

Factors affecting the energy requirements of healthy adult cats include age (young vs. mature adult), spay/neuter status, indoor vs. outdoor, level of activity, environment, and history of obesity or the likelihood of the cat becoming obese. The resting energy requirement (RER, kcal per day) of an adult cat is calculated as

COMMUNICATION TIP

In addition to meeting the nutritional needs of adult cats, it is important to meet their needs from a feeding management perspective and to maintain an ideal BCS.

$70(BW_{kg})^{0.75}$. The maintenance energy requirement (MER) for cats in ideal body condition is likely to range between 40–75 kcal/BW_{kg}/day and can be calculated using a factor of 1.0 up to 1.6 x RER depending on the spay/neuter status or activity level.[30] The best measure of "ideal MER" is weight stability at an ideal body condition. If the initial estimate is too high, there will be subsequent weight gain requiring a reduction in calculated MER. Similarly, weight loss requires an increase in the MER factor to get the cat back to the original weight and ideal body condition.[31]

THE IMPORTANCE OF MAINTAINING IDEAL BODY CONDITION

Body condition scoring (BCS) for cats ranges from 1–9 where 5/9 is considered ideal for cats and scores on either end of ideal suggest mild to severe malnutrition.[32] A BCS of 4/9 may be ideal for some cats. Lower scores indicate undernutrition while higher scores suggest overnutrition, both of which may also be associated with unbalanced diets and inappropriate energy intake.[33] A thorough nutritional assessment should be performed for each adult cat with a goal for maintenance of an ideal body condition.[34,35]

CONSIDERATIONS FOR PROACTIVE NUTRITION

The two major goals of complete and balanced nutrition for the healthy adult cat are centered around providing the appropriate amount of energy (MER) and the right amount of water, macronutrients, and micronutrients to support optimal health. These two goals are directed to maintaining ideal body condition and muscle condition for a healthy young adult and middle-aged cat to decrease risk of diseases.

- Prevention of obesity decreases the risk of several diseases not limited to diabetes mellitus, hepatic lipidosis, calcium oxalate urolithiasis, and inflammatory bowel disease[2,44,45] in cats.
- Decreased water consumption leads to highly concentrated urine with increased risk of urolithiasis or other urinary problems. Increasing urine volume through increased water consumption remains the mainstay of urolithiasis prevention in cats.[46,47]
- Specific dry foods and dental chews may decrease build-up of dental plaque and prevent the formation of calculus but do not replace owner commitment to consistent at-home and veterinary dental care.[48,49]

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NUTRITIONAL SUPPORT OF SENIOR CATS

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KEY TAKEAWAYS

- Senior cats have highly individualized nutritional needs.
- Some cats might require a calorie-restricted diet to avoid or treat obesity, while others can be maintained on their regular diet or even switched to a higher calorie/fat diet.
- Senior cats might have one or more subclinical underlying conditions that lead to minor or no clinical signs (e.g., stage 1 or 2 CKD, mild chronic enteropathy) leading to slow and gradual weight loss. These conditions must be investigated, correctly diagnosed and taken into account before dietary recommendations can be made.

Nutritional needs likely change as a cat ages, but the literature is lacking definitive information about nutrient requirements and optimal nutrition of senior cats. Therefore, recommendations on feeding senior cats may be general and tentative. Although a clear definition of when a cat is considered senior is lacking, a commonly used cut-off is 7–10 years. However, it needs to be kept in mind that senior cats may vary substantially between one another with regards to health status and, therefore, nutritional recommendations should be individualized.

Improvements in the control of infectious diseases, nutrition and health care of dogs and cats have resulted in a gradual increase in the average lifespan in these species.[1] Longevity has become an emerging science in human beings and several groups of investigators aim to improve both lifespan and health span in humans. Several factors can affect lifespan including health care, genetics, environmental factors and nutrition. Aging is not considered a pathological process, but rather comprises the normal time-dependent changes that occur during the life of every individual. Several undesirable changes occur during aging including development of disease, changes in mobility, muscle wasting, and changes in cognitive function. Nutritional goals for aging cats include promoting health, preventing the onset or slowing the progression of age-related health disorders, and enhancing the pet's quality of life and life expectancy.

LIFESPAN OF CATS

From an evolutionary perspective, domesticated dogs and cats present a unique example of species that enjoy an extended lifespan beyond successful maturation and reproduction. The average lifespan of cats that are kept indoors is approximately 14 years, and the cat's maximum lifespan may be as high as 35 years. Although this is extremely rare, it is not uncommon for cats to live up to or beyond 20 years of age. As in dogs, there might be differences in lifespan among different breeds, with crossbred cats living on average longer than purebred cats.[1]

MAJOR AGE-RELATED PHYSIOLOGICAL CHANGES (BOX 1)

Metabolic effects and changes in body composition

Normal aging in animals is associated with decreases in lean body mass (LBM) and total body water and an increase in the proportion of body fat.[2] A decline in body water accompanies the loss of lean body tissue because lean tissue contains 73% water, while adipose tissue contains only 15% water.[3] Data collected from a colony of young and old cats and dogs found that the body fat of young cats averaged 30% and increased to 35% in cats that were older than 7 years.[4] However, it needs to be pointed out that these changes are affected by several factors such as activity, nutrition, and health status.

Changes in energy requirements

Maintenance energy requirements (MER) are the energy needs required for the normal animal to survive

with normal activity. Energy requirements change substantially with age in virtually all animal species. Energy requirements in association with age are somewhat controversial and puzzling in cats. Some older short-term studies suggested no changes in MER in cats as they age.[5] However, subsequent studies have showed that MER decreases with age up until the age of 10–12, and then it increases again, especially as the cat gets close to 13–15 years of age.[5-9] Reduction of MER in mature cats might be associated with the reduction in LBM, which is known to decrease with age and is the main driver of basal metabolic rate.

Changes in digestion and absorption

Histological and functional changes of the gastrointestinal tract in aging cats have not been well described. Recent yet unpublished evidence suggests many clinically healthy cats may have subclinical histopathological changes of the small intestine but it is currently unknown how these changes translate to changes in intestinal function. Previous studies have shown that 20–30% of cats older than 12 years of age have reduced ability to digest fat and protein.[5,8,10] These changes may contribute to weight loss and muscle loss in aging cats.

Changes in the integumentary system

With aging, the skin loses elasticity and becomes less pliable as a result of increased pseudoelastin in the elastic fibers. Additionally, many animals also develop hyperkeratosis of both the skin and follicles. The loss of melanocytes in the hair follicles and reduced activity of the enzyme tyrosinase that results in the production of white hairs in humans and dogs does not seem to be that prominent in cats.[3]

Changes in the urinary system

Chronic kidney disease (CKD) is a major cause of illness and mortality in senior cats. A slow, gradual decline in renal function might be considered normal with aging. It is known that a substantial loss of functioning nephrons (>75%) must occur before biochemical and clinical changes occur.[3,11] Therefore, research often focuses on early detection of CKD. The point where normal loss of functional nephrons due to aging crosses over to CKD is difficult to determine clinically. To what degree nutrition can cause or prevent loss of renal function is currently unknown. It is also unknown at what point during renal function decline nutritional interventions might be initiated. This is currently a topic of controversy because large, randomized, controlled clinical trials are lacking and it is not clear which nutritional strategies (e.g., protein restriction, phosphorus restriction) are most useful at certain stages of CKD.

Box 1. Physiological changes seen in senior cats

- Energy requirements
- Body composition — BCS and lean muscle mass
- Digestion and absorption
- Skin and coat health
- Renal and urinary health
- Behavior
- Immune function
- Senses — vision, hearing, smell, and taste

Changes in the musculoskeletal system

Together with the gradual reduction in LBM (**Figure 1**), aging is associated with a decline in bone mass.[3] Both the number and size of muscle cells decrease with age, and the cortices of the long bones become thinner, dense, and brittle. The composition of the articular cartilage matrix changes with age; specifically, a reduced number of chondrocytes leads to decreased production of glycosaminoglycans, type 1 collagen, and chondroitin sulfate. Orthopedic and especially joint disorders are common in senior cats.[5] Radiographic evidence of osteoarthritis has been reported to occur in more than 60% of cats >6 years, despite the fact that obvious clinical signs of lameness or discomfort are not recognized in most of these cats.[12]

Changes in behavior

Changes in behavior are common in senior cats and may be related to concurrent degenerative or other disease, primary central nervous system disease, cognitive dysfunction syndrome (CDS) or true behavioral disorders.[3,13] Several of these behavioral changes may affect their ability or desire to obtain adequate nutrition. For example, a cat with chronic pain due to chronic pancreatitis or osteoarthritis may avoid moving towards the feeding bowl or avoid standing to receive food.[3,13] With advancing age, cats also become more resistant to environmental changes. For example, the introduction of a new pet can lead to profound stress and lead to a state of anorexia or altered eating behavior.

Changes in cognitive function in older cats may occur due to age-related functional or degenerative changes in the central nervous system. CDS refers to a collection of behavioral changes of senior cats (such as anxiety, disorientation, memory loss, depression, altered eating and drinking behavior, aggression, inappropriate urination or defecation, excessive vocalization) that have no obvious organic cause.[3,13]

Changes in the immune system

Several changes occur in the immune system during aging. Similar to humans, immunocompetence declines with age in cats, contributing to increased risk for infections, immune-mediated or degenerative diseases, and cancer in senior cats. Cell-mediated immunity (i.e., T-cell immunity) is most severely affected.[3,8]

Changes in senses

Aging is accompanied by a gradual decline in the sensations of vision, hearing, smell, and taste.[3] Nuclear sclerosis and cataracts of the lens are frequently seen in older cats and can lead to partial or complete blindness. Hearing impairment caused by cochlear degeneration is also common. Finally, a decrease in smell and taste may be related to degeneration of nervous tissue and may contribute to decreased interest in food leading to reduced food intake and weight and muscle loss in senior cats.

NUTRIENT REQUIREMENTS OF SENIOR CATS

The AAFCO and FEDIAF guidelines for adult maintenance are used to formulate diets for senior cats. As mentioned, the literature is lacking information regarding nutrient requirements and optimal nutrition of senior cats. In addition, cats age differently, which can complicate having a common nutritional standard for aging cats. Therefore, some of the recommendations made for senior cats are not based on solid evidence-based data. Diets marketed for senior cats vary widely in nutrient composition and product claims.[14,15] The ideal nutrition for a senior cat should focus on providing optimal levels of essential nutrients, maintaining a healthy body weight and muscle condition, and helping to delay age-related physiological changes. Obviously, senior cats need the same nutrients as younger cats. However, the quantities of these nutrients may be different than those of younger cats.

COMMUNICATION TIP

It needs to be kept in mind that senior cats may vary substantially between one another with regards to health status and, therefore, nutritional recommendations should be individualized.

Energy

As mentioned, energy requirements decrease in many cats over the age of 10–12 years.[5-9] If energy intake is not reduced accordingly, then obesity will develop. Therefore, many commercial foods that are formulated for senior cats are moderate in energy density (and they achieve this mainly through the reduction of fat), while still providing optimal levels of essential nutrients.[5-9] However, senior cat nutrition should be highly individualized as many cats will maintain a stable body weight throughout their senior years, while others will experience weight loss. It is unclear whether this last group of cats experiences an actual increase in energy expenditure, or whether the weight loss is a result of reduced digestive function. It has been shown that 20–30% of cats over the age of 12 may have reduced ability to digest protein and fat, potentially leading to weight loss.[5-9] As is the case at any age, energy intake should aim to maintain a lean body weight. Therefore, these cats may benefit from a more energy dense, highly digestible diet to compensate for these age-related changes. Nutritional assessment of senior cats should be a crucial step before recommending a diet, as individual cats may have completely opposite nutritional needs.

Unintentional weight loss and poor body condition might be associated with increased mortality in senior cats. Therefore, it has been recommended by some practitioners that senior cats should be maintained at a higher normal body condition (or even slightly overweight) in order to have enough reserves in case a serious illness develops. This has not yet been proven to be beneficial in well-designed studies. In any case, obesity should be avoided because it has been shown to have detrimental effects.

Figure 1. Muscle wasting and weight loss in a senior cat



Protein

A decrease in LBM occurs with aging in most senior cats. This leads to reduced protein reserves that can normally be used by the body during periods of stress and disease. Many diseases that develop in senior cats are highly catabolic and mobilization of body protein is increased in these situations. Lack of adequate LBM may be associated with increased mortality. Therefore, maintenance of adequate LBM is important for senior cats. Cats of any age have high protein requirements. Given that some cats experience reduced protein digestion capabilities above 12–14 years of age, adequate protein intake is crucial.[5-8] Protein quality is also important in those cases, and highly digestible proteins should be selected. The ideal amount of dietary protein intake for senior cats has not been determined and likely differs between individuals.

There has been some controversy regarding dietary protein and the development of CKD. However, there has been no evidence that normal protein intake causes CKD in either dogs or cats, and protein restriction is never recommended in a healthy cat, regardless of age.[5-8]

Fat

Many commercial foods that are formulated for senior cats are slightly lower in fat in order to reduce the energy density of the food. This can be beneficial because many senior indoor cats are prone to obesity.[8] However, not all senior cats are prone to obesity and many may actually be prone to weight loss. Therefore, providing a lower fat diet might not be indicated in all senior cats and individualized recommendations are recommended.

Carbohydrates

Carbohydrates are often overlooked in feline nutrition. It has been hypothesized that higher dietary carbohydrate concentrations may increase the risk for development of diabetes mellitus (DM) in cats but this has not been proven.[16] There have also been concerns that this might be a bigger problem in senior cats. Unfortunately, there has been no adequate research in this area and therefore solid recommendations cannot be made as to adequate carbohydrate content in feline senior diets.

Other nutrients

Several other nutrients have been studied, mainly in dogs, to prevent certain pathologic conditions (e.g., CDS), boost the immune system, or increase longevity

when the animals reach their senior years.[17] These include antioxidants (such as vitamin E, vitamin C and carotenoids), fatty acids (e.g., n-3 and n-6 fatty acids), medium-chain triglycerides (for improvement of cognitive function), and prebiotics.[3,17] In one study, older cats fed a diet with a combination of fatty acids, prebiotics, and antioxidants lived longer than cats who consumed a control diet without those supplemental nutrients.[17] Older cats fed a diet supplemented with specific nutrients including fish oil, antioxidants, arginine, and B vitamins were shown to have better performance on learning and memory tasks versus cats consuming a control diet.[18] However, there have been only isolated such reports in cats and further research is required before definitive recommendations can be made.

CONCLUSION

In general, senior cats have highly individualized nutritional needs. Dietary recommendations should only be made after a careful nutritional history and investigation of the individualized needs of the cat. Some cats might require a calorie-restricted diet to avoid or treat obesity, while others can be maintained on their regular diet or even switched to a higher calorie/fat diet if the cat is losing weight with no obvious underlying reason.

It needs to be pointed out that senior cats might have one or more subclinical underlying conditions that lead to minor or no clinical signs (e.g., stage 1 or 2 CKD, mild chronic enteropathy leading to slow and gradual weight loss). These conditions must be investigated, correctly diagnosed and taken into account before dietary recommendations can be made. Therefore, preventive testing and a thorough history and physical examination are necessary to be done routinely in senior cats. If any underlying conditions are diagnosed, then nutrition should be targeted to the specific underlying condition, while concurrently meeting all the nutritional needs for a senior cat. If no underlying disease is present, then nutrition should aim to maintain an ideal body weight and a normal muscle condition, while again meeting all the nutritional needs for a senior cat.

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NUTRITIONAL SUPPORT OF REPRODUCING AND LACTATING CATS

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KEY TAKEAWAYS

- Cats should have an ideal body composition (BCS 5/9) before breeding.
- From first day of gestation on, queens show a steady, nearly linear weight gain; therefore energy supply needs to be increased at the beginning of breeding. Switching to a diet suitable for gestation and lactation is recommended at the time of breeding.
- Queens are in a negative energy balance during lactation; therefore they typically lose weight.

Fulfilling the nutritional requirements of cats during reproduction is crucial. Both under- and oversupply of nutrients and calories can impair reproductive performance and can have negative effects on the health status of both queen and kitten. Furthermore, it is important to avoid anything that might harm the health of the mother and her offspring during development or delivery. As breeding pets often is a rather emotional endeavor, providing cat owners with precise information on their pet's unique nutritional requirements is important to prevent them from relying on myth or anecdotal evidence.[1] Commercial complete and balanced (complete) diets generally fulfill these needs,[2,3] and home-made diets have a high risk of being unbalanced and are not often recommended.[4,5] The primary goal of feeding reproducing animals is to create optimal conditions throughout the reproductive process, ensuring high reproductive performance and optimizing the litter size as well as the kittens' survival and growth.

Aims of feeding reproductive cats include:
1) Optimization of ovulation rate as well as sperm quality

2) Promoting optimal placenta function and best conditions for implantation of the embryo(s)

3) Optimum nutrient supply during gestation, allowing the best possible development of the fetuses during the intrauterine phase and allowing the queen to build up body reserves

4) Avoiding any situation that might have negative effects on the process of giving birth (e.g., bradytocia or problems of widening of the birth canal)—thus best enabling the queen to deliver the kittens

5) To ensure the queen has the best nutritional support in order to produce high-quality colostrum and milk furthering the development of the kittens

6) Supporting the kittens during the transition process when switching from milk to additional food, and later, promoting the weaning process

PRE-BREEDING FEEDING OF THE QUEEN

Cats are seasonally polyestrous, and ovulation is induced by copulation. Ideal body condition (BCS 5/9) is crucial for reproductive queens. Being underweight before breeding may result in lower energy and nutrient supply to kittens, resulting in low birth weight and poor lactation performance of the queen; overweight cats may face difficulties giving birth as the kittens grow too big[6] or suffer from dystocia.[7] Although no studies exist about the effects of "flushing feeding" in cats, some veterinarians recommend feeding a higher energy supply before mating to optimize ovulation rate. During the pre-breeding phase and estrus, the queen should be fed according to the maintenance energy requirement (MER).[7] The MER for adult cats varies widely according to body weight, age, and body composition (lean body mass) with 100 kcal x kg body weight $(bw)^{0.67}$ for lean cats or 1.2–1.4 x (70 x $(kg\ bw)^{0.75}$). The energy density of the food fed during gestation should be high enough to fulfill the needs of lactating queens so that the diet can be fed consistently throughout the whole breeding period, minimizing stress due to diet change (**Table 1**).[7]

Therefore, it is recommended to feed a highly digestible, complete and balanced food designed for pregnancy, nursing, and growth (either a kitten or an all-life stage formula) from the beginning of the breeding process.[8] Switching to this diet before the critical time of egg fertilization and embryo implantation helps reduce problems based on reduced food intake or digestive upsets. Food should be changed gradually, and food intake should be monitored to prevent oversupply of energy.

GESTATION AND GROWTH OF KITTENS (INTRAUTERINE AND POSTPARTUM)

Gestation in queens lasts between 62 and 70 days, with an average of 63–65 days; larger breeds tend to have a longer gestation period. Like all mammals, both the queen and the fetuses maintain a positive energy and nitrogen balance during gestation. Queens experience a steady, nearly linear weight gain starting from the first day of pregnancy,[9] with a total increase of up to 50% of their initial body weight. The queen's weight gain is primarily due to fat storage, which serves as an energy reserve for lactation. This contrasts with bitches, which typically show a weight gain after the 28th day of gestation, relying on food intake during lactation to meet their energy needs. Energy requirements increase depending on the number of kittens and the stage of gestation. Compared with the MER, the queen needs an additional 20–56% by the end of gestation.[8,9] Placentation occurs 28 to 30 days after mating. The weight of each fetus depends on the breed, the queen's condition, and the litter size. At birth, a kitten's weight typically accounts for 2–3% of the queen's body weight. Parturition results in a weight loss of about 12% for the queen. During the nursing period, kittens gain weight rapidly, putting high demands on the queen (**Figure 1**). Relative to their birth weight, expected weight gains are as follows: 7 days: 175%; 14 days: 275%; 21 days: 329%; 28 days: 400%. By 4 weeks of age, kittens reach about 10% of their adult body weight. By the 10th week, they are approximately 30% of their adult weight, 60% by 20 weeks, and 85% by 30 weeks.[10]

COMMUNICATION TIP

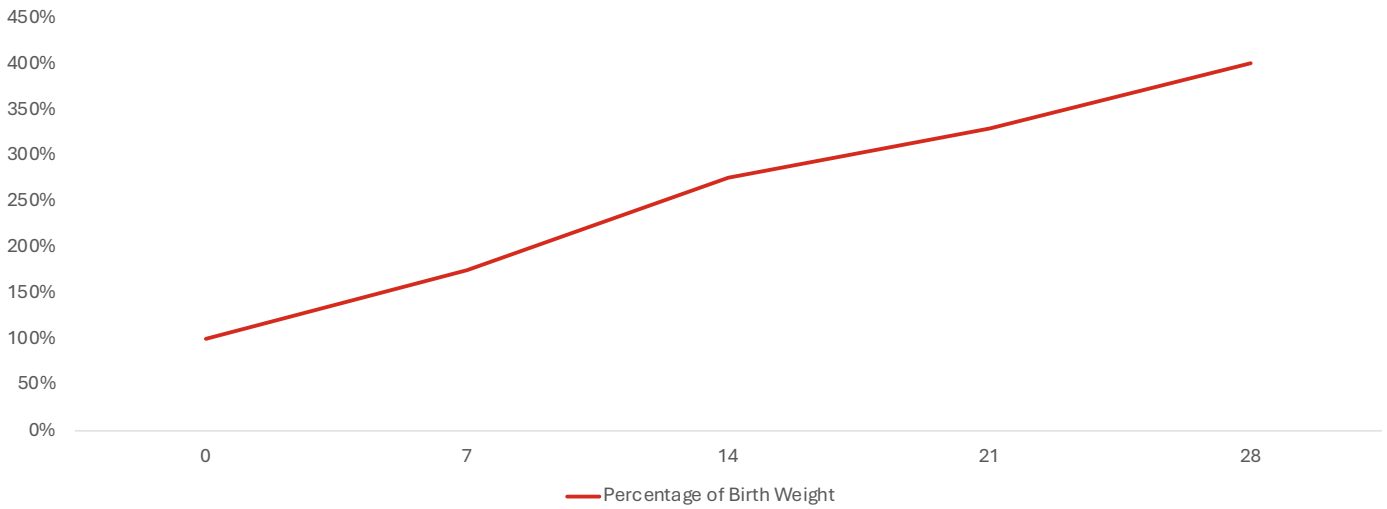
Lactation is the most nutritionally demanding stage of a queen's life, so ensuring an adequate supply of energy and nutrients can be challenging.

Many reproducing queens can regulate their own food intake, making ad libitum feeding a viable option. However, for cats prone to obesity, it is important to carefully monitor their weight evolution to prevent undesired gain.

LACTATION

Lactation is the most nutritionally demanding stage of a queen's life,[8] so ensuring an adequate supply of energy and nutrients can be challenging. To meet these needs, it may be necessary to feed the queen several times a day or provide free-choice feeding of a complete and

Figure 1. Weight gain of kittens in percentage of birth weight by day after birth[10]



balanced diet for gestation and lactation to encourage adequate food intake.

During the first few weeks of lactation, queens typically experience a negative energy balance[11,12] as they rely on fat stores accumulated during gestation to meet their increased energy demands (typically 2–2.5 times the MER when the litter consists of more than two kittens). Over the 7–9 weeks of lactation, the queen may lose 700–800 grams of body weight, depending on the litter size.[13] Queens with smaller litters (1–2 kittens) may lose up to 5 grams per day, while those with larger litters (more than four kittens) can lose up to 20 grams per day. In case of higher weight loss the energy density of the diet should be increased or kittens should receive supplementary food. Queens with only one kitten generally do not have significantly higher energy needs during lactation. For the first few weeks of the kittens' lives, the queen's milk is a complete food, providing the necessary energy and nutrients for their growth.

Colostrum

Unlike other species, the composition of cat colostrum is quite similar to that of mature milk in terms of protein, fat, and lactose content, with only slightly higher protein levels and lower lactose values. The concentration of IgG in colostrum is around 40–50 mg/mL and decreases by about 50% within the first 24 hours. After this period, the IgG levels drop to around 1 mg/mL. Kittens depend on the antibodies provided by the queen's colostrum, but these antibodies can only be absorbed during the first 16–24 hours of life.[16]

Milk composition

Compared with cow's milk, queen's milk contains a higher proportion of long-chain fatty acids, similar to that of dog's milk. The fat is primarily composed of linoleic acid (20.6% of fat) and arachidonic acid (1.7% of fat). The concentration of linoleic acid increases throughout lactation, while the content of arachidonic acid decreases. It is important to feed a diet that contains fish oil, allowing for adequate docosahexaenoic acid (DHA) concentrations in milk. The protein content in queen's milk is higher than in cow's milk, although the amino acid profile is similar to that of dog and cow milk. Taurine is also present at a concentration of 30.6 mg per 100 g.[17] Mineral concentrations in queen's milk increase during lactation. At the start, the calcium content is relatively low (46 mg/100 g), but it rises to 182 mg/100 g by the fourth week. Phosphorus is relatively high in colostrum (114 mg/100 g), increasing to 162 mg/100 g by the fourth week. As a result, the calcium-to-phosphorus ratio in colostrum is below 1:1 but increases in milk to 1.17 by the fourth week of lactation. Queen's milk also contains significant levels of vitamin A, with 736 IU per 100 g in the first week and 519 IU per 100 g by the fourth week.[17]

Milk yield

Milk yield depends on the lactation stage and the number of kittens, ranging from 0.9–8% of the queen's body weight, with an average of 4.14% during peak lactation between the third and fourth weeks postpartum.[17]

As the energy density of the milk increases throughout lactation, the queen's energy demands remain high despite a decrease in milk yield after it peaks at week 4 postpartum. During the first weeks of lactation, queens experience a negative energy and protein balance. However, in the second half of lactation, a positive balance helps rebuild lost body tissue, and by the end of the lactation period, the queen's body weight typically returns to pre-mating levels.[9]

Table 1. Recommendations for energy and protein supply of queens (relative to MER),[14] modified[15]

Phase of reproduction	Energy	Protein
Gestation		
Early gestation	1.4	1.5
Mid and late gestation	2.0	1.5
Lactation		
Lactation: 1 or 2 kittens	1.3	1.4
Lactation: 3 or 4 kittens	2.0	2.1
Lactation: 5 or more kittens	2.5	2.7

Supplementary feeding of nursing kittens

After the fourth week, kittens need additional food as the queen's milk alone can no longer meet their nutritional demands. The queen's diet should be mixed with water to help transition the kittens to additional food. Initially, mix 1 part dry food with 2 parts warm water, and by weeks 5–6, adjust to 2 parts food and 1 part water. This helps introduce the kittens to gruel and additional food.[10] More information on weaning is found in the chapter on pediatric nutrition.

FEEDING OF THE QUEEN DURING THE WEANING PROCESS

The weaning process begins naturally when kittens are between 5 and 8 weeks of age, with the queen determining the appropriate timing. However, it is recommended to wait until kittens are at least six weeks old, as research shows that extended nursing has positive effects on behavior later in life.

On the day before weaning, it is important to separate the kittens from the queen, and her food intake should be limited or even removed to help reduce milk production and facilitate the drying-off process. The night before weaning, kittens should be allowed to nurse one last time. On the actual weaning day, the queen is then separated from the kittens.[7,10]

The queen should be fed 0.25 MER in the form of the maintenance diet (the same one used before breeding) on the first day after separation. Over the next three days, her food intake should be gradually increased to reach her full MER.[12]

MALE CATS

During the breeding period, energy demand increases by 10%, while in between breeding, MER is sufficient. To ensure high sperm quality, a complete and balanced feline adult maintenance diet is needed. Zinc, vitamin A, and arachidonic acid are especially essential.

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NUTRITIONAL SUPPORT OF GERIATRIC DOGS AND CATS AND PALLIATIVE CARE PATIENTS

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KEY TAKEAWAYS

- Geriatric pets are at or near the end of their expected life span and experience physical, functional, and metabolic changes that are still amenable to nutritional intervention to improve health and quality of life.
- Use a framework of nutritional prioritization and planning for managing comorbidities in geriatric pets.
- Palliative nutrition emphasizes supportive care that prioritizes comfort and quality of life (QoL) by aligning nutritional strategies with the client's goals and empowering them to participate in care decisions.

INTRODUCTION

Nutrition is crucial for growth and sustaining health throughout life, yet feeding geriatric pets requires a unique shift in focus, addressing age-related changes and emerging challenges to maintain vitality and function, or "health span." Geriatric pet care is increasingly important for veterinary health care teams (VHCT) and pet owners alike because pets are living longer. Senior pets in the US are estimated to make up well over one-third of the population with this proportion continuing to grow.[1,2] Pet owners generally believe their aging pets have different nutritional needs, resulting in a plethora of commercial options aimed at elder pets with the goal of improving function such as mobility, digestion, immune support, cognition, etc.[3] However, with no accepted standard for nutritional requirements for a "senior" pet life stage[4-6] (see chapters on senior dog and senior cat), studies have confirmed a significant disconnect between VHCT and pet owner assumptions regarding nutrient features of diets marketed for elder pets and the actual composition.[7,8] There is wide variation in nutrient profiles of these products, with some nutrient modifications depending on the philosophies of the manufacturer. Feeding a product marketed for aging pets does not ensure it is appropriate for the individual pet.

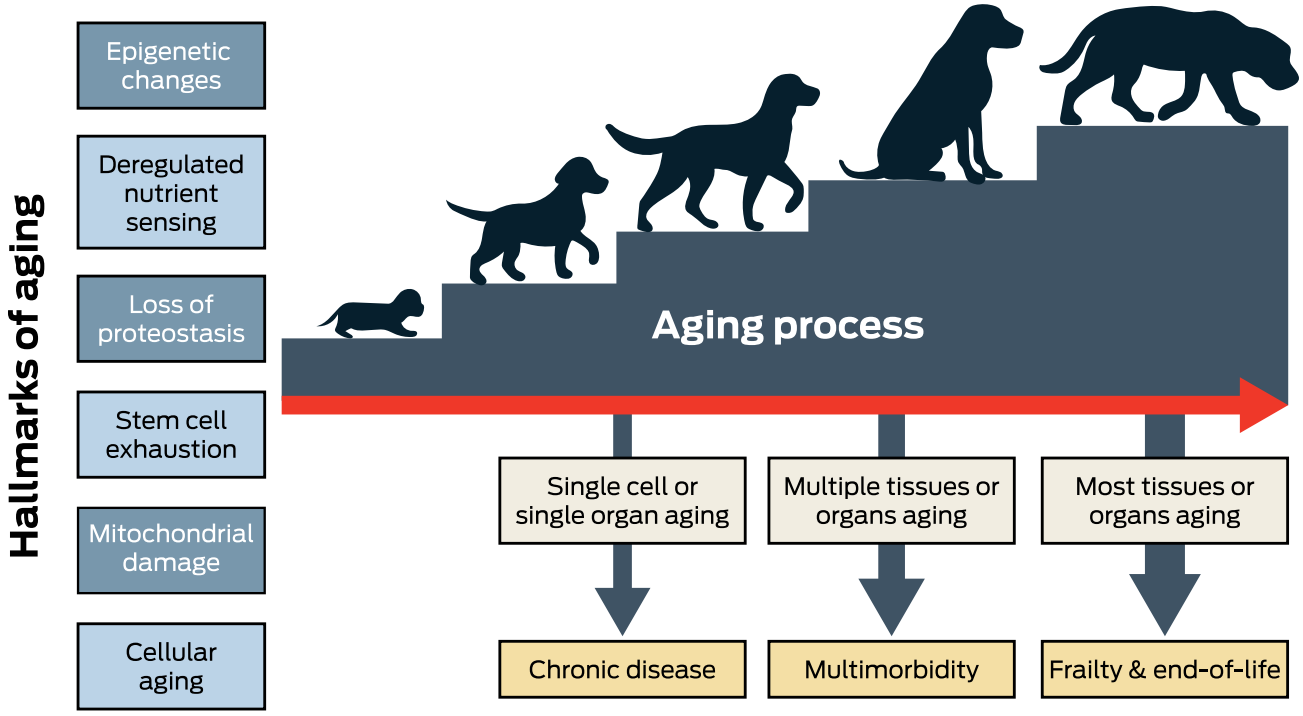
THE AGING PROCESS

Aging is characterized by a functional decline and deterioration at the cellular, tissue, and organ level.[9] Optimal performance of cells, organs, and the individual is maintained through maintenance mechanisms of DNA repair, and protein and lipid synthesis. With age, various cellular changes occur, including epigenetic changes and losses of proteostasis, nutrient sensing, and cellular repair (**Figure 1**).[10] This results in a loss of robustness, the ability of the individual to maintain optimal physiologic function and resilience, the ability to return to function after disruption by external stressors.[11] Aging is characterized by the gradual accumulation of changes over time, resulting in increased vulnerability to chronic disease, multi-organ dysfunction, frailty, and ultimately, death. The aging process is highly individual depending on genetic and environmental factors. For this reason, chronologic age, the time a pet has been alive, is less helpful in determining the health of elder pets than their biologic age, the extent to which aging changes impact function.

WHEN IS A PET GERIATRIC?

In veterinary medicine, the term geriatric remains poorly defined and is frequently used interchangeably with senior in the literature. Geriatric terminology also varies between canine and feline patients. The 2021 AAHA/AAFP Feline Life Stage Guidelines and the 2021 AAFP Feline Senior Care Guidelines define senior cats as those greater than 10 years of age and "super senior" (geriatric) cats as those more than 15 years of age.[12,13] Aging changes and life spans in dogs vary significantly based on breed and size, so the 2019 AAHA Canine Life Stage Guidelines define senior as "the last 25% of estimated life span through end of life."[14] Geriatric dogs are those at or beyond their

Figure 1. Hallmarks of aging



expected life span. The point at which a pet reaches advanced "biologic age" is variable, so chronologic age groupings are merely arbitrary demarcations. VHCTs should focus attention on an individual pet's progressive physiologic and functional decline that occurs with advancing "geriatric" age. McKenzie et al. propose a conceptual framework for geriatric dogs, Canine Geriatric Syndrome (CGS), to include multiple interrelated physical, functional, behavioral, and metabolic changes and the resulting clinical manifestations, including frailty, diminished quality of life, and age-associated disease.[11] This framework could also apply to cats and for the purpose of this discussion, "geriatric" will refer to advanced aging senior pets with a constellation of key physical and functional changes that predispose them to age-related dysfunction, disease, and death. Although defining the onset of a geriatric life stage is challenging and aging is inevitable, proactive preventive care and nutritional management throughout life can help mitigate age-related declines in health, reduce morbidity and mortality, and improve quality of life.[3,15-18] Nutritional support of geriatric pets builds upon the foundation described in the chapters on nutritional care of senior cats and dogs and will emphasize and highlight important considerations for advanced-age geriatric and palliative care for patients nearing their end of life.

NUTRITIONAL ASSESSMENT

Before recommending any diet changes, a thorough nutritional evaluation should be performed. The goal of the nutritional assessment is to obtain the necessary information to provide a specific nutrition recommendation. Nutritional assessment is an iterative process including evaluating the patient (animal factors), all foods (diet factors), and the human and environmental factors.[19] Signalment, dietary and medical histories, and a complete physical examination with appropriate diagnostic testing for the geriatric pet encompass the nutritional assessment. Geriatric pets require an extended evaluation in the nutritional screening process. This evaluation should include eating (both appetite and intake), oral examination, aspects of activity and mobility, sleep, cognitive function, and behavior (**Box 1**).[15]

REASSESSMENT AND ADJUSTMENT OF THE CARE PLAN

Nutritional assessment of geriatric pets should be approached as an ongoing, dynamic process due to the wide variability in age-related metabolic changes and the increased risk of progressive physiological decline. Individualized care plans are essential and should be regularly re-evaluated to reflect the evolving needs of

each patient. Effective communication with pet owners is critical to establishing expectations for continuous reassessment and adjustments to the nutritional strategy, rather than relying on a general senior care protocol. A structured monitoring plan facilitates early detection of emerging problems and provides timely opportunities to intervene or refine the nutritional plan to optimize health outcomes. Collaboration with clients is key to promoting adherence and achieving long-term success in meeting nutrition and monitoring goals.

HIGHLIGHTING NUTRITIONAL CONCERNS OF GERIATRIC DOGS AND CATS

Water

The prevalence of dehydration among elderly humans ranges from 20% to 30%, primarily due to a diminished thirst response and reduced renal concentrating ability. Hypohydration or chronic mild dehydration has been linked to increased frailty, morbidity, and mortality in older adults.[20] Furthermore, even mild dehydration has been associated with impaired

Box 1. Extended screening: Assessing geriatric pets for nutritionally relevant age-related factors

Extended evaluation includes assessment of physiologic changes or diseases in geriatric pets that may impact nutritional recommendations or requirements or food intake. The following areas should be evaluated in pets with multiple nutritional risk factors during their nutritional assessment:

- **Abnormal body and muscle condition:**
  - Note any changes in body weight or abnormalities in BCS or MCS.
- **Diet and intake evaluation:**
  - Quantify whether the pet is eating appropriate amounts (≥ 90 %) of a complete and balanced diet.
    - Assess appetite, patterns of food intake, and actual food intake.
    - Evaluate ability to eat: prehension, mastication, and swallowing, particularly in underweight patients.
    - Perform thorough oral examination (periodontal health, tonsils, other abnormalities).
    - Assess sensory input: olfaction, vision, food palatability.
  - How is the owner administering any medications or supplements?
  - Are treats, palatability enhancers, and foods for medication administration ≤ 10% limit for unbalanced additions?
- **Mobility and access to food and water:**
  - Assess if the pet can walk and access food/water bowls independently.
  - Evaluate influence of other pets or environmental factors limiting food access.
  - Assess mobility, exercise, and MCS.
  - Screen for osteoarthritis, lameness, or pain that may impair comfort or mobility.
  - Activity helps preserve lean mass and contributes to mental and physical health.
- **Cognitive function:**
  - Observe the pet for the following signs of cognitive dysfunction:
    - Signs of disorientation or failure to recognize familiar people or surroundings.
    - Changes in family interactions (isolation or decreased engagement).
    - Altered sleep/wake cycles or increased nocturnal activity, pacing, panting, or anxiety.
    - Inappropriate elimination without medical cause.
  - DISHAA or VISHDAAL assessment
- **Changes in clinical status suggesting disease onsets:**
  - Unintentional weight loss.
  - Recent unintentional changes in BCS or changes in MCS, even if the pet is at an ideal weight.
  - Changes in overall energy, demeanor, or well-being.
  - Changes in urination or fecal quality (volume, frequency, consistency).

cognitive function, altered mood, and increased pain perception in elder humans.[21-23] Although specific water intake recommendations for senior dogs and cats have not been established, it is prudent to monitor hydration status closely in aging companion animals. Pets with reduced mobility may benefit from environmental modifications, such as providing multiple water bowls placed throughout the home to ensure consistent access to clean, fresh water. Offering water bowls on a lower surface may be helpful for cats,[24] yet dogs with laryngeal dysfunction may find it easier to drink when the water bowl is elevated. Water consumption should be monitored and ensured during physical activity and in warmer conditions. Additionally, subclinical renal insufficiency may predispose geriatric pets to dehydration. In cases where appetite remains robust but water intake is questionable, strategies to enhance hydration such as changing to a moist food, adding water to the food as the pet tolerates it, or considering a nutrient-enriched water supplement to improve hydration should be considered.

Energy

Factors impacting daily energy needs are complex, especially in geriatric patients where energy requirements may decrease, increase, or stay the same. Thus, no calculation for maintenance energy requirement (MER) is accurate for the individual. In general, as dogs become geriatric, their metabolic rate decreases 20–25% compared to their young adult needs and may even be less than their calculated resting energy requirement (RER).[3,25] Reduced activity in many older dogs due to a number of common co-conditions such as osteoarthritis and cognitive dysfunction leads to loss of lean mass, a primary determinant of energy needs. In contrast, cats exhibit a decline in MER beginning in middle age and continuing through their senior years.[26,27] However, in the geriatric stage, many cats demonstrate an increase in MER. This elevated energy demand in geriatric cats may be partially explained by the fact that approximately one-third of them experience impaired digestion of fat and protein.[27,28] Varying energy needs throughout life stages in both dogs and cats highlight the importance of monitoring body condition (BCS) and adjusting calorie intake to maintain an ideal BCS throughout life. Body composition is the most extensively documented factor influencing both life span and disease development in dogs and cats. Excess body fat, even without obesity as a result from excess energy intake, is associated with accelerated aging and reduced longevity across multiple species.[18,29] Excess body fat also contributes to inflammaging, chronic inflammation that contributes to the pathogenesis of age-related diseases.[30] Conversely, moderate energy restriction is associated with increased life span. The observed relationship between BCS and longevity may be partly attributed to the role of adipose tissue in increasing the relative risk for a range of diseases. Obesity can reduce life expectancy,[18,29] negatively impact quality of life,[31,32] and is associated with various comorbidities.[33,34] Obesity contributes to metabolic derangements,[35-38] significant functional impairment (such as respiratory, cardiovascular, and renal function),[36,37] and is a significant emotional and financial burden on owners.[39] Therefore achieving and maintaining ideal BCS promotes healthy aging and health span.

COMMUNICATION TIP

Geriatric pet care is increasingly important for veterinary health care teams and pet owners alike because pets are living longer. Pet owners generally believe their aging pets have different nutritional needs, resulting in a plethora of commercial options aimed at elder pets.

Protein needs of geriatric pets

Although exact protein requirements for geriatric pets are unknown, decreased protein synthesis and increased protein turnover and muscle loss (sarcopenia) are progressive changes of aging.[40,41] Sarcopenia in elder pets, as in humans, increases the risk of frailty, morbidity, and mortality.[42] Healthy elder pets do not benefit from protein restriction and in fact may show reduced function when dietary protein is limited. Based on human literature, geriatric pets may benefit from increasing protein intake by 1.5–2 times maintenance intake with the inclusion of muscle building amino acids (lysine).[42,43]

As a general guide the adult daily maintenance protein requirement should be considered "minimum." Based on the NRC 2006[5] recommended allowance of daily protein requirements for healthy adults:

- Cats should have at least 5 × $BW_{kg}^{0.67}$ grams of protein/day with geriatric protein needs 7.5–10 × $BW_{kg}^{0.67}$ grams of protein/day.
- Dogs should have at least 3.5 × $BW_{kg}^{0.75}$ grams of protein/day with geriatric needs 5.25–7 × $BW_{kg}^{0.75}$ grams of protein/day.

This level of protein intake should minimize the risk of deficiency, support the preservation of lean body mass (LBM), and only be restricted when medically necessary. Given the wide variability in energy requirements as pets age, protein intake must be evaluated within the context of the individual's caloric needs. While many older pets require fewer calories beginning in middle age, those in very advanced age may experience reduced food intake or, as in the case of cats, impaired nutrient digestion. Therefore, it is essential to align both energy and protein intake to support the maintenance of ideal body weight and minimize the loss of LBM.

Maintaining healthy body and muscle condition, along with encouraging daily physical activity throughout life, contributes to improved quality of life and maximized health span. In general, diets for geriatric dogs should provide not only fewer calories but a higher percentage of protein, or a greater protein-to-calorie ratio to meet age-related nutritional demands, unless there is a co-condition necessitating more moderate protein. Unless contraindicated, diets for geriatric cats may need to be high protein, highly digestible, and calorie dense to help maintain body weight. An important aspect of monitoring and managing the nutritional health of elder pets is to confirm that daily protein and calorie needs are being met with regular reassessment of the diet history, body weight, BCS, and MCS. Unintentional weight loss has been shown to precede diagnoses of disease, especially in cats,[44-46] and early detection may provide an opportunity for early diagnosis and nutritional or medical intervention.

Other nutrients

Antioxidants and dietary fats such as the omega-3 polyunsaturated fatty acids eicosapentaenoic and docosahexaenoic acid (EPA, DHA) and medium-chain triglycerides (MCT; in dogs) benefit senior and geriatric pets by modulating inflammation, supporting muscle mass and cognitive function, and providing adjunctive management of various diseases.[3] Prebiotic fibers may support gut health in aging pets. These nutrients are described in greater detail in the chapters on the senior dog and senior cat. Note also that increasing total dietary fat to achieve therapeutic MCT or omega-3 levels may be contraindicated in patients with fat intolerance or those requiring caloric restriction. While EPA and DHA can be provided through both complete diets or supplements, the total omega-3 content is not a reliable indicator of their specific EPA/DHA concentrations. Safe upper intake limits and evidence-based recommendations for EPA and DHA supplementation exist for dogs in the context of disease management, but greater caution is warranted when applying these guidelines to cats.[47]

MANAGING THE CONUNDRUM OF COMORBIDITIES

Making a nutritional recommendation is relatively straightforward in healthy geriatric pets. However, the complexity increases when patients present with multiple often competing or conflicting comorbidities, such as geriatric life stage needs and liver dysfunction, or overweight patients with renal disease. Except for obesity and osteoarthritis, there is limited research guiding the management of multiple concurrent conditions. However, in the absence of evidence, appropriate nutritional intake is essential. A general framework for prioritizing comorbidities for nutritional planning is described in **Box 2**. Typical nutrient adjustment ranges for managing common combinations of conditions are outlined in **Table 1**. For example, an overweight geriatric cat or a dog with early kidney disease may benefit from a modestly high-protein, lower-phosphorus diet.[48] The treatment plan for these patients would likely include some degree of caloric restriction so increasing protein will be needed to meet needs. Once a therapeutic diet plan is implemented, the patient should be monitored to see whether the desired effect is achieved with a repeated nutritional assessment and modifications to the plan as necessary in an iterative process.

SUPPORTING PETS THROUGH PALLIATIVE CARE

Nutrition and nurturing are intimately linked, and food is a primary way of caring for pets. When the pet approaches end of life or is facing advanced stages of a progressive life-limiting illness or disability, it offers a unique opportunity for the VHCT to support both the pet and the family. Nutrition is a component of the integrated end-of-life treatment plan outlined in the 2016 AAHA/International Association for Animal

Hospice and Palliative Care (IAAHPC) End-of-Life Care Guidelines.[49] Palliative nutrition emphasizes supportive care that prioritizes comfort and quality of life (QoL) by aligning nutritional strategies with the client's goals and empowering them to participate in care decisions. This applies to chronic disease management as well as terminal diagnoses. Normalizing aging changes in appetite and intake can be helpful to families. Age-related decline in sensory perception such as decreased taste, smell, or cognition may impact appetite and intake and require a different feeding strategy. Geriatric pets commonly have a shift in their usual feeding schedule with owners reporting their pet no longer eats well in the morning but will eat later in the day. Although concerning to owners, it is not problematic if the pet eats enough over the day to maintain BW. Consider the following key areas of intervention to help improve nutritional intake in pets; however, due to individual variability, these strategies often require trial and adjustment.

The patient

Chronic disease, pain, and nausea can significantly impair food intake. When possible, address and manage underlying factors that may contribute to reduced appetite, including ongoing pain, disease progression, adverse effects of medications, and interactions related to polypharmacy. Trialing appetite stimulants may be appropriate in some cases. Additionally, a thorough reassessment of the current medication regimen can identify opportunities for a "medication holiday" from less essential or ineffective drugs or supplements, thereby reducing the overall medication burden and its potential contribution to nausea and stress.

The diet

In hyporexic pets, transition to a complete and balanced, energy-dense diet whenever possible. This approach allows for meeting nutritional requirements with a smaller volume of food, and the novelty or enhanced palatability may help stimulate appetite. Advise pet owners to make dietary changes gradually to minimize the risk of gastrointestinal upset. It is also important to counsel clients that debilitation or reduced activity lowers caloric requirements and thus reduces the amount of food needed.

Palatability can often be improved by warming the food;[50] trialing different food aromas, textures, or forms; or adding moist "toppers" to encourage intake. Caution owners that excessive treat feeding may displace complete and balanced foods; when treats are offered, choose those that are nutritionally complete to maintain dietary quality. If intake becomes challenging, consider giving the pet and caregiver permission to skip a meal or resume favorite foods that might have been discouraged in the past because of the underlying medical condition.

Box 2. Framework for nutritional triage in patients with comorbidities

Management of nutrition in geriatric or medically complex patients often requires resolving conflicting dietary needs. In the absence of evidence-based guidelines, the following stepwise approach can help guide clinical decision-making to develop a balanced, individualized nutritional plan:

1. **Start with the basics:** Ensure the diet meets the animal's essential species- and age-specific nutritional requirements (complete and balanced nutrition).
2. **Characterize each comorbidity:** Determine whether it is acute or chronic, stable or progressive.
3. **Rank by impact:** Conditions most affecting quality of life or with the most severity and appetite/intake should be prioritized.
4. **Forecast progression:** Give more weight to progressive or life-limiting diseases.
5. **Compile a list of nutrient needs and limitations:** For each condition, note nutrients to enrich, restrict, or avoid.
6. **Find balance:** When needs conflict, aim for the best compromise. Prioritize needs that are most urgent or restrictive.
7. **Make a nutrition recommendation:** Match a commercial or homemade diet to the cumulative nutrient targets using **Table 1** to consider key nutrient ranges.
8. **Implement with specificity:** Provide precise instructions for product selection, portion size, and feeding frequency.
9. **Reassess over time:** Monitor weight, body and muscle condition, clinical signs, and laboratory values. Adjust the plan accordingly.

Table 1. Reference values to assess adult dog and cat diets with nutrient modifications

Nutrient to be modified (enriched or restricted)	AAFCO minimum	FEDIAF minimum for 110 x $BW^{0.75}$ (dog) or 100 x $BW^{0.67}$ (cat)	Ultra Low*	Low*	Moderate*	High*
Protein - Dog	4.5 g/ 100 kcal	4.5 g/ 100 kcal		< 5.0 g/ 100 kcal	6.0–7.0 g/ 100 kcal	≥ 9.0 g/ 100 kcal
Protein - Cat	6.5 g/ 100 kcal	6.3 g/ 100 kcal		< 7.0 g/ 100 kcal	7.0–8.0 g/ 100 kcal	≥ 10.0 g/ 100 kcal
Fat - Dog	1.4 g/ 100 kcal	1.4 g/ 100 kcal	< 2 g/ 100 kcal	≤ 2.5-3.5 g/ 100 kcal	3.5–5.0 g/ 100 kcal	≥ 5.0 g/ 100 kcal
Fat - Cat	2.3 g/ 100 kcal	2.3 g/ 100 kcal		≤ 3.0 g/ 100 kcal	4.0–5.0 g/ 100 kcal	> 5.0 g/ 100 kcal
Crude Fiber - Dog	ND	ND		< 1.0 g/ 100 kcal	1.0–2.0 g/ 100 kcal	> 2.0 g/ 100 kcal
Crude Fiber - Cat	ND	ND		< 0.5 g/ 100 kcal	0.5–1.0 g/ 100 kcal	> 1.0 g/ 100 kcal
Fiber (TDF) - Dog	ND	ND		< 2.0 g/ 100 kcal	2.0–4.0 g/ 100 kcal	> 4.0 g/ 100 kcal
Fiber (TDF) - Cat	ND	ND		< 0.5 g/ 100 kcal	1.0–2.5 g/ 100 kcal	> 2.5 g/ 100 kcal
Phosphorus - Dog	100 mg/ 100 kcal	100 mg/ 100 kcal		< 100 mg/ 100 kcal	< 180 mg/ 100 kcal	
Phosphorus - Cat	125 mg/ 100 kcal	64 mg/ 100 kcal	< 125 mg/ 100 kcal	< 160 mg/ 100 kcal		
Sodium - Dog	20 mg/ 100 kcal	25 mg/ 100 kcal	< 70 mg/ 100 kcal	< 100 mg/ 100 kcal		
Sodium - Cat	50 mg/ 100 kcal	19 mg/ 100 kcal	< 70 mg/ 100 kcal	< 100 mg/ 100 kcal		
EPA & DHA - Dog (mg of combined)	ND	ND			~ 10–15 mg/ 100 kcal	≥ 15 mg/ 100 kcal [wide variation]
EPA & DHA - Cat (mg of combined)	ND	ND				≥ 15 mg/ 100 kcal [wide variation]

*FEDIAF and AAFCO minimum levels listed are for adult canine and feline maintenance. The terms ultra-low, low, moderate, and high are the author's opinion and provided as a guide. This table is not intended to imply that any specific nutrient amount is inherently "good" or "bad," but rather to serve as a reference to assist veterinary clinicians when nutrient modifications are desired.

Adapted from Churchill, J. A., & Eirmann, L. (2021). Senior pet nutrition and management. *Veterinary Clinics: Small Animal Practice, 51*(3), 635-651 and Moreno, A., Parker, J. A., Winston, J. A., & Rudinsky, A. J. (2022). Dietary fiber aids in the management of canine and feline gastrointestinal disease. *Journal of the American Veterinary Medical Association, 260*(S3), S33-S45.

Feeding management and environment

Frequency and access to food should be assessed. Support hydration by ensuring water is available in multiple accessible locations. Alternate feeding locations and food bowl types, such as large shallow bowls for cats to avoid whisker contact, because pet preferences may change. Pets usually fed twice daily may benefit from smaller, more frequent meals or meals offered later in the day, to increase overall intake. Pets with limited mobility, pain, or decreased cognitive function may benefit from food delivered or hand fed to them. Competition for access from other

pets should be addressed by offering food in separate locations accessible only to the affected pet. This also facilitates quantification of food consumed so the VHCT can accurately assess intake. While veterinary professionals recognize that decreased food and water intake is often a natural part of the end-of-life process, caregivers may mistakenly believe that they simply have not yet found the "right" food their pet will eat. This misconception can be highly stressful to both the pet and the caregiver. Discourage force-feeding, which may lead to food aversion and cause distress to both the pet and caregiver. Instead, remind clients of shared goals, reframe realistic expectations of food intake, and encourage coaxing and reassurance to both the pet and caregiver.

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PRACTICAL TOOL: NUTRITION FOR SHELTER DOGS AND CATS

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Proper nutrition is a cornerstone of animal welfare, especially in shelters where dogs and cats often face stress, potential malnourishment, exposure to pathogens, and unknown parasite burdens. A well-designed nutritional program can significantly enhance the health, behavior, and adoptability of shelter animals. This chapter outlines the essentials of nutrition management in shelters, providing practical guidance for optimizing dietary practices in this unique environment.

INTAKE EXAMINATION

A nutritional assessment should be part of a shelter intake exam. This includes an assessment of the animal's body condition score (BCS), muscle condition score, dietary history including any known medical conditions, a physical examination to identify signs of malnutrition, and weight.[1] Animals should be weighed upon intake to the shelter and animals staying long-term should be weighed monthly. This assessment forms the foundation for creating individualized feeding plans tailored to each animal's needs.

FEEDING PRACTICES

Regular feeding times help reduce stress and allow for monitoring of appetite and food intake. Dogs should ideally be fed twice daily, while cats should have access to food throughout the day or be offered multiple small meals. If continuous feeding is not possible, cats can also be fed twice daily. Uneaten food should be removed after 24 hours, and food should never be shared between animals in different enclosures. The type and amount of food provided should be tailored to each animal's individual needs, activity level, and health status.

Healthy puppies, kittens, and lactating or pregnant animals require small, frequent meals or continuous access to food throughout the day. Fresh, clean water must always be available.

For co-housed or group-housed animals, at least one food dish per enclosure should be provided. Puzzle feeders, slow feeders, and treat-dispensing toys can enhance mental stimulation and reduce overall stress.

To support quick decision-making in the shelter environment, **Table 1** summarizes feeding recommendations for common categories of shelter animals, based on age, condition, and special needs.

FOOD STORAGE

Proper storage of dog and cat food in shelters is needed to maintain quality and prevent contamination. Food should be kept in airtight, pest-proof containers in a cool, dry area away from sunlight. Shelters should follow first-in, first-out system to use older stock first, and regularly check for expiration dates or signs of spoilage. Donated food must be inspected for damage or expiration before use.

MONITORING (FIGURE 1)

Daily monitoring of food and water intake helps shelter staff identify animals with medical conditions or those struggling to adapt to the shelter environment. This is particularly important for group or co-housed animals to ensure that all animals have access to food. Animals that are not eating regularly or are losing weight may have underlying medical issues or be experiencing significant stress that requires attention. Cage-side monitoring sheets are useful for recording daily food intake and identifying animals with diarrhea or other health concerns. The monthly weighing of shelter residents will also allow shelters to adjust the amount of food fed.

Table 1. Nutritional guidelines for common shelter animal scenarios

Animal type/condition	Feeding frequency	Diet type	Special considerations
Healthy adult dog	2x daily	Complete, balanced adult dog food	Monitor intake and weigh monthly
Healthy adult cat	Free feed or 2–3x/day	Complete, balanced adult cat food	Remove uneaten food in 24 hrs; monitor appetite
Puppies/kittens	3–4x daily or free feed	Growth formula; puppy/kitten food	Ensure access to fresh water and socialization
Pregnant/lactating	3–4x daily or free feed	High-calorie puppy/kitten food	Monitor weight and appetite closely
Malnourished/ emaciated	Small meals every 4–6 hrs	Low-fat, highly digestible diet (2.5–3.5 g fat/100 kcal)	Begin with 25–50% caloric needs, increasing over 5–7 days; monitor for refeeding syndrome
Stressed (colitis)	2x daily	Highly digestible, consistent diet	Minimize diet changes; use a probiotic such as *Enterococcus lactis* SF68 if indicated
Parasite-positive	2x daily	Normal diet unless otherwise directed	Administer appropriate dewormers; clean feeding areas rigorously
Group-housed animals	2x daily (dogs), free feed (cats)	Individual portions	Ensure at least 1 bowl per animal; use puzzle feeders or enrichment tools for stress reduction

MANAGING SHELTER-SPECIFIC CHALLENGES

Shelters often face unique challenges pertaining to nutrition including but not limited to:

Food insecurity and limited diets

Limited budgets may necessitate reliance on donated food. It's essential to ensure donated food is of good quality and not expired. Approaches to addressing limited or inconsistent food supplies include forming partnerships with food suppliers. These can include partnerships directly with pet food companies who may offer shelter discounts, or retail partnerships such as pet supply stores, grocery stores, or warehouses. Some shelters may establish a community pet food bank where community members can donate food for shelter animals and pets in need. Leveraging grants and funding opportunities specifically for sourcing pet food and encouraging in-kind donations from the public, highlighting specific needs such as kitten milk replacer or special diets, can be helpful.

Stress colitis

Stress-related diarrhea is common in shelters. Shelters should attempt to feed a consistent, highly digestible diet, avoiding sudden changes in diet to minimize gastrointestinal upset. Environmental changes are equally important to reduce stress colitis. This includes maintaining a consistent daily routine for feeding, cleaning, and handling; providing quiet, low-traffic areas for stressed animals; and offering toys, puzzle feeders, and opportunities for exercise and human interaction. Staff should be trained to recognize early signs of stress colitis, such as diarrhea, lethargy, or decreased appetite. Timely vaccinations and parasite prevention, including deworming at intake, can help reduce colitis. In some cases, probiotics such as *Enterococcus lactis* SF68 may be of benefit.[2]

GI parasites

Shelters must implement prophylactic deworming protocols for all incoming animals. This includes administration of broad spectrum anthelmintics (i.e., pyrantel pamoate, fenbendazole), based on the common parasites in the area.[3] Regular fecal testing of shelter animals using flotation or antigen-based test can help identify parasites and target treatment, especially for harder to detect parasites such as *Giardia* and coccidia. Disinfecting enclosures, food bowls, play yards, and litter boxes can help reduce environmental contamination.

Figure 1. Daily monitoring checklist for shelter animals

1. Food & Water Intake

- Did the animal eat all its food?
- Was water bowl full and clean?
- Note appetite changes

2. Elimination

- Stool: Normal, soft, or diarrhea
- Any vomiting observed?
- Litter box/area clean

3. Behavior & Condition

- Activity level
- Signs of stress, lethargy, or aggression
- Body condition changes

4. Notes & Alerts

- Unusual observations
- Health concerns
- Weight checks (weekly/monthly)

Malnourished animals

Shelters frequently receive animals that are victims of neglect, cruelty, or starvation, and staff must be adequately trained in appropriate refeeding protocols to prevent refeeding syndrome, a potentially fatal complication resulting from the rapid reintroduction of nutrition. Refeeding should begin with small, frequent meals providing only 25–50% of the animal's calculated caloric needs during the first 24–48 hours. In otherwise healthy but emaciated animals, a highly digestible, moderate- to low-fat diet (2.5–3.5 g/100 kcal) may be appropriate initially to reduce gastrointestinal stress and support gradual metabolic adjustment. However, in animals with concurrent illness ("sick starved"), nutritional needs may differ, and higher-fat diets may be indicated to meet caloric requirements. Gradual increases in caloric intake over 5–7 days are generally recommended.[4] Shelter staff should be trained to monitor for signs of refeeding syndrome, such as weakness or tremors. Addressing underlying conditions like parasites and providing a calm, warm environment to minimize stress are also important. The focus should be on slow, steady weight gain and feeding a life stage-appropriate diet.

CONCLUSION

A comprehensive nutrition program is essential for promoting the health and well-being of shelter animals. By addressing individual dietary needs, implementing consistent feeding protocols, and overcoming shelter-specific challenges, shelters can enhance the lives of animals in their care. With proper planning, education, and resource management, shelters can make a significant impact on the welfare of the animals they serve.

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PRACTICAL TOOL: MANAGING CAT ALLERGENS THROUGH NUTRITION

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THE PREVALENCE OF HUMAN ALLERGY TO CATS

Globally, human allergy to cats is the third most common cause of respiratory allergies after pollens and house dust mites.[1-6] Around 5–20%[2,6-10] of humans are sensitized to cats, and cat allergy is approximately twice as common as dog allergy.[2] The major clinical symptoms are rhinitis, conjunctivitis, and asthma,[2,3,9,11] and in some cases severe symptoms develop rapidly on contact with cats.[2] Cat allergy may also influence the severity of atopic dermatitis in affected individuals.[12]

THE CAUSES OF CAT ALLERGY

At least eight cat allergens are recognized,[1,5,6,9,13,14] but Fel d 1 is the only major allergen. Around 90–96% of cat-allergic individuals are sensitized to Fel d 1, and it causes 60–90% of the total allergic reactivity.[1,5,9,13,15-18] Fel d 1 is a 38 kDa glycoprotein,[13,19,20] and the major sources are saliva and sebaceous gland secretions (**Figure 1**),[21-28] with some in lacrimal and anal gland secretions and in urine.[24,28,29] Saliva is a major source of Fel d 1, and is distributed throughout the haircoat during grooming.[9,30] The biological function of Fel d 1 is uncertain, but a role in the transport of steroids, hormones, or pheromones is proposed.[13,31,32]

Fel d 1 in the haircoat and on the skin is shed into the environment in substantial amounts on dander (dried saliva, cutaneous flakes, and debris).[1,17,33] These small particles settle in dust but can also remain airborne for several days and are readily inhaled.[13,34-36] Dander particles are sticky, and although highest concentrations are found in houses with cats, spread outside of the home readily occurs on clothes or human hair,[37] leading to immunologically significant levels in many public environments.[13,17,33-36,38-55]

METHODS FOR MANAGING CAT ALLERGY

As with management of any allergy, allergen avoidance (or reducing exposure below a critical threshold) is considered the highest priority when feasible and can be used alongside pharmacotherapy and immunotherapy.[56] It is widely accepted that combining several environmental control measures is likely to achieve best clinical efficacy when trying to minimize allergen exposure (**Figure 2**).[6,57-60]

Removing the cat

Removing the cat from the home reduces both direct and indirect Fel d 1 exposure, but it may take 4–6 months for environmental Fel d 1 levels to decline after removing cats.[6,34,56,61-63] The strength of the human-cat bond also means few owners are willing to part with their cat, even when recommended to do so,[19,64-68] and many cat-allergic owners still replace the cat once it has died.[65] This emphasizes the importance of alternative cat-friendly measures to help control environmental Fel d 1.

Restricting cat access within the home

Preventing the cat accessing certain rooms in the house (e.g., bedrooms, rooms with carpets) may help,[6,56,57,59,61,69-72] but the characteristics of dander mean these measures alone are unlikely to control signs of allergy.[57,70] Environmental restriction and limiting contact with the cat might also have important welfare implications for cats and the human-cat bond, and may cause frustration and behavioral issues.[72,73]

Environmental modification and cleaning

Modifying and cleaning the environment may be effective in improving clinical disease, but continuous and rigorous implementation is required.[74-80] Common suggestions include removing carpets (having hard flooring) and upholstered furniture; using hypoallergenic mattress/pillow covers; cleaning floors and furnishings regularly with a HEPA-filtered vacuum; washing clothing, floors, bedding, curtains, and walls regularly; increasing natural ventilation; using HEPA air filters; and using night-time laminar airflow over beds.[6,33,34,57,61,62,74,76]

Bathing the cat

Bathing cats is commonly recommended[6,33,34,57,58,61,70,71,76,81-83] but results of studies suggest this may only reduce

environmental shedding of Fel d 1 temporarily and bathing at least two or three times weekly is needed to have an important impact.[84-87] Potential benefits again need to be assessed against the stress this would cause for the cat, and damage to the human-cat bond.

Hypoallergenic cats

All cats produce Fel d 1,[61,71] but the amount varies considerably between and within individual cats,[84,86,88-93] and some tend to remain higher (or lower) producers.[84,86,92-96] Entire males produce more than neutered males or females,[76,88-92,95,97-99] but production is not affected by coat color or hair length[4,27,48,92,95,100-102] and there is no data to substantiate claims of significant differences between different breeds.[68,70,103,104]

Inducing auto-immunity to Fel d 1 in cats

Immunization of cats to induce anti-Fel d 1 auto-antibodies appears to reduce Fel d 1 secretion,[105,106] but this approach is not commercially available and the long-term safety of vaccine-induced auto-immunity in cats would need very careful safety studies.

Using a diet supplemented with anti-Fel d 1 IgY immunoglobulins

Polyclonal anti-Fel d 1 IgY (chicken egg-derived) antibodies can be ethically produced in large quantities. Orally administered IgY antibodies have been safely used for decades to manage many conditions in both animals and humans,[107-113] and studies have shown that IgY anti-Fel d 1 antibodies successfully block the binding of IgE[114-119] rending the molecule non-allergenic without affecting its production.

Feeding cats a kibble coated with anti-Fel d 1 IgY was able to neutralize a substantial proportion of active Fel d 1 in cat saliva,[115,117] and on hair samples.[114,119] Further, studies of cat-allergic individuals exposed to bedding from cats before and after the cats were fed a diet of kibble coated in the IgY antibodies have demonstrated a significant reduction in symptoms as a result of lower Fel d 1 exposure.[117-119] Long-term use of the diet by feeding cats in the home environment of more than 40 cat-allergic individuals also showed very significant benefits,[120] demonstrating the clinical value of this novel and cat-friendly approach.

Figure 1. Major sources of Fel d 1

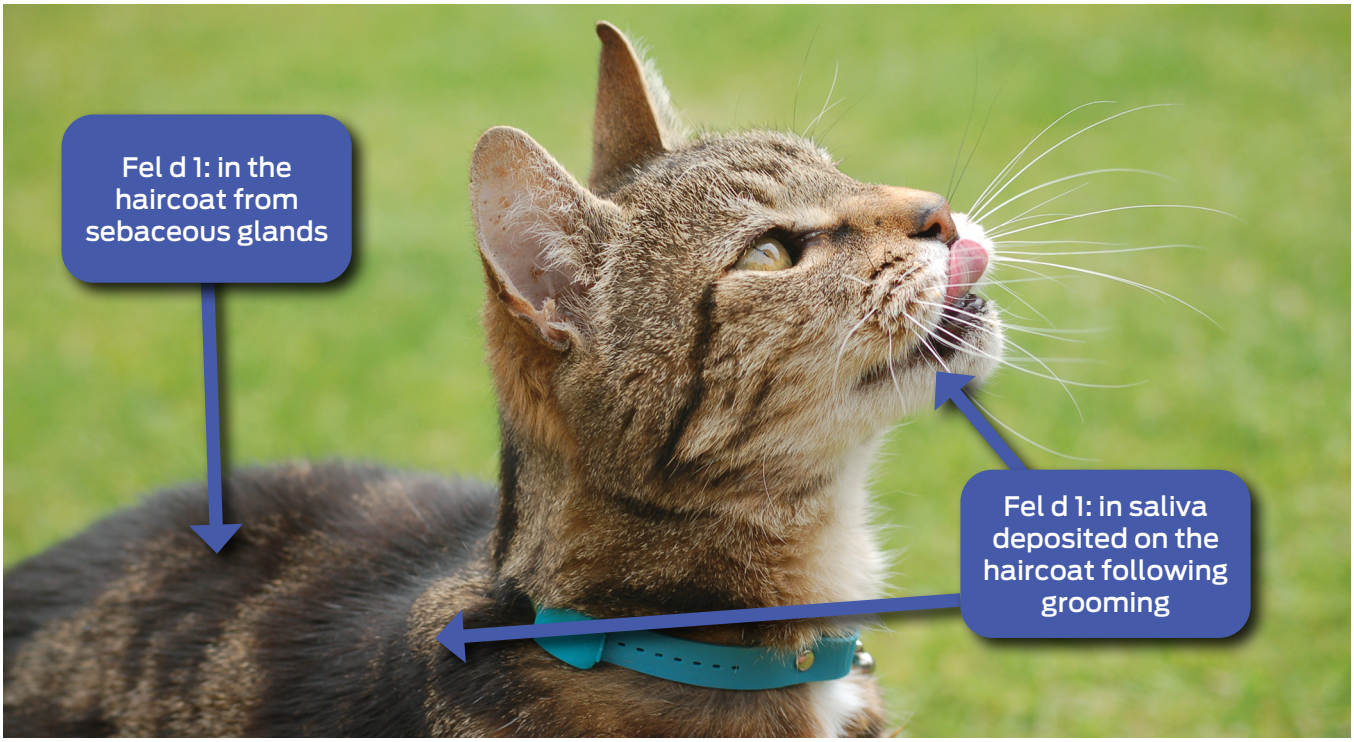
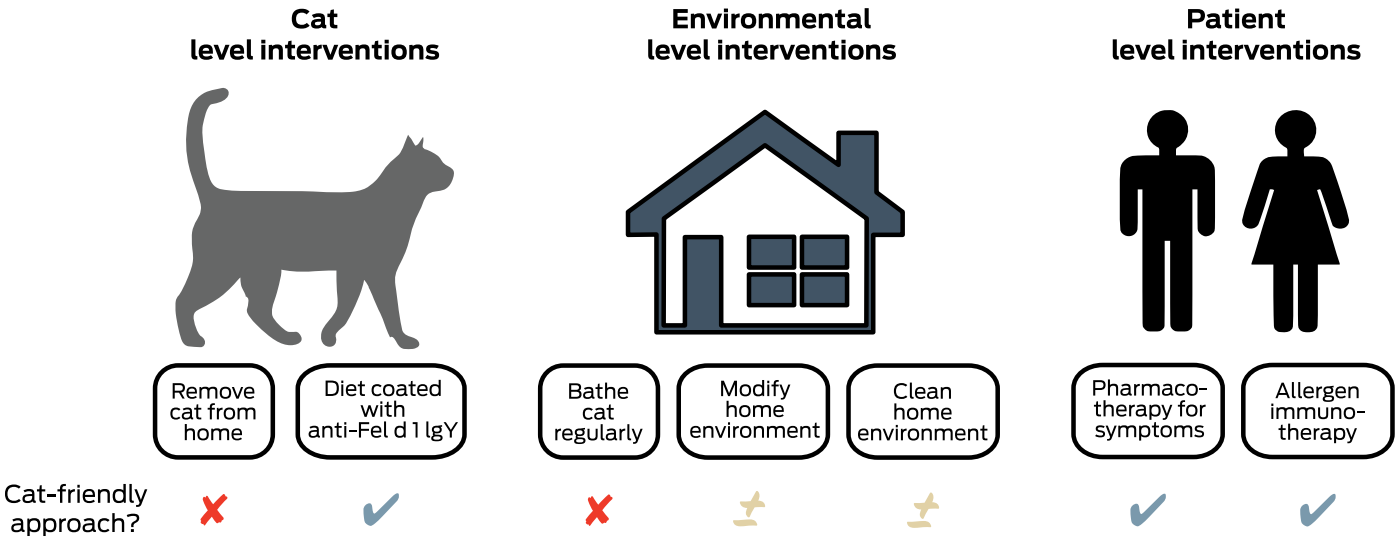


Figure 2. Overview of control measures currently available for managing allergy to cats



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PRACTICAL TOOL: BIOLOGICAL AGE AND ITS IMPLICATIONS IN WELL-PET NUTRITION

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Aging involves a gradual decline in organ and cellular function. In humans, dogs, and cats, aging is often associated with a decline in mobility and cognitive function, onset of chronic diseases, decreased quality of life, and other factors.[1] However, the aging process may occur at different rates in individuals depending on genetic and environmental factors.[2] Chronological age refers to the number of years, months, and days an individual has been alive, while biological age refers to how well the body is functioning and aging compared with individuals of the same chronological age. Decreased biological age reflects improved function and aging, while increased biological age is indicative of accelerated aging. Therefore, animals may have the same chronological age but different biological ages.

Biological age is estimated by algorithms called biological age clocks. These clocks may use complex analyses such as assessing DNA methylation or may require more routine parameters found on bloodwork to calculate biological age. Having a higher biological age versus chronological age is a sign of accelerated aging[1] and may significantly impact survival. In one study in dogs,[1] when biological age was accelerated above chronological age, there was a significant association with mortality. Each 1-year increase in biological age above chronological age was associated with a 1.75-fold increased risk of death irrespective of the dog's chronological age.[1] The cited study used data points from routine lab work, the complete blood count and serum biochemistry profile, to create an algorithm that measures biological age in dogs. In this study, the lab parameters did not have to be abnormal to show a difference in biological age. In dogs with a biological age that was at least 1 year greater than their chronological age, only about 50% had markers outside of the reference range.

Factors that may influence the rate of aging in dogs and cats are shown in **Table 1**. In humans, other factors, including smoking and alcohol consumption, impact biological age.[3] Some, but not all, of the factors that impact biological age relate to nutrition. It is possible that nutrients that support healthy aging may be beneficial for dogs with increased biological age, but there is more work to be done in this area. Analysis of samples from the Purina life span study showed that feeding to a lean body condition reduces biological age, an effect that can be quantified at mid-life years before a difference in survival is observed.

The impact of biological age on survival can vary among species.[1] While this is a new concept in veterinary medicine, considering factors that impact a pet's biological age when examining a pet may provide veterinarians with another tangible assessment of health. Considering biological age may help improve overall health, quality of life, and survival by

Table 1. Factors that may influence biological age in dogs and cats[1,3]

Factor	Influence on biological age
Complete and balanced diet	Decrease
Feeding to a lean body condition	Decrease
Obesity	Increase
Sedentary lifestyle	Increase
Presence of chronic health problems	Increase
High treat consumption (over 10% of total daily calories)	Increase
Air pollution	Increase

encouraging pet owners to make positive changes and providing a more quantitative assessment of response to interventions.

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NUTRITIONAL APPROACH TO ORAL AND DENTAL HEALTH

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KEY TAKEAWAYS

- Periodontal disease is theoretically preventable, and nutritional products can be a part of that.
- Dental diets, treats, and chews work by mechanical and chemical (non-mechanical) means; the mechanical effects require sufficient chewing time.
- Harder chews can result in tooth fracture.

The oral cavity is the beginning of the alimentary tract, and certain aspects of an animal's diet can impact the health of the oral cavity and teeth. This chapter will cover appropriate nutrients that support oral and dental health during development and adulthood, in addition to ways to assist with oral hygiene in dogs and cats and what to avoid.

MALNUTRITION

Though very rare in developed countries, malnutrition can impact the formation of teeth and structures in the oral cavity, with the majority of information found in human medicine literature. While more commonly a result of disease, fever or trauma, enamel hypoplasia or hypocalcification (as well as delayed eruption) can be the result of significant vitamin D and calcium deficiencies.[1] Vitamin B and iron deficiencies can result in inflammation and ulceration of the tongue, or aphthous ulceration. Protein energy malnutrition in general can impact disease progression of the oral cavity by altering the homeostasis, reducing resistance to the oral microbiome, and decreasing tissue healing.[1]

PERIODONTAL DISEASE

Historically, it has been thought that the most common way nutrition or diet can impact the oral cavity is its influence on the accumulation of plaque and its conversion into calculus in the process of periodontal disease. With a few exceptions, periodontal disease is preventable if the plaque can be decreased or removed before it mineralizes into calculus. Calculus itself is not considered an active player in the role of periodontal inflammation, but the rough surfaces encourage further plaque retention. Regular professional cleaning to fully remove both supragingival and subgingival plaque and calculus can be supplemented with good home care oral hygiene for optimal results. If this removal or control is effective at the gingival margin, the inflammatory process of bacterial colonization and resulting periodontal disease can be avoided or at least lessened. Newer concepts consider the influence of the oral microbiome, as periodontal disease is thought to be initiated through disturbance of the microbiome equilibrium.[2]

Evaluating the impact of diets and consumed products on oral health

The parameters of plaque and calculus accumulation, gingival health (gingivitis/gingival bleeding index), stain and malodor are common means of evaluating a product's or action's impact on periodontal disease. An Oral Health Index (OHI) also includes evaluating regional lymph nodes.[3] Reduction of plaque, calculus and malodor are standard goals to help demonstrate efficacy, without making a disease-modifying claim. Malodor has been measured by individuals in the past, but volatile sulfur compounds (VSC) can also be measured. Claims of reduction in gingival indices, including gingivitis and gingival bleeding index, while clinically important,[4,5] are considered disease-modifying. These claims would be regulated by the FDA, so label information does not often include these.

Assessing the oral microbiota changes has become another way to evaluate the impact of a product or process on periodontal disease. In the progression from healthy gingiva to mild periodontal disease,[6] there is a shift from "good" bacteria (health-related bacteria, often gram-positive, non-motile genera) to "bad" bacteria (disease-related bacteria, often gram-negative anaerobes). In fact, these bacteria that are associated with poor oral health produce VSC that cause halitosis.

Several studies have evaluated these microbiomes, some sampling just supragingival areas,[7] and others also sampling subgingival and salivary populations.[2]

DIETARY IMPACT

Wet vs dry

For the most part, studies show that the potential mechanical action of chewing a dry kibble can help decrease residue as compared to wet food, including home-cooked diets.[3,8] By leaving less residue in the mouth for bacteria, this can potentially slow plaque accumulation.[9] This positive influence on oral health and periodontal disease has been measured by decreased dental deposits (plaque, calculus) and decreased incidence of mandibular lymphadenopathy.[3]

In studies looking at the effect of diet type on oral microbiota, even when plaque, calculus and gingivitis scores did not differ significantly, plaque buildup was lower, breath sulfur concentrations were lower and salivary pH was higher in dogs fed the dry diet compared to those fed the wet food.[10] Bacteria associated with poor oral health were higher in dogs fed the wet food than in dogs consuming the dry diet, which had higher counts of oral health-associated genera.[10]

Natural diets and raw bones

While there may be some concern that feeding commercial pet food contributes to periodontal disease, even in a group of African wild dogs eating a natural diet, periodontal disease was still present, along with a number of fractured teeth.[11] In studying colonies of feral cats, the prevalence of periodontal disease was similar to cats fed commercial diets, though calculus was decreased.[12-14] So, while raw bones and diets containing them may help decrease calculus, it is not necessarily protective against periodontal disease, and tooth fracture risks are elevated (**Figure 1**),[15] not to mention zoonotic disease and other raw food risks.[16] Based on the absence of evidence of benefits, these diets should not be recommended.[17]

HOME CARE THROUGH NUTRITION

Oral hygiene can be divided into active and passive methods, but an active method such as brushing by the owner is seldom done effectively. Some pet owners may be more successful with using dental wipes, especially in cats and small dogs. Many owners may employ passive methods such as water additives, products added to the food, dental chews and dental diets. Even the best passive methods (diets, chews) will typically

Figure 1. This fractured tooth (108) was found during a "routine" dental cleaning, once the calculus was removed. The dog had been eating well and showing no overt signs of discomfort, yet there was extensive inflammation and infection present. He had a history of chewing raw, meaty bones. (Image courtesy of Dr. Heidi Lobprise)



only affect the coronal two-thirds of the tooth, so including effective brushing remains the gold standard for home care. The combination of tooth brushing and the offering of dental treats was very effective in maintaining oral health, provided they were practiced daily.[8] Even brushing weekly and adding a daily chew and water additive in a dirty mouth model (not cleaning the teeth prior to the study) demonstrated a reduction in dental deposits and improved periodontal health, though regular home and professional care is optimal.[18]

Passive methods can also be divided into mechanical and chemical (or non-mechanical) categories, with some products having both effects. The mechanical effects of a dental chew or diet depend on many factors. The size, shape, nutritional composition (including fiber content), and texture of the kibble or treat can impact the removal of soft plaque on the crown, but only on the teeth that do the chewing. This primarily includes the carnassial teeth in the back of the mouth. The amount of time spent chewing the food or device also matters; minimal effect will occur if a pet swallows the kibble or treat whole.

Mechanical effects of diets

Even knowing the different impacts of wet vs dry diets, standard dry kibble typically will not have the best size or texture for plaque control, as the kibbles break apart too quickly to act efficiently on the tooth surface. Most diets labeled for dental health have a kibble size and texture with an increased fiber content that allow the tooth crown tip to penetrate into the kibble before it separates. This allows the kibble to gently abrade the tooth surface, acting to remove soft plaque from the surface.[19] However, the kibble primarily impacts the incisal edge of the crowns, and usually just the carnassial or chewing teeth. The effect on plaque accumulation at the gingival margin is where the impact on periodontal disease is most critical.[20] Feeding a dental diet as the maintenance nutrition for adult pets provides the best results, as the benefits decline when fed as a portion of the diet, or merely as a treat.[21] However, if fed as the sole diet, the higher fiber content usually makes these diets not appropriate to support conditions requiring high energy intake, such as growth, gestation or lactation.

Mechanical effects of treats and chews

The effectiveness of treats and chews also relies on the size, shape and physiochemical properties (abrasiveness, density and hardness) of the item.[22]

COMMUNICATION TIP

The combination of daily tooth brushing and offering dental treats can be very effective in maintaining oral health. However, even the most effective home care regimen needs to be accompanied by regular oral examinations and management by the veterinary health care team.

Inclusion of different agents may add to the mechanical effect. Wheat gluten products have a semi-moist consistency that promotes chewing resistance and increased contact with the teeth. Various forms of fiber (oat, powdered cellulose) can help provide a scrubbing effect during chewing.[22]

No matter how well the product is developed, success also depends on the dog's or cat's use. Selecting the right product, size and ingredients can depend on the pet size, the surface for chewing and the length of chewing time. If a patient swallows an item whole, or a large portion of it, it can be caught in the esophagus or intestinal tract if not properly digested.[23,24] All pets should be closely monitored when given treats or chews, especially with a product new to them. The veterinary team should also determine how many calories the product might have, especially if weight management is a concern. Calories from treats (including all unbalanced items such as dental chews but also table foods, supplements, flavored medications, and other treats) should not make up more than 10% of total daily calories.[25]

In reviewing consumable items that promote chewing activity, most products have demonstrated efficacy on the reduction of plaque and calculus levels, the two indices evaluated for recognition from the Veterinary Oral Health Council (VOHC).[26] Additional information on the reduction of halitosis (VSC), gingival indices and oral microbiota may also be published.

In addition to kibble-type products, products developed for enhancing chewing may include compressed or spongy wheat or vegetable-based chews, jerky-like treats,[27] a chew that allows the teeth to sink in further to

Table 1. Chemical/non-mechanical dental home care ingredients

Ingredient or compound	Mode of action	Comment
Chlorhexidine (CHX)[4,35]	Oral antiseptic "gold standard"	The amount in most products does not allow sufficient contact time
CHX plus TrisEDTA[36]	Oral antiseptic	Some synergy possible
Plaque-reducing nutrient[37]	Plaque-reducing nutrient	Belongs to sodium ascorbyl phosphate group
Glucose peroxidase with lactoperoxidase	Enzymatic system	In toothpastes and some chews; low-grade evidence for efficacy[21]
Chlorophyll[38]	Impacts halitosis	Alfalfa and parsley in daily chew
Delmopinol[39]	Inhibits plaque biofilm	Spreads throughout the mouth with adequate chewing time
Pomegranate[40,41]	Anti-aggregative and antioxidant effect against oral bacteria	Has been combined with inulin and erythritol[42]
Xylitol	Reduces bacteria associated with oral disease; low levels in veterinary products generally safe[43]	Accidental ingestion of human products can cause hypoglycemia and hepatic issues[44]
Polyunsaturated fats	Antioxidant properties	A study failed to show impact on periodontal disease[45]
Folic acid[46]	Reduce *Porphyromonas gulae* activity and halitosis	Impact on other bacteria and side effects unknown for doses needed
Probiotics[47]	Decrease *P. gulae* activity	Other studies needed

have mechanical effects at the gumline, and products of nearly any shape and size that are developed to help increase chewing surfaces and times. Consumable chewing aids such as rawhides don't have any nutritional value (other than caloric content). While some products have been tested,[28,29] the great majority have not been evaluated for efficacy, or even safety, so caution is necessary. Chewing times, avoiding ingestion of large pieces and monitoring the pet for any signs of illness (vomiting, diarrhea, polyuria, polydipsia, etc.) after introducing a new treat are important aspects to consider.

Chemical (non-mechanical) effects

Chemical, or non-mechanical, compounds (and some biological, non-mechanical ones) are commonly implemented in dental treats, chewing devices and certain additives, often to supplement the mechanical effects. In vitro testing of a certain compound does not always translate into clinical efficacy in any given product, unless verified scientifically in vivo, so discernment is important. There are many variations available commercially; not every compound will be included here.

Some diets and treats have sodium phosphate salts that act as chelators to decrease the amount of calculus that accumulates by forming soluble complexes with cations such as calcium.[30,31] Since calculus is not considered an "active" player in periodontal disease, additional effort should be made to remove the plaque that has not mineralized. The additional intake of sodium and phosphorus should be taken into account for some pets. Lactic acid supplementation has also been considered in a role as a chelating agent.[32]

Ascophyllum nodosum (brown algae seaweed), though its mode of action is not clear, is thought to assist in host immune function and possibly to interfere with bacterial growth and accumulation. In a study, the treatment group had decreased prostaglandins compared to the placebo group's increasing levels of proinflammatory leukotrienes and prostaglandin metabolites.[33,34]

Highlights of some other compounds can be reviewed in **Table 1**. As with any newly introduced item, its acceptance and effective implementation should be evaluated. The animal's size should be taken

into consideration, and initial use should be closely monitored. If the pet chews for a few seconds, then swallows a portion of the device whole, that might not be an appropriate item for that pet. The caloric content is highly variable among individual chews or treats, and can be quite high, especially if several treats are recommended for daily use. The added calories might not be beneficial for a pet struggling with weight issues.

While the plethora of products, some making unsubstantiated claims, can be overwhelming, using the listing of products that have data supporting their efficacy can be helpful.[27] That doesn't mean that a product without the VOHC seal is ineffective, as it can be quite costly to do the research for the appropriate data. All chosen products should be safe, accepted by the pet, and have some expectation of effectiveness behind them.

Even products with the VOHC seal do not completely eliminate plaque and/or calculus; but if an owner is showing an interest in providing some of the nutritionally based items to help their pet's oral health, the door for further conversation and encouragement has been opened. Even the most effective home care regimen needs to be accompanied by regular professional oral examinations and management, such as cleaning, radiographs and treatment, often on at least a yearly basis.

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NUTRITIONAL APPROACH TO SUPPORTING A HEALTHY WEIGHT

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KEY TAKEAWAYS

- Obesity in pets significantly impacts health and reduces lifespan.
- Genetic predispositions, owner behaviors, and lifestyle factors all contribute to obesity risk.
- Consistent monitoring, owner education, and tailored feeding strategies are essential for maintaining an ideal body condition.

INTRODUCTION

Obesity is a prevalent and significant health concern in companion animals, reducing lifespan and increasing risk for osteoarthritis, metabolic disorders, and certain cancers.[1] Recent large-scale data from the United States estimate the prevalence of overweight and obese body conditions at approximately 49.4% in dogs and 41.6% in cats.[2] Given the high prevalence, it is imperative that veterinary professionals recognize obesity early and implement effective prevention and management strategies to improve long-term health outcomes. While overweight and obese correspond to different levels of excess body fat, these terms are often used interchangeably in the literature and will also be used that way in this chapter.

HEALTH RISKS OF OBESITY IN DOGS AND CATS

Obesity significantly increases the risk of numerous health conditions, including osteoarthritis in both cats and dogs.[3,4] The effect on osteoarthritis is dramatic; mildly overweight Labrador Retrievers show initial radiographic evidence of osteoarthritis at a median age of 6 years, compared to 12 years in ideal weight dogs.[5,6] In dogs, the strongest associations with obesity include hyperlipidemia, orthopedic disease, pancreatitis, endocrine disease (hypothyroidism, hyperadrenocorticism), lower urinary tract disease, and oral disease.[7,8] In cats, obesity is most strongly linked to musculoskeletal disorders, arthritis, asthma, urinary tract disease, oral disease, diabetes mellitus, dermatopathy, and neoplasia.[9,10] The risk association between diabetes mellitus and obesity in dogs remains unclear, with conflicting research findings.[7,8] This is likely because diabetes in dogs typically results from pancreatic β-cell destruction rather than insulin resistance, which is the primary mechanism in cats. Obesity does cause insulin resistance in dogs, however, even though this resistance alone does not typically progress to diabetes.[11,12]

Breed and size also influence survival outcomes. Smaller breeds have a higher risk of death when overweight, and overall, all dogs experience increased mortality risk and decreased survival time when overweight.[13] For instance, the median lifespan of male German Shepherds is reduced by approximately 5 months, while overweight male Yorkshire Terriers show a reduction of about 2.5 years.[13] Conversely, lean Labrador Retrievers (BCS 4.6/9) have an extended median lifespan of 1.8 years, compared to their overweight (BCS 6.7/9) counterparts.[14] Additionally, each additional kilogram of excess weight in older Labrador Retrievers correlates with a higher risk of mortality.[15]

Beyond longevity, weight management yields improvements in quality of life. Dogs that successfully complete weight loss programs demonstrate increased vitality and decreased emotional disturbance and pain scores, contributing to health-related quality of life.[16] Even modest weight loss, reductions as small as 6.1% of starting weight, can yield significant clinical benefits, such as improved lameness scores in dogs.[17,18]

CAUSES OF OBESITY: GENETICS AND RISK FACTORS

Peak obesity prevalence occurs during mature life stages, approximately between 5–12 years old in dogs (depending on size) and in cats.[2,9,19–21] In dogs, neutering is a well-established risk factor, associated with higher obesity incidence regardless of breed, with some variation related to breed size and age at neutering.[7,8,22–26] For example, Golden Retrievers are at increased risk regardless of neuter age.[26] Conversely, some data suggest that large dogs have a reduced risk if neutered at 1 year, while toy, small and medium-sized dogs benefit from neutering at 6 months.[22] More research focusing on pubertal status, rather than age alone, may clarify optimal timing to minimize obesity risk.[27]

In cats, neutered males demonstrate the highest prevalence of obesity, with intact males and spayed females similarly affected.[9,19,21] In dogs, females generally have a higher prevalence,[8,28–33] though when sex and neuter status are combined, some studies indicate neutered males face a higher risk of obesity than spayed females.[22,26,29] Other research shows mixed results, indicating neutered males are at increased risk compared to intact males, while females remain at risk regardless of neuter status.[28] Overall, both intact and spayed females, as well as neutered male dogs, are at increased risk of obesity.

Breed and body size are influential; toy and small breed dogs have higher obesity risk, whereas giant breeds tend to be less prone.[22] Specific breeds such as Pugs, Beagles, Golden and Labrador Retrievers, English Springer Spaniels, Pekingese, Pomeranians, Cocker Spaniels, Shetland Sheepdogs, Dachshunds, Dalmatians, and Rottweilers[8,24,29,30,32] are linked to increased risk. Similarly, certain purebred cats, including British Shorthairs, Norwegian Forest Cats, Persians, and Manx, show higher prevalence.[9,34,35] Crossbred cats may also be at increased risk,[9,21] though evidence varies.[19,20]

Activity level is critical; reduced activity and prolonged sleep are associated with overweight status in cats.[21] Indoor cats, especially those living in apartments, are more likely to be overweight.[21,36,37] In dogs, every additional hour of weekly exercise reduces obesity risk by approximately 4%.[38] Dietary factors also influence risk: Overweight cats are often fed dry food,[21] and free-feeding may[39] or may not increase obesity risk.[19,21] Treat feeding correlates with higher obesity prevalence in both species,[8,38–40] although cat owners with indulgent feeding practices, likely to include treats, are actually associated with a decreased risk.[37] Dogs with high food motivation are more likely to be overweight.[41,42]

Household factors impact risk and cats living with children tend to be less overweight.[19] The effects of cohabitating with other animals are mixed: Some studies show no effect,[19,21] while others suggest that cats living with dogs may have a lower risk of obesity.[43] Conversely, households with only cats or single-cat households may have higher risk.[36,43] Owner perceptions also influence risk; underestimating a pet's body condition increases obesity likelihood.[19,40,43] Providing a variety of complete and balanced diets may be protective, perhaps due to a reduction in boredom and begging behaviors.[37] In addition, owner demographics influence obesity risk. In dogs, older owners are associated with higher obesity risk,[38,40] whereas higher income correlates with lower risk.[38] **Table 1** provides a summary of these risk factors for both cats and dogs.

NUTRITIONAL ASPECTS OF OBESITY PREVENTION

The most important aspect of nutrition for preventing obesity is controlling calorie intake, especially in animals with known risk factors. Several methods exist to estimate energy requirements for cats and dogs. As outlined in the practical tool on nutritional calculations the resting energy requirement (RER) is calculated first, followed by the maintenance energy requirement (MER). For animals at higher risk of obesity, using more conservative, "obese-prone" life stage factors to determine MER can better manage intake. In the authors' clinical practice, calculations are based on the animal's ideal weight rather than its current weight.

At least 90% of a cat's or dog's daily caloric intake should come from the main meal, which should be complete and balanced in nutrients. For animals at increased risk of obesity, or those already with a BCS of 6–7/9, their diet can be modified to achieve weight management goals. Consider diets higher in protein to help maintain lean muscle mass and promote satiety.[44,45] Additionally, fiber, particularly insoluble, bulking sources, can be increased to enhance satiety. However, this approach has shown variable effectiveness in dogs for reducing intake,[44,46] and has

Table 1. Obesity prevention overview

Risk assessment	Prevention actions	Monitoring
High-Risk Breeds/Types • Toy/small sized dogs • Dog breeds: Pugs, Beagles, Golden and Labrador Retrievers, English Springer Spaniels, Pekingese, Pomeranians, Cocker Spaniels, Shetland Sheepdogs, Dachshunds, Dalmatians, Rottweilers • Cat breeds: British Shorthairs, Norwegian Forest Cats, Persians, Manx	**Nutrition Management** • Calculate MER using obese-prone factors if at risk • Weigh food portions (grams, not cups) • Limit treats to <10% daily calories	**Schedule** • High-risk pets: At least quarterly • All pets: Annual minimum • Every visit: Weight + BCS
Life Stage Factors • Recently neutered pets • Ages 5–12 years • Decreased activity levels	**Feeding Strategy** • Eliminate free-feeding • Use smaller bowls/ measuring tools • Pre-measure daily treat allowances	**Action Triggers** • BCS >5/9: Discuss with owner • Weight trending up: Adjust plan • Growth charts for young pets
Lifestyle Risk Factors • Indoor cats, apartment living • High food motivation • Treat-focused owners	**Owner Education** • Teach home body condition scoring • Provide written feeding guidelines • Emphasize non-food rewards	**Key Messages** • Focus on lifespan impact • Early intervention prevents obesity • Small changes yield big benefits

not reliably induced voluntary energy intake reduction in cats.[47,48] Even if fiber does not always make the animal feel full enough to decrease energy intake on its own, high-fiber diets are valuable tools for reducing overall caloric density of food, allowing owners to maintain a reasonable daily calorie limit. In cats, feeding high-moisture diets has been shown to decrease overall energy intake and body weight, while also naturally encouraging increased physical activity.[49–51] This may explain why there was no difference in owner-perceived satiety between cats fed canned high-fiber diets and those fed canned low-carbohydrate, low-fiber diets.[47] When more significant caloric restriction is necessary to help a cat or dog maintain an ideal weight (i.e., below RER), it is important to ensure that appropriate nutrient balance is still maintained. Therapeutic diets formulated for weight loss are designed with an extra level of fortification to support this feeding practice and can be considered. Despite theoretical concerns, no clinical signs of deficiencies have been reported when feeding therapeutic diets below RER.[52–55] An additional consideration is avoiding excess dietary fat, as fat provides more than twice as many calories per gram compared to protein and carbohydrate, and reducing fat intake can help control total caloric consumption.

The remaining 10% of a cat's or dog's daily calories can come from treats, which generally are not complete and balanced. Owners often view treats as important tools for managing behavior, supporting health-related activities, and strengthening their bond with their pet.[56] Their high value to owners and the satisfaction they derive from giving treats, combined with a lack of guidance on appropriate treat use, can pose barriers to reducing treat intake—especially in pets that are obese.[56,57] Many owners estimate treat portions visually, which may contribute to overfeeding.[58,59]

FEEDING STRATEGIES FOR OBESITY PREVENTION

Although ad libitum feeding has been inconsistently reported as a risk factor for obesity,[19,21,39] research shows important consideration for feeding methods. Owners tend to portion larger amounts of food when using large bowls and scoops compared to smaller

ones,[60] and dogs tend to eat significantly more as meal portions increase.[61] Measuring cups for volume measurements result in poor precision and variable accuracy, especially when measuring smaller volumes of food.[62,63] Additionally, providing scheduled, smaller meals via automated feeders has been shown to make cat weight loss programs easier for owners, reduce food-seeking behaviors, and improve the overall success compared to traditional manual feeding from bowls.[64] Using food-dispensing toys has increased daily activity levels in primarily indoor-housed dogs compared to bowl feeding, and this effect may be maintained if the toys are routinely rotated to preserve novelty.[65] In cats participating in weight loss programs, weight reduction was associated with owner-perceived improvements in quality of life, but the use of a food-dispensing toy had no significant effect compared to standard food bowls.[66] Overall, these findings suggest that feeding enrichment methods are most beneficial for activity and quality of life, but may not be highly effective as stand-alone weight management strategies.

TIPS FOR OBESITY PREVENTION

Growth charts are invaluable tools for monitoring progress in puppies (up to predicted adult body weight of 40 kg) and kittens, ensuring healthy development while avoiding unintentional excessive weight gain.[67–69] These charts help veterinary teams identify when growth patterns deviate from normal and intervene before obesity develops. For all pets regardless of age, every time body weight is recorded, it should be accompanied by a body condition assessment.[70,71] All pets should have a weight recorded annually and for pets at a higher risk of obesity, quarterly (or more frequent) weigh-ins are recommended. Weight and BCS should be tracked over time to identify upward trends as early as possible. Teaching owners to assess body condition at home can improve monitoring between veterinary visits, and web-based tools that include written explanations and instructional videos are available for both cats and dogs.[72]

When BCS exceeds 5/9, the veterinary team should discuss the pet's current status with the owner, review feeding practices, and provide specific recommendations for weight reduction. If owners are reluctant to make changes, emphasizing how weight management could potentially extend the pet's lifespan can be particularly motivating.[73,74] It's important to tailor the approach by species, as cat owners are often also concerned about food costs,[74] while dog owners typically prioritize the impact of weight on arthritis.[73] Providing educational materials to support behavior change is also beneficial. Research shows 80% of owners report changing how they feed, exercise, or interact with their pets when provided with weight management resources, with preliminary evidence suggesting improvements in weight and BCS.[75]

COMMUNICATION TIP

Clear communication is key, and providing both verbal and written information about daily treat allowance, caloric content of current treats, and calorie content of lower calorie alternatives allows treats to remain part of the diet without causing overfeeding.

Eliminating free-feeding by switching to measured meal portions is an essential strategy for controlling calorie intake. Food should be weighed on a gram scale, rather than measured by volume, to improve precision and accuracy. Since treats are highly valued and difficult to limit, veterinary teams should provide guidance on appropriate incorporation. Practical strategies include using portions of the main complete and balanced meal as treats, switching to lower calorie treat alternatives, and premeasuring daily treat portions to prevent overfeeding.[1,76] Clear communication is key: Providing both verbal and written information about daily treat allowance, caloric content of current treats, and calorie content of lower calorie alternatives allows treats to remain part of the diet without causing overfeeding. Additionally, incorporating non-food rewards, such as play, praise, and attention, especially during training and behavior management, can reduce reliance on food-based rewards. **Figure 1** outlines key veterinary strategies for obesity prevention, while **Table 1** presents a structured overview of risk assessment, preventive actions, and monitoring protocols.

Figure 1. Key steps for veterinarians to support obesity prevention

1. Monitor and educate

- Weight, BCS
- Discuss risks when upward trends are identified
- Adjustments based on age, breed, health status

2. Personalized prevention plan

- Specific calorie targets for meals and treats
- Appropriate exercise and activity routines
- Environmental enrichment
- Routine monitoring & owner engagement

3. Weight & BCS assessments at least every 3–12 months

- Reinforce owner understanding of ideal BCS
- Address weight gain early & adopt strategies proactively

CONCLUSION

Maintaining a healthy weight is fundamental to safeguarding the overall health, longevity, and quality of life of cats and dogs. Obesity is influenced by genetic predispositions, owner behaviors, activity levels, and dietary practices. Its associated health risks—ranging from metabolic disorders and orthopedic problems to cardiovascular complications and reduced lifespan—highlight the importance of proactive prevention strategies. Nutritional management and client communication play a crucial role in this effort; ensuring that pets receive appropriate caloric intake and optimal macronutrient balance can significantly reduce the risk of weight gain. Regular monitoring through body condition scoring, growth charts, and weight tracking enables early detection and intervention, while owner education fosters responsible feeding practices. Tailoring nutrition and activity plans to each pet's needs, combined with consistent veterinary guidance, ultimately supports long-term health and well-being. By prioritizing these approaches, the veterinary team can significantly contribute to enhancing long-term health and quality of life in cats and dogs.

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NUTRITIONAL APPROACH TO HEALTHY DIGESTION

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KEY TAKEAWAYS

- Nutrition has many direct effects on the gastrointestinal tract, including effects on the microbiota, mucosal immune system, epithelial barrier, motility, and regulation of gene expression.
- In addition to ensuring the animal is consuming a complete and balanced diet, dietary fiber, digestibility, and high-quality ingredients are also important in supporting gastrointestinal and systemic health.
- Acute vomiting and diarrhea are commonly seen in otherwise healthy pets. Animals with episodes of acute gastroenteritis can be supported with dietary strategies such as increased digestibility, low fat, or fiber enriched, and probiotics.
- Diets enriched with insoluble fibers can help with hairball management in cats.

THE ROLE OF NUTRITION IN GASTROINTESTINAL HEALTH

Nutrition has many direct effects on the function of the gastrointestinal tract. Particular nutrients are able to influence the intestinal microbiota, direct the mucosal immune system, modulate gene expression via epigenetics, enhance epithelial barrier function, and impact gastrointestinal motility. Therefore, diet plays a central role in gastrointestinal health in dogs and cats.

The influence of diet on the intestinal microbiota

Diet is considered to be one of the most important influencers of the intestinal microbiome with fat, protein, and fiber all showing a strong impact. For example, dietary fiber helps to preserve intestinal barrier function via maintaining the inner mucus layer by promoting beneficial changes in the microbiota.[1,2] Hence, a diet low in fiber may result in a shift toward mucin degrading bacteria that cause a thinning of the inner mucus layer, resulting in reduced antimicrobial peptides and immunoglobulins, as well as increased accessibility of bacteria to the enterocytes.[2,3]

The impact of diet on the gastrointestinal mucosal immune system

A second mechanism of the direct effect of diet on gastrointestinal function is via the impact on the immune system.

- Fish oil and soy are immunomodulatory.[4]
- Amino acids can target the gastrointestinal immune system by several mechanisms, such as inhibition of receptors belonging to the innate immune system (arginine, glutamine) and antimicrobial production (arginine, isoleucine).[5]
- Vitamin D and retinoic acid, a derivative of vitamin A, play a crucial role in the innate immune system.[6,7]
- Dietary fiber impacts the immune system via multiple mechanisms. For example, microbial fermentation of fermentable fiber results in production of butyrate, which has anti-inflammatory properties.[8,9]

The role of diet in epigenetic modification

Epigenetics studies the reversible and inheritable changes that regulate gene function without affecting their sequence.[10] Several nutrients, such as selenium, polyphenols, and curcumins, have been shown to be involved with epigenetic modifications. Also, various dietary substrates, such as methionine, folate, choline, pyridoxine, and cobalamin, are necessary for DNA methylation, a form of epigenetic modification. Finally, the short chain fatty acids may play an important role in the epigenetic control of the inflammatory response.

THE IMPORTANCE OF A COMPLETE AND BALANCED DIET IN GI HEALTH

Given the importance of the macronutrients and different vitamins and minerals in maintaining gastrointestinal health and function, some as outlined above, ensuring the animal is consuming a complete and balanced diet is of paramount importance to gastrointestinal and systemic health. A complete and balanced diet ensures all the essential nutrient requirements are met when that food is fed as the sole main diet. Selecting a diet that is complete and balanced for the pet's life stage is therefore mandatory for all dogs and cats.

KEY NUTRIENTS AND DIET FEATURES FOR SUPPORTING HEALTHY DIGESTION IN DOGS AND CATS

Given the importance of dietary fiber, digestibility, and high-quality ingredients in supporting gastrointestinal function, these nutrients are discussed in more detail below.

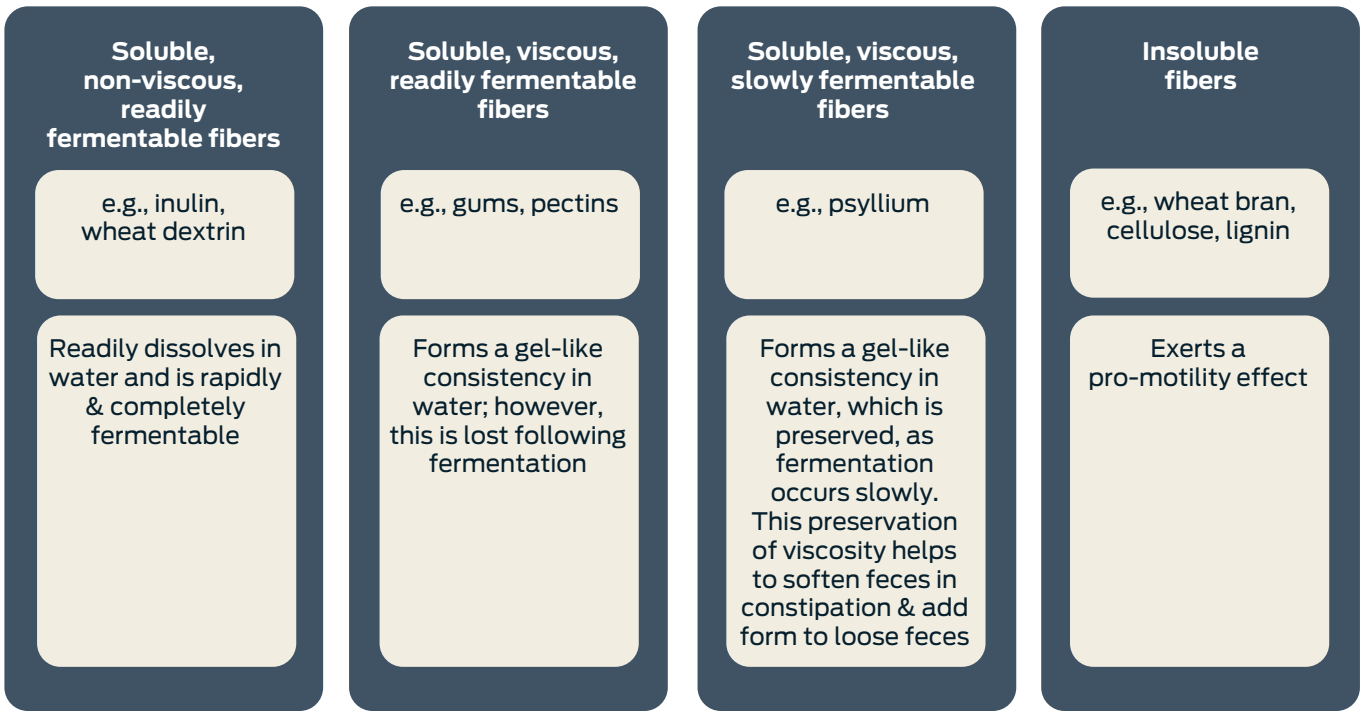
Dietary fiber

Dietary fiber is defined as the edible parts of plants that are not digested or absorbed in the small intestine of mammals. Instead, fiber passes unchanged into the colon where it is fermented by select bacteria. Given the broad definition of dietary fiber, it includes many compounds present in edible plants, such as lignins, celluloses, hemicelluloses, pectins, gums, oligosaccharides, waxes, resistant starches, and associated compounds such as polyphenols.

Although dietary fiber is not yet considered essential for dogs and cats, it is important for the maintenance of gastrointestinal health. Dietary fiber is classified based on its solubility, viscosity, and fermentability. These three physiochemical properties help govern how the fiber functions within the gastrointestinal tract (**Figure 1**).

- Soluble fibers disperse fully when mixed with water and include pectins, gums, and mucilages, whereas insoluble fibers typically consist of cellulose and lignin. Insoluble fibers that are slowly fermentable help to provide a laxative effect.
- Fibers that are described as viscous can form a thick, sticky, and semi-fluid gel when mixed with water. Examples of viscous fibers include psyllium, gums, and pectins. Fibers that are viscous are able to reduce the rate of passage of digesta through the gastrointestinal tract by stimulating the ileal break phenomenon, which has been defined as "a distal to proximal feedback mechanism to control transit of a meal through the gastrointestinal tract in order to optimize nutrient digestion and absorption."[11]

Figure 1. Properties, examples, and functional description of various dietary fibers



This also helps to slow gastric emptying, which can help to increase satiety resulting in less food intake and can also reduce the amount of ingesta entering the colon. In people, fibers with increased viscosity also help improve glycemic control and reduce cholesterol by slowing nutrient digestion and absorption and increasing fecal bile acid loss, respectively.[12]

- Fibers can be fermented by commensal bacteria in the colon, resulting in the production of short chain fatty acids. Therefore, based on this characteristic, they can be described as slowly to rapidly fermentable. Fibers that are more rapidly fermentable produce more short chain fatty acids in a shorter period of time than slowly fermentable fibers. Short chain fatty acids consist of butyrate, propionate, and acetate. The proportions of each produced are determined by the specific fiber type being fermented and the bacterial species that is fermenting the fiber. **Figure 2** lists the broad beneficial properties of short chain fatty acids.

Prebiotics

An additional functional classification of dietary fiber, in addition to solubility, viscosity, and fermentability, is prebiotic function. Fibers with prebiotic function are selectively fermented to allow specific changes to the composition, activity, or both of the gastrointestinal microbiota, which then contribute to the overall health of the animal.[13] Prebiotic fibers traditionally target bacteria considered beneficial, such as *Bifidobacteria* and *Lactobacillus* species. Prebiotic fibers also contribute to overall health by helping to reduce fecal odor by modifying fecal concentration of metabolites and to improve immune function by influencing gut-associated immune cells. Examples of fibers that are classified as prebiotics mainly include oligosaccharides, which are polymers made up of nine sugars, with examples including mannanoligosaccharides, fructooligosaccharide, and galactooligosaccharide, and lactulose, inulin, aleurone, and resistant starch. Many of these prebiotic fibers occur naturally in foods such as wheat bran and chicory.

Digestibility

Digestibility describes the extent to which food or macronutrients within the food are digested and absorbed by the gastrointestinal tract and is usually expressed as a percentage. Digestibility can be influenced by many factors related to the ingredients and to the animal:

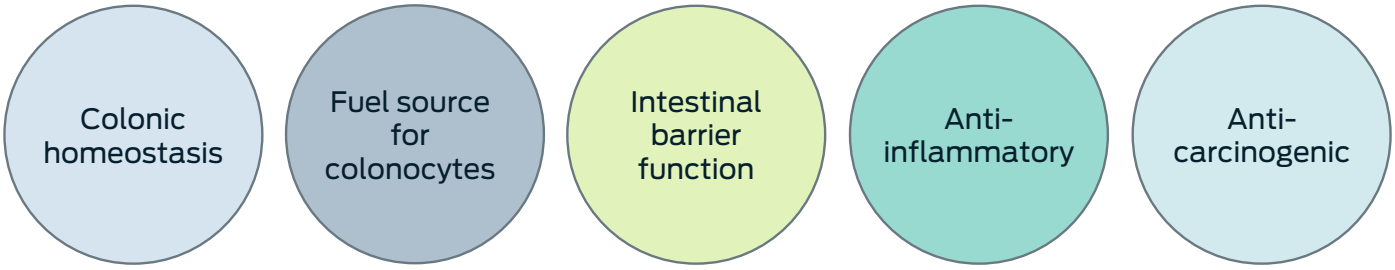
- **Ingredients** – e.g., fiber content, as digestibility is directly affected by this, or amount of ingestible material (e.g., high ash meals, or collagen rich meat).
- **Manufacturing** – e.g., heat generally increases the digestibility of starch but decreases the digestibility of protein.
- **Animal** – e.g., breed, as larger breed dogs typically display lower digestibility of food compared to smaller breed dogs,[14] age (approximately 20% of cats older than 12 years have decreased protein digestibility),[15] GI health, physiologic status, and the amount of food consumed.

Although the definition of a highly digestible diet is not currently standardized, diets with a total digestibility of at least 80% and macronutrient digestibility of at least 90% are typically considered as highly digestible.

High-quality ingredients

Although quality is a subjective term, high-quality ingredients are those ingredients considered to be safe, free of contaminants, and reliable in their production. Therefore, feeding of high quality ingredients helps ensure overall health. High quality may also pertain to the increased bioavailability of nutrients within that ingredient, which would help to ensure the animal obtains all the necessary nutrients from the ingredient.

Figure 2. Summary of the various broad functions of short-chain fatty acids



Additionally, due to this greater bioavailability, fewer intact or undigested nutrients, such as protein and fat, enter the colon, where their presence could be detrimental to the microbiota and epithelial lining.

STRATEGIES TO HELP SUPPORT DIGESTION IN HEALTHY PATIENTS

The following strategies may help to support healthy digestion in dogs and cats.

Dietary transitions

Any dietary transition should ideally be performed slowly, over at least 7 days to ensure the gastrointestinal tract has time to adjust to any significant changes between the diets. A longer transition over at least 10–14 days could be done for sick or sensitive animals. This smooth transition will ensure less abrupt changes to gastrointestinal tract function, which could otherwise result in gastrointestinal signs, such as diarrhea and flatulence.

Number of meals per day

For susceptible animals, dividing the daily amount of food into multiple small meals per day may aid gastric emptying and intestinal motility. However, the feeding frequency should be assessed for each individual animal, as in some instances animals may do better when fed less frequently.

Slowing down rate of ingestion

Increased rate of ingestion could be associated with aerophagia and indigestion. If the animal eats very quickly, puzzle bowls can slow down eating.

Reducing stress during meal times

Stress during meal times could result in gastrointestinal dysfunction and therefore should be adequately addressed if present.

MANAGING ACUTE GASTROENTERITIS WITH DIET AND PROBIOTICS

Acute gastroenteritis is a common presentation in veterinary practice. Although the etiology is rarely confirmed, various causes include infectious, inflammatory, toxic, stress, and dietary. Treatment is aimed at addressing the underlying cause if identified, symptomatic care, and nutritional management once the animal is adequately rehydrated and stabilized.

COMMUNICATION TIP

Diet plays a central role in gastrointestinal health in dogs and cats.

In order to maintain gastrointestinal integrity and function, food should not be withheld and instead prioritized once the animal is adequately hydrated and stabilized. Indeed, a prospective, randomized controlled clinical trial showed that early enteral nutrition in dogs with severe parvovirus enteritis was associated with more rapid clinical improvement versus withholding food during the early stages of disease.[16] Although studies are lacking to determine the ideal dietary composition for dogs and cats with acute gastroenteritis, the different nutritional strategies that may be advantageous include increased digestibility, low fat for dogs, or high dietary fiber. In addition, the use of probiotics may help in cases of acute gastroenteritis.

Increased digestibility

Acute gastroenteritis may compromise the digestion and absorption of nutrients, and therefore diets with high digestibility can be beneficial in these cases. Additionally, diets with high digestibility produce fewer residues in the gastrointestinal tract, which can help to prevent overloading of the gut, as well as help to alleviate any osmotic diarrhea. Commercial therapeutic gastrointestinal diets are generally classified as highly digestible.

Low dietary fat

A reduction in dietary fat may help to hasten gastric transit, and therefore this strategy may be beneficial in those dogs with acute gastroenteritis resulting in nausea, regurgitation, or vomiting. Also, as dogs with acute gastroenteritis may experience reduced fat digestion and absorption resulting in excess dietary fat passing into the colon, which may result in dysbiosis, as well as secretory diarrhea, reducing the dietary fat in these cases may help to reduce or alleviate these effects. Although further studies are needed to determine the role of dietary fat in acute gastroenteritis in cats, one study showed that this macronutrient did not seem to affect the outcome of cats with chronic diarrhea.[17]

High dietary fiber

Diets high in fiber may be beneficial for colitis; however, not all animals with large intestinal signs will respond to this strategy. Thus, trial-and-error with this approach is needed and should be prioritized for colitis cases that do not respond to a highly digestible diet, and especially before the use of empirical antimicrobials. Indeed, one randomized controlled clinical trial showed that for dogs with non-infectious acute colitis, dietary management with an easily digestible diet with or without the soluble, non-fermentable fiber psyllium proved a superior treatment strategy versus metronidazole.[18]

Probiotics

Several probiotic studies in dogs and cats with acute gastroenteritis have shown beneficial effects, such as significantly reducing episodes or duration of diarrhea, and improving stool consistency.[19-25] However, as the effects are likely strain specific, larger scale studies assessing efficacy and safety, particularly in immunocompromised animals, are needed.

NUTRITIONAL MANAGEMENT OF HAIRBALLS IN CATS

In order to aid the passage of hairballs into the duodenum and prevent them from being vomited, insoluble fibers have been added to cat food. The literature shows that feline diets enriched in insoluble fibers, such as cellulose, are able to reduce signs associated with hairballs and increase fecal hair excretion in cats.[26,27] The exact mechanism is likely due to the insoluble fiber preventing the agglomeration of single strands of hair in the stomach and therefore increasing the transit of loose hairs into the duodenum. Insoluble fiber can also accelerate the transit time of ingesta and therefore the propulsion of duodenal hair in feces.[28]

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NUTRITIONAL APPROACH TO BEHAVIORAL WELLNESS

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KEY TAKEAWAYS

- Behavioral health is not only the absence of behavior problems, and is a balance of physical health, environment, nutrition, and mental state.
- Over 99% of dogs exhibit at least one moderate-to-severe behavior problem, many due to chronic stress. Stressors include diet changes, environmental unpredictability, lack of space, caregiver stress, and systemic health issues.
- Nutrition directly impacts behavior and mental well-being. Diet composition and feeding methods affect canine behavior, cognitive function, and emotional stability. Providing food choice and feeding enrichment (e.g., puzzle toys) helps reduce stress and improve overall well-being.

ASSESSING BEHAVIORAL WELLNESS

Assessing the behavioral wellness of our patients is subjective, unique to each individual, and influenced by pet parent bias. Is a pet considered behaviorally well if it is free from behavior problems or if the balance of good days and bad leans toward the good?[1] The Five Domains Model of Animal Welfare[2] is a commonly accepted guideline for animal wellness. In this model, Mellor asserts that an animal's mental state is at the center of wellness, receiving input from all other domains (**Figure 1**).

For example, if a pet's caloric intake (nutrition) is reduced due to a prescribed weight-loss diet, they may exhibit behavioral changes (mental state) such as aggression, begging, and barking, stemming from frustration, hunger, and a lack of control over when and what they can eat. Conversely, if a pet is overweight (health), they may struggle to jump up, hide, or move away quickly from other pets or children, potentially leading to fights with family pets, biting children, or self-segregation. The pet may be presented for aggressive behavior in both cases mentioned above, emphasizing the importance of a holistic approach to behavioral clinical signs and wellness. It might be easiest to consider behavioral wellness as the sum of all things–systemic health, environment, nutrition, and behavior.

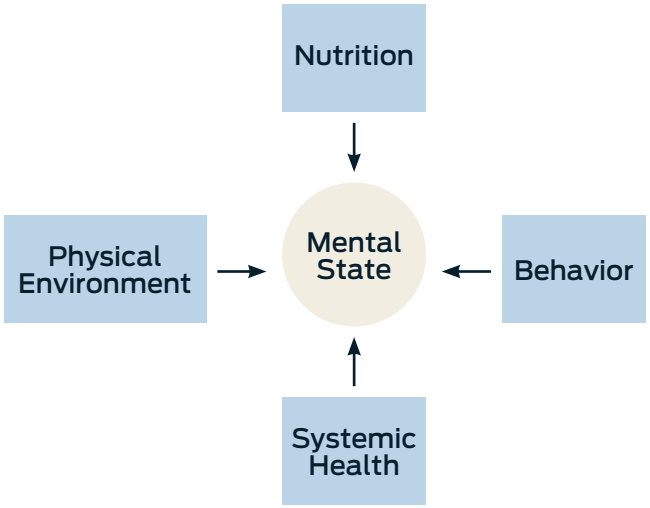
WHAT DO DOGS AND CATS HAVE TO BE STRESSED ABOUT?

In a recent survey of 45,517 dog pet parents, over 99% of dogs exhibited at least one moderately serious to serious behavior problem, suggesting that many of our patients may be behaviorally unwell.[3] Pets may not show serious behavior problems until the stress is chronic, leading to negative systemic and emotional changes and a breakdown of the human-animal bond. Yet many pets are under chronic daily stress, which goes unnoticed by pet parents and veterinary healthcare team members.[4] The list of stressors for dogs and cats can be extensive, including changes in routine,[5] environmental sounds,[6,7] diet changes, incompatible social groups, lack of space,[8,9] caregiver stress,[10] lack of agency, environmental and social unpredictability, and systemic health issues.[11] Exacerbating daily stress, dogs and cats often struggle to communicate their needs clearly to pet parents who, although well-meaning, do not fully grasp dog or cat body language.[12,13] Daily stress can snowball into chronic physiologic stress, increasing the risk of dermatologic disease,[14] high blood pressure,[15] shortened life span,[14] behavior problems, and neoplasia[16] when compared to nonstressed individuals. For the health and well-being of our patients, we must address their mental state and behavioral wellness. What do we have to lose?

HOW CAN WE MEET THE EMOTIONAL NEEDS OF ANIMALS?

A quick checklist of the emotional needs of animals includes exploratory behavior, play, self-care, social interaction, mental stimulation, agency, predictability,

Figure 1. Five Domains Model of Animal Welfare (Adapted from Mellor, 2020)



coping skills, and cognitive challenges.[1,17] Two widely overlooked aspects of behavioral wellness are predictability and agency. When animals reliably anticipate events[18] and have control over the outcomes of events, they experience less physiological stress.

Unpredictability is subtly interwoven throughout the environment of most pets. For instance, one family member feeds the dog from the table, while another scolds it for sitting nearby during meals, which confuses the dog about whether approaching the table is safe. Pet parents may observe barking, circling, or aggression[19,20] as they try to move the dog away from the table. Although convincing all family members to interact with the pet consistently can be challenging, many will agree to give the dog low-calorie treats from a food toy in a separate room, behind a baby gate, or on a bed across the room, allowing everyone to feel satisfied and reducing the dog's internal conflict.

Agency refers to an individual's capacity to effect change in their environment and influence outcomes through the conscious expression of behavior. Providing pets with agency over their basic needs has been shown to reduce stress.[21] Consider this: pets cannot choose what to eat, when to eat, or how to obtain food. They lack the ability and self-control to make decisions regarding their health and well-being, so how can we give them control over what they eat? While it is true that if most pets could choose their food, they might opt for less adequate options and overindulge, we can still allow them to make feeding decisions that do not directly impact their nutrition. One way to facilitate this is by letting the pet decide where and how to obtain food through simple choice games. At mealtime, the pet parent can present two empty options: a puzzle toy and a bowl, or two different puzzle toys. The pet can choose by moving toward their preferred way of eating. Once the choice is made, the pet parent can collect both items and fill the selected one with the pet's meal. Similarly, the pet parent can offer two different bowls or two different puzzle toys containing a small amount of nutritionally comparable diets. The pet can decide what to eat at that meal, after which the pet parent can finalize meal preparation by placing the entire meal in the chosen bowl or puzzle toy. Another easy way to give pets agency over their food is rotating diets and allowing the pet to choose which food to eat on any given day, while keeping nutrient and calorie intake consistent. In situations where pet parents intend to expose their pet to different foods, it should be done gradually and with veterinary supervision to avoid gastrointestinal upset. These practices can give pets some control over their lives, reducing stress. Puzzle toys and bowls can also be rotated to introduce variety.

Historically, controlling food has been a part of training animals, whether to increase motivation by reducing satiation during training sessions or due to the misconception that controlling food asserts dominance over animals. Techniques can include hand-feeding meals, restricting access to food before training sessions, feeding after training sessions, using the daily ration for training throughout the day, and limiting the time for food consumption. While the theory behind this type of food manipulation may seem sound (hungry animals will be more willing to work for a food reward), research in dogs indicates that much like children who are better able to focus in school when they have eaten a meal as opposed to feeling hungry, dogs perform better when they are fed.[22] Controlling access to food is necessary to ensure that pets are at a healthy weight and get adequate nutrition. Skipping meals before training sessions, restricting the duration of mealtime, and eliminating meals so that dogs work for all food is stressful for them and counterproductive for learning.

ENRICHMENT

Environmental enrichment enhances an animal's emotional well-being by modifying its environment and offers benefits beyond just addressing energy levels and boredom. In geriatric dogs, social and cognitive enrichment has been shown to increase brain-derived

neurotrophic factor (a protein enhancing the brain's development and function),[23] improve learning,[24] and reduce age-related loss of hippocampal (memory) neurons.[25] In non-geriatric dogs, it can positively influence neuroplasticity (the brain's ability to adapt), the acquisition of new skills, and memory.[26]

One of the most common forms of enrichment involves feeding pets through food puzzles or toys. Most pets tend to be food-motivated, and food toys are easily accessible. Toys filled with food have been shown to reduce excitability,[27] increase activity,[27,28] improve learning from positive reinforcement,[29] and decrease barking frequency[30] in dogs. Additionally, they have been shown to decrease anxiety associated with separation-related disorders during eating and for 15 minutes afterward.[31] In a recent study, chewing a long-lasting chew after a training session improved memory consolidation (laying down and stabilizing memories).[32]

Puzzle toys are often recommended for cats. Some cats may resist changing how they eat. As a preventative measure, it may be advisable to introduce kittens to various eating methods and types of diets. While foraging toys for cats have been studied, they have not demonstrated effectiveness in weight loss or in enhancing the pet parent's perception of quality of life. Nevertheless, they appear to engage cats, as indicated by a study involving pet and shelter cats, where food was the second most popular enrichment category after human interactions.[33] Although food toys have not been proven to reduce aggression in shelter situations, 85% of the cats in one study interacted with the puzzle toy, and the cats did not show increased aggression over the resource.[34]

Pet parents who use puzzle toys should be encouraged to initially select toys that are easy for their pets to manipulate so that reinforcement comes quickly. Every pet is unique, with some requiring simpler toys than others. Additionally, like us, each animal has a perfect level of stimulation. For some pets, certain puzzle toys will be over-stimulating, and for others, only the most difficult toys will do. Pet parents may notice that as their pet becomes more adept at acquiring food from puzzle toys, they must purchase more exciting or challenging ones. Promoting high-value, low-calorie foods and reasonably adjusting the pet's daily calorie intake will help prevent weight gain (**Figure 2**).

Some dogs and many cats may be slow to adapt to new items in their environment, such as puzzle toys. Unless the pet shows overt fear of the object, pet parents should be encouraged to leave the toy out so the pet can become accustomed to it. For some cats, it can take several weeks to accept novel items. Even if the cat engages with it for a couple of seconds, it is beneficial. Utilizing high-value treats in the toy can also promote its use. Pressuring the pet to eat from a food toy that frightens them by restricting their food supply to only that puzzle toy is not advisable. The enrichment is for the pet's benefit and should be enjoyable or aimed towards that goal.

COMMUNICATION TIP

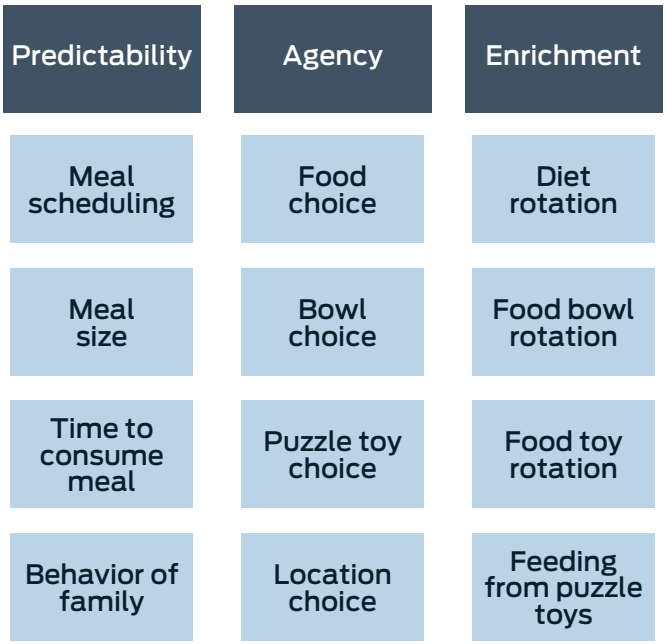
Letting a pet decide where and how to obtain food — by presenting puzzle toys and/or bowls as options — can allow them to make feeding decisions without impacting the nutrition they receive.

Food is love to many pet parents. One study found that 40% of pet parents who participated in a survey gave treats to their dogs to show their love.[35] Unfortunately, this food-is-love philosophy may lead to overtraining and obesity. Over and underconditioning can lead to changes in behavior, such as lack of energy and ability to exercise, limiting some forms of enrichment. Underconditioning can lead to increased hunger and aggression. Reducing diets that are used to address obesity can cause begging, aggression, and attention-seeking behaviors. Changes in diet to veterinary therapeutic diets with potentially decreased palatability can do the same. Each time that a change is made to the pet's nutritional environment, even if for the pet's health and wellness, their mental state and outward expressions of behavior can be affected.

NUTRITION AND BEHAVIOR

We have much to learn about the role of nutritional ingredients in the behavioral well-being of animals. Gut microbiome differences have been associated with aggression, anxiety, and memory performance in dogs, with changes detectable in as little as 24 hours.[36-38] In addition, the gut microbiome plays a role in producing monoamine neurotransmitter precursors and GABA, which modulate fear, anxiety, aggression,

Figure 2. Nutritional approach to behavioral wellness



hypervigilance, muscle tension, and stress.[39] Certain probiotics have been shown to alleviate stress in cats and dogs. In dogs, a low-protein diet (18%) with concurrent tryptophan supplementation may reduce certain types of aggression.[40] In another study, lower (17%) and moderate (25%) protein contents were shown to decrease territorial aggression in dogs in which the underlying cause was fear, but did not affect other types of aggression or other behavior disorders.[41] Food allergy, food aversion, and nutritional imbalance may be associated with changes in behavior, such as aggression and anxiety.[42] In dogs, behavior changes alone can be the sole clinical sign of food intolerance. However, they may accompany gastrointestinal signs, such as plant-eating and vomiting.

As is the case throughout our lives, once our attention is drawn to something, we begin to see it everywhere. It is the same for the behavioral wellness of animals. Noticing changes in behavior can be vitally important and may be the first signs of systemic illness and deficits in the other domains of wellness. Seeking out and changing the stressful parts of an animal's life does not have to be complicated or costly, and the payoff can be immense.

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PRACTICAL TOOL: FEEDING THE FINICKY FELINE

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While changes in appetite can be a sign of an underlying medical concern, even healthy cats can be picky about their food. This practical tool is intended to serve as a guide for supporting veterinary health care professionals in answering pet owner questions about finicky healthy cats.

WHAT DOES "PICKY" MEAN?

When a client describes their cat as "picky" (or fussy, finicky, or selective about their foods), it is important to clarify what that means to them (**Box 1**). The client's answers can be combined with the cat's current BCS and weight history to determine whether there is an opportunity for more education—for example, around appropriate caloric intake or the importance of not over-feeding treats—and to help determine the best course of action for the client's specific concerns.

APPETITE MANAGEMENT FOR HEALTHY CATS

Cats, as a species, are considered neophilic, which means they naturally tend to prefer new foods compared with familiar foods. It is hypothesized that this tendency evolved in cats to ensure that they were always hunting different prey in the wild and maximizing the chances of getting all their required nutrients.[1] Neophilia can be one factor behind the common experience of cats suddenly refusing to eat a previous favorite food. Encourage pet owners to find creative ways to meet their cat's need for novelty without risking digestive upset. There are multiple ways to achieve this, such as feeding a consistent dry diet to meet the bulk of the cat's caloric needs but including a rotation of wet foods and treats (while keeping treats at less than 10% of total daily calories). In another example, owners can rotate different flavors and/or textures of the same brand of wet food.

While neophilia is common, some cats may be neophobic, meaning they prefer familiar foods and may reject new foods. The easiest way to reduce neophobia is to continue giving cats opportunities to try new foods. Studies have shown that for some cats,

Box 1. Questions to ask pet owners with finicky cats

"Picky" can mean a lot of different things – answering these questions can ensure both the practitioner and client are on the same page, provide the practitioner with information needed to offer guidance for possible solutions, and help set reasonable expectations for cat feeding behavior. These questions do not need to be asked in any specific order.

- **Is the cat not finishing any meals or not eating "enough"?**

  How is the owner defining "enough"? What is the cat consuming? How is the owner assessing or measuring consumption? Owners may overestimate what is a reasonable portion for cats to consume.

- **Is the cat eating well but reluctant to try new foods?**

  What does "eating well" mean to them?

  What does "new" mean to them? Flavors, brands, food forms?

- **Is the cat eating plenty of treats but refusing main meal products?**

  Clients may underestimate how many treats they are giving their pets— suggesting they keep a detailed log of everything offered for a week may be helpful.

- **Is the cat willing to try new foods, but tires of them quickly?**

  Are they willing to eat those foods again after some time has passed?

- **When did this behavior begin?**

  Were there any other environmental, dietary, or health changes at the same time?

neophobia to a specific food may be overcome in as little as two exposures,[2] although it may take more than that. Patience pays off, and cat owners should be encouraged to persevere as many simply give up too early.

Cats are more likely to be neophobic when they are feeling stressed or experiencing changes in their environment.[3] For the best outcome, introduce new foods in a familiar setting when the cat is relaxed and comfortable. The appeal of the new food may also be increased by associating it with good things, like attention, praise, or play. Warming the food so that its temperature more closely matches body temperature (37° C) can also increase appeal.[4]

The feeding environment can also have an impact on food consumption. First, owners should ensure that the serving dish is appealing to the cat. There is anecdotal evidence that bowls with very high sides may cause irritation to the cat's whiskers, commonly referred to as "whisker fatigue" or "whisker stress"; cat owners may have more success feeding their cat off a flat plate. The serving dishes also need to be cleaned and sanitized daily and should be placed far from the litter box in a space where the cat feels safe and can eat undisturbed.

Finally, appetite may also be improved by making mealtime part of a routine. For cats who are currently free fed, owners should consider transitioning to meal feeding. Feeding several small meals every day closely mimics normal hunting behavior,[5] and putting the meals on a fixed schedule may increase the cat's anticipation and enjoyment of the meal. Scheduling play sessions before mealtimes and/or providing meals in food puzzles may further increase appetite and interest in food.[1]

PREVENTING PICKINESS: DEVELOPMENT OF TASTE AND FLAVOR PREFERENCES IN CATS

One of the best ways to reduce the number of picky adult cats seen in your practice is to provide feeding advice to the clients while the cats are still kittens. Relative to adult cats, kittens' palates are more flexible and easily modified. If kittens are fed only one form and flavor of food, then they may become neophobic as adults; on the other hand, kittens exposed to a wide variety of foods while young generally continue to have broader food acceptance as adults.[6]

Helping finicky felines requires a comprehensive understanding of their behavior and environmental factors. By implementing these strategies and encouraging owners to be patient and persistent, veterinarians can play a crucial role in ensuring that cats receive the nutrition they need for a healthy and happy life.

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NUTRITIONAL APPROACH TO HEALTHY JOINTS

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KEY TAKEAWAYS

- Feeding a complete and balanced diet to prevent skeletal deformities is important in all life stages. Large breed dogs are especially sensitive to nutritional excesses and deficiencies.
- Help prevent osteoarthritis by keeping dogs and cats in ideal body condition throughout their lives.
- Current evidence is limited for the use of specific nutrients important for maintaining healthy joints, such as glucosamine, chondroitin, EPA+DHA, and antioxidants.
- Normal activity is needed to maintain healthy joints, whereas excessive exercise can be detrimental.

Healthy cartilage and bone development is important, as disturbances can affect the joints later in life. This requires feeding a complete and balanced diet, especially during the rapid growth phase. Maintaining healthy joints requires feeding a complete and balanced diet in amounts to maintain a healthy body weight and an ideal body condition score, as overweight conditions are related to osteoarthritis (OA). Some nutrients have proven to be effective in maintaining a healthy cartilage layer, whereas other nutrients are associated with reduced inflammation, which potentially slows down the breakdown of cartilage. Exercise stimulates the exchange between nutrients and cartilage and is essential for maintaining healthy joints, whereas excessive exercise can be detrimental. All these aspects will be discussed in more detail.

COMPLETE AND BALANCED NUTRITION

The nutritional approach to healthy joints starts during growth. Puppies and kittens need complete and balanced diets to ensure proper skeletal development. Imbalances in calcium, phosphorus, and/or vitamin D will result in skeletal deformities in all life stages, and large breed dogs are most sensitive to these imbalances.

All-meat syndrome can be seen in dogs and cats fed (homemade) diets based on meat only. These diets usually lack sufficient amounts of calcium and vitamin D and have an inverse calcium-to-phosphorus ratio. This results in the demineralization of bones due to secondary nutritional hyperparathyroidism. The thin bones can fracture spontaneously (pathologic fracture) and cause permanent skeletal deformities.

Studies demonstrated the need for more strict requirements for calcium in large breed dogs. Great Dane puppies developed skeletal deformities and pathologic fractures when fed a diet deficient in calcium (550 mg of calcium per 100 g dry matter or 138 mg per 100 kcal). And, when fed a diet with excess calcium (3300 mg of calcium per 100 g dry matter or 825 mg per 100 kcal), puppies developed osteochondrosis (disturbed development of cartilage and bone), radius curvus (bent legs), enostosis (growing pains), and wobbler syndrome (malformation of vertebrae).[1] In contrast, miniature Poodle puppies developed pathological fractures when fed a diet deficient in calcium (50 mg of calcium per 100 g dry matter or 12.5 mg per 100 kcal), whereas no effects were seen at 3300 mg of calcium per 100 g dry matter (825 mg per 100 kcal).[2] In growing cats, the calcium requirements are also higher compared with adult maintenance, although a maximum level has not been determined.

Overnutrition has been demonstrated to be a risk factor for enostosis in dogs, and this was attributed to an increased growth rate due to excessive intake of protein and/or fat.[3] Switching from a puppy diet to an adult maintenance diet was therefore recommended in the past. However, more recent studies demonstrated that

Figure 1. Bent legs in a cat that was fed a diet with nutritional imbalances



neither protein[4] nor fat[5] influenced the development of enostosis. Overnutrition by consumption of too much energy in addition to excess calcium and/or phosphorus is the most likely explanation for the development of enostosis as this prevents bone resorption from occurring. This results in the narrowing of the nutritional channels within the bone, causing congestion both intramedullary (causing the milky appearance that is visible on radiographs) and under the periosteum (bone membrane), which can cause pain during movement and on palpation. Switching to an adult maintenance diet in cases of enostosis in puppies is thus not a good idea, and feeding an adult maintenance diet to a puppy can even be harmful because of different levels of calcium and phosphorus levels in adult maintenance diets compared to puppy diets.[6] Moreover, adult diets might not meet the growth requirements of other nutrients and could result in problems later on in different organ systems.

Excessive vitamin A intake from (exclusively) raw liver consumption results in hyperostosis in cats. The tolerance for vitamin A regarding skeletal deformities is quite high. However, a suggestion has been made that the current requirements should be revisited as despite no skeletal deformities being shown, hepatic changes did occur in cats that were being fed food with vitamin A levels that are below the current safe upper limit.[7]

In general, imbalances in calcium, phosphorus, vitamin A, and/or vitamin D can result in orthopedic diseases and impair proper cartilage and bone development (**Figure 1**). Clinical signs of deficiencies and excessive intake of these nutrients are very similar. Therefore, it is important to feed every dog and cat a diet that is complete and balanced for the appropriate life stage. As overconsumption of energy is also implicated in these diseases, it is important to promote a controlled rate of growth during the puppy and kittenhood periods.

MAINTAIN HEALTHY BODY WEIGHT

To maintain healthy joints, it is important to keep dogs and cats in ideal body condition throughout growth and in adulthood. An increased risk for overweight dogs and cats to develop OA has been demonstrated.[8,9] Overweight conditions negatively affect bone and cartilage by increased pressure due to weight bearing, but also due to inflammatory cytokines that promote the production of cartilage degrading enzymes (matrix metalloproteinases [MMPs]).[10,11] Leptin seems to play an important role.[12] The pro-inflammatory signaling by leptin may be even more important in OA development compared to the bearing of excessive weight. Keeping dogs and cats in ideal body condition throughout growth and in adulthood will prevent overloading of the joints and prevent increases in inflammatory markers, thereby contributing to maintaining healthy joints.

NUTRIENTS FOR HEALTHY JOINTS

Overall, well-pet diets need to be complete and balanced and should be fed in the proper amounts to stimulate healthy growth and prevent overweight and obesity. Nutrients that may support joint health can be included in a diet or added as a supplement. The exact nutrient blend that can support healthy joints and the recommended amounts of these nutrients for healthy pets are unclear. Studies have been done in other species or with dogs and cats with OA.

Several nutrients play a role in cartilage development and maintenance (**Table 1**). Glucosamine and chondroitin are building blocks of glycosaminoglycans that form the cartilage matrix. Although they can be synthesized from precursors, and therefore are not regarded as essential, addition can still have beneficial effects. Observations in humans suggest that oral administration of glucosamine (2 grams per day for 16

Table 1. Nutrients that may support healthy joints

Nutrient	Reference(s)
Glucosamine	13
Chondroitin	13
Collagen hydrolysate	15
EPA+DHA	18
Green-lipped mussel	20, 21

weeks) exerts a chondroprotective action on healthy subjects (soccer players) without joint disorders. This effect was achieved by improving cartilage metabolism (suppressing type II collagen degradation while maintaining type II collagen synthesis), without causing apparent adverse effects.[13] Other effects of glucosamine and chondroitin in human medicine have been reported such as maintaining the current state of articular cartilage by helping to maintain its sponge-like qualities, and stimulation of collagen synthesis not only in cartilage but also in ligaments and tendons.[14] Furthermore, potential inhibition of chemical biomarkers that cause the breakdown of cartilage has been reported.[14] Despite the fact that these studies have been performed in people and are lacking in dogs and cats, it can be extrapolated that glucosamine and chondroitin have similar effects in other species. Studies demonstrated that glucosamine and chondroitin alone did not significantly improve signs of OA in dogs and cats.[15,16] This does not necessarily mean that glucosamine and chondroitin cannot help maintaining healthy joints in dogs and cats. Human studies are also inconclusive for the effect of glucosamine and chondroitin in OA management, but in healthy subjects, glucosamine and chondroitin showed promising results for maintaining healthy joints.[13,14]

Cartilage structure is provided by collagen which keeps the matrix of glycosaminoglycans in place. Supplementation of collagen hydrolysates might therefore be effective as building blocks for cartilage, or by acting as an alternative substrate for cartilage-degrading enzymes. A study demonstrated that serum levels of cartilage-degrading enzyme MMP-3 decreased in dogs with OA during collagen hydrolysate treatment, whereas concentrations of cartilage-degrading enzyme inhibitor tissue inhibitor of metalloproteinase-1 and collagen synthesis marker procollagen type II increased.[17] Whether collagen hydrolysate also has preventative effects in slowing down the breakdown of cartilage and stimulating collagen synthesis in healthy dogs and cats, and therefore supports the maintenance of healthy joints, still needs to be determined.

The inflammatory component in OA plays a key role in cartilage degradation by stimulating the production of MMPs. Long-chain polyunsaturated omega-3 fatty acids eicosapentaenoic acid and docosahexaenoic acid (EPA and DHA) have anti-inflammatory effects and have proven to be effective in dogs and cats with OA.[18] As the benefit of EPA and DHA is aimed at inflammation, most effects can be seen when there is an active ongoing inflammatory process. It remains to be determined if EPA and DHA can be considered important nutrients in the maintenance of healthy joints, as currently, evidence based on long-term clinical trials in healthy dogs and cats is lacking.

The green-lipped mussel has been proposed to support healthy joints in people, as the coastal Maori population had fewer osteoarthritic lesions compared with others.[19] Although marketed as a different supplement, it is a combination of omega-3 fatty acids (including EPA+DHA), glucosamine, and chondroitin.[19] A study in working dogs demonstrated increased activity and better performance when fed a supplement with green-lipped mussel concentrate daily.[20] In cats, only one study combining green-lipped mussel with antioxidants and phytochemicals has been reported, with positive results in cats with OA.[21]

Other important anti-inflammatory nutrients are antioxidants; however, studies investigating their effectiveness for the maintenance of healthy joints in dogs or cats with OA are inconclusive.[18]

ACTIVITY FOR HEALTHY JOINTS

Maintenance of cartilage is stimulated by regular exercise. By putting pressure on cartilage, turnover of cartilage matrix components is stimulated, the cartilage matrix and the synovial fluid interact to remove waste products, and there is diffusion of nutrients as building blocks into the cartilage due to hydrostatic pressure.[14] Cats regulate their exercise by themselves but should be stimulated to move, for example by offering feeding puzzles and play. In dogs,

COMMUNICATION TIP

Overnutrition by consumption of too much energy, in addition to excess calcium, phosphorus and/or vitamin D, is the most likely explanation for nutrition-related orthopedic disease in dogs and cats.

low- to moderate-intensity, longer-duration walks are preferred to maintain healthy joints versus shorter, more intense activities. The goal is to gradually increase the intensity and duration of the exercise if needed. There is no evidence-based recommendation for the number of walks and duration of walks for puppies.[22] In animals with a poor muscle condition score, or when weight loss is intended, walking activity can be combined with strength training exercises performed at aerobic capacity. This strategy helps to minimize the risk of musculoskeletal injury and contributes to the preservation of lean body mass. Examples of activities that meet these criteria include sit-to-stand exercises, balance work, targeted core strengthening exercises, controlled walking exercises, and hydrotherapy.[23] Strenuous exercise, without sufficient training, can be detrimental. Attention should also be paid to proper housing conditions like avoiding slippery floors.

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NUTRITIONAL APPROACH TO PROMOTING A HEALTHY SKIN AND COAT

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KEY TAKEAWAYS

- Skin and coat health depends on a complete and balanced diet. Feeding a diet that contains all the necessary nutrients, vitamins, minerals, and fatty acids will promote healthy skin and coat.
- The skin and coat are indicators of overall health, and owners who feed a diet that is not complete and balanced may notice a change in their pet's skin and coat quality.
- Supplements can improve some deficient diets, provide nutritional support for specific conditions, or support dermatological health; however, product quality and efficacy can vary and should be evaluated critically.

Healthy skin and a beautiful coat! You can probably see those words on every supplement or bag of dog and cat food products. Pet owners commonly seek products that benefit their pets' longevity and health. Today's commercial landscape is more complicated because products can be marketed indirectly to pet owners through social media and influencers who can make unproven claims of health benefits, ranging from curing allergies or solving gastrointestinal issues to improving the skin and coat.

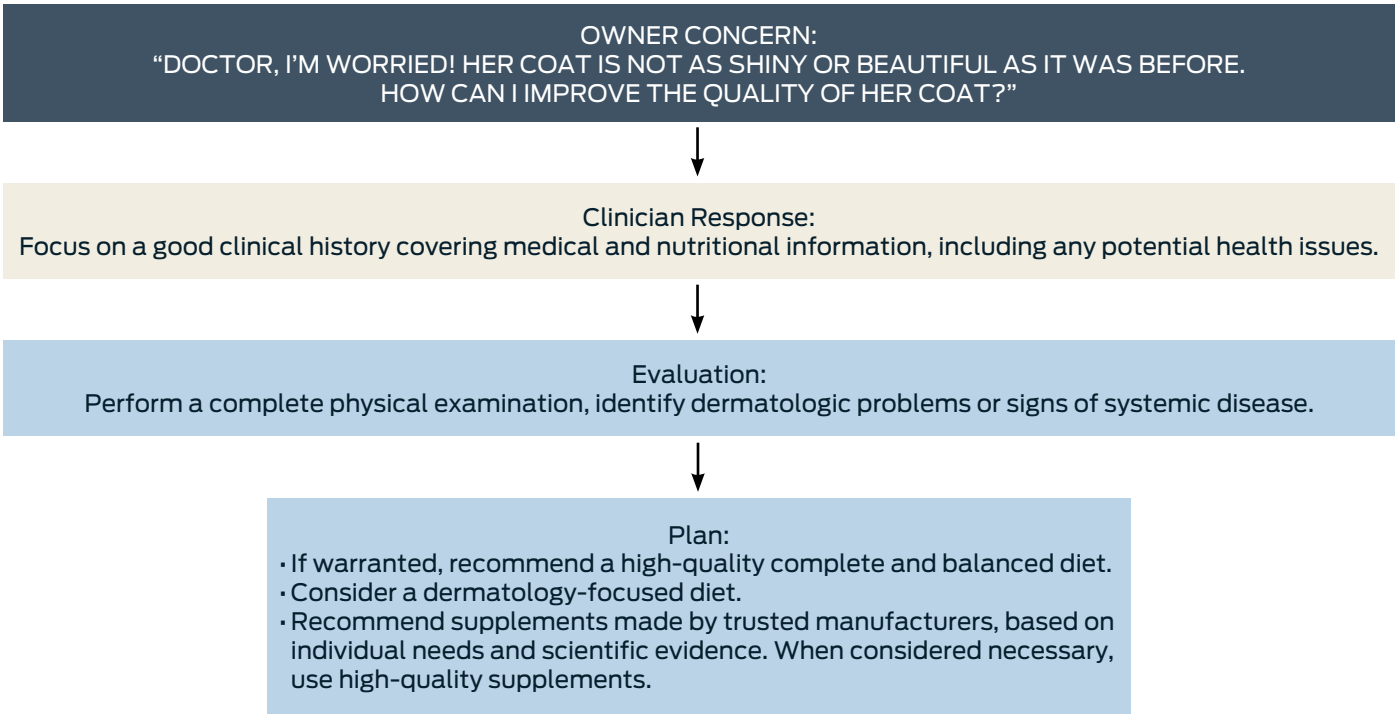
Commonly, owners seek veterinary care to address perceived or real skin and coat changes (**Figure 1**). However, these visits might be dismissed by the medical team as trivial or merely cosmetic, but clinicians should not disregard skin changes as a cosmetic nuisance. In clinical practice, veterinary work addresses owners' concerns, and the state of the skin and coat can be part of it, even if it is considered less important medically. Nutrition is essential to general health; the skin and coat reflect an animal's health status.[1] In dermatology, we routinely detect systemic diseases based on changes in the skin. Some dietary interventions can help treat and correct dermatological problems,[2] which will be addressed in this chapter.

A complete clinical history is key in every consult and should include a nutrition and feeding history. In some cases, the type of diet that the patient is being fed will immediately cause concern and require further investigation. Engaging in nutritional conversations is necessary to provide a complete medical assessment of a patient.[3] Discussing feeding and nutrition can be challenging and time-consuming, requiring a base of nutritional knowledge and training from the medical team. When suspicion around diets as a cause of disease or clinical signs exists, it is critical to learn more about feeding practices, the number of treats, human foods, and other food sources, even when a complete and balanced diet is used. Recently, the author has faced situations where patients are being fed diets far from ideal, where the animal's health is endangered by strange feeding practices, such as single-ingredient diets (only one animal protein). If a diet like this is fed long enough, nutritional deficiencies will arise, and skin and hair coat changes will manifest.[4]

Feeding practices have changed with owners' perceptions of a good diet and where they get their information. In the recent past, the internet was the most frequent source. However, now social media, influencers, and artificial intelligence are gaining traction as a way to receive medical and nutritional recommendations.[5]

Nutritional deficiencies are rare when pets are fed complete and balanced diets formulated to meet established nutrient standards.[6] These diets can be home-cooked or commercial. However, deficiencies may occur with reduced intake, poor formulation or storage, impaired nutrient utilization from disease or genetics, or dietary interactions caused by formulation errors, extended storage, or excessive supplementation.

Figure 1. Evaluating and making recommendations for dogs and cats with skin issues



Recently, because of new feeding trends and fads, clinicians have seen more cases with clinical manifestations of nutritional deficiencies.[7] Interestingly, the pet supplement business has grown considerably. The global pet supplements market was valued at USD 2.47 billion in 2024. Supplements are widely available and are distributed through online and offline sources. Many pet owners will purchase supplements sold directly to them to improve their pet's general health. Still, the real benefit of using supplements for skin and coat is unknown for many dogs and cats. The use of the aforementioned products is often unnecessary, used incorrectly, and on occasion, can potentially be harmful or toxic (e.g., vitamin A, D, calcium).[3] Some dermatological conditions warrant supplementation of specific nutrients, and appropriate use of these products can be beneficial. Generally, providing a high-quality, complete, and balanced diet will suffice for most pets. Using a qualified veterinary nutritionist or a board certified veterinary nutritionist will help avoid deficiencies for animals being fed home-cooked diets, and any necessary supplements will be recommended.[8]

SKIN-FOCUSED COMMERCIAL DIETS

Several commercial diets are formulated to support the skin of dogs and cats; it is essential to familiarize oneself with the characteristics of such diets to recommend them properly. The nutritional profile should be adequate for the specific patient's needs. The properties of skin-focused diets include increased omega-3 fatty acids (EPA/DHA), often derived from marine oils, which can modulate inflammation.[9] Total omega-3 content alone may be misleading due to varying bioactivity and poor conversion of alpha-linolenic acid to EPA and DHA.[10] Nutrients enhancing barrier function include vitamins A and B and zinc, which contribute to keratinocyte differentiation, skin repair, and reduced trans-epidermal water loss (TEWL). Skin-focused diets also support an immune response by optimizing overall nutrient profiles and by providing all essential nutrients.[11]

Skin-focused commercial diets may focus on well pets or helping manage dermatologic disease (veterinary therapeutic diets). All skin-focused diets differ in fatty acid composition and micronutrient levels. Clinical trials using dermatologic diets have shown improved coat quality, reduced pruritus scores, and potential sparing of antipruritic medications for dogs and cats with dermatologic disease.[12] A complete and balanced therapeutic diet may offer superior outcomes compared to supplementing standard diets for cases with dermatologic disease, especially given complex nutrient interactions. Its role should be considered part of a multimodal management plan for dermatologic conditions.[13]

An important advantage of veterinary skin-focused diets is that the need for supplements can be reduced or avoided, simplifying the treatment of a dermatological concern.

ESSENTIAL FATTY ACIDS

Essential fatty acids (EFAs), specifically omega-3 and omega-6 polyunsaturated fatty acids, are indispensable nutrients in canine and feline diets due to the inability of these species to synthesize them de novo.[6,9] Linoleic acid (LA), the primary omega-6 fatty acid, and alpha-linolenic acid (ALA), the main omega-3 precursor, must be provided through the diet. Although dogs can enzymatically convert LA and ALA into longer-chain derivatives such as arachidonic acid (AA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), these conversions are generally inefficient—and more so in cats, who have minimal delta-6 desaturase activity.[6,9]

EFAs play a pivotal role in maintaining skin and coat quality, immune homeostasis, and cellular membrane integrity in healthy pets. LA is particularly essential for the biosynthesis of ceramides in the stratum corneum and is directly responsible for maintaining the integrity of the skin's water barrier. Suboptimal intake may increase TEWL resulting in dry, flaky skin and a dull coat—reversible clinical signs with dietary correction.[9,11]

Studies in healthy dogs have shown that supplementation with LA above maintenance requirements leads to improved coat gloss, reduced scaling, and enhanced skin hydration. In a controlled study, Watson et al. (2018) demonstrated that dogs fed a high-LA diet exhibited significantly lower TEWL, reflecting improved epidermal barrier function.[11] Similarly, Marsh et al. (2000) found that LA supplementation, particularly when combined with zinc, resulted in significantly glossier coats and less dandruff compared to control groups.[12]

Although clinical EFA deficiency is rare, it may occur in pets consuming unbalanced or poor-quality diets. Deficiency typically develops over several weeks to months, and clinical signs include dull coat, hyperkeratosis, seborrhea, alopecia, and sometimes secondary infections and pruritus.[3] Diagnosis is based on clinical signs, and resolution is usually achieved by correcting the diet and ensuring appropriate EFA intake.

COMMUNICATION TIP

Pet owners who visit a veterinary clinic for a wellness check or vaccination will often inquire about interventions to improve their pet's coat quality and beauty. This can be an excellent opportunity for the veterinary team to discuss nutrition, feeding practices, supplement use, and skin and coat care, such as topical products used for bathing.

While most scientific evidence on EFAs focuses on therapeutic uses in atopic dermatitis, recent studies suggest that supplementation in healthy animals may support skin homeostasis, reduce seasonal coat dullness, and improve general skin condition. These benefits may enhance perceived wellness and coat aesthetics, often important to pet owners.[11] When recommending EFA supplementation in healthy pets, clinicians should select veterinary products that include validated LA, EPA, and DHA levels, with documented bioavailability, stability, and palatability.[14]

PROTEIN

Hair is considered a metabolic luxury; nutritional requirements must be fully met for the hair coat's optimal condition. Hair is composed of 95% protein; normal hair growth and keratinization of the skin will require around 25 to 30% of the animal's daily protein intake.[1,15] Amino acids provide essential components for keratinization, pigmentation, and hair growth substrates.[3]

For a long time, pet owners and pet food companies have focused on the protein content of commercial diets, which is commonly promoted and advertised. While claims of high-protein formulas are still prominent in commercial advertisements and perceived by the consumer as an important decision-making point, all complete and balanced commercial pet food diets contain sufficient protein, and deficiencies are rare. They are more common in undernourished animals fed an inadequate amount of food or an unbalanced diet.

Figure 2. 3-year-old male Siberian Husky with zinc-responsive dermatosis



Protein deficiency can result in dermatological changes, including hyperkeratosis, epidermal hyperpigmentation, scaling, alopecia, dull hair coat, and increased hair fragility. Histological findings include disruption of the keratin layer and vacuolated collagen.[1] Hair follicle cycling is affected, with a shift toward the telogen phase and reduced anagen activity. Subclinical deficiency may impair hair fiber synthesis, decreasing diameter, length, and tensile strength.

Phenylalanine and tyrosine are precursors to melanin, and relative deficiencies may induce reddening of black coats.[3] Methionine and cysteine, the primary sulfur-containing amino acids, are incorporated into hair in large amounts[3] and may be the "limiting" amino acids (i.e., those that limit protein synthesis) in some pet diets. Deficiency of these amino acids may reduce hair growth and increase hair fragility.

As mentioned, most commercial diets formulated for healthy pets contain sufficient protein and essential amino acids to promote skin and coat health. These diets should meet nutritional requirements for the appropriate life stage, and no additional supplementation should be necessary.

ZINC

Zinc is a vital nutrient that supports many essential functions in the body. It acts as a cofactor for hundreds of enzymes involved in DNA and RNA synthesis, fatty acid metabolism, and maintaining healthy skin and immune function. Because of this, zinc is essential in tissues with high cell turnover. In dogs, about 20% of the body's zinc is found in the skin, particularly in heavily keratinized areas like the nose, paw pads, and tongue.[16]

Zinc supplementation above baseline requirements in healthy dogs may enhance skin and coat quality. In a controlled trial, Marsh et al. (2000) demonstrated that dogs receiving additional dietary zinc showed significant improvements in coat gloss and reduced scaling. Combined with linoleic acid, zinc supplementation also improved epidermal hydration and barrier function.[12]

In clinical practice, selecting diets or supplements with bioavailable forms of zinc, such as zinc methionine or proteinate, can support skin integrity, particularly in growing dogs, northern breeds, or those with marginal dietary intake.[17] Zinc-responsive dermatosis is a condition that occurs in dogs and responds to zinc supplementation (**Figure 2**).[18]

VITAMIN A

Vitamin A, primarily as retinol and its active metabolite retinoic acid, is essential for maintaining healthy skin, adnexal structures, and mucosal immunity in companion animals. It regulates epidermal differentiation, keratinization, sebaceous gland function, and follicular turnover, critical to skin barrier integrity and coat quality. In healthy dogs and cats, sufficient dietary intake of vitamin A supports normal epithelial structure, efficient turnover of keratinocytes, and the visual and immune systems.[7]

Dogs can utilize both preformed vitamin A (retinyl esters) and provitamin A carotenoids, while cats require preformed vitamin A from animal-derived or synthetic sources.[3,6] Absorption of vitamin A is lipid-dependent and may be compromised in patients with fat malabsorption (e.g., EPI, chronic enteropathy, bile acid insufficiency). Stabilized forms like retinyl acetate or palmitate are preferred in commercial diets due to their oxidative stability and consistent bioavailability.

Deficiency, while rare in pets consuming complete commercial diets, may present as dry, scaly skin, dull or brittle hair coat, follicular hyperkeratosis, impaired wound healing, conjunctival keratinization, and increased susceptibility to skin infections.[19] In growing animals, it may also delay growth and epithelial maturation.[6]

Oversupplementation, however, presents greater clinical concern. Chronic vitamin A toxicity in dogs has been associated with dermatologic signs (seborrhea, alopecia), musculoskeletal changes (hyperostosis, joint pain, reduced mobility).[3,6] In cats, particularly those consuming liver-rich homemade diets, hypervitaminosis A may result in cervical spondylosis, exostoses, and reduced mobility due to vertebral fusion.[20] Toxicity is dose- and duration-dependent and should be considered in patients receiving unregulated supplements or non-standardized homemade diets.

Short-term supplementation for patients with increased skin turnover (e.g., post-parasiticide dermatoses or seasonal shedding) may be considered at 100–200 IU/kg body weight/day, provided dietary intake is factored in and duration is limited to avoid toxicity.[7]

VITAMIN E

Vitamin E, mainly in the form of α-tocopherol, is a crucial fat-soluble antioxidant that protects cell membranes, especially those rich in polyunsaturated fats, from oxidative damage. Its role is vital in the skin, immune system, and fat-rich tissues.

Dogs and cats need more vitamin E when their diet is high in PUFAs, as these fats are more prone to oxidation. Vitamin E also works alongside antioxidants like selenium and vitamin C.

Since vitamin E is absorbed with dietary fat, anything that interferes with fat digestion (like pancreatic or intestinal disease) can reduce absorption. Processing and storage can also degrade vitamin E in pet foods, so more stable forms like tocopherol acetate are often used. A minimum of 0.6 mg of vitamin E per gram of PUFA in the diet is generally recommended to ensure proper antioxidant support.[20,21]

CONCLUSION

Pet owners who visit a veterinary clinic for a wellness check or vaccination will often inquire about interventions to improve their pet's coat quality and beauty. This can be an excellent opportunity for the veterinary team to discuss nutrition, feeding practices, supplement use, and skin and coat care, such as topical products used for bathing.

Preparing and training the veterinary team to have positive and fruitful interactions with owners of healthy pets looking to improve their health and longevity will create a space to provide high-yield preventative medicine interventions that the pet owner will value.

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NUTRITIONAL APPROACH TO URINARY HEALTH IN CATS

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KEY TAKEAWAYS

- Although optimizing hydration and water intake may be a key strategy for managing cats with renal disease, there is no evidence that the moisture content of the diet is a risk factor for development of chronic kidney disease.
- Control of phosphate intake is not only important in managing chronic kidney disease, but may also have a role in preventing renal damage.
- Optimizing body weight (preventing obesity) and feeding diets with carefully controlled mineral balance and acid-base balance are important strategies in helping maintain lower urinary tract health.

The urinary tract includes the two kidneys, the ureters, the bladder, and the urethra. Together, these structures play a vital role in many processes including:

- Excreting and eliminating metabolic body waste
- Regulating hydration and water turnover
- Regulating concentrations of many electrolytes and acid-base balance
- Regulating blood pressure
- Regulating erythropoiesis
- Vitamin D activation
- Storage and voiding of urine

The two most common disease syndromes affecting the urinary tract in cats are chronic kidney disease (CKD), which is reported to be the most common cause of death in cats over five years of age and may affect up to 40% or more of cats over 10 years of age;[1,2] and feline lower urinary tract disease (FLUTD), which typically accounts for 2–5% of cats presented in primary care practice.[3-6]

NUTRITIONAL SUPPORT OF RENAL HEALTH

CKD is a disease syndrome with many potential underlying causes, although in the majority of cats the initiating cause remains uncertain. Several studies have evaluated risk factors for the development of CKD in cats, although it is recognized that such studies can be difficult to conduct and interpret as initiating events may occur long before a clinical diagnosis of CKD is made, and associations between disease and risk factors do not necessarily imply causality. However, from epidemiological, clinical observational, and experimental studies, a number of important conclusions arise from current evidence about feeding cats for renal health.

Feeding of dry or wet commercial cat food

To date, no study has found the feeding of dry cat food (which may be associated with a lower overall water intake: see Strategies to Support Healthy Hydration in Cats) increased the risk of cats developing CKD.[7-10] In cats with existing CKD, feeding a high moisture (wet) diet may help reduce the risk of dehydration, and there may be some rationale to feeding wet diets to healthy older cats (who may have subclinical CKD and impaired urine concentrating ability). However, from existing studies there is no evidence of a link between cats being fed dry cat food and them developing CKD. One study did find evidence that both dehydration and anesthesia in the preceding 12 months were associated with an increased risk of diagnosing CKD.[8] Although cause and effect could not be established, this does emphasize that it is prudent to pay attention to hydration status of older cats.

Protein content of the diet

The AAFCO[11] and FEDIAF[12] recommended minimum dietary protein allowances are shown in **Table 1.**

One epidemiological study found that a history of feeding higher dietary protein concentrations was associated with a lower risk of CKD development in cats.[9] Although higher dietary protein intake may be associated with increased serum urea concentrations,

Table 1. AAFCO[11] and FEDIAF[12] recommended minimum and maximum allowances for selected nutrients for adult cat maintenance (expressed as units per 1000 kcal ME)

Dietary component	AAFCO minimum	FEDIAF minimum (for MER of 100 kcal/ $kg^{0.67}$)	FEDIAF minimum (for MER of 75 kcal/ $kg^{0.67}$)	AAFCO maximum	FEDIAF maximum
Protein	65 g	62.5 g	83.3 g		
Phosphorus	1.25 g	0.64 g	0.85 g		
Calcium	1.5 g	1.00 g	1.33 g		
Ca:P ratio		1:1			2:1
Vitamin D	70 IU	62.5 IU	83.3 IU	7520 IU	7500 IU
Potassium	1.5 g	1.5 g	2.0 g		
Sodium	0.5 g	0.19 g	0.25 g		
Magnesium	0.1 g	0.1 g	0.13 g		

there is no evidence of any detrimental effect on kidney function in healthy cats.[13-16] Rather, studies suggest that with inadequate protein intake, nitrogen balance may be maintained in cats at the expense of a loss of lean body mass,[17,18] and that the absolute protein requirement may increase with age.[18] Further studies are needed to determine optimum protein levels required to prevent loss of lean body mass in both health and disease.[17]

Phosphorus content of the diet

While it has been well established that dietary phosphorus intake is linked with progression of CKD in cats,[19,20] recent studies also suggest that high dietary phosphorus intake might be an initiating cause of renal damage especially where the Ca:P ratio is <1.0.[19-22] Importantly, the bioavailability of phosphorus varies greatly depending on its source in the diet.[19,20] There is a need for further research to determine maximum safe dietary levels, as concentrations vary widely in different diets.

Calcium and vitamin D content of the diet

Maximum upper limits for vitamin D are important for renal health as there have been numerous reports of hypervitaminosis D occurring in cats fed diets or supplements containing excessive levels of vitamin D, leading to hypercalcemia and consequent adverse effects including CKD.[23-27]

Potassium and acid-base balance of the diet

Cats with CKD may suffer excessive urinary potassium loss that may exacerbate their renal disease.[28,29] Further, there is evidence that acidifying diets with low potassium content (potentially combined with high protein concentrations) can actually induce renal damage and CKD over time.[29-32]

Salt content of the diet

Moderately increased sodium levels (e.g., 3.0–3.5 g/1000 kcal ME) are sometimes used to increase water intake and urine dilution in cats fed dry foods (e.g., for management of urolithiasis). Although questions have been raised in the past about the potential safety of this with respect to renal health in cats, many studies on both healthy and aged cats (including long-term studies of up to five years) have shown no adverse effects on blood pressure or renal function from such diets.[33-36] Care may be required to avoid excessive sodium intake in cats with existing CKD.[37,38]

Other nutrition-related factors

Recent evidence suggests that magnesium supplementation and avoiding hypomagnesemia may be important in managing cats with CKD.[39] While no information is available about the effect of magnesium

COMMUNICATION TIP

Feeding high quality complete and balanced commercial diets that are carefully formulated may play a role in helping maintain lower urinary tract health.

on renal function in healthy cats, maintaining normal magnesium intake appears prudent.

Interestingly, one small epidemiological study suggested increased dietary magnesium concentrations may be associated with a lower risk of CKD,[9] and that study also identified lower risks with ad libitum feeding, increased dietary fiber, increased protein, and increased salt content. However, further studies are required to explore these observations and to identify any potential causal relationships.

Summary – nutrition and renal health

There is currently limited data on optimizing nutrition to prevent renal disease in cats, and there is no evidence that the protein or moisture content of the diet are important for prevention. More research is needed on the potential role of phosphorus in the diet in its various forms, but maintenance diets should be chosen that are of high quality, are complete and balanced, and contain levels of phosphorus, calcium, and vitamin D that are not excessive. Diets should also be replete in potassium. Information on helping clients select a diet can be found elsewhere in this book.

NUTRITION AND LOWER URINARY TRACT HEALTH

Feline lower urinary tract disease has many potential underlying causes, but the most commonly diagnosed conditions are feline idiopathic cystitis (FIC), urolithiasis (predominantly struvite or calcium oxalate), urethral obstruction, and bacterial cystitis.[6] Epidemiological studies have identified a number of nutritional or nutrition-related factors that may be associated with an increased risk of FLUTD, and these are summarized below.

Feeding dry food and/or a lower water intake

Some studies of FLUTD in general,[40-43] of cats with urolithiasis,[43-46] and of cats with FIC[43,47] have identified feeding predominantly dry cat food and/or a low water intake as being risk factors associated with disease.

There are good reasons to suspect that lower water intake, higher urine concentration, and reduced frequency of urination may be factors involved with the development of urolithiasis (and possibly FIC).[3,43,45,46] While increasing water turnover and reducing urine concentration may be important in managing these cats, the diseases are complex with many other significant contributing factors,[3,43-46] and low water turnover is likely to be a factor in a cat already predisposed to developing disease for other reasons, rather than being a primary cause of the disease. In general, for healthy cats it is considered that feeding either high quality dry or wet foods is adequate to maintain health, with both having potential advantages.[48-50] Long-term feeding of higher moisture diets or using other means to increase water turnover has not been explored as a method of preventing FLUTD, and is probably unnecessary given the vast majority of cats fed on either type of diet will never develop FLUTD. Nevertheless, it is important to ensure all cats have adequate water turnover and that under- or hypo-hydration is avoided.

Obesity and overweight

Obesity has been identified as a risk factor associated with both urolithiasis and FIC,[3,42,44,45,47,51,52] which may increase disease risks because of the association with excessive nutrient intake (including calculogenic materials), lethargy, and potentially reduced urination frequency. Given the other known health risks associated with obesity,[53,54] maintaining an optimal body weight is important, and may help reduce the risk of FLUTD developing.

Dietary mineral content and urine pH

At least 90% of all cases of feline urolithiasis are due to struvite or calcium oxalate stones,[45,55,56] and it is well recognized that diet, as it affects supersaturation of the urine with calculogenic materials and urine pH, plays an important role as a modifiable risk factor.

Carefully formulated therapeutic diets can be designed that will dissolve struvite and help prevent recurrence of struvite and calcium oxalate uroliths.[45,55-57] High

Table 2. Suggested considerations for environmental enrichment in cats and mitigation of environmental stress[60,62]

Five pillars of creating a healthy environment
1. Providing a safe place · Provide suitable hiding places · Provide climbing areas, perches, and shelves · Consider allowing some outdoor access (controlled or free-access) · In multicat households ensure all cats have access to safe places · Try to identify and resolve conflict between cats in multicat households
2. Providing key resources · Key resources include feeding, drinking, toileting, scratching posts, play, and resting/sleeping areas · Resources should be available in multiple separate locations · Consider possibility of locating resources outdoors · Ensure toileting areas are physically separated from other areas · Ensure all cats in a multicat household have adequate access to resources · Ensure sufficient resources are available so all cats have a choice of which to use
3. Providing opportunity for play and predatory behavior · Cats should be able to engage in pseudo-predatory behavior and feeding behavior · Provide toys and opportunities for human-cat play engagement · Rod or wand toys are helpful to allow the cat to engage in chasing/catching behaviors · Feather/fur toys can be pounced on, and large soft toys can be bitten/raked · Use feeding puzzles or practices that require the cat to engage in finding/retrieving food · Food (especially dry food) can be hidden in different locations to encourage hunting
4. Providing positive human-cat interactions · Let the cat initiate interactions and try to interact at the cat's level · Gentle stroking and talking are good ways to help initiate contact · Ensure individual cats' preferences for interaction are respected · Consider the use of audio-visual stimulation when the owner is away from the house
5. Providing an environment suitable for a cat's sense of olfaction · Cats are heavily reliant on olfaction and chemical signaling · Try to avoid using products (including cleaning agents) that will overwhelm or mask smells the cat relies on · Keep the litter box(es) clean, use clumping litter, but avoid the use of scented cat litter · Use synthetic pheromones in the environment where helpful · Use scratching posts (which allow the cat to deposit scent from its feet) · Avoid cleaning areas that have been facially marked by the cat · Never punish a cat for scent marking (e.g., urinating or defecating outside the litter box)

quality commercial adult maintenance diets designed for healthy cats or well-pet urinary diets may also play a role in prevention of urolithiasis by producing urine that is moderately acidic with low levels of supersaturation for struvite and calcium oxalate through careful formulation that avoids excessive calcium, phosphorus, or vitamin D, ensuring a correct calcium to phosphorus ratio, and avoiding excessive magnesium among other factors.[45,55,56]

Summary – nutrition and lower urinary health

Feeding of high quality complete and balanced commercial diets that are carefully formulated, especially in relation to mineral content and the resultant urinary pH, may play a role in helping to maintain lower urinary tract health. Keeping cats at optimum body weight should also be prioritized to maintain health.

ENVIRONMENTAL ENRICHMENT AND STRESS REDUCTION

Stress may be a feature of both renal disease[58] and different forms of FLUTD.[3,56,59] Although differentiating cause from effect is challenging, there is additional evidence that stress may be involved in the pathogenesis of FIC.[3]

Stress management through environmental enrichment strategies and conflict management between cats in multicat households (see **Table 2**) has become part of the standard approach to management of cats with FIC,[60] and given the potential involvement of stress in other diseases this is an important welfare consideration. While there are no studies evaluating the preventive efficacy of stress management, creating an enriched living environment for cats and helping to mitigate the effects of stress is an important aspect of general preventive healthcare and welfare management.[61]

MONITORING URINARY HEALTH

In most cases, significant diseases affecting the urinary tract will result in altered drinking (increased or decreased intake) and/or altered urination (increase or decrease in volume, increase or decrease in the frequency of urination).

The ability to monitor water intake and urination quantity and patterns over time is therefore highly valuable as a tool to monitor urinary health. This can be partially achieved very simply by physically measuring the amount of water dispensed into a water bowl, and measuring the amount left each day to determine the amount drunk; and by using clumping litter in a litter box so that the number of urinations can be counted (the number of clumps) and an approximation of any volume change based on the size of the clumps can be made. However, newer technology is making monitoring much simpler: Smart (internet-connected) cat feeders and water bowls are available that will provide data on the frequency and amount a cat eats and drinks (and in some cases these can the linked to microchips to allow individual monitoring in multicat households). Additionally, smart litter boxes are becoming available that are able to monitor the frequency and amount of urination and defecation. The use of such approaches with data linked to a smartphone application will help to transform the future potential to monitor the health of pets and detect early signs of urinary tract disease among other conditions.

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STRATEGIES TO SUPPORT HEALTHY HYDRATION IN CATS

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KEY TAKEAWAYS

- Water is a key nutrient for life, and maintaining adequate water intake and hydration is essential for maintaining health.
- While there is no evidence cats are less sensitive to dehydration than other mammals, maintaining adequate hydration may be more challenging in older individuals and in the face of diseases that increase water loss.
- Feeding a diet with a high moisture content (typically >75%) is an excellent way to ensure good water intake, but other methods to enhance voluntary water intake that have evidence to support their use include the use of flavored water, feeding multiple small meals, and offering nutrient-enriched water.

Water is the main constituent of the body and is essential for life. Using different techniques, it has been estimated that in adult cats water comprises 46–71% of total body weight (typically around 60%),[1-11] with increasing adiposity being associated with lower values.[4] Approximately two thirds of total water (~40% body weight) is intracellular, with one third being extracellular (~20% body weight), and the latter comprising approximately ~15% in interstitial fluid and approximately 5% in plasma (see **Figure 1**).[6,12,13]

WATER HOMEOSTASIS

As in other mammals, hydration and water turnover in cats are tightly regulated to maintain normal homeostasis. This means that obligatory water losses (in urine, feces, saliva, and through evaporation from the respiratory tract and skin) must be matched by water intake from that present in ingested food, from voluntary drinking, and from water produced by oxygenation of ingested hydrogen-containing substrates (metabolic water, generally up to around 10% of total water intake).[1,6]

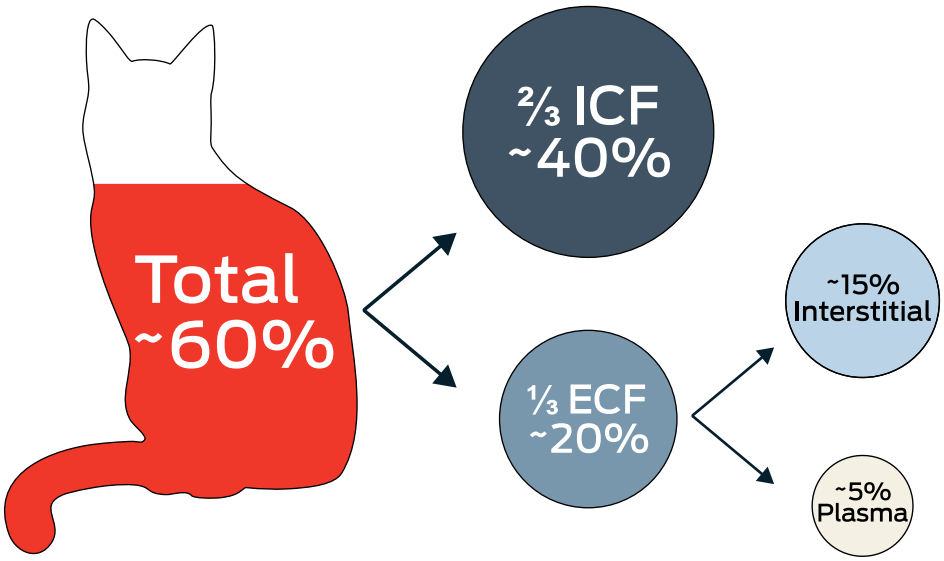
Neurohormonal control of hydration in mammals is complex, and **Figure 2** provides a brief overview. Sodium and potassium cations help maintain an identical osmolality in extra- and intracellular fluids, respectively.[14] An increase in osmolality (from dehydration or salt ingestion) is detected within neurons in the third ventricle of the brain, which signals to the hypothalamus stimulating thirst and arginine vasopressin (AVP) release. Aquaporin 2 (water channel) is expressed in renal collecting duct cells under the influence of AVP, allowing water resorption from glomerular filtrate across the medullary concentration gradient.[14-17] Specialized osmoreceptors in the oropharynx and intestine signal to the brain when water is ingested, and this reduces AVP release and the thirst response before the osmolality is fully corrected, avoiding excessive consumption of water.

Extracellular mechanisms (baroreceptors in the aorta, carotid sinus, and major veins) are stimulated by hypovolemia (from dehydration or blood loss), also resulting in increased thirst and AVP release. Stimulation of baroreceptors in the renal juxtaglomerular apparatus causes release of renin and thus increased angiotensin II concentrations, resulting in vasoconstriction and stimulation of both thirst and aldosterone release (the latter increasing renal sodium resorption). Both intra- and extracellular mechanisms generally work together to maintain hydration and osmolality at its normal physiological set point (around 300 mOsm/L).[14,15,17] Studies have shown the same homeostatic mechanisms exist in cats as in other mammals.[18-24]

ARE CATS INSENSITIVE TO DEHYDRATION?

It has been suggested that cats have a weak thirst drive and are relatively insensitive to dehydration,[25-27] and that this may be an evolutionary adaptation to living in environments where access to water is limited.

Figure 1. Overview of total body water distribution



However, the physiological rationale and evidence supporting this is weak. One study showed that when cats and dogs are dehydrated and deprived of water, cats are slower than dogs to replenish the lost water when allowed to drink again.[28] However, the same study showed that dogs and cats were equally good at maintaining hydration in a hot dry environment with a supply of drinking water. The slower rehydration seen in cats after dehydration might easily be explained by their less efficient lapping of water and fixed rate of lapping compared with dogs,[29,30] rather than anything to do with their "thirst drive."

WATER REQUIREMENTS OF CATS – THE EFFECT OF ENVIRONMENT, DIET, AGE AND DISEASE

Daily water requirements for a healthy adult cat are hard to determine as they are affected by diet, physical activity, environmental factors, and individual variations, as well as age and disease status. In general, it has been suggested the requirements for healthy adult cats are in the range of 40–60 mL/kg/day, 1.5–3 mL/g of food (dry matter), or 0.7–1.0 mL/kcal of food,[25-27] but as noted, this will vary and will also be impacted by the protein and solute (especially sodium) content of the food.[5]

Because cats are able to concentrate their urine to a higher level than dogs or humans,[6,25-27,31,32] their absolute water requirement is lower, and in the absence of extreme environmental conditions, cats are potentially able to derive all their water requirements from the ingestion of a high moisture diet.[8]

Effect of diet

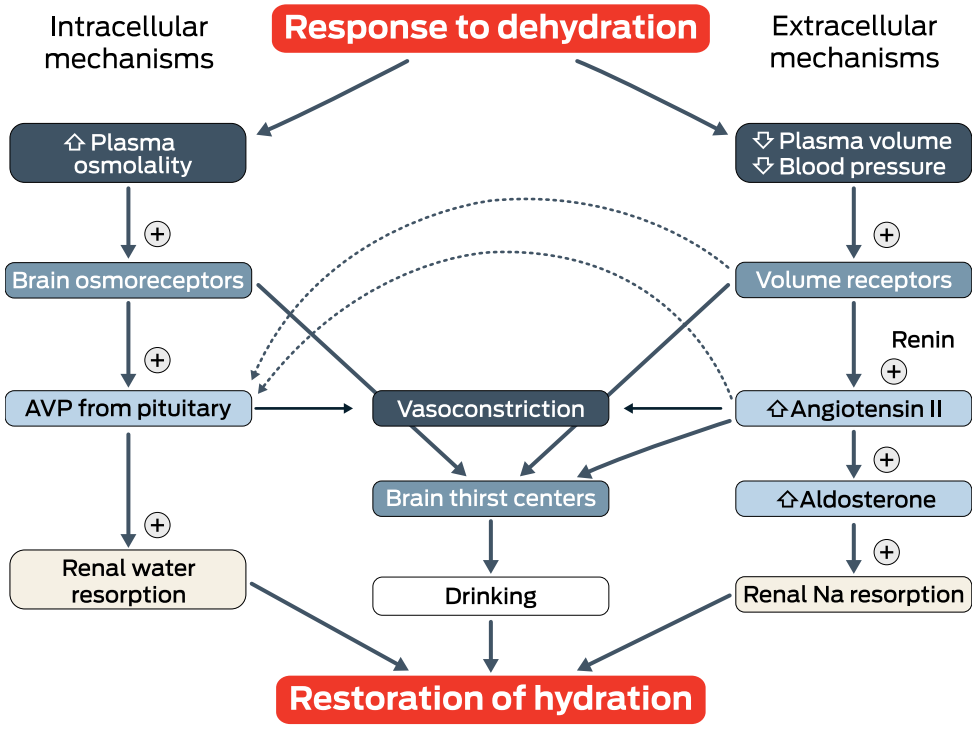
Studies of healthy adult cats fed prepared wet or dry diets show that in general:[5,31,33-36]

- Cats fed on dry foods spontaneously drink more water than cats fed on wet foods.
- Total water intake (through both drinking and water present in the food) is generally higher in cats fed wet foods compared with cats fed dry foods or a mix of dry and wet foods.
- The amount of free water drunk by cats fed dry food increases with increasing protein and salt content.
- For any given diet, total water intake (from drinking and in food) will remain constant across a range of dietary moisture levels until a "tipping point" is reached. At this point, dietary moisture levels meet water requirements, and higher moisture levels will result in higher total water intake and a lower urine specific gravity. This "tipping point" will vary between diets but is generally likely to be around 60-80% moisture content.
- Cats fed foods with lower digestibility have greater fecal water loss.

Effect of age

Older humans have a well-established increased risk of dehydration or sub-optimal hydration (underhydration) for several age-related reasons:[37-40]

Figure 2. Overview of hydration homeostasis, adapted from Thornton, 2010[14]



- A reduction in lean body mass results in a lower total body water.
- A reduced thirst response (attributed to neurohormonal and receptor changes).
- A reduced ability to conserve water (reduced AVP responses, reduced renin secretion, and subclinical kidney disease).

Although less is known about cats, it is well established that older cats have reduced lean body mass[41] and may also have blunted thirst responses;[36] these together with age-related declines in renal function almost certainly mean that older cats are similarly at higher risk of underhydration or dehydration.

CONSEQUENCES OF DEHYDRATION

While optimal levels of water intake and water turnover remain poorly defined in both humans and animals, there is growing data on the potential adverse effects of underhydration, dehydration, and low water turnover. Direct and indirect effects suggested from human studies include headaches and impaired cognition; increased risks of urolithiasis, urinary tract infections, development or progression of chronic kidney disease (CKD); and progression of other diseases like diabetes, obesity, hypertension, and heart disease.[42-45] While the precise role of hydration and water turnover sometimes remains controversial, a growing body of evidence suggests care is needed to avoid dehydration and underhydration, and to also consider increasing water turnover in the prevention or management of at least some diseases.

WHERE ARE HYDRATION AND WATER TURNOVER IMPORTANT IN CATS?

Ensuring cats remain well hydrated is clearly a fundamental requirement for health, but special consideration is warranted in older cats where there may be a higher risk of underhydration or dehydration, and in various disease states. These include any disease associated with increased loss of water including:

- Chronic kidney disease
- Hyperthyroidism
- Diabetes mellitus
- Vomiting and/or diarrhea
- Hypercalcemia
- Diabetes insipidus
- Acute kidney injury
- Increased insensible water loss as a result of pyrexia, skin disease, etc.

Of note, a number of these conditions commonly occur in older cats where CKD may already be present, and based on evidence in humans and rodents, if cats become dehydrated this may be an important risk for CKD progression.[45-47] This emphasizes the importance of maintaining hydration.

Certain other diseases may not necessarily be associated with an increase in water loss but may still benefit from increased water turnover to help in their management. These include:

- Urolithiasis
- Urinary tract infections
- Idiopathic cystitis
- Urethral plugs
- Constipation

It is important that life stage as well as any disease status is considered during assessment of cats, and when determining their water requirements. Routinely reviewing this during clinical appraisal (including wellness visits) is important, as typical clinical signs attributed to dehydration[48] are known to be highly inaccurate,[49] and there are no simple laboratory tests to measure hydration status. While older cats may have reduced urine concentrating ability and blunted thirst responses, there may be a need to consider increased water turnover even in healthy adult cats if, for example, there is a history of recurrent lower urinary tract disease.

EVIDENCE-BASED APPROACH TO OPTIMIZING HYDRATION, WATER TURNOVER AND HEALTH IN CATS

Diet

As already noted, healthy adult cats will be able to maintain normal water balance when consuming foods with a wide range of different moisture contents, adapting the amount of water they drink to meet their needs. Although their absolute water requirement will vary according to the solute load in the diet (protein and electrolyte content, etc.) along with environmental and activity levels, in general, if the moisture content is above 75–80%, the food will usually supply more than the minimum water requirement. This results in an increased total water intake and some degree of urine dilution.[31,33-35,50] Thus feeding a high moisture content and high-quality food (canned food, trays, or pouches with >75% water, or dry food mixed with adequate water) is a helpful and proven way to support water turnover and hydration. It is important, of course, to always ensure a cat has free access to sources of fresh water to ensure they are able to self-regulate their intake.

COMMUNICATION TIP

Hydration may be enhanced by using wet food, providing different sources of water, putting environmental modifications in place, or by giving the cat nutrient-enriched water.

Food palatability and food preferences in cats are complex and influenced by a wide variety of factors including smell, taste, texture, nutritional composition, genetics, early life and social exposures as well as learned experiences.[51-53] While some cats remain innately neophilic with an interest in exploring and eating unfamiliar foods, others may develop strong preferences for familiar foods over time.[51-53]

Given free choice, cats will both eat and drink during the day and night,[50,54,55] and episodes of drinking usually take place in close proximity to episodes of feeding.[50,56] Evidence suggests that a higher frequency of feeding may not only result in an increased frequency of drinking but may also result in a significantly higher overall water intake.[57] Thus feeding multiple meals throughout the day and night may also help to promote increased water intake.

Water preferences

It has been suggested that from an evolutionary and behavioral perspective, cats may have a preference for drinking from fresh running or moving water sources rather than stagnant potentially contaminated water.[58,59] Three controlled studies have been published evaluating the effect of various dynamic (moving) water sources compared with a water bowl, but none of these showed any overall significant effect on water consumption or urine concentration.[58,60,61] While individual preferences may mean some cats drink more from certain moving water sources,[58,61] the results of these studies suggest this is not a strategy that can

be relied on to increase water consumption. For some cats, an exploration of individual preferences may be worthwhile.

Cats can differentiate mineral water from chlorinated tap water,[55] and solutions of hydrolyzed proteins, amino acids, or emulsified fats added to water have been shown to increase intake compared with unflavored water.[62] These findings, and anecdotal observations, lend support to offering flavored water to cats (e.g., prawn, tuna, or chicken-infused water) and/or water from different sources (either alone or mixed in with food) to help increase water intake, although studies assessing the impact of such interventions are lacking. As with food, individual preferences are likely to mean that trial and error is needed to optimize such interventions. In a European survey of cat owners, it was reported that more than half the cats drank daily from outside water sources, including rainwater, suggesting choice and options of water sources may be important.[59] There is some evidence that cats may consume more water when it is cooled to below room temperature by the addition of ice cubes,[63] a finding that also warrants further research.

Other interventions

A variety of other recommendations are commonly made to increase water intake, many based around presumed feline behavioral preferences. These include:[59]

- Keeping water bowls away from food bowls and litter trays.
- Avoiding plastic water bowls (which may retain unpleasant smells).
- Placing water bowls in quiet locations.
- Having a minimum of one water bowl per cat in the household.
- Using wide, shallow bowls that are kept full of water (to avoid "whisker stress" from whiskers brushing the side of the bowl).

While there may be some rationale in making these recommendations, until they are subject to careful investigation it remains unknown whether they have any actual effect. Interestingly, a controlled study evaluating the effect of whisker stress on food consumption found no significant effect from using a "whisker-friendly" bowl, emphasizing the need for evidence-based recommendations.[64]

Use of nutrient-enriched water

Recent studies suggest the use of nutrient-enriched water may be a successful way to increase water intake and help improve water turnover in cats.[65,66] It has been shown that increasing water viscosity (by adding 1% methylcellulose) significantly increases water intake in cats in comparison to plain water, an effect likely attributable to a higher volume of fluid being ingested with each lap the cat takes.[67]

Two controlled studies have been published where water was modified by the addition of whey protein, glycerol, potassium chloride, hydrocolloids, and poultry digest (nutrient-enriched water containing ~98% moisture). When this was offered to healthy cats in addition to tap water, free water intake significantly increased by 40–118% when measured weekly over the course of eight weeks, urine volume significantly increased, and urine specific gravity and osmolality significantly decreased.[65,66] It is likely that both the increased viscosity of the nutrient-enriched water and the enhanced palatability were responsible for the increased free water intake, but these studies demonstrate the potential value of this approach in enhancing water intake and improving hydration and water turnover in those cats where it is desired.

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NUTRITIONAL SUPPORT OF A HEALTHY IMMUNE SYSTEM IN DOGS AND CATS

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KEY TAKEAWAYS

- Colostrum, omega-3 fatty acids, vitamins, and minerals play significant roles in enhancing immune function and overall health in dogs and cats.
- Colostrum and its bioactives provide passive immunity to newborns and support gut health, with studies showing that they can improve immune responses and microbiota stability in growing animals.
- Omega-3 fatty acids have anti-inflammatory properties and can modulate immune responses, with sources including fish oil and flaxseed oil.
- Vitamins and minerals, such as vitamin E and zinc, are crucial for supporting immune responses. Micronutrient deficiencies can lead to increased susceptibility to infections and reduced vaccine efficacy.

Recent advancements in the immunology of humans and companion animals over the past two decades have facilitated deeper exploration into the relationship between host nutrition, immunomodulation, and changes in host health.[1-9] The growing interest in integrating the fields of nutrition and immunology has proven valuable in understanding the progression of health and disease over time, as well as how nutrition can enhance immune function.[10,11]

INTRODUCTION TO THE IMMUNE SYSTEM

The immune system plays a crucial role in the host's defense against harmful agents from external sources, such as bacteria, viruses, and parasites, as well as internal threats like autoimmune diseases. It consists of two main components: the innate (nonspecific) immune system and the adaptive (specific) immune system (**Table 1**).[12]

The innate immune system comprises anatomical barriers and a cellular component. Key barriers, including the skin and the mucous membranes of the gastrointestinal (GI) tract, serve as the primary "first line of defense." When these barriers are breached by microorganisms, endotoxins, or any foreign substances, the complement system may be activated. This system involves proteins that facilitate functions such as phagocytosis, viral neutralization, and the elimination of virus-infected cells.[12,13]

The cellular aspect of the innate immune system includes phagocytes. Initially, neutrophils attach to pathogenic microorganisms, engulf them, and subsequently destroy them. While this response can be beneficial, an extended inflammatory phase can be harmful to the host. Monocytes and macrophages also play vital roles in nonspecific immunity by phagocytizing antigens, processing them, and presenting antigen fragments to T cells.[12,14]

The adaptive immune system comprises B and T cells, which are involved in humoral and cell-mediated immunity, respectively. B lymphocytes mature in the bone marrow and, upon stimulation by specific antigens, differentiate into plasma cells that produce and secrete antibodies. In contrast, cell-mediated immunity primarily depends on T lymphocytes from the thymus. Antigen-presenting cells, such as macrophages, initiate the adaptive immune response. Deficiencies in cell-mediated immunity are associated with increased susceptibility to infections.[12-14]

T cells mediate delayed hypersensitivity and the destruction of pathogenic microorganisms and malignant cells, and they also regulate the activity of other immune cells. The T cell subsets include helper-inducer T cells (CD_4), which assist plasma cells in producing antibodies and releasing lymphokines that

Table 1. Description of cells that are key to the innate and adaptive (humoral) immune systems

Cell	Description
Innate Immune Cells	
Basophil	Least common type of granulocyte. Involved in allergic reactions and inflammatory responses.
Dendritic Cell	Bone marrow derived cells found in most tissues. Conventional dendritic cells take up antigen in peripheral tissues, are activated by contact with pathogens, and travel to the peripheral lymphoid organs, where they are the most potent stimulators of T cell responses.
Eosinophil	Effective in defense against parasitic infections. It also works as an effector cell in allergic reactions.
Macrophage	Macrophages are derived from bone marrow precursors and are found in most tissues in the body. They are large mononuclear phagocytic cells important as scavenger cells, as well as pathogen-recognition cells. They are a source of pro-inflammatory cytokines in innate immunity as antigen presenting cells. They also act as effector phagocytic cells in humoral and cell mediated immunity.
Mast Cell	A large granule-containing cell found in connective tissues, most abundantly in the submucosal tissues and the dermis. Mast cells are involved in defenses against parasites and they have a crucial role in the allergic response.
Natural Killer Cell	Important in innate immunity to viruses and other intracellular pathogens. Also, a part of antibody-dependent cell mediated cytotoxicity.
Neutrophil	The most numerous type of white blood cell in peripheral blood. They enter infected tissues and engulf and kill extracellular pathogens.
Adaptive Immune Cells	
B Cell	A B cell, also known as a B lymphocyte, is a white blood cell that produces antibodies to fight infection. B cells are part of the adaptive immune system, which helps the body recognize and fight specific threats.
Naïve T Cell	A mature T cell that has yet to encounter any antigens. It is a key component in the immune system's defense against infection.
T Helper Cell	An effector T cell found in lymphoid follicles that helps B cells with antibody production.
Th1	Part of the pro-inflammatory pathway, Th1 cells are a subset of CD4 effector T cells characterized by the production of certain cytokines like IFN-ϒ. They are mostly involved in activating macrophages but can be involved in the stimulation of B cells to produce antibodies.
Th17	Part of the pro-inflammatory pathway, Th17 cells are a subset of CD4 T cells that are characterized by the production of the cytokine IL-17. They also help recruit neutrophils to the sites of infection.
Th2	Part of the anti-inflammatory pathway, Th2 cells are a subset of CD4 T cells that are characterized by the production of the cytokines IL-4 and IL-10. They are also involved in stimulating B cells to produce antibodies.
T regulatory cells (Treg)	Effector CD4 T cells that inhibit T cell responses involved in controlling immune reactions and preventing autoimmunity.

modulate interactions between lymphocytes and other cells. Cytotoxic-suppressor T cells (CD8) can destroy target cells, inhibit antibody responses, or suppress the inflammatory response.[12-14]

Innovative foods and food components have been recognized as "functional" due to their ability to provide health benefits that extend beyond merely supplying essential nutrients, including vitamins, minerals, water, proteins, carbohydrates, and fats.[15] Progress in

understanding the immune system's response to diet has transformed the approach to feeding companion animals. Investigations focused on how diet can influence immune function have uncovered additional roles for colostrum, omega-3 polyunsaturated fatty acids (PUFA), vitamin E, and minerals like zinc.

NUTRITIONAL INTERVENTIONS TO SUPPORT A HEALTHY IMMUNE SYSTEM

Colostrum

In dogs and cats, only small quantities of antibodies are transferred to developing fetuses through the transplacental route, with approximately 5–10% in dogs and up to 25% in cats. Consequently, the levels of immunoglobulins in newborn dogs and cats are relatively low at birth.[16-18] Therefore, neonatal dogs and cats rely on the maternal immunity obtained through colostrum for passive immunity, which is essential for providing systemic and gastrointestinal immune protection during the first 3–6 weeks of life.[18,19]

During their first year of life, kittens and puppies face numerous new and challenging experiences, such as weaning, vaccinations, and re-homing. These challenges can negatively impact their health. Stress may weaken the immune system and cause changes in the gastrointestinal (GI) tract. Considering the variety of new experiences encountered by kittens and puppies, along with the underdeveloped state of their immune systems, it is unsurprising that the post-weaning period is linked to a higher risk of infection[20] and gastrointestinal disturbances.[21]

In a study by Gore et al., the authors report on the effect of feeding a diet containing 0.1% spray dried bovine colostrum (BC) to growing kittens on gut-associated lymphoid (GALT) tissue responses, systemic immune responses, and on intestinal microbiota stability.[22] BC supplementation induced increased fecal IgA expression, and a faster and stronger antibody response to a rabies vaccine booster, indicative of better localized and systemic immune function, respectively. BC supplementation also helped to maintain kittens' intestinal microbiota stability in the face of a mildly challenging life event. These results show that BC supplementation can help strengthen the immune system and enhance the gut microbiota stability of growing kittens.[22]

Colostrum not only fulfills the specific nutritional requirements of neonates but also provides passive immunity and supports the growth and development of the gastrointestinal tract.[23,24] While the importance of colostrum for neonates is well recognized, there is a growing interest in the systemic effects of administering BC orally to adult humans.[25] BC is rich in various bioactive components,[26] including growth factors such as insulin-like growth factor-1, insulin-like growth factor-2, transforming growth factor beta, and epidermal growth factor, as well as antimicrobial substances like lactoferrin and immunomodulatory agents such as immunoglobulins, transferrin, and cytokines. The presence of these bioactive compounds in BC has prompted its application in the treatment and prevention of diseases in both humans and animals.[24,27]

In 2013, Satyaraj et al. conducted a study investigating the effects of BC on the immune response in dogs. The study included 24 adult dogs randomized into two groups and was divided into two phases: pre-test (8 weeks) and test (40 weeks).[28] In the pre-test phase, both groups were fed a single nutritionally complete diet (control diet). At the end of the pre-test phase, a canine distemper virus (CDV) vaccine was administered to the dogs, and dogs in the test group were switched to the test diet. The test diet was similar to the control but supplemented with 0.1 % spray-dried BC. Response to the CDV vaccine was assessed with vaccine-specific plasma IgG levels. Gut-associated lymphoid tissue function was assessed by measuring fecal IgA levels. Gut microbiota were also evaluated. Vaccine response and fecal IgA levels were significantly higher in test group dogs. Supplementing diets with BC also resulted in significantly increased gut microbiota diversity and stability. These data suggest diets supplemented with BC can influence the immune response in dogs.[28]

Omega-3 fatty acids

Omega-3 fatty acids are among the most well-known supplements that modulate the immune system. When considering omega-3 polyunsaturated fatty acids (PUFA) for their immune-enhancing properties, the source of these fatty acids is crucial. Alpha-linolenic acid (ALA), which is derived from plant sources, is often supplemented in animal diets in the form of flaxseed. In contrast, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are sourced from marine environments, including fish and algae. Nonruminant animals do not possess the necessary enzymes or efficiency to convert ALA into bioactive EPA and

COMMUNICATION TIP

As our understanding of immunology and nutrition continues to evolve, it becomes increasingly clear that tailored dietary strategies can significantly influence the immune capabilities of dogs and cats, thereby promoting their well-being throughout various life stages.

DHA, making supplementation essential for obtaining immune benefits.[12,29-31]

Omega-3 polyunsaturated fatty acids (PUFA) have strong anti-inflammatory effects. They can reduce the production of various inflammatory substances, including certain eicosanoids, pro-inflammatory cytokines, chemokines, adhesion molecules, and reactive oxygen and nitrogen species. In addition to this, omega-3 PUFA help increase the production of anti-inflammatory cytokines like IL-10 and support the creation of pro-resolving mediators, such as resolvins and protectins. Overall, omega-3 PUFA also lower T cell activity by inhibiting the development of Th1 and Th17 cells, while they have little effect on Th2 and regulatory T cells.[11,12,32,33]

In a study by Park et al., 14 mature female cats were fed different diets: a control diet, or a diet enriched with fish oil or flaxseed oil, each for 12 weeks.[34] The omega-6 to omega-3 fatty acid ratios were 20:1 for the control and 5:1 for both the fish and flaxseed oil diets. The researchers evaluated the cats' immune responses at the start, and after 6 and 12 weeks, as well as their skin sensitivity at 6 and 12 weeks. Both fish and flaxseed oils reduced skin inflammation caused by histamine. Both oils decreased certain immune cell populations and the response of leukocytes to a specific stimulant. However, there were no changes in other immune functions, such as lymphocyte proliferation or plasma IgG levels. Overall, fish and flaxseed oils can lower skin inflammation in cats, but flaxseed oil seems to have a milder immunomodulatory effect compared to fish oil.[34]

Vitamins & minerals

Vitamins and minerals (micronutrients) are crucial in regulating and influencing the immune response. Deficiencies in these micronutrients often lead to insufficient or dysregulated cellular activity and cytokine production, which can negatively impact the immune system. Low levels of natural killer cells, granulocytes, phagocytic cell activity, and the proliferation and trafficking of T and B cells are linked to insufficient micronutrient levels. This deficiency can also increase susceptibility to various health issues, including inflammatory disorders, infections, and reduced vaccine efficacy.[35] Below is a summary of how zinc and vitamin E affect the immune system. Further information on a broader selection of minerals and vitamins and their immune effects is presented in **Table 2**.

Zinc

Under normal physiological conditions, a dog's or cat's access to zinc is primarily dependent on their oral intake. Zinc serves as a crucial cofactor for various enzymes that participate in cellular metabolism; a deficiency in this mineral can lead to significant immunodeficiency. Common indicators of zinc deficiency include lymphopenia and thymic atrophy, along with a reduction in thymic hormone activity. A lack of zinc results in diminished delayed-type hypersensitivity (DTH) reactions, lower populations of CD4 (T-helper) cells, and higher populations of CD8 (T-suppressor) cells. Zinc is a vital element supporting the function and viability of phagocytic cells.[12,36,37] It is essential to feed all dogs and cats a diet that is complete and balanced for their life stage so they can consume adequate amounts of zinc and other key nutrients.

Vitamin E

In addition to its established role as an antioxidant, vitamin E has been reported to potentially enhance immune factors indirectly. This enhancement is believed to occur through the inhibition of macrophage secretion of PGE2, which in turn suppresses the production of IL-1.[12,38] There have been a limited number of studies on companion animals that assess the relationship between dietary vitamin E levels and immunity. Research conducted by Meydani and colleagues indicated that a higher dietary vitamin E concentration (280 IU/kg diet) was effective in maintaining lymphocyte proliferative activity compared to lower levels (27 IU/kg diet) in Beagles.[39] Additionally,

Table 2. Summary of immunomodulatory capabilities of minerals and vitamins. Other than vitamin C, these nutrients are all part of a complete and balanced diet. These nutrients may be added to diets in increased amounts to support immune health.[12]

Nutrient	Description
Minerals	
Iron	Necessary for neutrophil and lymphocyte function.
Copper	Required for the metabolism, signaling, and maintenance of reactive oxygen species in important immune cells.
Selenium	Plays a crucial role in supporting a healthy immune system by acting as an antioxidant, enabling proper function of immune cells like T and B lymphocytes, and helping to fight infections.
Iodine	Stimulates antibody production and phagocytosis of cells.
Magnesium	Helps the immune system fight infections.
Manganese	Directly activates the innate immune response.
Vitamins	
A	Has many effects on the immune system, including: immune cell development, mucosal barrier integrity, regulating the development and function of T and B cells, and preventing excess inflammation through anti-inflammatory pathways.
B6	Has many effects on the immune system, including: the facilitation of the production of antibodies, T lymphocyte production, and immune cell regulation.
C	Supports the immune system by helping white blood cells differentiate, fight infections, and reduce inflammation.
D	Helps the immune system function optimally by influencing immune cell activity and promoting immune tolerance.

diets providing vitamin E at levels between 250 and 500 IU/kg appeared to offer immunological benefits to older, healthy cats.[38]

CONCLUSION

The nutritional support of a healthy immune system in dogs and cats is a multifaceted endeavor that underscores the critical interplay between diet and immune function. The evidence presented highlights the importance of specific nutrients or ingredients, such as colostrum, omega-3 fatty acids, vitamins, and minerals, in enhancing immune responses and overall health in companion animals. As our understanding of immunology and nutrition continues to evolve, it becomes increasingly clear that tailored dietary strategies can significantly influence the immune capabilities of these animals, thereby promoting their well-being throughout various life stages. Future research should focus on further elucidating the mechanisms by which these nutrients exert their effects and exploring innovative dietary formulations that can optimize immune health in dogs and cats.

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PRACTICAL TOOL: THE IMPACT OF MAINTAINING HEALTHY WEIGHT ON LIFE SPAN

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Obesity is a disease of global significance that affects both quality of life and longevity in dogs and cats. The prevalence of veterinary-diagnosed overweight and obese animals has been cited as up to 65% in dogs and up to 63% in cats in some populations.[1-5]

The prevalence of obesity in dogs and cats is increasing over time.[3,6] Multiple pet- and owner-related risk factors, such as breed predisposition, lack of exercise, and providing excessive treats can contribute to a pet gaining excess weight. Obesity diminishes a pet's quality of life due to an increased risk of many chronic diseases, including osteoarthritis and feline diabetes, and has been shown to reduce longevity.[7-10]

In the landmark 14-year Purina Life Span Study,[8] scientists monitored the health of 48 Labrador Retrievers from puppyhood and throughout their lives. Labrador Retrievers were grouped in pairs and, starting at 8 weeks of age, both dogs were fed the same complete and balanced diet. However, the "control" dogs were fed free choice initially, and then maintained at a body condition score of ≤ 7/9. The "lean-fed" dogs were fed 25% less than their paired control dog and

Table 1. Strategies to help achieve or maintain ideal body condition

Strategy	Notes
Implement a weight loss plan to achieve weight loss	• Necessary for pets with a BCS ≥7/9 • Requires commitment from the pet owner • In most cases, may necessitate a change to a therapeutic weight loss diet • Overcome communication barriers with pet owners • Identify owner behaviors that may prevent success; empathize and provide support • Requires the veterinary team to obtain a thorough nutritional history and an accurate accounting of food intake, weight monitoring, and diet adjustments
Increase activity levels	• Increase walking, exercise, or play • Implement strategies to mimic hunting (for cats)
Increase meal duration	• Use slow feeders to slow down the speed of eating • Use enrichment toys such as food puzzles
Decrease the amount of the current diet fed	• If an adult maintenance diet or well-pet weight management diet is being fed, decreasing daily feeding amount can be beneficial in cases where BCS is 6/9 • Reduce food intake by 5-10% provided nutrient needs continue to be met • If ideal body weight is not achieved, or if the pet's body condition score is ≥7/9, a weight loss plan and a therapeutic weight loss diet are needed
Redirect begging behaviors	• Utilize automatic feeders capable of dispensing timed small meals multiple times per day • Replace treats with affection and play
Reduce treat consumption	• Treats that are not complete and balanced for the appropriate species and life stage should be fed at no more than 10% of total daily calories • Requires the veterinary team to obtain a thorough nutritional history to understand the amounts and types of treats given • A food diary may help the owner reduce treats

were maintained in ideal body condition. This study had remarkable results. Most notably, results showed dogs have a longer life span when fed to maintain lean body condition from puppyhood and throughout their lives.

- The lean-fed group had a 15% longer median life span—13 years compared to 11.2 years for the control group.[8]
- The lean-fed dogs had delayed onset of clinical signs of chronic diseases. For example, the mean age at which 50% of the dogs first required long-term treatment of osteoarthritis was significantly later for the lean-fed group at 13.3 years than the control group at 10.3 years.[8]

An association between excess body weight and a shorter life span has also been demonstrated in cats.[10] Researchers also found that obesity in cats is associated with more prevalent health conditions, including diabetes mellitus, allergic disease, and lower urinary tract disease.[11]

Despite the health risks, research has shown that pet owners often do not perceive their pet's excess weight as a problem.[4,12] As a result, talking to pet owners about their pet's body weight and body condition score can be difficult for many veterinarians.[13] When discussing pet obesity, the negative effect of excess body weight on life span and health is a potential conversation starter. Researchers found that the most influential factor veterinary health care teams can discuss when having conversations with pet owners about obesity is the effect of ideal body condition on increased life span.[14,15] Strategies should be implemented to help dogs and cats achieve ideal body condition when needed (**Table 1**).

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PRACTICAL TOOL: MANAGING WEIGHT IN SPAYED AND NEUTERED DOGS AND CATS

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Numerous studies have shown that neutering is a major risk factor for obesity in cats and dogs alike.[1-3] The reasons are not only reduced voluntary activity and increased interest in food, but the absence of sexual hormones that reduces energy requirements.[1,2]

In recently spayed female beagle dogs and cats, a 30% reduction in energy intake was required to maintain body weight.[4,5] In both species, weight gain was almost exclusively an increase in body fat percentage. There are multiple causes for this increased risk of weight gain. The increase in the concentration of insulin-like growth factor 1 (IGF-1) after spay and neuter surgery promotes adipocyte growth.[6] Furthermore, spaying and neutering appears to influence the gene expression for messenger substances of fat metabolism such as leptin and lipoprotein lipase.[7] A bidirectional interaction between microbiota and endocrine status of the host has been shown.[8] Food intake may also increase post spay and neuter surgery.

Because there is a significant increase in the risk of weight gain, body condition of neutered animals should be monitored even more carefully than before spay or neuter surgery. **Table 1** shows strategies to help maintain ideal body condition after spay and neuter surgery.

Table 1. Strategies to maintain ideal body condition after spay and neuter surgery

Strategy	Notes
Decrease food intake after spay/neuter surgery to accommodate for metabolic changes	· Food intake should be reduced by at least 10-15% immediately after spay/neuter surgery to accommodate for the metabolic changes that occur after surgery. · A diet appropriate for the dog or cat's life stage should be fed, but a less energy dense option can be chosen if available. · For spayed and neutered puppies and kittens, it is important to continue a growth diet and monitor body weight and BCS[9,10] frequently to ensure growth occurs at a slow and steady rate.
Regular weight checks should be part of routine health care	· Since scales can vary in accuracy, the same scale should be used each time. · Bathroom scales are not accurate enough for small dogs and cats. Pet scales or baby scales are preferred. For miniature dogs and cats, a basket, bag, carrier, or transport box may be used to facilitate weighing. · It is often recommended that the owner holds the dog or cat and gets on the scale, but this leads to inaccurate results and is therefore not the preferred method. · Many pet stores and veterinary clinics offer the use of scales for larger dogs free of charge. Visiting the veterinary practice regularly without fear or pain (but with positive reinforcement such as praise and treats) will make it a positive experience for the dog from early on. · Weighing every day is not necessary for healthy, weaned pets. We recommend weighing every two to four weeks in large dogs. Those who want to weigh more often should calculate the average over a week to monitor weight gain or loss.

Table 1. *Continued*

Strategy	Notes
Body weight is only part of the story; the body condition is at least as important	· The body composition (percentage of lean body mass, body fat, and water) may change with aging or disease; therefore, body weight and BCS should always be assessed together. · BCS is simple and easy to carry out; every cat and dog owner should be familiar with it. Especially in cats and dogs with a long or dense coat, palpating of the reference points should always go together with weighing.
Overweight must not become the new normal	· Unfortunately, most pet owners are used to seeing overweight dogs and cats on a regular basis. Many people might mistake an animal in optimal body condition for being ill or too thin. · A lack of awareness of what normal body condition looks like can even lead to a situation where an owner of a slim animal is accused of neglect or even animal cruelty. Pet owners should be instructed on how to react and use this as opportunities to teach others about healthy body condition. · BCS charts can be provided for clients as printouts at the front desk or as downloads from the clinic website or app.
Keep in mind that energy requirements vary from individual to individual	· Especially in dogs, average daily energy requirements are subject to many different influences besides neutering, like breed, husbandry, coat quality, exercise, and temperament.[11] · Feeding instructions on food and treat packages are based on average values and are starting points. Over time, food intake should be adapted to the individual requirements of the animal and the preferences of the owner. The adaptation requires obtaining the animal's weight and BCS and adjusting caloric intake up or down in 5% increments, as needed.
Prevention is key	· Overfeeding during growth may not only lead to developmental orthopedic diseases, but also often results in obese adults.[12-14] · Findings from the "Generation Pup study," a longitudinal study on dog behavior and health,[15] showed that owners' behaviors related to feeding and diet began to change when puppies reached 12 months of age indicating less concern since the dogs had "grown up healthy." Owners should be educated about the importance of keeping pets at a healthy body weight and BCS during adulthood.
Consider the human-animal bond	· Pets depend, in terms of their food and lifestyle, on the attitudes and behavior of their owners. Several studies have shown that both the weight and health awareness of owners influence the eating habits and physical activity of their dogs and cats.[16-18] · Veterinary health care professionals can help develop and design strategies to encourage pet owners to engage in physical activity with their dogs as tolerated, for the benefit of both.

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PRACTICAL TOOL: NUTRITIONAL MANAGEMENT OF SPAYED AND NEUTERED CATS

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INTRODUCTION

Neutering in cats is commonly performed for population control and offers several health benefits, such as reducing the risk of mammary gland neoplasia.[1] In the United States and the United Kingdom, an estimated 80-92% of cats are gonadectomized.[2] Despite its benefits, neutering is also associated with adverse effects, influenced by factors such as the age at neutering, sex, and breed.[1,3] One notable adverse effect is an increased risk of obesity and overweight.[1] Therefore, nutritional management and regular follow-up are essential to prevent post-neutering weight gain.

Gonadectomy is typically performed pre- or peri-puberty, with traditional age of gonadectomy occurring at 6-9 months and early-age gonadectomy between 7 weeks and 5.5 months.[2] Since kittens are still growing during these periods, they require additional nutrients and energy compared to adults. However, rapid growth and weight gain following gonadectomy can predispose cats to adult obesity.[4] This practical tool focuses on strategies to prevent weight gain in both gonadectomized kittens and adults.

PATHOGENESIS OF POST-NEUTERING WEIGHT GAIN AND OBESITY

Neutering in cats leads to a reduction in energy requirements by up to 30%[5] and an increase in appetite. Food intake can increase by up to 50% post-neutering when food is provided ad libitum.[6] This imbalance often results in rapid weight gain, primarily due to increased adipose tissue accumulation.[2,3] The removal of gonadal hormones causes an acute rise in food intake post-gonadectomy, though this effect may be age dependent. For instance, acute hyperphagia is more pronounced in female cats neutered at 31 weeks compared to those neutered at 19 weeks.[7] On the other hand, the adverse upwards inclination of growth was more pronounced in kittens neutered at a younger age.[8] Further research is needed to clarify the effects of neutering age on growth and weight gain.

NUTRITIONAL MANAGEMENT OF NEUTERED KITTENS

Gonadectomy often results in a positive energy balance,[2,3] with an accelerated growth trajectory observed in both sexes, particularly in females.[8] Since rapid growth and weight gain are linked to adult obesity,[4] preventing these outcomes post-neutering is critical. Monitoring growth using evidence-based growth charts for male and female kittens[8] allows for individualized assessments and prompt interventions.[2] Although the Body Condition Scoring (BCS) system[9] has not been validated in kittens, teaching cat owners to assess BCS early can aid in obesity prevention later in life.[2]

Growing kittens require more nutrients than adults[10] and should be fed diets formulated specifically for kittens. Energy restriction during growth is not recommended;[2] however, excessive energy intake leading to rapid growth should be avoided. Free-feeding practices should be discouraged, and kittens should be fed based on their individual energy needs.[2] For kittens at risk (e.g., neutering, breed, strict indoor housing) or kittens showing rapid growth, check available diets for the growth life stage to find one with a slightly lower energy density. Any chosen diet should meet all nutritional requirements for growth, thereby helping prevent nutrient deficiencies due to reduced energy intake. Reducing the quantity of regular kitten food below the minimum recommended amount on the label can potentially cause nutritional deficiencies and should be avoided. Kittens with exceptionally low energy requirements should be referred to a qualified veterinary nutritionist to develop a safe feeding plan to prevent rapid growth.

NUTRITIONAL MANAGEMENT OF NEUTERED ADULT CATS

Neutering is a significant risk factor for obesity, and prevention is more effective than treatment.[11] Effective prevention involves three key components:

1. **Energy Requirements:** Ad libitum feeding should be avoided. Each cat should receive an appropriate amount of food based on individual needs.[3] FEDIAF (2024) recommends lower energy requirements for neutered (75 kcal/kg$^{0.67}$) compared to active cats (100 kcal/kg$^{0.67}$).[10] This serves as a baseline, with adjustments made based on regular monitoring of weight and BCS (every 2-4 weeks).

2. **Diet Type:** Diets with lower energy density are preferable for at-risk cats.[12] Options include diets formulated for neutered cats or light diets, though their nutritional compositions and energy density can vary. Inappropriate energy restriction without an appropriately balanced diet can cause nutrient deficiencies. For cats with very low energy needs, weight loss diets may also be used to help prevent weight gain. Feeding predominantly dry food may also increase the risk for developing obesity.[12] Proposed reasons for this include an increased risk of dry food being fed ad libitum.

3. **Feeding Management:** Beyond diet quantity and composition, management practices are vital. Treats should not exceed 10% of daily energy requirement.[11] Regular weight checks are crucial for early detection of weight gain. Encouraging physical activity can be challenging in cats, but food puzzles (commercial or homemade; see www.foodpuzzlesforcats.com) and interactive feeding methods (hiding food, simulating a chase for kibble, using vertical space) can all promote activity. Smart feeders can help manage portion control in multi-cat households.[13]

Box 1. Nutritional strategies for spayed and neutered cats

- Weigh and assess BCS regularly to ensure the cat does not gain weight after gonadectomy
- For kittens, feed a diet complete and balanced for growth. A growth diet with a lower energy density (kcal/kg) can be selected. Follow up by monitoring growth and avoid rapid growth. Nutritional deficiencies can develop if food intake is restricted too much.
- For adults, feed a diet complete and balanced for adult maintenance. Diets selected for spayed and neutered cats at risk for weight gain should be lower in energy density than a standard adult maintenance diet but should still be complete and balanced.
- Avoid ad libitum feeding
- Encourage including wet food in the cat's diet
- Keep treat calories at less than 10% of total daily calories
- Promote activity
- Manage potential difficulties with portion control in multi-cat households

CONCLUSION

Addressing the feline obesity epidemic requires a focus on prevention. Neutering significantly increases the risk of obesity, particularly when combined with rapid growth during development. Preventative measures should begin immediately after neutering, regardless of the cat's age at the time of the procedure. Regular monitoring of weight and growth facilitates early detection of excessive growth rates, allowing for timely nutritional adjustments. Diets formulated for neutered cats can support obesity prevention and typically have a lower energy density and fat concentration compared to typical diets for the life stage. Early implementation of personalized nutritional strategies may promote lifelong adherence to healthy practices, reducing the risk of obesity, especially in cats with multiple risk factors such as neutering, breed predispositions, and indoor confinement.

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PRACTICAL TOOL: NUTRITIONAL MANAGEMENT OF INDOOR CATS

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Indoor cats have unique needs, including activity, environmental enrichment, and nutrition. The nutrition of healthy indoor cats presents an opportunity to focus nutritional goals on prevention of disease, enhancing the quality of life of the cat, and promoting the human-animal bond. Through diet, we can promote gastrointestinal and urinary health as well as healthy body weight and composition. The feeding management of an indoor cat also involves an assessment of the environment and human factors to make well-rounded nutritional recommendations that not only benefit the cat but the humans residing with the cat.[1]

There is no standard definition for "indoor cat" food. Rather, the differences in an "indoor" cat formulation versus a "non-indoor" cat formulation are at the discretion of the manufacturer. Diet selection for an indoor cat should be based on an individual nutritional assessment.

Table 1. Preventative nutritional strategies for indoor cats

Category	Key considerations	Nutritional modifications
Weight management	Promoting ideal body weight and body condition is paramount for disease prevention and longevity. Indoor cats may have less opportunity to exercise than their outdoor counterparts. This contributes to lower maintenance energy requirements, which can lead to weight gain. Further, spaying or neutering an indoor cat can also decrease their maintenance energy requirements significantly following surgery.[2]	· To prevent inappropriate weight gain, give clients specific diet and feeding recommendations to ensure they are not over (or under) feeding. · Feed a diet with a reduced caloric density. Reduction in caloric density is accomplished through added fiber and/or reduction in fat content, particularly with dry, extruded foods. · Higher levels of protein promote lean muscle mass which has a higher metabolic rate than fat mass. · Canned food may promote satiety in cats.[3] · Teach owners to body condition score (BCS) their cat at home. · Consider regular weighing at home. This can be done with a pet or infant scale or with technology such as a smart litter box monitor.
Gastrointestinal health	Feeding a diet that promotes optimal stool quality while reducing stool volume and fecal odor is not only important for the cat \ but also important for the human(s) residing with the cat and maintaining the litter box. Together, these support the human-animal bond.	· Feeding a diet with highly digestible ingredients and balanced fiber content can help reduce stool volume and odor. · Diets with added fiber help with hairball control (primarily insoluble) and promote gastrointestinal motility. · Added prebiotic fibers can promote gastrointestinal health by supporting beneficial microbiota in the GI tract.

Table 1. *Continued*

Category	Key considerations	Nutritional modifications
Urinary health	Promoting urinary health and hydration may help reduce the risk of various lower urinary tract conditions seen in cats. Environmental management including enrichment and litter box management is also key for maintenance of urinary health.	• Owners can consider a cat food with a urinary health claim like reducing urinary pH or promoting a healthy mineral content in the urine. These claims can be substantiated through protocols measuring urine pH or relative supersaturation, respectively. Claims related to urinary health may be regulated depending on the location; for example, the Food & Drug Administration (FDA) provides guidance for making urinary health claims in the United States.[4,5] • Cats consume more water with canned food versus dry.[6] • Consumption of a nutrient-rich water supplement can increase fluid intake and decrease urine specific gravity in healthy cats.[7] • Consider technology like smart litter box monitors to track urinary behaviors.
Feeding management	Feeding recommendations should include not only a specific diet, but also recommendations for feeding management and modifications of the environment. Owner perceptions and goals for feeding should also be taken into consideration. In a multi-cat household, every effort should be made to ensure feeding recommendations take into account individual cats. Limitations and opportunities in the environment should be identified to avoid overfeeding. Strategies for separate feeding in a multi-cat household require an extended nutritional assessment to identify the best plan for a specific household.	• Portion food with a gram scale versus a measuring cup for greater accuracy when feeding.[8] • Consider smaller, more frequent meals with opportunities for foraging activities. • Avoid ad libitum feeding, as this may be associated with weight gain and obesity. • Feeding dry food from a toy or a treat ball can provide enrichment but has not been associated with increase in activity in a pilot study of generally healthy cats.[9] • Cats may have individual preferences for a water bowl type including material (glass, ceramic, or steel) and/or water movement (still versus flowing). Water fountains have not been associated with an increase in water intake or change in urinary parameters.[10] • Fresh, clean water should be accessible at all times. • Food and water bowls should be separated from litter boxes. Some cats may prefer their water bowls away from their food. • For multi-cat households, consider separate or supervised feeding where possible. Consider technology like microchip feeders to ensure separate feeding.

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PRACTICAL TOOL: MONITORING TOOLS AND NUTRITION FOR COGNITIVE FUNCTION

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INTRODUCTION

One of the most rewarding yet challenging responsibilities in small animal practice is the early recognition, monitoring, and management of cognitive dysfunction in aging companion animals. Cognitive Dysfunction Syndrome (CDS) is a highly prevalent neurodegenerative condition that significantly impacts the quality of life of pets and their caregivers—many of whom share a bond with their dogs as strong as that between a parent and child.[1] Fortunately, advances in validated questionnaire development and targeted nutritional support now provide veterinarians with reliable, practical tools, enabling timely intervention and improved patient outcomes by slowing cognitive decline.

WORKFLOW FOR COGNITIVE HEALTH IN SENIOR PETS: EARLY SCREENING, DETECTION, AND INTERVENTION

A third of a pet's life is spent in the senior life stage, during which clinical cognitive decline is increasingly common. Around 30% of dogs aged 11–12 years and 60% of dogs aged 15–16 years show clinical signs of cognitive dysfunction syndrome.[2] The most commonly seen change in behavior in CDS is anxiety, then spatial or temporal disorientation, altered interaction with family members and animal companions, changes in sleep-wake cycles, house-soiling, and vocalization (cats) (DISHAA in dogs: **D**isorientation, social **I**nteraction, **S**leep-wake cycle, **H**ouse-soiling, learning and memory, **A**ctivity, **A**nxiety; VISHDAAL in cats: **V**ocalization, alterations in **I**nteractions (e.g., increased affection), changes in the **S**leep-wake cycle, **H**ouse-soiling, **D**isorientation, alterations in **A**ctivity levels, **A**nxiety, and **L**earning and memory).[3,4] Clinical signs of CDS may be more pronounced in animals concurrently affected by dental disease, osteoarthritic pain, systemic medical conditions, or other behavioral disorders. These comorbidities should be carefully considered during diagnosis and management of patients with CDS. Moreover, such conditions can not only exacerbate cognitive dysfunction but often present more prominently, potentially complicating diagnosis—especially for less experienced clinicians.

Cognitive dysfunction often also remains under recognized because of its gradual onset and subclinical course. Unlike orthopedic or internal medical conditions, CDS typically begins with subtle behavioral changes, detectable only through standardized, validated owner questionnaires before more overt clinical signs develop. Regular application of such questionnaires—ideally annually for senior pets—should become a standard operating procedure in geriatric wellness visits.[5] Early detection is crucial, not only to improve quality of life but also to enable timely interventions that may decelerate disease progression. Owners completing these questionnaires in advance of the clinical visit allows targeted discussion of relevant clinical changes and effective monitoring over time.

Among the most commonly used tools are the Canine Dementia Scale (CADES), the Canine Cognitive Assessment Scale (CCAS), the DISHAA scale, and the Canine Cognitive Dysfunction Rating scale (CCDR).[5] CADES and DISHAA scales are designed for use with veterinarian involvement, often in collaboration with the owner, whereas the others are to be filled in by the owners only. The recent comparative study by Haake et al. (2024)[5] demonstrates that CADES offers superior sensitivity in detecting mild to moderate cognitive impairment, whereas CCDR is better suited to identifying more advanced cases. The CCAS correlates well with CADES but may under-detect severe decline. Selecting the appropriate tool, or combining tools depending on the clinical scenario, improves early diagnosis and ongoing assessment.

Apart from clinical signs of CDS, magnetic resonance imaging of the brain can reveal brain atrophy (sulci widening, ventriculomegaly) and vascular lesions, such as infarcts or microhemorrhages. Recent research into CDS related biomarkers is promising, but not yet clinically diagnostic.

Table 1. Potential nutritional solutions for CDS in dogs[4,6,7]

Risk factors	Nutritional solution	Potential benefit
Glucose hypometabolism	MCT	Increase in ketones, alternative source of energy
Mitochondrial dysfunction	L-carnitine	Improved mitochondrial function and mitochondrial lipid metabolism
Mitochondrial dysfunction	DL-alpha-lipoic acid*	Improved mitochondrial function; cofactor for mitochondrial respiratory chain enzymes
Oxidative stress	Vitamins C and E, beta-carotene, selenium, flavonoids, carotenoids	Protection of brain against oxidative stress
Altered neurotransmitter levels	S-adenosyl–L-methionine	Rebalance of monoamine neurotransmitter levels, cell membrane integrity
Chronic inflammation	DHA and EPA	Anti-inflammatory
DHA or phosphatidylserine deficiency	DHA or phosphatidylserine	Support of brain function and structure
Hypertension	Arginine (nitric oxide-releasing compound)	Improvement in blood pressure and blood circulation
High homocysteine	B vitamins	Prevention of high homocysteine associated with cognitive impairment
Low B6, B12, folate	B vitamins	Support of energy metabolism, DNA maintenance, biosynthesis of neurotransmitters

*Toxic in cats

MANAGEMENT: NUTRITION AND ENVIRONMENTAL ENRICHMENT AS CORNERSTONES[4,6,7]

Once CDS is identified, multimodal management strategies are warranted. Primarily, dietary modification and environmental enrichment outweigh pharmaceutical therapies in current evidence.

Nutritional intervention

Several dietary strategies support cognitive health. Commercial diets enriched with medium-chain triglycerides (MCTs)—notably octanoic and decanoic acids—provide alternative brain energy sources, compensating for the age-related decline in cerebral glucose metabolism. MCTs also confer neuroprotective benefits, supporting mitochondrial biogenesis, reducing oxidative stress, and modulating neurotransmission.

Diets combining antioxidants (vitamins C and E, selenium, flavonoids), omega-3 fatty acids (DHA, EPA), B vitamins, and mitochondrial cofactors (e.g., L-carnitine, alpha-lipoic acid) have demonstrated a "brain protection" effect, mitigating neurodegeneration and slowing clinical progression.[4,6] It is advisable to recommend commercially formulated diets that incorporate these nutrients for senior dogs showing early cognitive changes providing there are no comorbidities that may impact diet choice.

Environmental management

Alongside nutrition, environmental enrichment—including exercise, interactive play, sensory stimulation, novel experiences, and routine—has well-substantiated benefits on neuroplasticity and behavior. Owners should be guided in providing daily cognitive challenges tailored to their pet's health and abilities.

IMPLEMENTATION AND FOLLOW-UP

- Integrate annual cognitive screening questionnaires for all senior dogs, with more frequent monitoring as changes arise. Use the same screening test for each assessment.
- Initiate dietary interventions at the first recognition of cognitive dysfunction and reinforce owner

education regarding the role of nutrition and enrichment.

- Reassess cognitive status and adapt management plans longitudinally to enhance the well-being and longevity of our senior patients.

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PRACTICAL TOOL: MONITORING FELINE HEALTH IN A HOME SETTING

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Feline medicine is at an exciting time as the veterinary landscape continues to evolve. As the global pet population increases primarily in millennial and Gen-Z households[1] and many cats live longer lives due to the availability of improved care, some cats do not receive veterinary care. In one survey done in the United States, less than half of owners surveyed are bringing their cat to the veterinarian.[2] This decrease in visits may be for a variety of reasons including perceived lack of need, stress of the cat and owner, reliance on online information, financial constraints, and access to care.

Monitoring of feline health within a home environment therefore becomes an essential responsibility for cat owners. Given the unique behavioral traits of cats, which often include a tendency to mask discomfort or illness, it is critical for owners to be proactive to ensure their pets' well-being.

THE IMPORTANCE OF OWNER MONITORING OF CAT HEALTH

One of the paramount advantages of vigilant health monitoring is the early identification of potential health concerns. Cats are adept at concealing symptoms, making it challenging for owners to discern when their pet may be unwell. Regular observation allows for the recognition of subtle behavioral changes, alterations in appetite, or changes in physical condition (**Box 1**), all of which may indicate underlying health issues. Early detection is crucial, as it often leads to more favorable outcomes through timely veterinary intervention.

It is essential to establish a baseline for normal behavior through consistent monitoring. Cat owners can develop a comprehensive understanding of what constitutes normal behavior. This encompasses eating habits, activity levels, grooming behaviors, and social interactions with the owner and other pets in the household. A well-established baseline enables owners to promptly identify any deviations that may warrant further investigation, thereby enhancing the likelihood of early intervention.

Box 1. Signs of physical condition that cat owners can monitor in a home setting

- Weight loss or gain
- Muscle loss
- Skin and coat quality
- Litter box habits
- Fecal score
- Water consumption
- Food consumption
- Vocalization
- Changes in behavior around the owner or other pets in the household
- Time spent sleeping or resting
- Energy level
- Activity level
- Ocular discharge
- Nasal discharge
- Sneezing
- Coughing
- Vomiting
- Hydration status

Additionally, regular health monitoring fosters a deeper connection between owners and their cats. Engaging in activities such as grooming, playtime, and health assessments not only promotes physical health but also enriches the emotional well-being of both the cat and the owner, strengthening the human-animal bond.

POTENTIAL MONITORING TOOLS FOR OWNERS TO USE IN A HOME SETTING

A variety of tools are available for the in-home setting and include anything as basic as maintaining a health journal to smart devices that utilize artificial intelligence. Health journals serve as an effective

method for tracking a cat's health over time. Owners can document variations in appetite, weight, behavior, fecal scores, and litter box usage. This comprehensive record can prove invaluable during veterinary consultations, providing a detailed overview of the cat's health history.

Wearable devices are increasingly acknowledged for their capabilities in remote clinical monitoring. They can assist owners in tracking their cat's daily activity levels. These devices provide valuable insights into exercise routines, sleep patterns, physiologic parameters such as heart rhythm and rate, and activity level. Some monitors even enable owners to set goals and receive alerts if their cat exhibits decreased activity. Smart feeders for cats can play a vital role in promoting better feeding habits and overall health. They allow pet owners to schedule meals, control portion sizes, and monitor their cat's eating patterns. When coupled with other devices, they may better detect changes in the baseline of a cat, alerting the owner of the need to connect with the veterinary professional.

Litter box monitoring systems provide useful insights into a cat's urinary and digestive health by tracking litter box habits. At a basic level, these systems function as a scale, allowing owners to monitor weight trends over time. More advanced versions go further by measuring the frequency and volume of urination and defecation, alerting owners to possible health concerns such as signs of feline lower urinary tract disease, gastrointestinal issues, renal dysfunction, and endocrine disorders.

A wide range of mobile applications are available to help cat owners monitor their pet's health. These apps typically include features for tracking food consumption, logging weight, and storing medical records. Many also offer reminders for veterinary visits and vaccinations, helping owners stay organized and proactive about their cat's well-being.

Wearable devices, litter box monitoring systems, and mobile applications will also be able to integrate data into practice information management systems (PIMS), which may allow for more proactive and preventive care. The app on the owner's phone would collect the data that then feeds into the PIMS of the respective veterinary hospital. Importantly, this data must be clinically relevant and reliable to the veterinary team and demonstrate improved patient outcome.

Lastly, veterinary telehealth services have emerged and transformed the landscape of veterinary care. These services enable owners to consult with veterinarians remotely, providing guidance on health monitoring and addressing any concerns. This approach can be particularly advantageous for owners facing challenges in accessing veterinary care in person.

CONCLUSION

Monitoring feline health within a home setting is a fundamental aspect of responsible pet ownership. By recognizing the significance of health monitoring and employing various available tools, veterinary health care teams and pet owners can ensure cats remain healthy and thrive. Regular observation and proactive measures not only facilitate early detection of health issues but also foster stronger bonds between owners and their pets, ultimately enhancing the quality of life for our feline companions.

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PURINA Institute

Advancing Science for Pet Health

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COMMUNICATION STRATEGIES TO UTILIZE WITH PET OWNERS

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KEY TAKEAWAYS

- A well-stocked communication skill toolkit for all veterinary team members supports relationship-centered and collaborative nutrition conversations and decision-making with clients.
- A thorough nutritional history that includes clients' perspectives, goals, and beliefs is the foundation of a tailored nutritional recommendation.
- Shared decision-making principles can be used to help overcome resistance to recommendations and create a tailored, feasible nutritional plan for the client and patient.

INTRODUCTION

Many veterinary health care teams (VHCT) face challenges when encouraging pet owners to discuss or make changes to a pet's nutritional plan. Recommendations made by the VHCT may be met with ambivalence or resistance. Developing a strong set of communication skills for the whole team to employ during nutrition conversations can help implement strategies that build trusting relationships with clients, promote client understanding of the benefits of nutritional recommendations, and foster collaborative decision-making to address barriers to adherence.

STRONG SKILLS PROVIDE THE FOUNDATION FOR STRATEGIC TEAM COMMUNICATION

Nutrition can be an emotionally laden topic, and a wide range of client beliefs and circumstances may factor into the complex decision of what to feed a pet. The knowledge and opinions of the VHCT may differ from those of clients, and these differences can pose a threat to the relationship and have consequences for patient care without thoughtful and skilled navigation. Like any conversation in veterinary practice, talking about nutrition draws on a wide array of communication skills to gather accurate information and craft a clear message that is heard, understood, and received in a way that encourages action, while protecting a positive relationship with the client. Five specific skills to highlight for consideration are: asking permission, open-ended inquiry, empathy, partnership, and non-verbal communication.

Asking permission

Opening a nutrition conversation by asking the client's permission demonstrates respect for the client and signals the intent for the next part of the discussion while allowing them to have input on the conversation's progression. For example, "Nutrition is an important component of Clyde's overall health. Is it alright with you if we spend time now discussing his nutrition and activity?" notifies the client that nutrition is your next planned topic and offers a chance for them to prepare for or decline the change in direction. Clients are likely to respond positively and remain engaged in the discussion when asked for permission. Paying close attention to verbal and non-verbal responses can also help the VHCT recognize a client's willingness to discuss the proposed topic or receive a recommendation. A disengaged, apprehensive, or negative response indicates an opportunity to preserve the relationship by checking in or moving the conversation in another direction.

Open-ended inquiry

Open-ended inquiry is used to collect a comprehensive nutritional history, explore the client's knowledge and beliefs, and elicit their perspective on both the pet's current nutrition plan and any recommendations received from the VHCT. The language used in open-ended inquiry invites clients to share their story and can help gather information more efficiently than a series of narrow or closed-ended questions that typically garner short or one-word answers. A broad,

open-ended statement such as "Tell me everything Bonnie eats in a day, from first thing in the morning through to the end of the day" is likely to capture more dietary information than a question such as "What is she eating?" which often elicits client responses that are limited to a brand name.[1] Coupling open-ended inquiry with reflective listening lets the client know they've been heard, confirms or invites corrections to the information gathered, and can be used to focus on a particular topic or concern that has been raised ("You mentioned you're worried about making a switch to canned food. Tell me more about your concerns.").

Empathy

Empathy is a skill used to acknowledge and appreciate the client's situation or perspective. Being able to recognize and relay back the client's point of view makes room for acknowledgment and validation of their feelings and beliefs, strengthening the relationship by creating a nonjudgmental space to discuss nutrition. The breadth of nutrition-related information and beliefs that clients may bring into the consultation is enormous, and some VHCT members may be wary of validating the beliefs clients share with them, particularly when these are informed by unreliable sources. It is important to recognize that validating a client's feelings or ideas does not equate to agreement or confirmation that their information or opinion is correct.[2] Empathy and validation are powerful relationship builders because they acknowledge and normalize feelings for the client, creating trust and reducing the potential for conflict, which in turn can enhance the client's receptivity to information and adherence to future recommendations. For example, "I can appreciate how stressful it's been to limit Buddy's treats. As is the case for many of us with our pets, it's important to you to reward him and maintain the close relationship you have" recognizes a client's struggle and the bond with their pet, and normalizes what they are going through. Beware the well-intentioned urge to immediately correct opposing views, as this can spur defensiveness and erode the relationship. Instead, use open-ended inquiry and empathy to explore and acknowledge the client's perspective before asking permission to introduce alternative information.

Partnership

Nutrition is a team sport, both within the clinic and between the VHCT and clients. Explicitly establishing a partnership empowers clients to work with veterinary professionals towards mutually agreed upon goals and plans. Partnership language can help manage feelings of uncertainty or concern by reassuring the client they are not alone.[3] For example, "Navigating all the nutrition information out there can be overwhelming, and we will work together to decide on the best dietary plan for Bella, keeping in mind our goal of supporting her joints as she ages." Verbalizing the desire to work as a team also lays the foundation for shared decision-making and opportunities to support the client and their pet beyond the initial consultation.

COMMUNICATION TIP

Clients want to be partners in their pet's veterinary care. Clients that understand the beneficial outcome for their pet (the "why" behind recommendations) are more likely to adhere to plans of care.

Non-verbal communication

Actions speak louder than words, and non-verbal communication underscores all the talk that happens during a consultation. Learning to both demonstrate appropriate non-verbal cues and pick up on the non-verbal cues of others facilitates relationship-building by demonstrating attentiveness to the client.[2,3] When verbal content matches non-verbal cues, the message carries more weight. When the two are inconsistent, non-verbal cues are likely to override the verbal message.[2,3] While veterinary professionals remaining aware of their own non-verbal cues is critical, equally important is verbally verifying or acknowledging clients' non-verbal cues to clarify, avoid assumptions, and head off any misunderstandings. For example, picking up on a client's closed-off body language to check in on their perspective may sound like, "I'm sensing some hesitancy from you about that option. What are your thoughts?"

Finally, investing in training and support for the development of a well-stocked communication skill toolkit for all VHCT members will enhance the messages clients receive when interacting with different professionals throughout their time at the practice. Pairing effective communication from the whole team

and a unified practice ethos on nutrition can ensure consistent messaging and strong relationships with clients at every touchpoint with the VHCT.

NAVIGATING COMMON COMMUNICATION CHALLENGES

Challenge #1

Client resistance to recommendations is a common communication challenge to navigate during nutrition-focused conversations. One source of resistance arises from obtaining an incomplete nutritional history before making recommendations. A limited understanding of the client's current perception and knowledge base regarding their pet's nutrition may lead to recommendations that are not tailored or appropriate for the client and patient and do not align with the client's goals or beliefs. Client, patient, and environmental factors that are not uncovered and explored when gathering information can form the basis of client resistance due to the reduced feasibility of implementing suggested changes.[4]

Lower the risk of running into this challenge by having a member of the VHCT spend focused time on gathering a comprehensive nutritional history. A detailed history that explores all animal, diet, environment, and human factors related to a pet's nutrition provides a baseline from which appropriate and palatable recommendations are developed and delivered.[5] The more information gathered about the patient's current diet, the environment, the client's perceptions and knowledge base, client goals and priorities, and anticipated barriers, the more individually tailored recommendations can be. Written and verbal communication strategies can support obtaining a complete history. Asking clients to fill out a nutritional history form at home prior to the scheduled appointment may improve the thoroughness of the nutritional history when paired with effective verbal communication during the assessment.

Challenge #2

Another source of client resistance to recommendations is rooted in a client's understanding of the benefit or necessity of the recommendation for their pet.[6] Clients tend to view value through the lens of benefits to their pet's health and well-being, while VHCT members may focus their explanations on the features and functions of a recommendation.[7,8] While the features (what it is) and functions (how it works) of a nutritional product or intervention may inherently represent value to a VHCT member, clients may not immediately recognize the benefits to their specific pet in the context of their pet's overall health.

Navigate this challenge by emphasizing the benefits of recommendations. Clearly communicating the "why" behind nutritional recommendations that aligns with the client's perceptions and providing explanations that are tailored to the individual client's goals and circumstances supports their understanding of the value of a recommendation. For example, "To support Logan's movement and help him continue to enjoy your walks together [benefit, tied to goal], we can explore several mobility diets [feature] that are designed to reduce inflammation and maintain joint health [function]."

Challenge #3

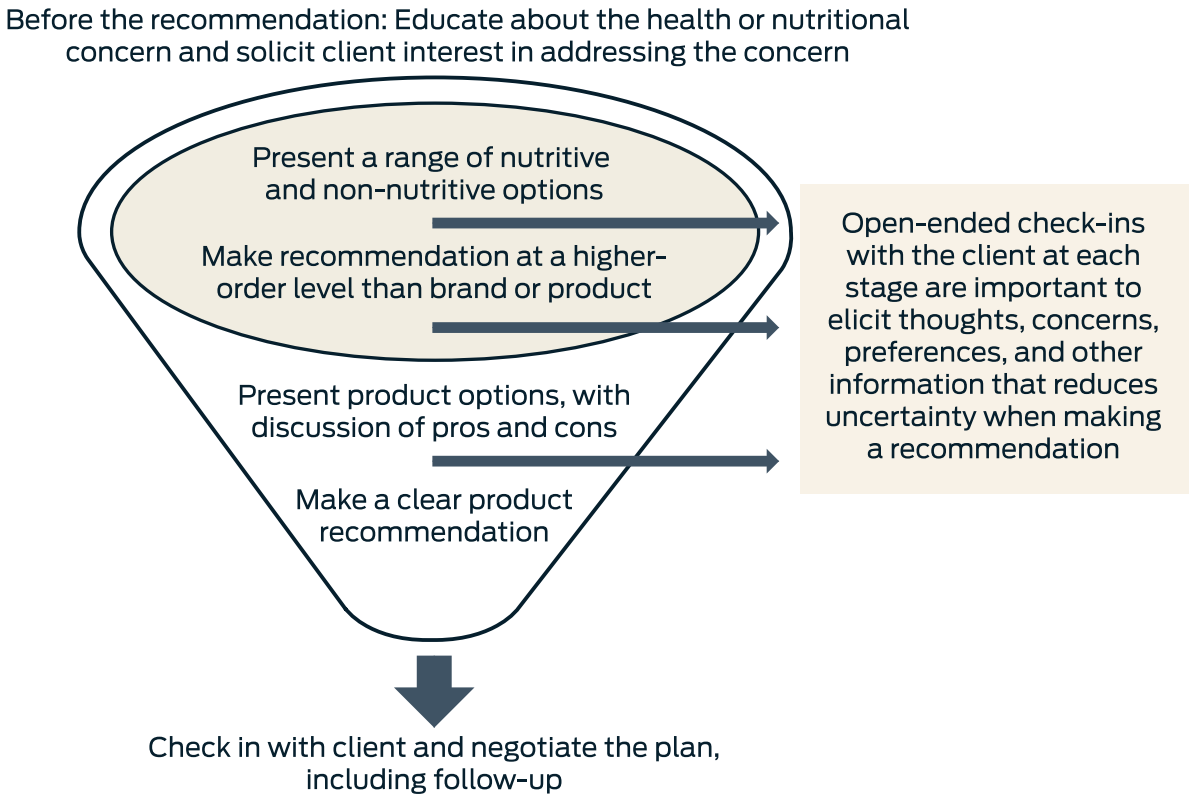
Resistance or skepticism may be encountered when a client perceives a recommendation from the VHCT as being driven by financial motivations and wanting to "make a sale." This perception can erode trust in the VHCT. In some cases, this perception is due to clients being presented with a single option and a lack of engagement in a shared decision-making process.[9]

When possible, rather than recommending a specific product off the bat, use a funnel approach to provide options in a sequential manner (**Figure 1**).[5,10] Begin by exploring the client's stance on nutritional intervention. Then, explain what options exist, before recommending a high-level product category. Next, discuss the product options available within that category and the pros and cons of each. Finally, if applicable, make a clear recommendation for a specific product. It is important to check-in for the client's perspective at each stage of the recommendation to modify as necessary.

ENCOURAGING CLIENT ADHERENCE TO NUTRITION RECOMMENDATIONS

After obtaining a comprehensive history, assessing a client's readiness to alter their pet's nutrition plan allows the VHCT to assess the most appropriate time to introduce recommended changes. Communication approaches that align with a client's current readiness to change can maintain a positive relationship and help overcome obstacles by implementing change when the time is right. For more in-depth discussion about communicating for behavior change, see:

Figure 1. The funnel approach to making a nutritional recommendation



Communicating With Clients About Nutrition to Promote Compliance in Reference 11.

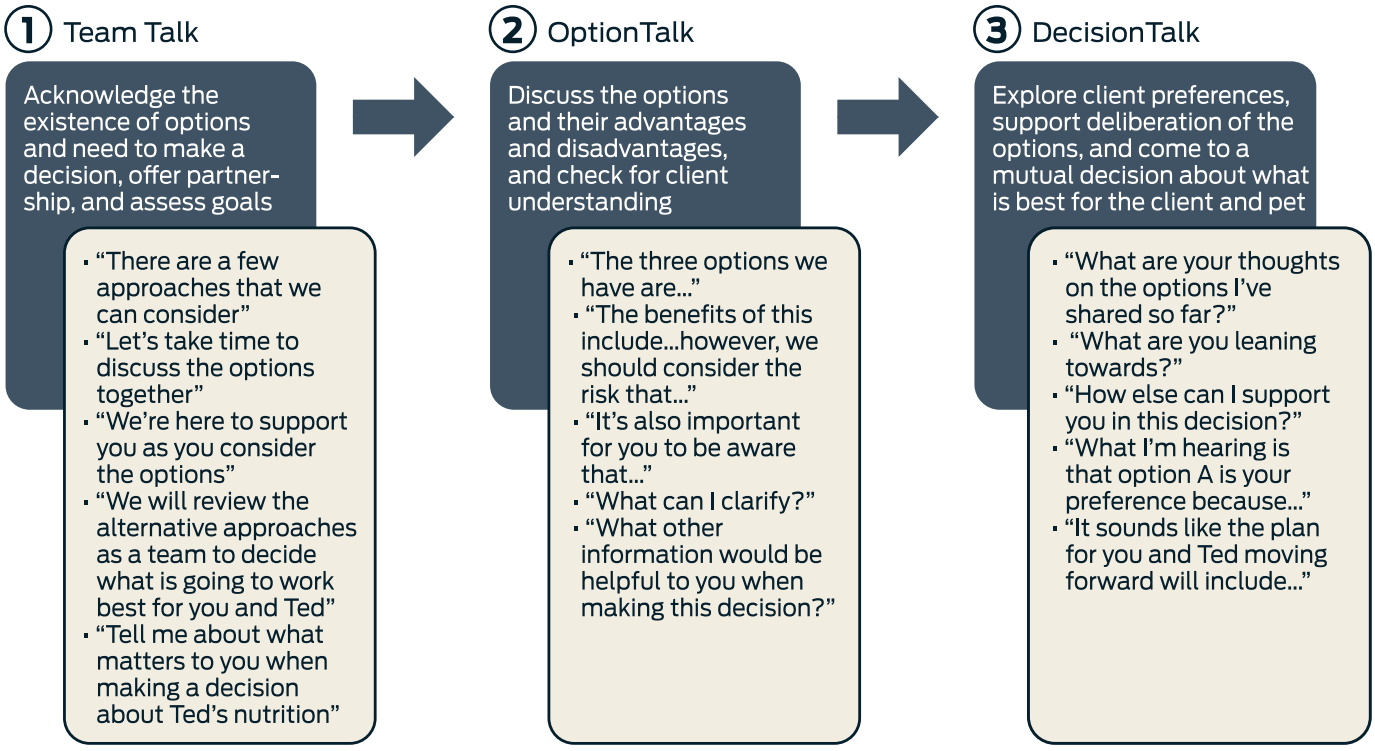
Explain recommendations in terms of benefits for the pet's health, function, and well-being, and refer back to client goals and priorities. Clients that understand the beneficial outcome for their pet (the "why" behind recommendations) are more likely to adhere to plans of care.[6,12] Adherence may be greatly increased when the VHCT employs communication methods with clear and thorough explanations and recommendations that clients perceive as necessary for their pet.[6] Clarity of the recommendation is also key: clients are 7x more likely to adhere to a clear recommendation than an ambiguous or obscure one.[13]

Relationship-building with clients has a positive impact on adherence. Conversations with higher relationship-centered care scores and a high empathetic tone are associated with increased odds of client adherence.[13] When effective communication builds trust between clients and the VHCT, follow-through on recommendations is enhanced. Another study found that owners who were most likely to follow through with recommendations were those with a strong client-veterinarian bond.[6]

Clients want to be partners in their pet's veterinary care.[9] Collaborative decision-making, in which the client and veterinary professional come to a decision for the pet's care together, is preferred by clients across all appointment types.[14] The entire VHCT has the opportunity to play a role in decision-making with clients. When veterinary technicians are involved in the decision alongside the veterinarian and client, client engagement and shared decision-making are enhanced.[15] See **Figure 2** for an overview of shared decision-making and example phrases.

Even if a client indicates readiness to implement a change or follow a recommendation during the appointment, barriers to adherence can arise and throw the plan off course when clients leave the clinic. Dedicated exploration of what clients anticipate as being potential challenges or barriers to implementing a recommendation at home provides an opportunity to troubleshoot as a team, before challenges appear. Discussing how to manage challenges and how to get support from the VHCT further establishes a partnership and can promote client confidence in their ability to overcome barriers. Clients with higher confidence are more likely to persevere when they come up against challenges. Follow-up from the veterinary team in the first days after making changes to a pet's nutrition plan

Figure 2. Implementing the three-talk model of shared decision-making[16] in nutrition conversations



is also critical to determine if the plan is being adhered to, what challenges the client has encountered so far, and the areas of the plan that need to be revisited, all while demonstrating that the VHCT is committed to being the client's ongoing partner in their pet's nutrition.

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ANSWERING COMMON PET OWNER QUESTIONS ABOUT NUTRITION

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KEY TAKEAWAYS

- Addressing nutritional misinformation pet owners have received from a variety of sources remains a major challenge for veterinary health care teams.
- Negative marketing claims imply to pet owners that the inclusion of these ingredients in pet food would be harmful to their pet.
- Communication strategies are critical when it comes to gathering misinformation from pet owners, while ensuring misinformation is not accidentally reinforced by the veterinary health care team.
- Effectively debunking misinformation requires a systematic approach focused on facts integrated with the relationship-centered approach.

SOURCES OF MISINFORMATION

Addressing nutritional misinformation pet owners have received from a variety of sources remains a major challenge for veterinary health care teams (VHCT), with sources of misinformation changing over time. In 2004, a validated, phone-based survey of primary caregivers (n = 1104) was conducted by five veterinary schools, and pet owners indicated their primary source for pet nutrition information was veterinarians (44.6%, 705/1581), followed by family/friends (14.2%, 225/1581), and the media/internet (11.1%, 176/1581).[1] At that time, pet owners that were surveyed also strongly disagreed with the statement, ***"I do not trust veterinarians to provide sound nutritional advice"*** (mean 4.60 ± 0.03, score 4 = mildly disagree and score 5 = strongly disagree, n=968).[2]

In 2020, pet owners in Canada and the United States (n = 1402), participated in an online questionnaire to explore their attitudes towards nutritional guidance provided by veterinarians.[3] Pet owner trust in veterinarians remained high (68.1% of cat owners and 62.7% of dog owners) when it came to nutritional recommendations. When asked what factors affect pet food choices, pet owners considered information read online (38.8%) and information shared by veterinarians (44.1%), indicating the gap had closed between information online and information provided by veterinarians.

COMMUNICATION STRATEGIES

Communication strategies are critical when it comes to gathering misinformation from pet owners, while ensuring misinformation is not accidentally reinforced by the VHCT. The first step is to gather a comprehensive nutritional history from every pet owner using both **written communication strategies** (i.e., nutritional history forms sent in advance of well-pet appointments to be completed by the primary caregiver at home) and **verbal communication strategies** (i.e., asking permission to discuss pet nutrition, asking open- and closed-ended inquiries, actively listening, seeking clarification, avoiding judgment, using empathy statements, avoiding medical/technical jargon, interpreting nonverbal cues, checking in with the pet owner, etc.).[4-6] Gathering a comprehensive nutritional history builds rapport and trust if implemented correctly by the VHCT using a **relationship-centered approach** (i.e., the written form does not replace verbal communication).

After reviewing the comprehensive nutritional history, check in with the pet owner to determine what specific concerns they have regarding their pet's nutrition.[4-6] For example, ***"Now that we have reviewed your pet's history, please tell me about any concerns you have regarding their nutrition."*** Active listening (i.e., making eye contact and not rushing the client) during their response is critical to ensure the pet owner feels heard.[4-6]

COMMUNICATION TIP

Keep in mind, assuming positive intent on the part of the pet owner when encountering nutritional misinformation, such as negative marketing claims they have shared, is an important first step to debunking misinformation.

Lastly, obtaining a comprehensive nutritional history takes time. Booking follow-up appointments via phone or videoconferencing platforms or telling clients to expect a longer appointment and scheduling time for the comprehensive nutritional history helps reduce the tendency to rush pet owners during nutrition conversations and ensures the veterinary health care team stays on schedule.[6]

MISINFORMATION VERSUS DISINFORMATION

Information that is false or incorrect is known as **misinformation**, and this false or incorrect information is subsequently shared without any ill intent on the part of the individual sharing the information.[7] In the author's experience, pet owners often share misinformation regarding pet nutrition with positive intent. For example, a well-intentioned dog owner shares a social media post that tells other pet owners to use canned pumpkin as a *"concentrated fiber source."* Canned pumpkin only contains 2.9 grams of dietary fiber in 100 grams (which is less than 3% by weight) and is 90% water.[8] While the information shared by this well-intentioned dog owner is unlikely to cause harm for most dogs, the information is still incorrect.

Unfortunately, any form of misinformation can lead to harm, even if the underlying intent was positive.[7] For example, a dog or cat consuming a homemade diet recipe found on social media, consisting of only cooked animal proteins (i.e., meat and poultry), could lead to nutritional secondary hyperparathyroidism. Nutritional secondary hyperparathyroidism develops over time due to low calcium and high phosphorus content (i.e., an inverse ratio of calcium:phosphorus).[9] For example, hypocalcemia (i.e., low blood calcium) can result in tremors or seizures, and osteopenia (i.e., reduced bone density) can lead to bone deformities/fractures.[9] Even if the recipe was shared with a positive intent to help pets, misinformation still leads to harm over the long-term.

On the other hand, **disinformation** is false or incorrect information that is shared with an underlying intent to mislead.[7]

Ideally, nutritional misinformation would be avoided altogether or at least anticipated by the VHCT so truthful information could be shared to try to avoid the misinformation from *"sticking"* in the future when a pet owner reads/hears it. Unfortunately, the ease of internet access for many pet owners makes avoiding nutritional misinformation next to impossible. Therefore, the best approach for the VHCT should be to both discuss and provide resources on common nutritional misinformation, which is known as **inoculation** or ***"prebunking"*** with *"cognitive antibodies."*[7] Inoculation aims to help make pet owners more resilient to nutritional misinformation in the future.[7] For example, a veterinarian could share the following at a well-pet examination, to slowly inoculate truthful information: ***"I often get questions about cooked homemade diets, and I have a couple of reputable resources I would like to share in case this is something you have questions about in the future."*** Then the veterinarian must encourage the pet owner to come back for further advice in the future: ***"If you are considering a cooked homemade diet in the future, please book an appointment so we can be sure it is the best decision for both you and your pet."***

Per Lewandowsky et al. (2020), one of the biggest challenges with misinformation is that the misinformation continues to *"stick"* even once the misinformation has been **debunked**, especially if that misinformation is widespread.[7] This challenge has been referred to as the **continued influence effect**.[10] For example, if a veterinarian provides a pet owner with a handout of common ingredients in commercial pet foods that includes truthful information on which essential nutrients are provided from those ingredients, and the pet owner has already read/heard many negative statements online about those same ingredients, it could be very challenging to "unstick" or debunk this misinformation without a systematic and supportive approach. Simply stating, "that is

false" or "that is not true" is very unlikely to completely "unstick" misinformation.[7]

NEGATIVE MARKETING CLAIMS

In 2020, the *"Pet Food Consumer Habit Survey"* assessed dog food purchasing habits of 3,300 pet owners from Canada, France, Germany, the United Kingdom, and the United States of America.[11] Negative marketing claims (i.e., "no" in front of an ingredient or ingredient-"free") were assessed as part of the survey. The majority of pet owners surveyed (61.8%) selected at least one of the following negative marketing claims when purchasing dog food: "no artificial colors or flavors" (38.6%), "no fillers" (30.1%), "no by-products" (28.3%), "no grain" (21.3%), "no corn" (16%), "no wheat" (15.7%), "no soy" (14.5%), "no pulse ingredients" (9.1%), and "gluten-free" (7.7%).[11]

The obstacle with **negative marketing claims** is that these claims imply to pet owners that inclusion of these ingredients in pet food would be harmful to their pet, sometimes without any explanation. It can be challenging to "unstick" or debunk negative marketing claims because they are so widespread, thus a systematic and supportive approach must be taken. Keep in mind, assuming **positive intent** on the part of the pet owner when encountering nutritional misinformation, such

Figure 1. Framework for a systematic approach to debunking misinformation [adapted from Lewandowsky et al. (2020)][7] integrated with the relationship-centered approach



FACT

- Ask the pet owner for permission: **"Thank you for sharing what you read/heard on [enter topic]. Would you be open to having me share some information on [enter topic]?"**
- If the pet owner gives permission, start with an empathy statement: **"I can tell you care a lot about [pet name]'s nutrition. It can be very challenging to find reputable information on [enter topic]."**
- Next state the fact (i.e., the truth) being shared and ensure it is:
  1) short (i.e., like a headline)
  2) simple (i.e., avoids medical/technical jargon)
  3) plausible (i.e., able to "fill the gap" of the false information)
- **Do not rely on "that is false" or "that is not true"**

WARNING

- State the misinformation (i.e., the false information) you aim to debunk: **"There is a lot of misinformation available online pertaining to [enter topic], including [enter one point shared by the pet owner previously]."**
- **Warn that misinformation is being shared to avoid reinforcing false information**
- **Only state the misinformation once (i.e., do not repeat)**

EXPLANATION

- Clearly explain why the misinformation is false by: 1) providing the truth (i.e., "filling the gap" of the false information) 2) by pointing out inconsistencies (i.e., the false information does **not** explain X, Y, and Z)
- **This explanation must occur right after the misinformation is stated to avoid reinforcing the false information**

FACT

- Restate the fact ensuring it is short, simple, and plausible
- Next, follow up with reputable resources: **"We have several reputable resources we can share for you to review at home if you are interested in more information."**
- Lastly, offer to book a follow-up appointment: **"We would be happy to book a follow-up appointment to address any further questions you have after reviewing the resources."**

Figure 2. Debunking misinformation example related to corn as an ingredient in dog foods



FACT

- Ask the pet owner for permission: **"Thank you for sharing what you read on corn. Would you be open to having me share some information on corn as an ingredient in dog foods?"**
- If the pet owner gives permission, start with an empathy statement: **"I can tell you care a lot about her nutrition. It can be very challenging to find reputable information on ingredients used in dog foods online."**
- Next state the fact (i.e., the truth) being shared ensuring it is short (i.e., like a headline), simple (i.e., avoids medical/technical jargon), and plausible (i.e., able to "fill the gap" of the false information): **"Corn is nutritious, and it provides dogs with starch, fiber, protein, and fat."**

WARNING

- State the misinformation (i.e., the false information) you aim to debunk: **"There is a lot of misinformation available online pertaining to ingredients in dog foods, including corn not having any nutritional value to dogs because their ancestors are wolves."**

EXPLANATION

- Clearly explain why the misinformation is false by providing the truth (i.e., "filling the gap" of the false information) and by pointing out inconsistencies (i.e., the false information does not explain X, Y, and Z)

"Pet dogs differ from their wolf ancestors. A study on the genetics of dogs compared them to their wolf ancestors and revealed dogs have adapted to thrive on starch-containing diets as they started to become domesticated."[13]

"Another important study showed near perfect digestion of starch, in fact it was 99%, by dogs fed certain dry food diets made with corn."[14]

"Corn oil is a concentrated source of the essential omega-6 fatty acid dogs require for skin and coat health, called linoleic acid."[15]

"Gluten is a term used to describe protein from plants. Corn gluten meal is a source of amino acids, which are the building blocks of proteins."

"Fiber helps provide a feeling of fullness, helps with regular bowel movements, and helps nourish the microbiome. Corn bran is a source of dietary fiber."

FACT

- Restate the fact ensuring it is short, simple, and plausible: **"Corn provides nutrition to dogs, which are very different from their wolf ancestors. Corn provides dogs with starch, fiber, protein, and fat."**
- Next, follow up with reputable resources: **"We have several reputable resources we can share for you to review at home if you are interested in more information."**
- Lastly, offer to book a follow-up appointment: **"We would be happy to book a follow-up appointment to address any further questions you have after reviewing the resources.**

as negative marketing claims they have shared, is an important first step to debunking misinformation.

A SYSTEMATIC AND RELATIONSHIP-CENTERED APPROACH TO DEBUNKING MISINFORMATION

Lewandowsky et al. (2020) have developed a systematic approach (four distinct steps) to debunking misinformation and provide an important reminder that, ***"The truth is often more complicated than some viral false claim. You must invest effort in translating complicated ideas so they are readily accessible to the target audience—so they can be easily read, easily imagined, and easily recalled."***[7] In the author's experience, this systematic approach works best layered with the supportive nature of the **relationship-centered approach** in veterinary medicine. **Figure 1** depicts a framework created to integrate both approaches and **Figure 2** provides an example of debunking misinformation related to corn as an ingredient in dog foods.

COMMON PET OWNER QUESTIONS

Table 1 summarizes common topics pet owners often have questions about with a focus on definitions, nutritional adequacy, and the author's advice for handling these types of questions. **Table 2** focuses on pet food claims and the associated misinformation pet owners often come across when searching for information on these claims. Facts are also provided to support debunking misinformation using the systematic approach [adapted from Lewandowsky et al. (2020)] integrated with the relationship-centered approach (see **Figures 1** and **2**).[7]

Table 1. Common topics in nutrition that pet owners often have questions about, with advice on handling these types of questions

Common topics	Definitions, nutritional adequacy, and author's advice
"Complete and balanced" foods	**Definitions for the United States:** ▪ "**Complete,**" as defined by the American Association of Feed Control Officials (AAFCO), means the pet food provides all the essential (i.e., required) amino acids, fatty acids, vitamins, minerals, and choline for a well-pet.[16] Typically, this assumes **no more than 10% of the pet's daily calories** are coming from "unbalanced foods."[17-19] ▪ "**Balanced**," as defined by AAFCO, means the nutrients are present in the correct ratios for a dog or cat of a particular life stage.[16] ▪ **Nutritional adequacy:** The AAFCO (2025) Official Publication provides recommendations for "complete and balanced" nutrition for the following **nutritional adequacy life stages**:[16] o Gestation, lactation, and growth o Adult maintenance o All life stages (i.e., meets the needs of gestation, lactation, growth, and adult maintenance). ▪ **Author's advice:** The nutritional adequacy statement *(sometimes called an "AAFCO statement")* is the most important piece of information on commercial pet food packages as it identifies if the pet food is "**complete and balanced**." **Definitions for the European Union:** ▪ According to European Union law (EC 767/2009), a pet food that is sufficient for the daily ration by virtue of its composition is considered "**complete**."[20] ▪ **Nutritional adequacy:** FEDIAF also provides tables with recommended nutrient levels so manufacturers can ensure the pet food meets all nutrient requirements.[21] ▪ **Author's advice:** Ensuring the pet food(s) being fed is/are nutritionally "complete" is a critical step during comprehensive nutritional history gathering; however, there is **no specific nutritional adequacy statement** required on pet food packages. **Definitions for all other countries/regions:** ▪ Please review legislation/recommendations in a specific country/region to determine if a particular pet food is "**complete**" and/or "**balanced**."

Table 1. *Continued*

Common topics	Definitions, nutritional adequacy, and author's advice
"Unbalanced foods" or "complementary" foods	**Author's definition:** ▪ "Unbalanced foods" include items that do not contain all the essential (i.e., required) amino acids, fatty acids, vitamins, minerals, and choline in the correct ratios. Typically, this assumes **no more than 10% of the pet's daily calories** are coming from "unbalanced foods."[17-19] **United States:** ▪ **Nutritional adequacy:** Per the AAFCO (2025) Official Publication, commercial "unbalanced foods" for pets will indicate:[16] o "This product is intended for **intermittent or supplementary feeding only**" on the package or must specifically state it is a "**snack**" or "**treat**" on the front of the package. ▪ **Exceptions:** Include flavored toys, chews, bones, hooves, feet, ears, snouts, pizzle sticks, etc. which are all **exempt from labeling**. **European Union:** ▪ **Nutritional adequacy:** For manufacturers following FEDIAF guidelines, "unbalanced foods" will be labeled as "**complementary**."[21] ▪ **Exceptions:** Include "unbalanced foods" containing only a single raw material, e.g., pig ears or chews, which include neither "complete" nor "complementary" on the label. **All other countries/regions:** ▪ Please review legislation/recommendations in a specific country/region pertaining to "unbalanced foods." **Examples of "unbalanced foods" include:** ▪ **Commercial treats/snacks:** Biscuits, soft chews, jerky, dehydrated/freeze-dried animal proteins, "lickable" treats, etc. ▪ **Pill administration treats**. ▪ **Hard chews:** Beef bones, beef hooves, pigs' ears, beef trachea, etc. o Bones/hooves are not recommended nor are open bulk bins in stores since they are at substantial risk for contamination. ▪ **Supplements:** Joint supplements, probiotics, fish oils, etc. ▪ **Human foods:** Chicken, cheese, peanut butter, yogurt, baby food, etc. ▪ **Pet foods that are not complete and balanced:** Cans of meat or fish without added essential fatty acids, vitamins, and minerals. **Author's advice:** ▪ Most "unbalanced foods" increase the cost per day of feeding drastically, so reducing them to under 10% of calories daily not only improves the balance of the diet, but also helps clients with cost constraints meet their pet food budget.[22]
"Mixed feeding"	▪ **Author's definition:** "Mixed feeding" involves feeding a combination of two or more diet types (e.g., dry food mixed with canned food or dry food mixed with a cooked homemade diet). ▪ **Nutritional adequacy:** If each product being fed is "**complete and balanced**," and no more than 10% of calories are being fed from "unbalanced foods" daily, then the "mixed feeding" approach will meet the nutritional needs of the well-pet *(see above for more information on "complete and balanced" and "unbalanced foods")*. ▪ **Author's advice:** Pets can be particular when it comes to textures of foods offered, especially cats and small dogs, so the author recommends introducing a variety of textures (e.g., dry food, morsels in gravy, pâté, homemade foods, etc.) as early as possible in life to ensure acceptance throughout life.

Table 1. *Continued*

Common topics	Definitions, nutritional adequacy, and author's advice
Cooked commercial diets (or "premade cooked homemade diets")	▪ **Author's definition:** Cooked commercial diets are *"prepared commercially to resemble a homemade diet,"* and are available in a variety of formats (e.g., shelf-stable boxes/bowls, refrigerated packages, or frozen packages).[23] ▪ **Nutritional adequacy:** Check the nutritional adequacy statement on the package to ensure the product is "complete and balanced" *(see above for more information on "complete and balanced").* ▪ **Author's advice:** Discuss the increased cost per day of feeding cooked commercial diets with pet owners and ensure they fit their pet food budget.[2]
Cooked homemade diets (or cooked home-prepared diets)	▪ **Author's definition:** Cooked homemade diets are *"prepared at home by the owner after purchasing individual ingredients"* (e.g., meats, grains, vegetables, vitamins, minerals, etc.).[23] ▪ **Nutritional adequacy:** Check the credentials or guarantee of nutritional adequacy by the originator of the recipe, if a recipe is being followed by the pet owner[23] as the majority of recipes are not "complete and balanced."[24,25] ▪ **Author's advice:** Providing reputable resources to pet owners who wish to prepare a homemade diet is critical to ensure the diet is prepared in a manner that minimizes harm to the well-pet). Using a specialist in veterinary nutrition, such as a board certified veterinary nutritionist, can help ensure the formula is appropriate for the pet.[26,27]
Raw commercial diets (or "premade raw homemade diets")	▪ **Author's definition:** Raw commercial diets are *"prepared commercially to resemble a homemade diet,"* and are available in either refrigerated or frozen packages.[23] In the United States, these commercially available diets must comply with the Food Safety Modernization Act, which has a zero-tolerance policy for pathogens.[28] ▪ **Nutritional adequacy:** Check the nutritional adequacy statement on the package to ensure the product is "complete and balanced" *(see above for more information on "complete and balanced").* ▪ **Author's advice:** Advise pet owners to ensure the manufacturer is using a methodology with a **validated kill-step to ensure bacterial pathogen reduction**, and that the **manufacturer's pathogen testing of finished pet foods** includes zero-tolerance for pathogens. If this information cannot be confirmed, recommend a product from a manufacturer that can confirm this information.
Raw homemade diets (or raw home-prepared diets)	▪ **Author's definition:** Raw homemade diets are "prepared at home by the owner after purchasing individual ingredients" (e.g., meats, eggs, dairy, organ meats, bones, vegetables, etc.), and the ingredients are fed uncooked.[23] ▪ **Nutritional adequacy:** Check the credentials or guarantee of nutritional adequacy by the originator of the recipe, if a recipe is being followed by the pet owner[23] as the majority of recipes are not "complete and balanced."[24,25] ▪ **Author's advice:** o Provide reputable resources *(see cooked homemade diets above for details).* o Encourage pet owners to cook all animal proteins (i.e., a cooked homemade diet) to a safe internal temperature as a kill-step for pathogens, which will also reduce anti-nutritional factors (e.g., avidin in raw egg whites and thiaminases in raw fish/shellfish).[29] o Encourage pet owners to provide safe options for chewing (**not bones, hooves, or antlers**) and provide resources on tooth brushing, which is the gold standard for oral health.

Table 1. *Continued*

Common topics	Definitions, nutritional adequacy, and author's advice
Commercial or cooked homemade "plant-based diets"	▪ **Definition:** "Plant-based" diets do not contain any ingredients of animal origin.[30,31] ▪ **Nutritional adequacy**: o "**Dogs** have dietary requirements for energy and essential nutrients, but they do not have a recognized requirement for animal-derived ingredients;" "however, special care must be taken when formulating "plant-based diets" to ensure that all nutrient requirements are met, particularly requirements for concentrations of total protein, methionine, taurine, DHA [docosahexaenoic acid], and vitamins A, B12, and D3 because these nutrients are typically obtained from animal-based ingredients."[30] o **Cats** are obligate carnivores and require nutrients from animal-based sources, such as retinol (vitamin A), cobalamin (vitamin B12), and arachidonic acid (an omega-6 fatty acid), and should not be fed plant-based diets as their sole **source of nutrition.**[23,30,31] ▪ **Author's advice:** o If a **dog owner** wishes to feed a "plant-based diet," provide reputable resources *(see cooked homemade diets above for details)*. o **Cats** should not be fed "plant-based diets," unless they are being fed as a treat (i.e., an "unbalanced food") and make up less than 10% of calories daily. o Avoid use of the term "vegan" to describe pet foods as "veganism" is a human lifestyle and involves more than simply dietary choices.[31]

Table 2. Pet food claims and associated misinformation: Facts for debunking misinformation

Claims, common misinformation, and facts	Details
"Human-grade" **Common misinformation:** Human-grade pet foods are more nutritious. **Fact:** The term "human-grade" pertains specifically to ingredient sourcing and manufacturing processes. It does not provide insight into the nutrition supplied by a particular product.	**United States:** ▪ **Definition:** "Human-grade" is a **voluntary claim** defined in the AAFCO Official Publication which pertains to **ingredient sourcing and manufacturing processes**.[16] ▪ **Regulations:** The AAFCO "human-grade" Pet Food Standard Checklist must be met when applying under the United States Department of Agriculture (USDA) Agriculture Marketing Service Process Verified Program to qualify as a human food facility.[32] ▪ **Ingredients:** 100% of the pet food must be made from human-edible ingredients (i.e., ingredients fit for human consumption), and must have been stored, handled, processed, transported, and documented consistent with human food regulations. ▪ **Manufacturing facility:** The facility is registered/licensed to produce human food and may also be registered to produce animal food. ▪ **Inspections:** An audit of the facility must be conducted annually by the USDA Agriculture Marketing Service and/or another enforcement authority with applicable food safety regulations. ▪ **Pet food labeling:** The term "human-grade" must be linked with the intended use of the product (e.g., "human-grade cat food" or "human-grade dog biscuits") and the remainder of the label must comply with all applicable labeling rules.

Table 2. *Continued*

Claims, common misinformation, and facts	Details
	European Union: ▪ There is currently no European-wide regulation for a "human-grade" claim. **All other countries/regions:** ▪ Please review legislation/recommendations in a specific country/region to determine if "human-grade" claims can be made.
"Natural" **Common misinformation:** "Natural" pet foods are more nutritious. **Fact:** The term "natural" refers to ingredients that are sourced only from plants, animals, or mined from the earth. It does not provide insight into the nutrition supplied by a particular pet food.	**United States:** ▪ **Definition:** "Natural" is a **voluntary claim** defined in the AAFCO Official Publication as an ingredient derived only **from plant, animal, or mined (i.e., from the earth) sources** that are either processed or unprocessed.[16] ▪ **Processed ingredients:** "Natural" ingredients may be "processed" in different ways and still considered "natural": o **Physical:** E.g., removal of feathers/hides, separating cuts of meat/bones, separating corn bran and oil from corn kernels, grinding/mixing of meat, etc. o **Heat:** Cooking ensures products are safe for consumption, including pasteurization of milk, retorting of canned foods, extruding of kibble, and cooking of homemade diets. o **Rendering:** Repurposes nutritious animal products that are simply not preferred by humans (e.g., bones, fats, and proteins) to provide safe/clean products, which is a **critical sustainable practice to reduce food waste**.[33] o **Fermentation:** Anaerobic (i.e., without oxygen) fermentation of carbohydrates by microorganisms (e.g., bacteria, yeast, and molds). o **Other methods:** Purification, extraction, hydrolysis, and enzymolysis can also be used with "natural" ingredients. ▪ **Unprocessed ingredients:** An example of unprocessed food would be an entire chicken carcass, including feathers, immediately after slaughter. ▪ **Excluded ingredients/processing:** Cannot include synthetic processes nor ingredients. ▪ **Pet food labeling:** The term "natural" may appear on pet food packaging in several ways that are not misleading to pet owners. o **Complete and balanced pet foods** require vitamins, minerals, and sometimes amino acids to ensure they are nutritionally complete, which requires some synthetic nutrients to be added, so a disclaimer can be added following "natural" so long as all other ingredients meet the definition (e.g., "Natural cat food with added vitamins, minerals, and nutrients"). o **Specific ingredients** can be referred to as "natural" so long as they meet the definition (e.g., natural tuna flavor). o **Treats (for intermittent or supplemental feeding only)** can be referred to as "natural" if 100% of the ingredients meet the definition (e.g., natural peanut butter flavor dog biscuits). Some functional treats may contain certain synthetic nutrients and be referred to as "natural" with the same qualifying language as for complete and balanced foods (e.g., "natural with added vitamins"). **European Union:** ▪ FEDIAF recommends that the term "**natural**" be used only to describe substances in pet food, derived from plant, animal, microorganism, or mineral, to which nothing has been added and which have been subjected only to such physical processing as to make them suitable for pet food production and maintain the natural composition.[21] **All other countries/regions:** ▪ Please review legislation/recommendations in a specific country/region to determine if "natural" claims can be made.

Table 2. *Continued*

Claims, common misinformation, and facts	Details
"Organic" **Common misinformation:** "Organic" pet foods are more nutritious. **Fact:** The term "organic" refers to agricultural practices. It does not provide insight into the nutrition supplied by a particular pet food.	**United States:** ▪ **Definition:** "Organic" is a voluntary claim that can be used if USDA National Organic Program regulations have been met.[16] ▪ **Regulations:** USDA National Organic Program certifying agents must review and approve pet food labels for compliance with organic claim regulations.[34] ▪ **Pet food labeling**: Four different "organic" labels can be used: o **"100% organic":** The entire product must be made from certified organic ingredients, requires certification for use of the USDA Organic Seal, and the name of the certifying agent must be included on the package. o **"Organic":** The product must contain at least 95% certified organic ingredients, requires certification for use of the USDA Organic Seal, and the name of the certifying agent must be included on the package. o **"Made with organic [specified ingredients or food group(s)]":** Must contain at least 70% certified organic ingredients that are identified on the ingredient list, requires certification, and the name of the certifying agent must be included on the package (cannot use the USDA Organic Seal nor "made with organic ingredients"). o **"Products containing less than 70% organic ingredients":** Can only specify specific ingredients are organic in the ingredient list and can state the percent of organic ingredients (does not require certification, cannot use the USDA Organic Seal, and cannot use "organic" on the front of the package). o **Excluded ingredients/processing:** Cannot contain genetically engineered ingredients, which only includes certain varieties of the following in the United States: Alfalfa, apple, canola, corn, cotton, eggplant, papaya, pineapple, potato, salmon, soybean, summer squash, sugar beet, and sugar cane.[35] **European Union:** ▪ Pet food can be labeled with the European Union organic production logo if 95% of its agricultural ingredients are organic (similar to food for human consumption).[36] **All other countries/regions:** ▪ Please review legislation/recommendations in a specific country/region to determine if "organic" claims can be made.
Dental-related claims **Common misinformation:** Canned foods cause dental disease. **Facts:** A prior study indicated that dry foods may help prevent buildup of plaque/tartar; however, other studies found no difference between dry versus wet foods when assessing levels of plaque/tartar.[37]	**United States:** ▪ **Definition:** Voluntary dental-related claims for pet products (e.g., pet foods, snacks, treats, rawhides, and other chews) that use **mechanical action (i.e., scrubbing/abrasion)** are allowable per the AAFCO Official Publication.[16] ▪ **Claim exclusions:** The claim should not imply that the product helps prevent or treat dental diseases (e.g., gingivitis, periodontal disease, etc.) as this type of product would require approval using a Food and Drug Administration (FDA) New Animal Drug Application; however, products that may reduce/prevent plaque/tartar/halitosis through mechanical means are "low priority" for enforcement. ▪ **Ingredient exclusions:** Ingredients not **Generally Recognized as Safe (GRAS)** for the teeth/gums may be considered unapproved food additives/drugs. **Veterinary Oral Health Council (VOHC) (Worldwide):** ▪ **Definition:** The VOHC authorizes use of the VOHC Seal on pet products that slow plaque/tartar formation based on at least two standardized studies that must prove a statistically significant benefit for pets and must be repeatable.[38]

Table 2. *Continued*

Claims, common misinformation, and facts	Details
Facts: Toothbrushing remains the best option for preventing dental disease. Dental chews and treats can be included if unbalanced calories are kept at less than 10% of total daily calories.	▪ **Precautions:** Many of the approved dental chews will **exceed 10% of daily calories**, which will unbalance the diet for many **All other countries/regions:** ▪ Please review legislation/recommendations in a specific country/region to determine if dental-related claims can be made.

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COMMUNICATING WITH PET OWNERS ABOUT INGREDIENTS IN PET FOOD

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KEY TAKEAWAYS

- Ingredients are the vehicles of nutrients. Ingredient quality is very important for the overall nutritional value and safety of pet foods and is a focus of pet owners when deciding what to feed their pets.
- There are many misconceptions surrounding pet food ingredients, and the veterinary health care team must be able to provide accurate and unbiased facts to pet owners.
- It is recommended to avoid engaging with myths or misconceptions and instead focus on what to communicate about the ingredient, to avoid further spread of the wrong concepts and to keep the conversation from becoming antagonistic.

INTRODUCTION

There are hundreds of pet food options for healthy cats and dogs. Making a choice can be an overwhelming decision for pet owners, and the veterinary health care team should be the main source of assistance.[1–4] However, it is an underutilized resource. For example, one survey-based study found that 53–54% of pet owners from the United States and Australia obtained their information on pet nutrition from the veterinary health care team,[4] with other sources being family and friends, the internet, social media, pet store staff, and pet paraprofessionals (breeders, trainers, and groomers). Another survey[2] among dog breeders in the United States and Canada found that veterinarians were identified as somewhat (32.8%) to very (36.1%) trustworthy regarding nutritional information, and 49.3% used veterinarians as a resource for nutrition information. The type of feeding practice (conventional, homemade, raw, etc.) can affect the degree of trust that the public has in the veterinary health care team.[2,3,5,6] Primary care veterinarians cite barriers[7] to discussing nutrition information with clients, plus not all patients necessarily receive a nutritional assessment.[8] One study[9] identified these barriers as lack of time, misinformation and information overload, pet owner's apprehension towards new information, and veterinarian's lack of confidence in nutrition knowledge and communication skills. These authors propose potential solutions, including improving education of veterinary teams both in nutrition and communication, access to client-friendly resources, and empowering veterinary technicians and other veterinary health care team members to discuss nutrition.

There is, therefore, room for improvement in client communication regarding nutrition, including discussing pet food ingredients. One of the main advantages of the veterinary health care team over other nutrition sources is that they can perform a nutritional assessment[10] to identify nutritional risk factors and narrow down the available choices for something adequate and customized for each individual pet. An additional way to help with diet choice is to assess the quality of the food. The WSAVA has tools to help with this task, mainly focused on vetting the manufacturer's expertise and quality control. While the label information can help with this decision as well, the nutritional information there is limited, including that provided by the ingredient list. It is important to know what information we can and cannot gather from this, as ingredient quality is important to pet owners.[3]

THE INGREDIENT LIST ON THE LABEL

The ingredient list differs depending on the country's legislation. For example, in the United States, all ingredients must be reported, by order of weight of inclusion, including both raw materials and additives such as vitamins and minerals. In the European Union (EU), only the raw materials are declared, also by order of inclusion, either by their individual name or as categories legally defined (**Table 1**). Ingredients that can be used in pet food are also regulated.

Table 1. Categories of ingredients that can be used instead of individual ingredient names in pet food in the EU (adapted from commission directive 82/475/EEC)[24]

Category	Description
Meat and animal derivatives	All the fleshy parts of slaughtered warm-blooded land animals, fresh or preserved by appropriate treatment, and all products and derivatives of the processing of the carcass or parts of the carcass of warm-blooded land animals
Milk and milk derivatives	All milk products, fresh or preserved by appropriate treatment, and derivatives from the processing thereof
Eggs and egg derivatives	All egg products, fresh or preserved by appropriate treatment, and derivatives from the processing thereof
Oils and fats	All animal and vegetable oils and fats
Yeasts	All yeasts, the cells of which have been killed and dried
Fish and fish derivatives	Fish or parts of fish, fresh or preserved by appropriate treatment, and derivatives from the processing thereof
Cereals	All types of cereal, regardless of their presentation, or products made from the starchy endosperm
Vegetables	All types of vegetables and legumes, fresh or preserved by appropriate treatment
Derivatives of vegetable origins	Derivatives resulting from the treatment of vegetable products, in particular cereals, vegetables, legumes, and oil seeds
Vegetable protein extracts	All products of vegetable origin in which the proteins have been concentrated by an adequate process to contain at least 50% crude protein, as related to the dry matter, and which may be restructured (textured)
Minerals	All inorganic substances suitable for animal feed
Various sugars	All types of sugar
Fruit	All types of fruit, fresh or preserved by appropriate treatment
Nuts	All kernels from shells
Seeds	All types of seeds as such or roughly crushed
Algae	Algae, fresh or preserved by appropriate treatment
Mollusks and crustaceans	All types of mollusks, crustaceans, shellfish, fresh or preserved by appropriate treatment, and their processing derivatives
Insects	All types of insects and their stages of development
Bakery product	All bread, cakes, biscuits, and pasta products

The ingredient name, however, does not give information on nutritional profile, bioavailability of those nutrients, or other indicators of quality (such as freshness) (**Figure 1**). Moreover, the overall nutritional value of the final product depends not only on the individual ingredients but also on their interaction and the effect of processing, none of which can be assessed by reading an ingredient list.

Another common recommendation, used by pet food ranking websites among others, is to look at the ingredient placement within the list, assuming that the ingredient will be providing more nutrients the higher it is on the list. This assumption is not true, as the order of the ingredients is based on the ingredient weight "as is." Therefore, high moisture ingredients will be high on the list due solely to their water content. Moreover, even if this were true, nutritional value cannot be predicted by ingredient order no more than by their name. It is also frequent to see ingredient claims as a way to claim higher quality, but with no relation to nutrient content.

For example, pet foods can claim high contents (> 50%) of fresh or frozen meat, without having a high protein content compared to other foods, as the meat provides not only a high amount of water but also of fat.

CONTROVERSIAL INGREDIENTS IN PET FOOD

Cereals (corn, wheat)

Grain free diets are very popular, and pet owners that use them might consider cereals, particularly corn and wheat, to be less healthy for their pet, promote allergies, and have other negative attributes. These ingredients are often called "fillers," insinuating that they have no nutritional value and are included to cheapen the product.

Cereals are great ingredients to use for canine and feline nutrition. They provide carbohydrates (mainly starch) as a readily available energy source. Carbohydrates are not an essential nutrient, because pets can synthesize glucose from other substances like certain amino acids. That said, in lactating dogs, carbohydrates are considered conditionally essential for adequate milk production. However, their inclusion has many benefits, including calorie moderation, avoiding excess protein (which is wasteful for the environment), and fiber provision. Cereals, particularly, not only provide starch but also protein, essential fatty acids, and a variety of vitamins and minerals.[11] Cereals have been used for decades in the pet food industry, and there is no evidence showing that they are inferior nutritionally to other carbohydrate sources (like root vegetables or pulses). All of these can be used safely in pet food as long as the manufacturer has the necessary expertise to know the correct amounts and processing needed for their use.

Some cereals provide gluten, and there are some disease conditions where gluten free diets could be helpful, but it is not a cause of problems for healthy pets.

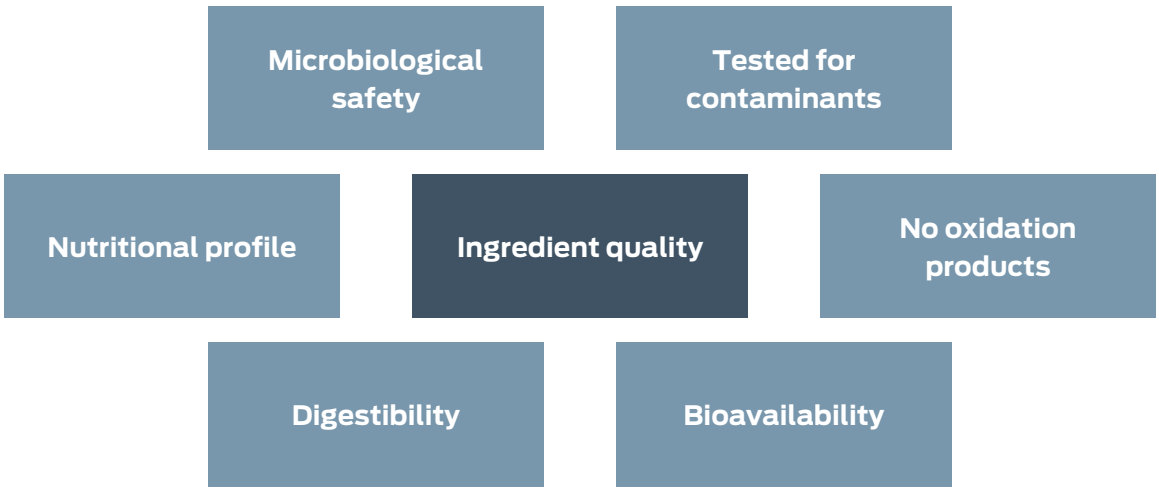
By-products

AAFCO defines by-products as secondary products produced in addition to the principal product.[12] For example, bran fibers are by-products of the bread and bakery industry, where the main product is the flour. Pet food uses several by-products, both from animal and plant origin, with animal by-products being the ones with a more fraught reputation. These by-products include edible parts of the animal that are not the noble cuts of skeletal muscle sold to people, but this can vary depending on the country, as what different cultures consider desirable varies greatly. Regulations in different countries will define which parts of the animal can and cannot be included as by-products; for example, in the United States, organ meats are included while other items such as horns, hooves, and intestinal content are excluded. The AAFCO Official Publication[12] has ingredient definitions that can be consulted to allay pet owner concerns. By-products, therefore, can be highly nutritious, and their use reduces waste.

Meals

Meals are a dehydrated protein source obtained by rendering meat, poultry, or fish, or meat/poultry/fish by-products. The rendering process[13,14] separates the fat from the water-soluble part, the latter then being dried and milled to make a meal. The separated

Figure 1. Factors affecting quality of an ingredient



COMMUNICATION TIP

If some ingredient questions come up frequently, it is useful and a time-saver to prepare and provide resources that the client can either take home or read on the clinic's website.

fat is also a common, highly palatable ingredient in pet foods (usually reported as "animal fat," can be identified with the name of the species, like "chicken fat"). Rendering increases microbiological safety and provides a concentrated source of protein, having thus an important role in sustainability.[15] Most people are concerned about the environment, and as such, explaining the benefits of not wasting perfectly nutritious ingredients can have a strong impact.

Meals, compared to raw meat, are heat processed before the pet food manufacturing process, which can have negative effects on digestibility of protein and amino acids.[16] The use of meals versus meat can also affect texture and flavor,[17] but not always in a negative manner. This stresses the importance of ingredient quality assessment (for by-products and for any ingredient) and pet food formulation expertise, to use these ingredients safely and to maximize their nutritional value.

TIPS TO ANSWER INGREDIENT QUESTIONS

There are resources to improve nutrition communication with clients.[18–21] One Canadian study[22] in particular identified client resistance to dietary advice when veterinarians proposed actions before gathering diet information, asking the client's perspectives, or educating them about the benefits of such changes. So, the first tip would be to ensure the veterinary health care team has performed a nutritional assessment and has asked the client for their preferences and opinions regarding their pet's dietary management. Ultimately, it is the pet owner who will buy and provide the food; therefore, they must be comfortable with any diet they choose, including the ingredients that the diet includes.

In the author's experience, keeping the conversation positive and judgment-free is important to communicate clearly, as nutritional conversations can be very emotional and personal. The author also recommends validating the pet owner's concerns about ingredients, as the amount of information and misinformation is staggering, and it is perfectly reasonable to be concerned about them. It helps to keep in mind that the pet owner and the veterinary health care team share the main goal: to ensure the pet gets a complete and balanced diet that will provide adequate nutrition for the species, life stage, and any sensitivities, and that will promote health and longevity.

Avoiding "myth busting" is also recommended.[23] It is best to focus on the facts you wish to communicate in a simple and concise manner (e.g., "cereals are safe and nutritious ingredients that provide many different important nutrients for your pet" or "by-products are very nutritious. They are considered delicacies in many cultures") and only mention the misconception after the fact has been communicated and why there are misconceptions about the topic, finishing up again with the information you want to communicate. This helps keep the conversation less antagonistic and puts less pressure on the pet owner.

Asking specifically why there is discomfort about certain ingredients will help identify the best way to discuss them. Even if the concerns cannot be allayed, knowing the details can help find complete diets for the patient that both the pet owner and the veterinary team are comfortable providing.

If some ingredient questions come up frequently, it is useful and a time-saver to prepare and provide resources that the client can either take home or check on the clinic's website. Then the pet owner can peruse at their own time. Both AAFCO and FEDIAF provide ingredient information on their website and can be used as resources for the clinic materials, in addition to articles and books on small animal nutrition.

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COMMUNICATING WITH PUPPY AND KITTEN OWNERS ABOUT NUTRITION

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KEY TAKEAWAYS

- Veterinary technicians are integral in maintaining regular communication with pet owners, guiding them on their puppy and/or kitten's nutritional goals, feeding management, and pursuing/advocating for appropriate growth rates, body condition scores, and muscle condition scores.
- Be creative in providing interactive feeding strategies, moving away from classic bowl feeding to stimulate cognitive engagement and potentially slow feeding consumption rates.
- Treats can be a major part of the human-animal bond for clients. Talk with owners early about the calorie allotment for treats and common categories providing concentrated calories and encourage owners to explore calories per treat when considering the options.

The opportunity to welcome a puppy or kitten into the home is an exciting experience, whether it is a pet owner's first or fourth. This excitement often brings a strong desire to provide the very best for their new companion, especially when selecting the diet. A survey reported 96% of pet owners trust their veterinarian on advice on pet nutrition.[1] Veterinary teams are in a unique position to guide owners, offering evidence-based nutrition support through a trusted relationship with the pet owner. When the veterinary team hesitates to offer clear nutritional guidance, owners are often left to seek advice elsewhere. This may complicate the pet owner's understanding and could interfere with future nutrition discussions when prioritizing the best diet for their pet. Veterinary nurses/technicians, including licensed technicians where applicable, are well-positioned to take the lead in discussing nutrition considerations outlined below when a puppy or kitten presents to the clinic.

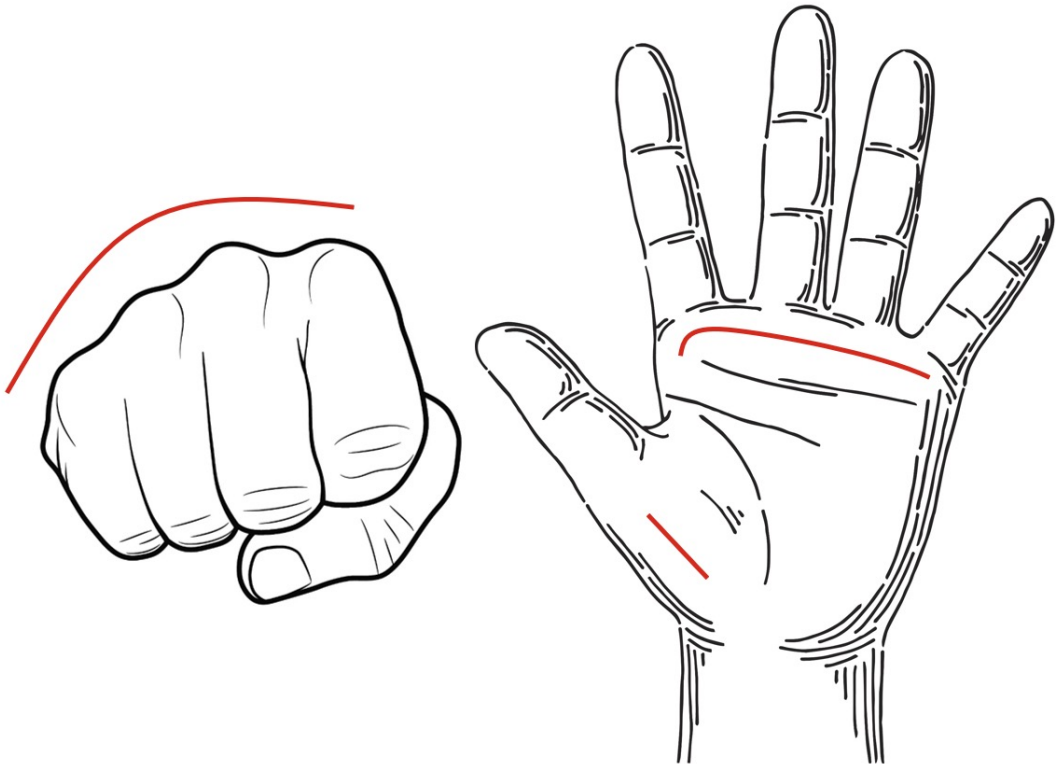
BODY WEIGHT, BODY CONDITION SCORING AND MUSCLE CONDITION SCORE

It has been reported that pet owners tend to underestimate the body condition of their pet,[2] emphasizing the importance of equipping every team member to perform and teach body condition scoring (BCS)[3,4] and muscle condition scoring (MCS),[5] at each visit. By involving the owners in the process of obtaining a body weight and estimating BCS and MCS, veterinary teams can identify trends that support proactive management while also enhancing the pet owner's understanding of what constitutes a healthy body weight, BCS, and MCS. Dogs with an ideal BCS can live up to two years longer compared to those that are overweight (BCS 6–7/9).[6] Communicating the longevity impact of maintaining a healthy weight provides pet owners an opportunity to prolong time with their beloved companion. If BCS is unfamiliar watch these short videos for how to perform a BCS assessment in a dog and cat.

One readily available tool to facilitate discussions about assessing body condition is the "hand example." **Figure 1** illustrates this concept using two hand positions—one closed and one open. When speaking with a pet owner, ask them to make a fist and then run a finger over the knuckles of the closed fist. This action simulates the rib space of an underconditioned puppy or kitten (BCS < 4/9). Next, have them open their hand and run a finger over the inside of the knuckles, which represents an ideal body condition (4–5/9 BCS). Finally, pressing against the thumb muscle demonstrates the difficulty of feeling the ribs in an overconditioned puppy or kitten (BCS 8–9/9).

Once a body weight, BCS, and MCS are obtained (at every visit), consider using published puppy and kitten growth charts starting at twelve weeks of age. Prepare

Figure 1. The "hand example" used to illustrate the assessment of body condition in puppies and kittens. The closed fist represents an underconditioned state, the open knuckles demonstrate an ideal condition, and the thumb region illustrates the difficulty in feeling ribs in an overconditioned pet.



the owner to track body weight every two weeks until the pet is six months of age, then monthly until fully grown. The growth charts feature curved lines that represent the expected normal growth for a puppy or kitten within the estimated adult weight category. If the body weight falls outside of the expected curve, adjustments to caloric intake should be made, either reducing or increasing the rate of growth depending on the desired outcome. Support staff should take body condition photos each time a puppy or kitten presents to the clinic. **Figure 2** provides examples of several photos that should be captured while the pet is standing, including shots from above (bird's eye), the side, front, and behind, along with a "personality" shot. These images can be uploaded to the pet's medical record for future reference, aiding in discussions about nutrition goals.

SELECTING A PUPPY AND KITTEN DIET

As part of the initial visit, many pet owners are quick to ask, "What should I feed my puppy or kitten?" Veterinary nurses can lay the groundwork for seeking expert nutrition advice from the veterinary team by educating pet owners in choosing the right diet(s) for puppies and kittens. Consider discussions focusing on labeling and explaining the importance of using a "complete" product—contains all the nutrients required—and "balanced" product—the nutrients are present in the correct ratios—as one step in supporting healthy growth. In Europe, the legislation requires using "complete" for complete and balanced products. Guiding owners through nutritional adequacy statements on labels (on the bag or sides of package, in small print), highlighting diets formulated to meet growth (or all-life-stages) for Association of American Feed Control Officials (AAFCO)[7] or FEDIAF,[8] empowers pet owners to match the pet's nutritional needs with the appropriate life stage goals.

Additionally, while it may seem intuitive to the veterinary profession, it is important to clarify that puppies and kittens require species-specific growth diets to meet their unique nutritional needs. This helps prevent unintentional deficiencies caused by the assumption that all growth diets are the same and can be intermixed. Dogs also require size-specific diets. For example, guidelines for large and giant breed puppies specify that these diets should meet the lower maximum calcium versus other growth diets, and these diets have a specific calcium to phosphorus ratio.[7] Large and

Figure 2. Body condition score and "personality" photos of a dog at 1 year of age and a kitten at 6 months of age



giant-breed puppies are at increased risk for orthopedic disease and overfeeding puppies increases the risk for developmental diseases. As a result, some large and giant-breed puppy diets have a reduced energy density to facilitate slow growth and help maintain an ideal BCS, but, in all cases, these diets should be carefully portioned to maintain an ideal BCS.

For small and medium-breed dogs and for cats, puppy and kitten diets should be fed until skeletal maturity is reached, typically around 1 year of age. However, in large and giant-breed dogs, skeletal maturity may not occur until 2 years, requiring an extended period of feeding puppy diets. Once the pet reaches adulthood, the pet owner should gradually transition to an adult maintenance diet over a period of at least 7 days. As a veterinary nurse/technician, it is important to provide the pet owner with specific guidance on the appropriate calorie goals and feeding volumes for the selected adult diet to support weight maintenance at a BCS of 4–5/9.

Given the large variety of puppy and kitten diets available and owner preferences, providing owners with the guidelines on selecting pet foods handout developed by the World Small Animal Veterinary Association (WSAVA)[9] can help assess the brand/company of interest beyond the marketing images and phrases on the bag. Although this method does not determine nutritional adequacy, it can provide insight into the company's approach in the development of pet food.

FEEDING MANAGEMENT

Once the appropriate puppy or kitten diet is selected, effective feeding management plays a key role in achieving and maintaining an ideal body weight while ensuring a complete and balanced diet throughout growth. With the veterinary team's involvement, the feeding amount can be tailored specifically to the individual puppy or kitten, which may differ from the recommendations on the product packaging. When choosing an appropriate growth diet, feeding volumes are primarily determined by the pet's caloric needs. To calculate this, first determine resting energy requirement (RER) and then apply a life stage factor to calculate the maintenance energy requirement (MER). These calculations are based upon the pet's current body weight, which at a BCS of 4–5/9 is considered ideal. Adjustments to the MER are necessary when the puppy or kitten is not of an ideal body condition. The caloric estimations are part of the iterative process in nutrition. As the pet returns for body weight rechecks, adjustments to the previously guided caloric and feeding targets may be required in order to continue supporting an ideal body weight, BCS, and MCS throughout growth. The calculations shown in **Box 1** are provided as an example to help determine a puppy's or kitten's energy needs and guide appropriate feeding adjustments based on their growth. More information can be found in the Practical Tool: Useful Calculations in Nutrition.

Box 1. Calculating energy requirements for puppies and kittens

Life Stage	Growth
Feline Life Stage Factor	≤ 4 months: 3.0 > 4 months: 2.0
Canine Life Stage Factor	≤ 4 months: 3.0 > 4 months: 2.0

Calculation example: 5-month-old, intact female, domestic short hair

Body weight: 2.4 kg (5.3 lb)

BCS: 5/9

MCS: normal musculature

RER = 70 ($2.4^{0.75}$)
= 70 (1.93)
= 135 kcal per day

MER = 135 x 2.0 = **270 kcal per day**

It is important to note that life stage factors are estimates used to calculate a pet's caloric needs. Use of growth charts alongside the BCS and MCS estimates help guide feeding goals. These life stage factors likely need adjustments periodically, either increasing or decreasing, throughout the growth phase to maintain an ideal body condition. This underscores the importance of not relying solely on the feeding guidelines provided on the product packaging or on formulas. By making calculated adjustments and clearly communicating these changes with the pet owner, as well as explaining why making these adjustments is important, you can reinforce the value of veterinary guidance in helping pets achieve and maintain an ideal body condition throughout growth and into adulthood.

For example, the 5-month-old intact kitten in the energy calculation example above will likely experience a decrease in energy requirements of up to 30% once she is spayed.[10] At this point, it is crucial to obtain an accurate diet and treat history to help determine the appropriate adjusted calorie goal and feeding volumes, allowing for proactive management of the hormonal changes affecting energy balance and appetite. This is an excellent opportunity for the veterinary nurse/technician to take the lead and provide support to both the pet and pet owner in collaboration with the veterinarian.

If a diet change is necessary or prompted by the pet owner, it is important to explain that diets are not always isocaloric, and feeding volumes must be adjusted with each new diet, regardless of diet format (canned, dry, semi-moist, etc.). Pet owners often continue using the same feeding volumes when switching diets, not realizing this may result in their pet not receiving the appropriate caloric intake. This is an excellent opportunity to revisit the method of quantifying food portions. Pet owners can choose to measure food by weight (in grams) or by volume (using a cup or can), depending on their preference and diet format. If cup measurement is the preference, confirm the use of a standard kitchen measuring cup. While weighing the food in grams provides the most accuracy, especially when multiple people are responsible for feeding, it is generally less favored in some countries, including the United States. However, there are now food scoops available for dry food with an integrated gram scale, offering a more efficient way to measure and feed pets with precision. **Box 2** shows an example for feeding targets based upon grams or cup measures.

Using grams can help ensure more precise feeding. For instance, if a pet owner was instructed to round up from 0.92 cups per day to one cup per day, this adds an additional 29 calories per day for the kitten. While this may not seem significant at first glance, it represents a 10% increase in caloric intake. This shift increases the life stage factor, which may or may not be ideal for the kitten. This again highlights nutrition as an iterative process. If one cup daily was recommended to the pet owner (increasing the daily calories), the kitten's body weight should be rechecked in 2 weeks to pivot and adjust, if the caloric recommendations led to excessive body weight. This example emphasizes the importance of carefully adjusting feeding targets post-spay and neuter to ensure adjusted caloric targets are met without unintentionally increasing intake due to rounding of cup or can measurements.

Once feeding targets are established, either by weight or volume, it is important to consider the method of feeding. Puppies and kittens, regardless of age, often benefit from interactive feeding—simply feeding in something other than a bowl. There are many creative ways to engage them during mealtimes, though initial supervision is crucial to ensure they do not ingest inappropriate items. Some options include:

- Slow feeder bowls
- Slow feeding towers for cats
- Lick mats (canned, semi-moist, soaked kibble)

- Treat dispensing toys (filled with diet/meal feeding)
- Food puzzles (ranging in complexity)
- Snuffle mats

Puppies and kittens older than 12 weeks of age should be fed two to three times a day. Increasing feeding frequency (not caloric targets) and utilization of interactive feeding methods may improve satiety and provide mental stimulation. These feeding practices can be continued into adulthood, with frequency adjusted as needed to align with the pet owner's lifestyle.

Offering a variety of diet formats to young puppies and kittens can be beneficial, helping them experience different textures and tastes. This approach prevents them from becoming accustomed to only one type of food, which could limit dietary options in adulthood if a change is needed for any given reason. To provide exposure to different diet formats, pet owners could incorporate them into the treat allotment, especially if they prefer not to adjust the current daily feeding routine.

Box 2. Example for feeding targets

Feeding amount example calculation:
5-month-old, female, domestic short hair
Body weight: 2.4 kg (5.3 lb)
BCS: 5/9
MCS: normal musculature
MER (2.0 life stage) = 270 kcal per day

Example dry diet being fed provides:
3,823 kcal/kilogram of food
OR
367 kcal/cup

STEP 1a: Determine how many kcal/gram; there are 1,000 grams per kilogram
$\frac{3{,}823 \text{ kcal}}{1{,}000}$ = 3.8 kcal/gram of food

STEP 2a: Calculate how many grams of food to feed daily to meet caloric targets
$\frac{270 \text{ kcal per day}}{3.8 \text{ kcal/gram of food}}$ = 71 grams of food per day

These two steps are the same when determining amount of canned food to feed, measured in grams

Step 1b: Calculate how many cups of food to feed daily to meet caloric targets
$\frac{270 \text{ kcal per day}}{367 \text{ kcal per cup}}$ = 0.74 cups per day

The step is the same when determining amount of canned food to feed, measured in cups or cans

TREATS

When discussing treats with pet owners, it can be helpful to categorize them into two groups: treats given for rewards or fun, and treats intended for dental health or distraction. Pet owners may unintentionally overlook certain treats as part of the conversation, especially if they view them more as a dental aid or distraction toy rather than a traditional "treat." It is essential to emphasize that all items given in addition to the main diet contribute to the total treat allotment. This is important to monitor, as pets should not receive more than 10% of their total daily caloric intake from treats.[11,12] Exceeding this limit can disrupt the balance of the pet's primary diet and may result in nutritional imbalances. When determining the daily calorie allowance for treats, be sure to subtract the 10% from the total daily calorie allotment before calculating the amount of food to feed. In other words, deduct the treat calories from the daily MER, rather than adding them on top of it.

Pet owners often inquire if there are treats that can benefit their pet's dental health. The Veterinary Oral Health Council (VOHC) identifies products that meet specific standards for plaque and tartar control in dogs and cats. Products awarded the VOHC seal suggest that regular use of these products, as recommended, can help reduce the severity of periodontal disease in pets. While some treats are designed to improve dental health, it is important to be mindful of their calorie content and how they fit into the pet's overall treat allotment, as they can sometimes exceed the 10% limit. In such cases, focusing on alternative preventative care methods, like teeth brushing or dental wipes, can be helpful in maintaining oral health without adding extra calories to the total daily intake.

Treats play an important role in most pet owners' relationship with their puppy or kitten. It is important to offer support in choosing appropriate treat options while also providing guidance on limitations to ensure balanced nutrition and a healthy body condition long term.

SUMMARY

Veterinary teams, particularly veterinary nurses/technicians, are positioned to guide pet owners in puppy and kitten nutrition. Educating pet owners on selecting the right food, monitoring healthy growth,

COMMUNICATION TIP

Veterinary nurses/technicians, including licensed technicians where applicable, are well-positioned to take the lead in discussing nutrition considerations during puppy and kitten visits.

and enhancing feeding and treat management to ensure a complete and balanced diet are key responsibilities within the veterinary nursing/technician role. By providing clear and comprehensive guidance, veterinary teams reinforce their expertise and encourage pet owners to rely on them for ongoing nutritional support, helping pets thrive throughout growth and into adulthood.

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COMMUNICATING WITH OWNERS OF SENIOR DOGS AND CATS ABOUT NUTRITION

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KEY TAKEAWAYS

- Owners of aging pets often have nutritional concerns as they observe changes in their pet's behavior.
- Nutritional assessments should be conducted at regular health checks to determine potential risks.
- Not all senior pets need to be transitioned to a senior pet food.
- Veterinary health care teams can educate and support pet owners by enhancing their communication skills around diet choices and feeding management.

INTRODUCTION

There is no formally accepted definition of "senior" dog or cat food written as published guidelines for the Association of American Feed Control Officials (AAFCO) or the European Pet Food Industry Federation (FEDIAF). The wide range of skeletal size and body weights among hundreds of dog breeds, as well as environmental factors, results in some breeds aging faster than others. Designating when a specific breed of dog may reach a "senior" or "geriatric" age is subjective and not defined well in the scientific literature. Cats also age at varying rates and no specific age has been identified as senior for all cat breeds worldwide. Instead, a classification system for cats 7 years and older was published over 15 years ago to help cat owners and veterinary health care teams to focus on disease risks for "mature," "middle-aged," "senior," and "geriatric" patients.[1]

Without a legal (or official) definition of what constitutes a senior dog or cat food, pet food manufacturers have shaped the characteristics of the senior pet food category based on research that aligns with their company philosophies, as well as with the nutritional needs of dogs and cats. Pet owners will find a variety of terms on pet food labels and online that represent the senior pet food category; some examples include "healthy senior," "senior prime," "healthy aging," "indoor mature," "adult 7+," "senior dog 6+," or "aging 12+." Nutrient modifications that may be present in senior diets are shown in **Box 1**. Regardless of the nutrient adjustments made, if a senior dog or cat food is marketed as "complete and balanced," it must meet the AAFCO or FEDIAF guidelines for adult canine or adult feline maintenance. This is the nutritional bar that every manufacturer is required to meet in order to sell products as "complete and balanced" or "complete" in countries using AAFCO and FEDIAF guidelines. Without consistent evidence-based nutritional reasons to create a senior category, manufacturers have used marketing as well as scientific research to develop senior diets. Owners of senior dogs and cats often have concerns that the veterinary team needs to address during both routine and sick patient visits (**Box 2**).

Box 1. Nutrient modifications that may be present in senior diets compared to adult maintenance diets

- Reduced energy density
- Increased energy density
- Reduced fat
- Moderate or reduced protein
- One or more reduced or increased minerals (e.g., phosphorus, sodium)
- Enhanced vitamin content (e.g., B vitamins, vitamin C, vitamin E)
- Increased dietary fiber
- Reduced dietary fiber

ANSWERING COMMON QUESTIONS THAT PET OWNERS ASK ABOUT SENIOR PETS AND NUTRITION

My pet is over 7 (or 8 or 9 or 10) years of age. Do they need to switch to a senior diet? The response

Box 2. Common nutritional concerns of owners of senior dogs and cats

- Timing or need to change the dog's or cat's diet to a senior diet
- Palatability concerns
- Changes in timing or routine of food consumption
- Changes in preferences for foods once liked
- Changes in food or water intake
- Changes in urination and/or defecation
- Weight loss or weight gain
- Decreased activity level
- Changes in cognitive function
- Dental and oral health
- Treats and foods for medication administration
- Supplements
- Maintaining health of the kidneys and other organs
- Longevity

to this question is based on the veterinary health care team conducting a nutritional assessment. Each patient must be assessed on a regular basis–either once yearly or every 6 months. The current diet (including the food in the bowl, treats, supplements, and water intake) must be assessed, and when necessary, the nutritional composition may need to be compared to alternative dietary options. Factors influencing the pet's primary environment also must be assessed. These factors include other pets and the number of humans sharing the home, where and how animals are fed, competition for resources, number of litterboxes and places to perch for cats, as well as any potential environmental stressors. If, for example, a veterinary health care team determines that the current food is meeting the pet's needs, and the owner is satisfied with the convenience and cost of the diet, then changing to a product marketed for a senior pet is not warranted. Communicating the findings of a nutritional assessment in this situation might sound like this:

"Based on your pet's body weight, body condition, and overall health today, they are maintaining a stable body weight, have a good appetite, good energy, and regular bowel movements with good fecal scores. Based on the food you are feeding and how you are feeding it, with few or no sources of competition in the home, and your pet getting regular exercise, there is no reason to switch from the food your pet is eating right now. We should re-evaluate your pet's health and overall diet when you return in 6 months."

An alternative scenario is when a pet owner directly expresses an interest in using a senior diet. The complete nutritional assessment must be conducted with careful evaluation of what the current diet provides, in order to compare and contrast nutritional features to one or more products marketed specifically for a senior dog or cat. When diet changes are made for any aging pet, a transition period should be included in the recommendation, as well as a plan to have a member of the veterinary health care team contact the client within a few days to determine if the transition has gone well. Here is how that communication might sound:

"Based on your pet's body weight, body condition, and overall health today, they are maintaining a stable body weight, have a good appetite, good energy, and regular bowel movements with good fecal scores. The food you have been feeding is still appropriate for a healthy aging adult animal like yours. With your interest in using a senior pet food, we examined several brands, including the two you are considering, and determined that several of them would be suitable for your pet. Our instructions have a specific gram amount to feed with a frequency of twice daily meals and we have allowed for some treats, too. We have included a transition schedule to gradually change from your current food to the new food over the next 7 days. Our team will be in contact at the end of next week to learn how your pet is doing. If there are no issues or concerns, we will want to re-evaluate your pet's health and overall diet when you return in 6 months."

My senior dog doesn't like her senior food; she tries to eat the younger dog's food. Is it okay if I feed them both the same diet? There are certainly times when the answer to this question is "yes," but there are also situations where the answer would be "no." Feeding dogs together in the same area can promote social competition, which can be helpful for some pets, especially those who do not have a strong drive to eat, but it may also create stressful tension at mealtimes for some dogs and cats. Evaluating both animals (i.e., understanding their nutritional needs)

and comparing and contrasting the available diets would be an important first step. If the senior diet is modified in some way with one or more nutrients, and the younger dog's food is not similar, then switching products could result in the older dog developing an issue. It is possible, however, that some of the younger dog's food could be used as a treat for the older dog–but no more than 10% of total calories should come from treats, so calculating the daily amount of food is necessary. With any diet or treat change, monitoring an older pet's response in terms of interest, intake, and any potential negative reactions will also be important.

My pet often refuses breakfast but eats fine later in the day. Is there something wrong? A fairly common observation is for older dogs or cats to develop the preference to eat a first meal long after the 6 am to 9 am window. It may not necessarily be an indicator of a health problem. However, monitoring the pet's food intake and making sure an adequate number of calories are being eaten each day will help assure pet owners and the veterinary health care team that the animal is not at risk for a nutritional problem. Whenever a new behavior is observed in an aging pet, it is not a bad idea to weigh the animal once every 10–14 days and closely monitor food and water intake, as well as urination and defecation. If there are unexplained changes, or concerns on the part of the pet owner, an evaluation by the veterinary health care team may be warranted. If no medical issues can be identified, then feeding the first meal of the day later in the day is reasonable, provided the dog or cat consumes an adequate amount of food throughout the day.

My older pet has been slowing down during the past 5 months (or losing weight, or gaining weight, or not sleeping through the night, or drinking more water, etc.). Is there a supplement I could (should) be giving? Common nutritional supplements sold for dogs and cats include pro- and prebiotics, omega-3 fatty acids (EPA/DHA), dietary fiber, individual amino acids (i.e., taurine, arginine), individual vitamins (cobalamin, thiamine, vitamin E, vitamin C) or multi-vitamins. There are numerous other supplement types available in the marketplace, but few supplements have been researched specifically in aging dogs or cats. The supplement industry is not well regulated in many parts of the world; this results in many veterinarians having significant concerns regarding both efficacy and safety of supplements. It can be difficult to select a supplement and to determine if a manufacturer is a reputable one. One tool is to see if a supplement has been evaluated by a third party. Any pet owner who decides to "trial" a nutritional supplement should speak with their veterinarian first, to discuss product selection, appropriate amounts, frequency and route of administration, what to monitor for in terms of behaviors in the pet, and when to seek help.

COMMUNICATION TIP

Regardless of the nutrient adjustments made, if a senior dog or cat food is marketed as "complete and balanced," it must meet the AAFCO or FEDIAF guidelines for adult canine or adult feline maintenance.

My pet has become more finicky about their food with age. What kinds of "enhancements" or "toppers" can I use and how much would you recommend? The safest kind of "toppers" or "enhancements" for aging pets are those that will not add a significant amount of dietary fat, protein, sodium, or phosphorus. Common human foods that meet this guideline are fresh or frozen fruits and vegetables. The amount is important because an "enhancement" or "topper" should be delivered in the smallest portion possible; its purpose is to improve the aroma in the pet's food bowl and encourage intake of the regular food. Commercially made treats and toppers tend to have more calories, and so a much smaller volume may be allowed per day, as compared to fruits or vegetables. No more than 10% of a pet's total daily calories should be coming from treats, foods for medication administration, and toppers, so calculating the daily portion for a pet is necessary. It is also important to clarify which fruits and vegetables may cause harm to pets, such as grapes.

My pet has enjoyed the same brand of commercial food for a number of years now, but lately they have rejected it. I have purchased two new bags from two different pet stores without any luck; they seem to prefer what we are eating for our own meals. Should I start making a home-cooked diet for my pet? Exploring the idea of making a home-cooked diet requires a conversation about advantages

and disadvantages to this feeding method, such that pet owners understand what is involved to get started, and what is required for appropriate monitoring of their pet over time. While there are many recipes to be found online and in books, most are not adequately balanced. The best guidance for pet owners who want to feed a home-cooked diet comes from consulting with a trained veterinary nutritionist who also has formulation experience.

My senior pet is not a great candidate for anesthesia with a dental procedure, so I want to know about dental chews or treats that could help support his teeth and oral health. Retail pet stores have treat aisles with a number of products devoted to "oral health" in dogs and cats. Most products marketed as dental treats and chews for dogs or cats have not been tested or proven to be beneficial. However, the Veterinary Oral Health Council places a seal on oral health products with proven efficacy (i.e., dental treats, chews, toothpastes, gels, wipes, and water additives). A seal of acceptance is awarded to a product if it has been tested and shown to effectively reduce plaque or tartar. Not all dental treats are reduced in calories; in fact, some are high in calorie content and so careful selection and monitoring of daily intake is important. Seeking input or guidance from the veterinary health care team will be important.

RELEVANT POINTS

Aging pets should be evaluated twice per year (every 6 months) in order to identify potential issues before they become major concerns. For some giant breed dogs, twice yearly evaluations begin at the age of 6 or 7, while for many smaller dog breeds and most cats, twice yearly evaluations begin at age 9 or 10. Prolonged clinical conditions (such as hyporexia, nausea, regurgitation, diarrhea, inactivity) are less tolerated in older pets and can result in compromised gastrointestinal, immune, or musculoskeletal systems.

A nutritional assessment should be completed on every patient, at every visit. Evaluating the pet with a thorough physical exam and routine lab work helps determine what is needed in terms of nutrient modifications and/or dietary management. Reviewing what the current diet (i.e., food in the bowl, water intake, treats, and supplements) provides, as well as exploring various environmental factors (e.g., where and how meals are fed, other pets and humans sharing the home, potential stressors in the environment, and resource competition) are critical to understanding if/when an alternative diet should be considered.

More research should be conducted to elucidate important mechanisms of aging in dogs and cats. Evidence in the veterinary literature is slowly building for specific nutrients that have been shown to positively impact one or more health outcomes associated with common diseases in aging populations of dogs and cats.[2] Nutrients of interest that have been investigated include antioxidants (vitamin E, vitamin C), fatty acids (linoleic acid, omega-3s, medium-chain triglycerides), amino acids (arginine, tryptophan, carnitine), plant-based fibers (chicory root), and B-vitamins (thiamine, riboflavin, cobalamin, folic acid). Macronutrient and micronutrient adjustments in the diets of aging pets can impact the immune system, gastrointestinal system, cognitive functions in the brain, and joint health. Translating in vivo and in vitro evidence into published dietary requirements for aging dogs and cats is important work yet to be done.

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COMMUNICATING WITH PET OWNERS ABOUT DIET SELECTION AND DIET CHANGES

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KEY TAKEAWAYS

- Providing nutrition recommendations is an iterative process that requires open communication while balancing the patient's requirements with the needs and philosophies of the owner.
- The diet selection process is based on an individualized patient approach with no one product being "the best." By providing recommendations for multiple products when possible, owners can feel more confident in their decisions.
- A diet change is warranted when a pet's life status or clinical status changes. Transitioning to a new diet should be a slow and gradual process.

GUIDELINES FOR MAKING DIET RECOMMENDATIONS TO PET OWNERS

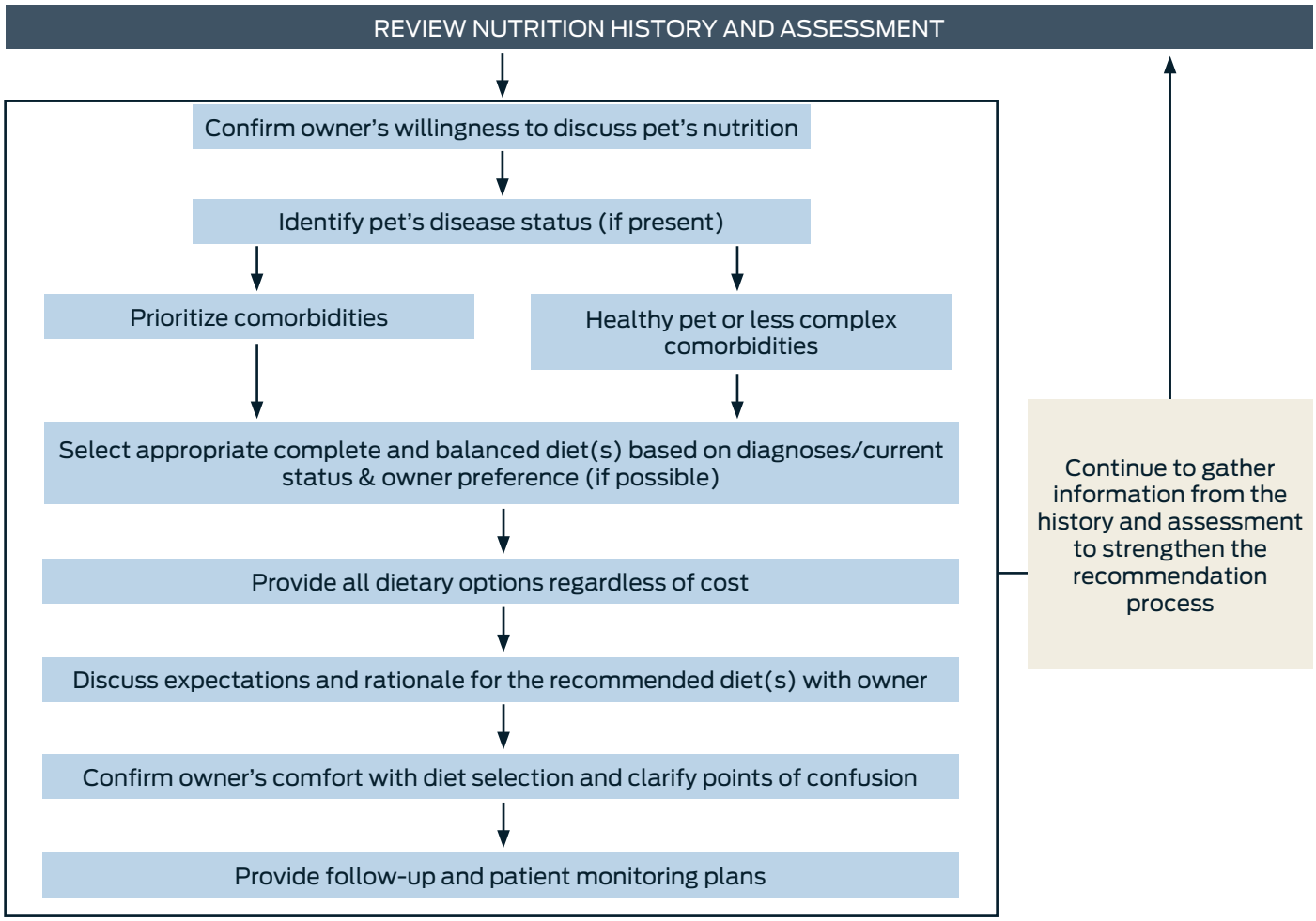
The nutritional assessment is a method for evaluating veterinary patients in the context of their diet and medical history, trends in body weight, and measures of body composition such as body and muscle condition scores. The goal of the assessment process is to provide an informed diet recommendation. It is crucial to obtain and evaluate a complete nutrition history, and to correlate calorie intake as well as nutritional profiles to the patient's status. Together with diet history information, evaluating the patient's medical status, lifestyle, life stage, weight trends, body composition, and appetite will dictate the success of the nutrition support plan.[1-3] As part of the assessment, it is important to not only review the specific product(s) the pet is currently consuming but also identify foods that were historically fed and the owner's feeding rationale. For example, owners might be using commercial foods with a specific marketing focus, or they may be feeding a home-cooked diet because they perceive commercial products as costly, or they could choose a raw diet due to concerns of ingredients in other commercial products.[1] Identifying an owner's perspective for feeding a specific type of food in a particular category (e.g., homemade, canned, dry, homemade-style, raw) can provide better alignment of the veterinary care team's recommendation to the owner's comfort level and ultimately increase owner compliance. Finally, a recent minimum database (complete blood count, chemistry, urinalysis, +/- total T4) should be performed when indicated as part of the nutritional assessment. Additional appropriate diagnostics such as imaging, urine protein:creatinine ratio, urine culture, repeat minimum database, etc. may be indicated if a clear diagnosis is not apparent in a patient who is exhibiting clinical signs (e.g., newly polydipsic/polyuric, nonspecific gastrointestinal signs).[2]

Figure 1 outlines the iterative approach to making a diet recommendation. The first step is confirming an owner's willingness to discuss their pet's nutrition. Assessing the owner's response for content, intonation, and body language will determine if proceeding with a nutrition conversation is appropriate and shows respect for the client–veterinary team relationship.

After the nutrition history and assessment have been thoroughly reviewed and completed by the veterinarian, identification and evaluation of disease conditions and prioritization of any comorbidities will inform the desired nutrition strategies and in turn the diet options. Balancing the needs of a complex patient can be challenging, especially if there are owner philosophies or pet preferences to consider. For example, some pet owners may only be interested in a homemade diet recipe, which can be a good option, but for any pet, these should be customized to the individual patient and formulated by a board-certified veterinary nutritionist.

For healthy pets, veterinary therapeutic diets are not needed, and there are many more options. At

Figure 1. The iterative approach to making a dietary recommendation. Adapted from AAHA 2021 "Communicating a Nutrition Recommendation to the Client."[1]



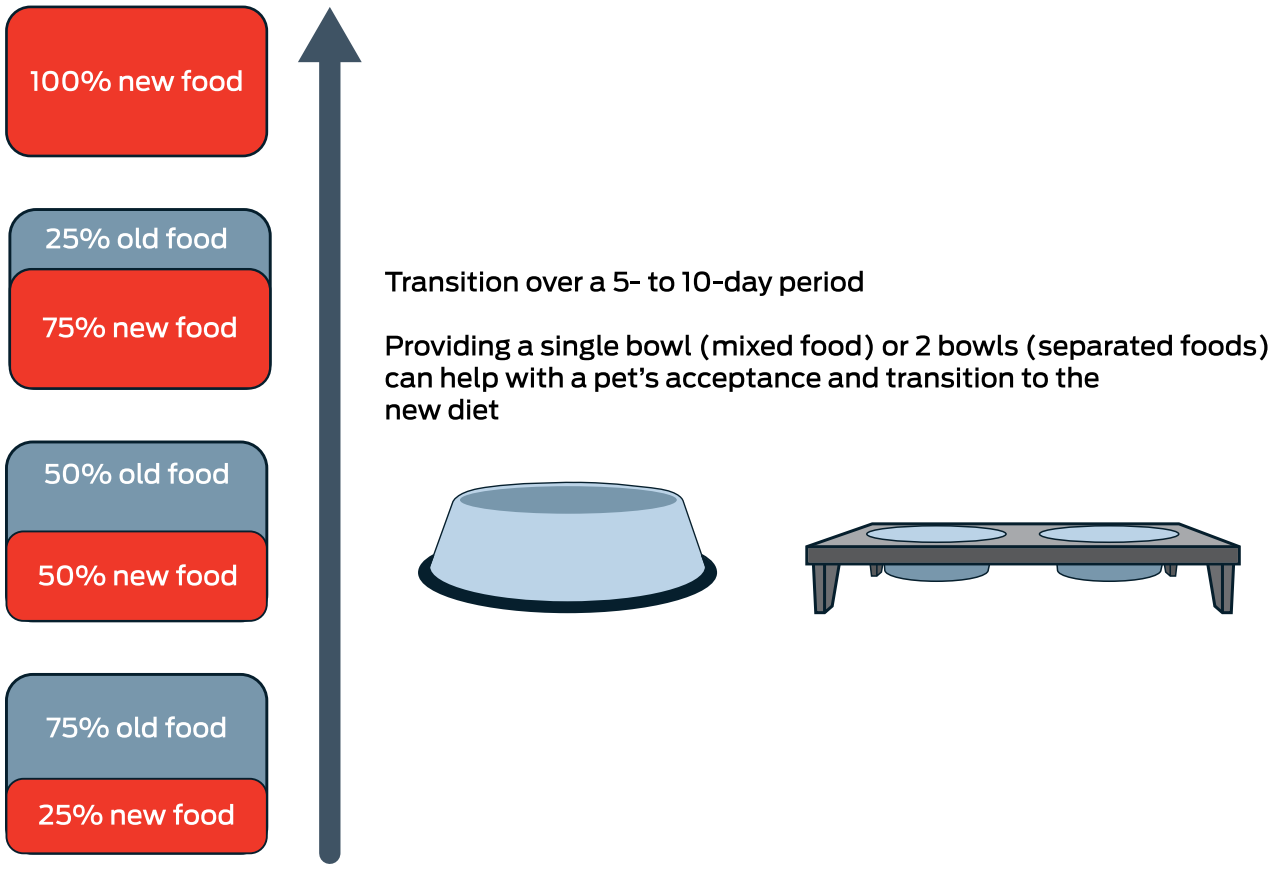
a minimum, the recommended diet(s) should be complete and balanced as well as appropriate for the pet's life stage. This information should be stated on the product's label.

Once an appropriate diet is selected based on the patient's needs and owner preference, when possible, the veterinary care team should consult with the owner to provide and discuss the expectations and rationale of the diet recommendation.[2] The client's understanding of the purpose and mechanism of the food is critical for adherence to the plan. All dietary options should be provided regardless of cost, with previous research showing both veterinarians and owners prioritize recommendations that are best for the pet, with secondary consideration of financial implications.[4,5] Whether for wellness or to address a specific disease, ensure an open discussion of the benefits and any drawbacks of the diet recommendation. This allows the owner to make an informed decision and be accountable in their pet's plan. Among the appropriate options, considerations that impact the ultimate choice might include:

- price
- diet palatability and/or texture
- owner preference

After this discussion, the veterinarian should ensure the owner understands the stated goals by providing opportunities for questions or meeting needs for clarification. Effective communication will help assess and ensure the client's comfort with the recommendation. Amendments to the recommended plan may be needed based on the owner's understanding. Clear instructions must be provided in both written and verbal communications to improve owner compliance.[2,6] A follow-up plan should be included as part of the recommendation to emphasize the importance of monitoring the patient's response. Reassessments are crucial to determining if modifications are needed. These can be performed by a

Figure 2. Example of a dietary transition plan



member of the veterinary health care team after the pet has started the transition to the new diet.[1]

HOW TO ADVISE PET OWNERS TO SELECT A DIET

One important point to communicate to pet owners is that there is not a single "best diet" for individual animals or for pets in general. Nutrition is an individualized approach.[7] It is also warranted to discuss the differentiation between marketing claims and those that describe quality and nutritional value in an evidence-based way. Many owners believe that more expensive pet food options are superior, so discussing this issue can be helpful and may be a relief to some clients. Finally, it should be emphasized that pets need nutrients, rather than specific ingredients, to meet nutritional requirements.

Other general guidance should include choosing a product from a manufacturer that can provide information regarding:[7,8]

- Quality control
- Nutritional adequacy
- Nutrient analysis
- Research and development
- Publications in peer-reviewed literature
- Employment of board-certified veterinary nutritionists or PhD nutritionists

Specific guidance should be provided regarding:

- The specific product's nutritional adequacy claim: appropriateness for species and life stage
- Consideration of textures and diet form (for example, kibble vs. canned)
- Targets for macronutrients (protein, fat, carbohydrate), if relevant for the patient
- Balancing the preferences and needs of both the client and patient
- Convenience, cost, owner's nutrition philosophy[2]

If possible, provide several options and review the benefits and disadvantages of the products with the owner to help with their decision. Including options from a range of price points and marketing categories may be helpful.

WHEN TO RECOMMEND CHANGING A PET'S DIET

Diet change may be warranted in a variety of situations. Many of these relate to the pet and changes in their health or life stage status, which will be identified in the nutritional assessment. Product availability or other external factors may also need to be considered.

Changes in life stage are an important time for ensuring adequate nutritional status. During the time puppies and kittens are weaning to solid food, throughout the growth period, and during gestation and lactation are all sensitive times when calorie and nutrient requirements are distinct from that of adult animals at maintenance. In addition, owners should be made aware that spaying and neutering are associated with an increased risk of obesity, and unintentional weight gain should be avoided after this procedure. Of course, these situations all comprise dynamic body weights and nutritional needs, so monitoring is recommended to ensure timely and appropriate adjustments are performed. However, maintaining a lean body condition should be the goal for all patients, and is the only intervention known to increase quantity and quality of life.[2,9]

Transitioning to a diet marketed for senior pets is not necessary in a healthy older dog or cat that is maintaining ideal body condition score, normal muscle condition score, and body weight. Products in this category are variable in calorie density and nutritional profile. There are no regulatory guidelines or standard modifications for senior diets. However, if there are any new or ongoing nutrient-responsive conditions, changing to an appropriate veterinary therapeutic diet should be discussed.

If any other risk factors are apparent from the nutritional assessment, such as the use of an incomplete and unbalanced diet or any potentially problematic food items (such as raw animal products or foods toxic to dogs and/or cats), client counseling and ultimately changes to the feeding plan are warranted.

MAKING A DIET TRANSITION

Any dietary transition should be a gradual process to mitigate potential gastrointestinal upset that may be associated with a sudden food change.[10] Although some dogs and cats tolerate rapid diet changes and even different foods for each meal, a gradual process should be pursued to reduce the possibility of gastrointestinal upset and optimize acceptance of the new food (**Figure 2**). Cats can be neophobic, so gradual introductions can help ensure they continue to consume adequate amounts to reduce the risk of hepatic lipidosis. There is no benefit of a rapid change, although at times, new diets may need to be abruptly introduced. As some examples, unexpected diet unavailability due to a product backorder, contamination of the current supply with pests, or loss due to flooding, house fires, or other similar incidents may mean that the owner needs to find another option quickly.

COMMUNICATION TIP

Patience is key. An initial food refusal does not indicate the pet will never accept the new food. Many pets require repeated exposure to the new food before consistently consuming it.

Successful acceptance of a new diet may involve some effort on the part of the owner. Diet temperature and texture are strong influences that strongly impact palatability for many pets. Meals may need to be warmed or freshly opened (especially for wet food) during this transition period. Consideration of the pet's preferences of location, presence of other animals or humans during feeding times, and meal schedules can help ensure a successful transition. The use of different types of bowls or plates can also be tried.

Patience is key. An initial food refusal does not indicate the pet will never accept the new food. Many pets require repeated exposure to the new food before consistently consuming it. It is important to monitor the patient's status including serial body weight measurements to confirm adequate intake. If gastrointestinal upset occurs, owners should contact their veterinary health care team for guidance. Ensuring owners take note of any new or progressive clinical signs during the transition can help with more accurate troubleshooting of diet tolerance.

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COMMUNICATING WITH PET OWNERS ABOUT WEIGHT MANAGEMENT

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KEY TAKEAWAYS

- Veterinary professionals have the important role of engaging and supporting caregivers in managing their pet's weight.
- Gathering a comprehensive nutritional history provides an important foundation for tailoring the weight management conversation to an individual caregiver, pet, and their situation.
- Using and discussing a patient's weight trend during every visit, from puppyhood or kittenhood throughout life, provides a way of normalizing the weight management conversation and of actively engaging the client in their pet's weight.
- Communicating the value of maintaining or addressing a pet's weight to the animal's overall health and wellbeing is a key step in discussing weight management.

OVERVIEW

Maintaining a dog's or cat's ideal body weight throughout life is fundamental to their ongoing health and wellbeing, including their overall quality of life and lifespan.[1-5] Given that the prevalence of pet obesity has increased steadily for decades, with 59% of dogs and 61% of cats currently classified as overweight or obese,[6] actions are needed to further engage caregivers in weight management for their pet. The success of maintaining a pet's ideal weight is largely dependent on the actions of their caregiver(s). Therefore, veterinary professionals have the important role of engaging and supporting caregivers in managing their pet's weight.

COMMUNICATION BETWEEN VETERINARY PROFESSIONAL AND CLIENT IS KEY

At the crux of this support is the communication between veterinary professional and client, which provides a process for exchanging information, building trust, overcoming challenges, and supporting a caregiver's weight-management efforts. Within the veterinary field, research to date has identified that opportunities exist to further optimize the communication between veterinary professionals and their clients, specific to weight-related discussions.[7] Examination of 150 video-recorded obesity-related discussions involving a veterinary professional and client revealed that only 43% included a weight-management recommendation and only 28% provided the client with a reason to pursue weight management for their overweight or obese animal.[7]

THREE KEY ELEMENTS FOR COMMUNICATING WITH CLIENTS

When considering communication with a pet's caregiver about weight management, it is important to recognize that this communication comprises three key elements: content, process, and perception.[8] The content represents the scientific or medical knowledge that exists for maintaining, reducing, or increasing a patient's weight (e.g., calculated energy requirements, life-stage factors to be considered, the science behind pet nutrition) as well as the information a client shares about themselves, their animal, and their situation. The process represents the verbal and nonverbal communication tools and strategies (e.g., open-ended inquiry, signpost, presenting options) that support the exchange of information between veterinary professional and client. The perception element relates to the thoughts, feelings, and ideas that the veterinary professional (e.g., clinical reasoning, assumptions, bias) and client (e.g., beliefs, values, readiness to consider change), respectively, bring to the conversation.

COMMUNICATION TIP

By asking the client's permission to discuss their pet's weight, we respectfully assess a client's readiness for the conversation, and we can begin to gauge a client's stage of readiness to address their pet's weight. This allows the veterinary team to tailor communication accordingly.

Although all three elements are significant, the perceptions that we, as veterinary professionals, bring to the conversation are an important starting point so that we can be aware of how these perceptions may shape the content and process of our communication. For example, research has found that most veterinary professionals carry some degree of unconscious weight bias,[9] which should be recognized and considered prior to engaging a client in a weight management conversation. Equally important to a veterinary professional's a priori perceptions are the perceptions a client brings to the weight-management conversation, one of which—caregiver commitment—has been acknowledged to be a key factor in weight-management success.[10]

UNDERSTANDING A CLIENT'S READINESS TO COMMIT TO WEIGHT MANAGEMENT

Understanding a client's stage of readiness to change, with respect to adapting behavior to manage their pet's weight, is an important first consideration—one which can inform a veterinary professional's approach for tailoring their weight-management conversation to a specific client.[10,11]

The five stages of readiness to change that clients can experience in relation to pursuing weight management for their pet have been described as:[10,11]

1. **Precontemplation** – caregiver lacks awareness of why their pet's weight is a problem or does not see the reason, or have a willingness, to change.
2. **Contemplation** – caregiver acknowledges a problem or a need for change with respect to their pet's weight yet is caught in deliberating the advantages and disadvantages leading to a static state of not changing.
3. **Preparation** – caregiver has committed to making a change to manage their pet's weight yet is only in the early steps or has not taken steps to make the change.
4. **Action** – caregiver is intentionally making changes to manage their pet's weight.
5. **Maintenance** – caregiver continues to work on sustaining changes to manage their pet's weight and avoid relapse.

Research in veterinary medicine has found that, among a sample of dog and cat owners who identify their own pet as overweight (i.e., BCS > 5/9), 94% indicated being at a lower level of readiness to make a change (i.e., precontemplation or contemplation) to address their pet's current weight (**Table 1**).[11]

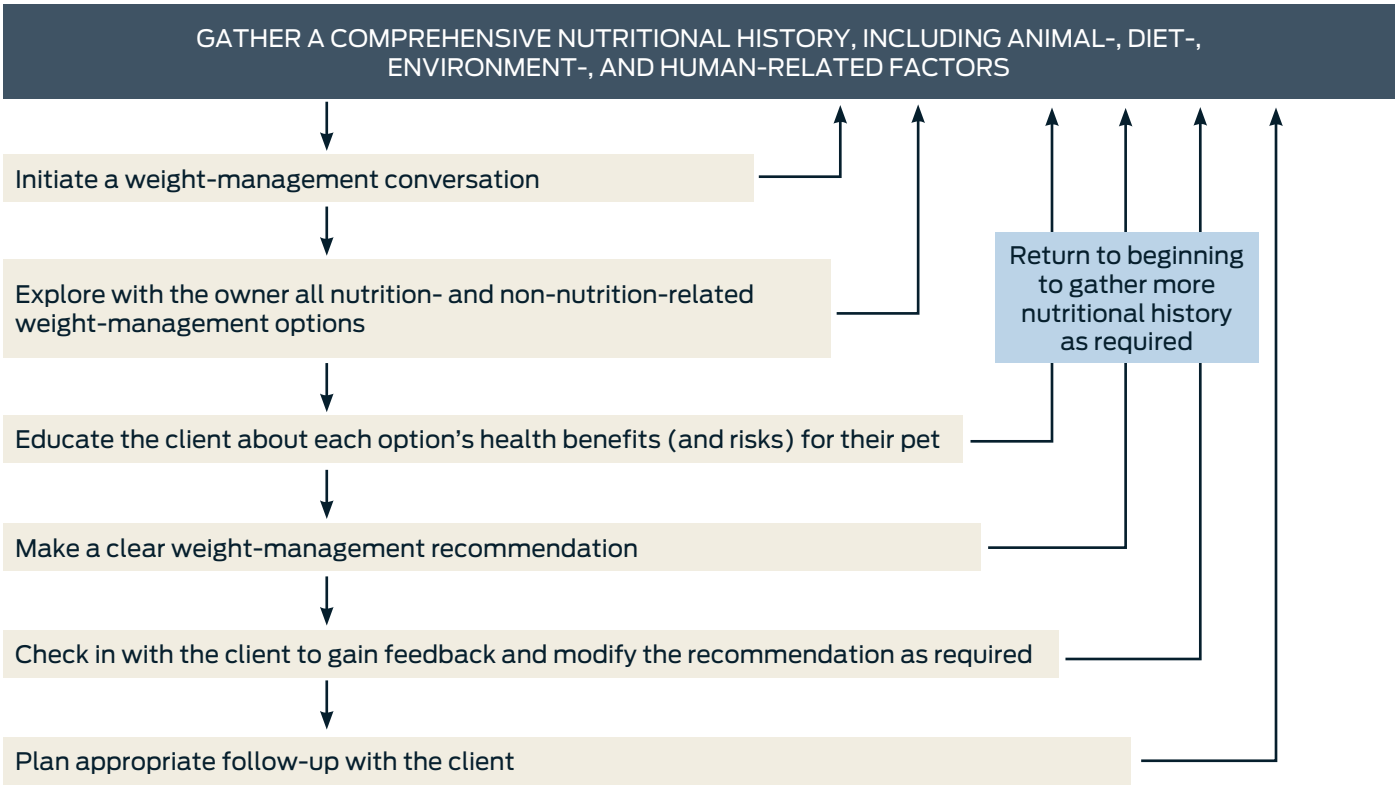
Regardless of a client's stage of change, the first step in preparing to communicate with a caregiver about weight management for their pet involves gathering a comprehensive nutritional history, which provides

Table 1. From a sample of pet owners who identified their own pet as being overweight (BCS > 5/9), the percentage of participants identifying with a specific stage of change (n = 119), and their respective mean levels of interest and confidence in managing their pet's weight (n = 100).[11]

Stage of change	Percentage of participants	Interest in addressing pet's weight (mean score)	Confidence in addressing pet's weight (mean score)
Precontemplation	52	6.9/10 [a,b]	7.6/10
Contemplation	42	8.6/10 [a]	7.1/10
Preparation/Action/ Maintenance	6	10.0/10 [b]	7.4/10

[a,b] Significantly different at $p < 0.05$

Figure 1. A general framework for communicating with pet caregivers about weight management (Adapted from the *2021 AAHA Nutrition and Weight Management Guidelines*, © American Animal Hospital Association, used with permission.)



the foundation for informing subsequent steps in the process (**Figure 1**).[8] Communication about weight management for a pet is an iterative process, meaning that at any stage of a weight management conversation, the veterinary professional and client may need to return to gathering additional nutrition history in order to ensure the conversation remains aligned with the client's perspective.

A FRAMEWORK FOR COMMUNICATING WITH PET OWNERS ABOUT WEIGHT MANAGEMENT[8]

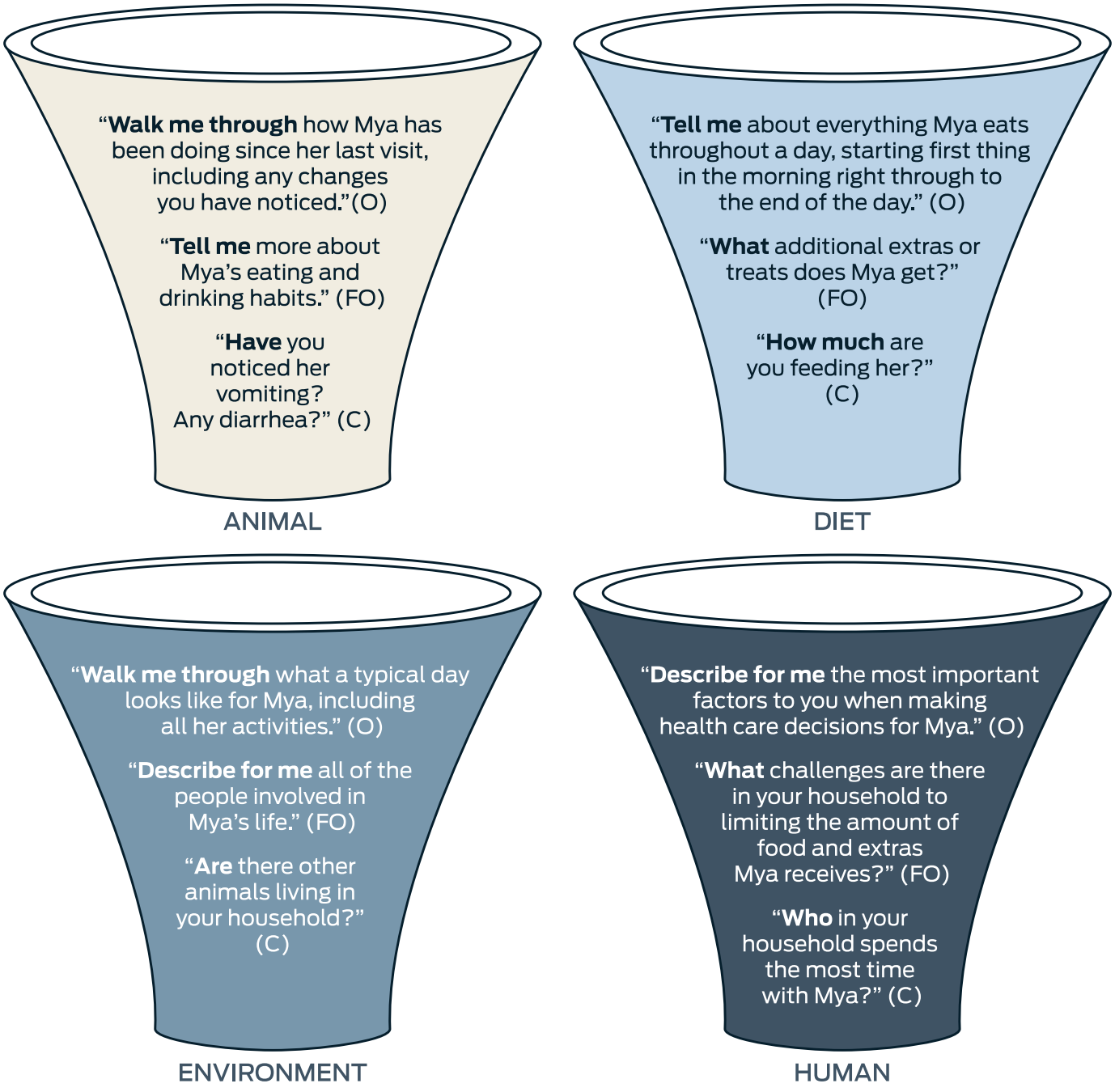
Gather a comprehensive nutritional history

The first step for engaging a client in a weight-management conversation, regardless of whether their animal is underweight, overweight, or currently at an ideal weight, is gathering a comprehensive nutritional history. This requires delving into relevant animal-, diet-, environment-, and human-related factors.[8] Using inquiry funnels can be an efficient and effective approach to exploring each of these factors respectively (**Figure 2**). An inquiry funnel, at its widest part, begins by using catchall, open-ended inquiries, which are broad, inviting statements or questions.[12] These are then followed by more focused, open-ended inquiries as you move down the funnel to explore specific areas in greater detail (e.g., patient preferences, specific diet factors, daily activities, other members of the household to consider). Finally, the inquiry funnel finishes with narrow, closed-ended inquiries (i.e., questions) to confirm or clarify final details (e.g., recent vomiting or diarrhea, brand of food).

Initiate a weight-management conversation

Once information on all relevant animal-, diet-, environment-, and human-related factors has been gathered, the next step involves initiating the weight-management conversation using a signpost, a form of transition statement, to shift the conversation. Asking permission is a special form of signpost,[12] which can be used intentionally to gauge a client's readiness to move into a weight-management conversation. By asking permission, we respectfully assess a client's readiness for the conversation (e.g., "Would you be open to spending a few minutes discussing Mya's weight?").

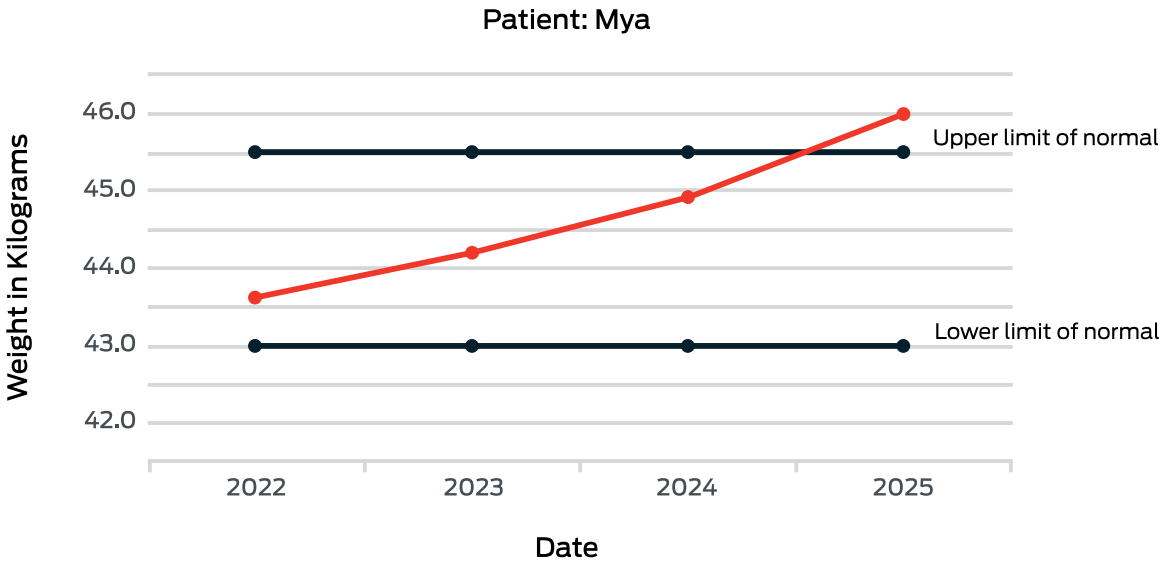
Figure 2. Examples of inquiry funnels for gathering animal-, diet-, environment-, and human-related factors, respectively. Each funnel includes examples of open- and closed-ended inquiries that can be used for gathering a comprehensive nutritional history (O – open-ended inquiry; FO – focused open-ended inquiry; C – closed-ended inquiry).



Through this process, we can begin to gauge a client's stage of readiness to address their pet's weight (e.g., precontemplation, contemplation, preparation, action, or maintenance), and tailor our communication accordingly. On occasion, a client will overtly decline our permission request (likely signalling they are set at a precontemplation stage of change), at which point it may be best to preserve the relationship by transitioning to another topic and reserving the weight-management conversation for a more acceptable time.

Using a visual aid to convey a patient's weight trend can also be a valuable tool to help a veterinary professional transition into a weight-management conversation (**Figure 3**), as it visually allows the client to assess and understand their pet's current weight trajectory.[13] This use of a visual aid allows both veterinary professional

Figure 3. Example weight trend chart



and client to partner in early identification of a pet trending toward being overweight or underweight, encouraging a preemptive discussion about preventive actions that can be taken.

Introducing the use of puppy and kitten growth curves, to monitor and support the healthy growth of puppies and kittens,[14,15] provides a great opportunity to begin normalizing weight-monitoring and weight-management discussions from a pet's early age. Using puppy[16] and kitten[17] growth charts can also provide a basis for veterinary professional and client to partner in establishing an animal's ideal weight at maturity, which further supports ongoing monitoring and regular weight-management conversations throughout a pet's lifetime.

Explore with the owner all nutrition- and non-nutrition-related weight-management options

Research consistently finds that veterinary clients want to be involved in decisions regarding their pet's health care, including being presented with all available options.[18-20] Providing options and engaging clients in decision-making offer a further way to partner with the client, demonstrate respect for their decision-making autonomy, and allow both the veterinary professional and client to contribute their respective expertise to a shared decision.[18,19]

During weight-management discussions, there are often options to consider. For example, for an overweight or obese animal, the veterinary professional and client might begin by considering the options of: doing nothing, increasing exercise alone, altering the animal's current intake of calories, or developing a formalized weight-loss plan with the client which might include a therapeutic weight-loss diet, precision measurement of food with a gram scale, an exercise plan tailored to the client's and patient's lifestyle, treat management and monitoring, and regular biweekly weigh-ins to monitor progress.

Educate the client about each option's health benefits (and risks) for their pet

To properly position a client for making a health care decision for their pet, it is important that the discussion of options includes discussing the currently understood advantages and disadvantages associated with each option. Research has consistently shown that understanding the benefit to the health and wellbeing of the animal is important for clients.[20-23] Specific to weight management, sharing information about the impact of the pet's weight on the animal's life expectancy has been found to be important for encouraging both dog and cat caregivers to pursue weight loss for an overweight pet (**Table 2**).[24,25] As such, it becomes important for veterinary professionals to proactively educate clients about the benefit of maintaining their pet at an ideal body condition when discussing weight management.

Make a clear weight-management recommendation

To support clients in their decision-making, when presenting the available options, it becomes important for the veterinary professional to make a clear

Table 2. Participating dog (n = 1108) and cat (n = 1095) owners' ratings of relative importance of five attributes for encouraging them to act on a veterinarian's recommendation for their pet to lose weight[24,25]

Dog owners	Cat owners
Impact on life expectancy (28.6%)	Impact on life expectancy (32.7%)
Timeline for developing arthritis (19.2%)	Change to cost of food (20.4%)
Future quality of life (18.9%)	Future quality of life (20.4%)
Change to cost of food (18.9%)	Future mobility (14.4%)
Future mobility (14.3%)	Risk of developing diabetes (12.2%)

weight-management recommendation[26] that takes into consideration the client's perspective on each option. When making a clear recommendation, it is also important to explain the reason behind the recommendation, specifically including how it will benefit the animal's health and wellbeing.

*"Based on our discussion of changes to help Mya lose weight, that you've said would work for you, I recommend we transition Mya to a therapeutic weight-loss diet beginning today, start measuring her daily food allowance using the gram scale you have at home, change her treats to small pieces of various vegetables, and then we'll have you bring her in every two weeks to keep track of our progress [**clear recommendation**]. By working together to reduce Mya's weight, we can help her live longer, have her be less likely to develop arthritis early, and provide her a better overall quality of life [**reinforce the health benefits for their pet**]."*

Check in with the client to gain feedback and modify the recommendation as required

Among dog and cat owners who identify their own pet as overweight (i.e., BCS > 5/9), research has shown that regardless of their identified stage of readiness to make changes to address their pet's weight, there was no significant difference found in their reported confidence for being able to manage their pet's weight (**Table 1**).[11] The findings suggest even pet owners that are committed to acting (i.e., those in the preparation, action, or maintenance stages of readiness to change) still require ongoing support in pursuing weight management for their pet. Checking in positions the veterinary team to address concerns, challenges, or obstacles a client may perceive to a proposed weight-management plan before they leave the examination room.

"What are your thoughts on transitioning Mya to a therapeutic weight-loss diet, measuring her food with the gram scale you have at home, changing her treats to small pieces of vegetables, and bringing her in every couple of weeks to monitor her weight loss?"

Plan appropriate follow-up with the client

Upon returning home, a weight-management plan can quickly derail for client and/or patient (e.g., pet rejects their new food, difficulty controlling calories from other members of the household); therefore, having a member of the team follow up with the client a day or two after beginning a new weight-management plan provides an opportunity to answer questions, troubleshoot challenges, rework the plan as needed, and remind the client that your team is there and available for support.

CONCLUSION

Effectively communicating with pet caregivers about weight management requires understanding and integrating the client's perspective. Starting with a comprehensive nutritional history positions the veterinary professional with an understanding of their client and patient, which provides the foundation for tailoring the weight-management conversation. Pursuing involvement of the client in the decision-making process allows the veterinary professional to contextualize the weight-management conversation in a way that holds relevance to an individual client, animal, and their situation. This tailoring often involves working collaboratively with the client toward a weight management plan where there becomes shared investment and commitment in the outcome.

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PRACTICAL TOOL: COMMUNICATING WITH FIRST-TIME PET OWNERS ABOUT NUTRITION

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It will come as no surprise to veterinary professionals working in general practice in the past decade: Pet guardianship is on the rise. It's not just the growth of existing pet-inclusive families; more homes are welcoming pets for the first time.[1–3] It is safe to say that the veterinary profession is amid a "pet boom."[4] This influx of new clients can add additional strain to the already busy veterinarian, who may neglect the nutrition conversation due to time constraints. A wealth of crucial information must be shared in initial appointments with new clients who may succumb to information overload without a tailored approach. Additional insights will improve the efficiency of these appointments, while ensuring that nutrition remains the foundation of our mutual care.

TYPES OF NEW PET GUARDIANS

A key consideration is to assess the client's past and current experience with pets, from the pet guardian with some experience to the truly novel owner. Each subset of clients may share a similar knowledge base, with associated challenges, opportunities and educational needs in the nutrition consultation. This will help establish what information may need to be shared, allowing for a targeted approach.

Start them right

Foundational concepts:

Do/Do Not

- Food safety
- Water access
- Toxins
- Treats

Monitoring

- Body condition scoring and weighing
- Fecal scoring
- Diet transitions

Information

- Combating misinformation
- The nutrition recommendation
- Feeding management and tools

Establish what they know, what they think they know, and potential misinformation, which better directs the needed information to be covered.

First-generation pet owner

The true blank slate! This client has not previously shared their family or current home with another species. They will likely require the greatest number of resources, have the most questions, and will require more time and follow-up (**Figure 1**). The keen veterinary team will ensure that they are the primary source of information in pet nutrition for a lifetime of care. *The primary goal should be to establish trust while sharing needed information without overwhelming the client. Consider a second, follow-up appointment if needed.*

Second-generation pet owner

This client has grown up with pets in their childhood home or had similar exposure to pet ownership in the past. Although they may have been directly involved with the care of their pets, their family members or past housemates were likely the key decision makers in the care of the family pet. They are likely familiar with key areas of pet nutrition, food selection and feeding management; however, the accuracy of learned information and appropriateness of the feeding practices will vary (**Figure 1**). It would be valuable to explore how their goals differ from or align with their first experience with pet companionship and nutrition. An example may be a client whose past roommate had an obese pet struggling with related comorbidities. Take the time with these clients to review their basis of knowledge and aim to address any areas of misinformation. In the case of preestablished biases that may be detrimental to the health of the new pet, be sure to educate in a respectful manner, seeking to establish common goals that can be integrated into required education and nutrition recommendations. Referring to the above example, your client questions the need for meal-feeding and reflects on the ease of free-feeding. By linking this feeding practice to the risk of obesity, the client may better understand the need for the new feeding plan. *Expect that this subset*

Figure 1. Different types of pet owners



First-Generation Pet Owner

All data needed

Focus: ensuring understanding, preventing information overload, and close follow-up

Establish goals, relationship



Second-Generation Pet Owner

May understand basics, such as food safety, water access

May have been previously misinformed, prior bias

Focus: possible educational updates, such as treats and obesity prevention



New to Species

May have a solid foundation of nutrition knowledge

Focus: specific differences in new species

Focus: possible educational updates

of new pet guardians may take more time and follow-up than first-generation pet owners, if preexisting biases exist.

New to species

This client has been the primary guardian of a pet previously or currently, but is new to caring for the species presenting to the appointment. Consider this client as both a novel and experienced pet guardian, as their prior experience may hinder or help their current education (**Figure 1**). They may hold preexisting misinformation or biases which could lead to malnutrition or underutilization of nutrition with their new pet. The new species may have similar needs to the previous, but some differences could be detrimental. Consideration of the core concepts of nutrition and feeding management differences between prior pets and current ones may indicate what additional education is required. For example, the rabbit guardian who feeds an herbivore fresh vegetables and free-choice hay may need to adjust to having a cat, which is an obligate carnivore, fed meals of complete and balanced food. *As above, expect this subset of new pet guardianship to take more time than the novel pet guardian, if reeducation is required.*

INTEGRATION OF THE TEAM

Utilization of the entire team in these appointments is essential to ensure that all information can be conveyed effectively and efficiently, starting with longer appointment times. Veterinarians can empower the Registered Veterinary Technicians (RVT; also called Certified or Licensed Veterinary Technicians or Veterinary Nurses) in their clinics to take the lead on nutrition conversations for healthy pets. Additionally, once the diagnosis and treatment plan have been established by the veterinarian, the RVT can continue to address any additional information required. Uncomplicated nutrition consultations—from diet history through the nutrition recommendation—can often be conducted by the RVT, supported by skilled Veterinary Assistants where appropriate. Integration of the team—by having different team members discuss important points with the pet owner—can be effective, and so can having breaks in information dissemination, which can minimize potential information overwhelm for the pet owner. Follow-up RVT appointments may be scheduled, supporting professional development and income generation without further strain to the busy veterinarian. The entire veterinary team may develop resources to support foundational concepts to be shared within and beyond the consultation. The new client will have the opportunity to establish a relationship and build trust with not just the veterinarian, but the entire practice.

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PRACTICAL TOOL: COMMUNICATING WITH PET OWNERS ABOUT THE RISKS OF MALNUTRITION AND UNBALANCED DIETS

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Malnutrition occurs if the daily ration exceeds or fails to meet the requirement of energy and/or nutrients.[1-3] Which, whether, and when consequences become apparent depends on the physiological function of the respective nutrient, the quantity required, if storages are available in the body, and the severity and duration of malnutrition. Signs of malnutrition may develop slowly, unnoticed by the pet owner. But excessive weight gain, weight loss, or muscle depletion can be apparent during veterinary consultation. Deficient intake of nutrients such as trace minerals may cause less obvious symptoms that are more difficult to diagnose, such as decreased skin health and poor coat quality. Severe and acute symptoms occur when the pet has an increased requirement for the respective deficient nutrient, such as calcium during lactation and growth (**Table 1**).[4,5] Preexisting diseases can exacerbate the consequences of malnutrition. The desire of pet owners to provide their pets with impaired health with food perceived to be particularly healthy is understandable. However, the risk of malnutrition increases further if unbalanced food is used.[6,7] Linking potential nutritional causes to clinical findings or diagnoses, as well as preventing diseases caused or aggravated by deficient nutrition of pets, is an essential task of daily veterinary practice.

Potential causes of malnutrition independent of feeding a homemade or a commercial diet include:[8-10]

- Inability of the pet to adequately digest the food and absorb nutrients (e.g., due to disease)
- Unbalanced daily rations
- Intended use not suitable for the specific life stage, species, or nutritional purpose
- Feeding instructions not adequate or not followed

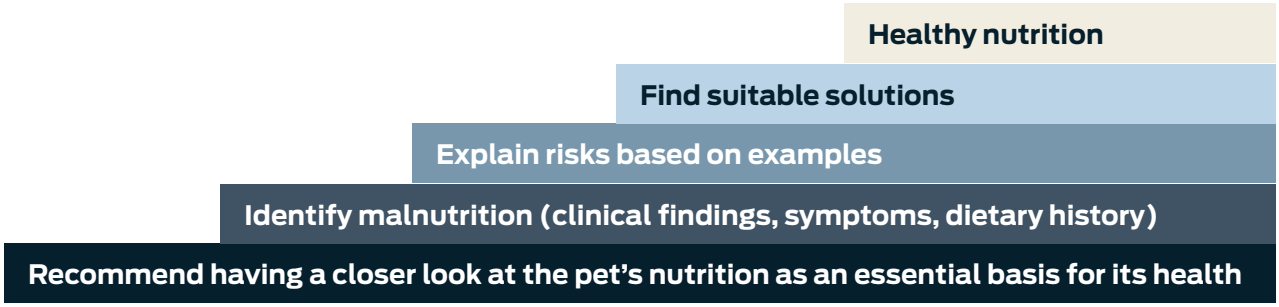
COMMUNICATION

Communication of potential risks of malnutrition and unbalanced diets is a delicate topic in daily clinical practice. Even if pet owners trust their veterinary health care professionals with clinical treatments like surgeries or medication, approaching their pet's nutrition often requires more sensitivity, empathy,

Table 1. Common examples of nutrient excess and deficiency and potential consequences

	Excess	Deficiency
Energy	Obesity, growth disturbances	Weight loss, emaciation, stunted growth
Protein	Intestinal dysbiosis (increased production of ammonia, amines, toxins), impaired fecal quality, flatulence	Weight loss, impaired growth, hypoalbuminemia, poor coat quality
Fiber	Impaired digestibility and availability of energy and nutrients, increased fecal volume; soluble/fermentable fiber: diarrhea	Impaired intestinal health (fiber is not an essential nutrient, but it significantly impacts health)
Calcium[11]	Puppies: impaired skeletal development, impaired availability and absorption of other minerals	Nutritional secondary hyperparathyroidism, bone rarefaction, seizures
Vitamin A[12]	Teratogenic effects; cats: vertebral and periarticular hyperostosis, liver fibrosis; dogs: lethargy, hair loss, intermittent lameness	Dogs, puppies: anorexia, weight loss, ataxia, xerophthalmia, skin lesions, deafness; cats: conjunctivitis, xerosis with keratitis and vascularization of the cornea, cataracts, abortions
Vitamin D[11]	Vascular and renal calcification	Poor muscle tone, lethargy, rickets, paralysis

Figure 1. Evidence based communication is the stairway leading to the door to balanced, healthy pet nutrition, unlocked by the key of mutual understanding



and experience. The responsibility of choosing the best food for their pet is taken increasingly seriously by pet owners. Help the owner to understand that talking about adequate nutrition and addressing potential issues thereof is important for their pet's health. Clients may misinterpret the supportive intention as critique of their choice. To help stress the veterinary health care team's partnership with the owner, ask questions to understand the owner's point of view. The ultimate goal, depending on the individual requirements of the pet and the owner's wishes, is to make a recommendation of a suitable complete and balanced food (**Figure 1**), scheduling a new appointment for more detailed evaluation of nutrition, or a referral to a qualified veterinary nutritionist.[13,14] However, a final decision does not have to be made in one day, and the conversation can be considered successful if the door is opened to continue the discussion at a subsequent visit.

HOW TO EXPLAIN MALNUTRITION – SAMPLE DIALOGUE

"A complete and balanced food fed daily in adequate amounts provides all the nutrients your pet needs for normal body function. Imagine nutrients are people fulfilling different tasks in a city. If one bus driver is missing in the morning, a few people will be late for work until a substitute driver arrives. If a train does not run, there are no busses at all, or no substitute bus driver is available and the bus cannot transport anyone during the entire day, more people and their tasks will be affected. If all traffic is stopped, life will be completely disrupted on that day. The longer this continues, the more serious the consequences will be." Additional sample communication tips are available in **Table 2**.

Table 2. Clinical examples indicating a risk for malnutrition and how to address these scenarios with pet owners

	Example	Communication
Manufacturers with questionable expertise ▪ **Never heard of the product?** ▪ **Too good to be true?**	Inadequate declaration, unrealistic, unsubstantiated advertising claims; suspicious labeling or claims: without additives, whole food, human grade, longevity claims	"To be confident that this product will provide everything needed to support your pet's health, I recommend we request some further information from the manufacturer. More details about the nutrient analyses or content, and the evidence the manufacturer has for the claims they make, will help us assess nutritional adequacy and make a decision about the benefit of feeding this food."
Homemade diet: Inconsistently followed or no calculated recipe[15,16]	"I neither measure the dog's food nor my own food" If an appropriate recipe is available, confirm compliance	"Nutrient requirements are different between us and our pets. Because our pets eat the same thing every day, it's important to make sure that what they eat contains all the nutrients required. Over time, feeding food that has too much or too little of a nutrient can create problems. Being consistent and using a recipe that is balanced to be sure all of your pet's nutrient requirements are met every day will help prevent that."

Table 2. *Continued*

	Example	Communication
Questionable source of recipe or diet recommendation	Internet, self-appointed experts lacking proof of knowledge	"Pet nutrition is a complex science, and a lot of conflicting information is available. When we have a pet with health concerns, the safest option to ensure nutritional adequacy is to follow the guidance of a veterinary specialist who has spent extra years to develop expertise in nutrition for both healthy and sick pets."
Questionable composition (screen for adequate sources of nutrients such as vitamins and minerals)	Huge variety of feedstuff and/or supplements Insufficient supplementation, obvious lack of nutrients, example: "pure beef (muscle meat), vegetables, herbs"– no source of calcium, essential fatty acids, vitamin D (and others)	"Creating a diet for a pet that has all of the essential components to meet their requirements is like putting together a large jigsaw puzzle. Unfortunately, it's not quite as easy as making sure there is a wide variety of ingredients. To make all of our pieces fit together to show the correct picture, we have to be careful and targeted in selecting ingredients and supplements in the correct amounts so everything adds up to meet the nutritional requirements for a diet your pet can eat safely every day."
Food following a special trend	Boutique diets,[17] no grain, vegan,[18] fresh pet food, homemade style[19]	"I see how committed you are to feeding your pet the healthiest food possible. Based on the evidence we have about the ability of these diets to meet all of your pet's nutritional requirements, I'd like to spend time discussing how we can find out more about the specifics of this food and learn how it matches up to what your pet needs."
Complementary food as main food	Confusion between complete and balanced and complementary food (both are available as dry kibble, canned, in pouches, jars, carton)	"Complementary food, in contrast to complete and balanced food, requires combination with other food, to meet the nutrient requirements of your pet."
Intended use not suitable	Age (e.g., complete and balanced food for adult dogs fed during growth), particular nutritional purpose (e.g., renal diet fed to all cats in the household, independent of their health status and age), species (e.g., dog food fed to cats)	"This food product has a specific purpose. At this time in their life your pet's individual needs are different from what this food is intended to do, which puts them at risk of nutritional deficiencies and could affect their health. It's important for us to explore some options that align with what your pet needs now to support their best health."
Feeding instructions not followed	Daily amounts fed deviate from recommendation, significant amounts of treats or table scraps fed instead of or in addition to complete and balanced food	"Feeding more or less of the food than recommended might lead to your pet getting too much or too little of certain nutrients. We also want to carefully look at the budget for treats and table scraps to ensure they are not receiving too many calories or excessive nutrients that might lead to weight changes or nutrient imbalances."
Unclear feeding recommendations	"Feed different varieties of our products alternately to meet nutrient requirements"	"A complete or complete and balanced food is one that meets all of your pet's nutrient requirements, even if it's the only food they eat. Alternating between different foods won't help ensure your pet is getting all the nutrients they need if those foods aren't complete and balanced, which is why it's important for us to explore food options that are complete and balanced and suited to your pet."
Additional supplements (type, variety, and daily amounts)	E.g., calcium, vitamin D supplements in addition to a complete and balanced diet	"A suitable complete and balanced food, when fed as recommended, provides nutrients in adequate and balanced amounts. Supplements in addition to a complete and balanced diet are not required and should be used cautiously to avoid nutrient oversupply and imbalance."

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PRACTICAL TOOL: COMMUNICATING WITH PET OWNERS ABOUT TREATS

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For many pets and pet owners, treats are an essential part of the human-animal bond and can play a significant role in training or just daily life. Although the term may invoke an assumption of rarity, both pet owners and veterinarians should be aware of the nutritional contribution of treats to a pet's diet, which can be significant.

A commonly used rule of thumb is to keep calories from treats under 10% of the pet's overall caloric intake to avoid unbalancing the diet as a whole. As demonstrated by the pet obesity epidemic, any source of additional calories should be examined to help maximize our pets' health and longevity.[1] Additionally, treats may push a diet outside the recommended content of certain nutrients. For example, growth is a demanding life stage, and large breed puppies especially can be sensitive to changes in nutrients or calories (**Table 1: Scenarios 1 and 2**). How quickly and overtly this "10% allowance" is used varies dramatically depending on the household lifestyle and type of treat given.

If treats are problematic, here are some tips:

1. **Specify the recommended maximum amount of treat calories.** Make this easy on the veterinary health care team. For example, the team can make a one-page template with a pet's expected overall caloric intake range, with a recommended breakdown between food (90% or more of total calories) and treats (10% or less of total calories). Give clients a specific amount of expected "treat allowance." Utilize spreadsheets to make this a feasible outcome for every patient.
    a. **Example:** A 10-kg adult dog may have an average caloric need of 550–630 kcal per day. A 10% treat allowance is approximately 60 kcal per day, and the rest of the calories should be coming from a complete and balanced diet.
2. **Give examples of caloric content.** Use low-calorie examples, such as vegetables or training treats, as well as their current treats, to help pet owners make educated treat choices. It is helpful to obtain the calorie content of commonly used commercial treats from the label or website, or by calling the manufacturer.
    a. **Example:** Treat allowance (~60 kcal per day) = one cup chopped raw broccoli (91 grams, 31 kcal)[2] + two of the pet's current treats (28 kcal)
3. **Train and leverage your team** to ensure you have a dietary history for each pet, especially during wellness visits. Use a dietary history form. Make sure to ask specifically about treats and other unbalanced food items such as foods for medication administration, chews, and anything else. Be sure to keep the conversation free of judgment.
4. **Ask for feedback.** How does the client feel about this recommended treat maximum? Is this feasible? If not, what kind of barriers do they have? How do they like to use treats?
    a. **Common roadblocks:**
        i. **Training:** Dogs in training may need high value treats. You can experiment with using a small amount of high value treats mixed in with lower calorie treats. For example, using one to two meat-based treats crushed with low calorie treats (such as treats with only 2–3 kcal). Using kibble is also a great option for these dogs as this does not need to come from their treat allowance. Finally, timing is key for increasing treat value. Instead of feeding a dog in training a full meal, make them "work" for a portion of the kibble.
        ii. **Shelf-stability:** Busy households that need shelf-stable treats may like the idea of fresh vegetables but are unable to have these easily on hand. These clients may like the idea of using plain human cereals, chopped dehydrated sweet potatoes, or apples.
        iii. **Chewers:** Dogs that need treats for environmental enrichment may like vegetables or fruits, such as carrot sticks, which avoids calorically dense long-lasting treats. Another popular option is using canned food or

Table 1. Treat scenarios

Scenario 1: If a 10-kg, large breed, 4-month-old puppy is receiving 10% vs 20% of his intake as cooked boneless skinless chicken breast,[4] it would alter his nutritional profile accordingly:

1. RER = 394 kcal ME/day
2. MER factor of 3.0 x RER = 1,181 kcal ME/day
3. Treat capped at 10% of intake = 118 kcal/day
4. Treats capped at 20% of intake = 236 kcal/day

	Example large breed puppy food at MER	Food + 10% MER as chicken	Food + 20% MER as chicken
Total Energy	1,181 kcal per day	1,299 kcal per day	1,417 per day
Nutrient per 100 kcal			
Protein	7.4 grams	8.5 grams	9.4 grams
Fat	3.9 grams	3.7 grams	3.6 grams
Calcium	332 mg	302 mg	278 mg
Phosphorus	257 mg	246 mg	238 mg
Ca:P	1.3	1.2	1.2
Sodium	102 mg	93 mg	85 mg

Scenario 2: If a 10-kg, large breed, 4-month-old puppy has 10% vs 20% of his intake *replaced* as cooked boneless skinless chicken breast,[4] it would alter his nutritional profile accordingly:

1. RER = 394 kcal ME/day
2. MER factor of 3.0 x RER = 1,181 kcal ME/day
3. Treat capped at 10% of intake = 118 kcal /day
4. Treats capped at 20% of intake = 236 kcal/day

	Example large breed puppy food at MER	Food + 10% MER as chicken	Food + 20% MER as chicken
Total Energy	1,181 kcal per day	1,181 kcal per day	1,181 kcal per day
Kcal from food	1,181	1,063	945
Kcal from treats	0	118	236
Nutrient per 100 kcal			
Protein	7.4 grams	8.6 grams	9.8 grams
Fat	3.9 grams	3.7 grams	3.5 grams
Calcium	332 mg	299 mg	266 mg
Phosphorus	257 mg	245 mg	235 mg
Ca:P	1.3	1.2	1.2
Sodium	102 mg	92 mg	82 mg

canned pumpkin frozen on a lick mat or in a rubber toy. Interactive feeders such as puzzles are also great solutions. If a larger chew is needed, review VOHC accepted products[3] and ensure these calories are accounted for in the pet's overall diet plan. If dental chews have higher calories, they can be given three days a week versus every day to avoid weight gain or other issues.

b. **Household habits:** Sometimes we find that the owners' habits are the roadblock. Ensuring everyone is on board with the plan for the pet and the "why" behind it is essential. For households that have multiple members, it can be easy to unintentionally go over the treat allowance. For these households, try measuring out the days' worth of treats and putting them into one bin. That way, all members have a clear visual on what the pet is allowed to have for the day.

5. **Goals:** Finally, it can be powerful to remind owners that treats don't have to be unhealthy. Use treats to further improve the nutritional profile of a pet's diet, to support dental health, to strengthen the human-animal bond, and/or to provide training and environmental enrichment. If treats are not serving these goals, examine what cues are behind treat-feeding and provide non-food paths to this goal. For example, if a pet begging typically provokes a treat as a response, engaging in a favorite activity such as playing with a toy or brushing may have a similar effect and may be in line with the owners' health goals for the pet.

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USING SUPPLEMENTS IN SMALL ANIMAL PRACTICE

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KEY TAKEAWAYS

- Many pet owners give supplements to their pets despite weak regulations leading to possible risks.
- Many supplements lack scientific studies proving their safety or effectiveness.
- Clinicians and their support staff should guide pet owners on the proper use of supplements, emphasizing a balanced diet and avoiding toxicity.

Recent reports indicate that 50% of dog owners and 32% of cat owners in the USA give their pets dietary supplements.[1] In Europe, sales of pet food supplements have been increasing at a rate of 4.7% per year from 2018 to 2022, with even greater growth expected in the coming years.[2]

These data confirm that the use of dietary supplements is a common practice among pet owners, driven by a rise in pet ownership and an increased focus on pet health and longevity. Additionally, pet owners are becoming more aware of scientific research regarding various health aspects, which enhances their trust in these products.[3] The abundance of available options, accessible through multiple channels and in different presentations (powders and liquids to add to the food, flavored treats, etc.), also contributes to this trend.

As qualified health professionals, veterinary clinicians and their support staff are being called upon to discuss the use of these products with pet owners. Therefore, gaining a better understanding of nutraceuticals and supplements is imperative.

VETERINARY DIETARY SUPPLEMENTS AND THEIR REGULATION

A nutraceutical is defined as a food or part of food that provides medical or health benefits beyond just the provision of essential nutrients.[4,5] The term "nutraceutical" is not officially defined, and regulatory bodies specify definitions for veterinary dietary or food supplements, which in turn dictate the regulations governing their commercialization.[6]

In the United States, the Dietary Supplement Health and Education Act defines a dietary supplement as a product intended to complement the diet, containing one or more of the following dietary ingredients: a vitamin, a mineral, an herb or other botanical, an amino acid, a dietary substance for use by humans to enhance the total daily intake, or a concentrate, metabolite, constituent, extract, or combinations of these ingredients. Nutritional supplements for pets must comply with the US Food and Drug Administration (FDA) and AAFCO regulations for animal feed; however, non-nutritive supplements are not subject to the same regulations. Although manufacturers and organizations have suggested labelling and safety oversight systems, non-nutritive supplements face less regulatory scrutiny compared to nutritional supplements and drugs.[6]

Within the European Union, food supplements are defined as concentrated sources of nutrients, including minerals, vitamins, and other substances with nutritional or physiological effects, such as amino acids, essential fatty acids, fiber, and various plant and herbal extracts.[7] In Europe, food supplements are regulated as complementary pet food, which governs how these products are marketed and regulates any functional claims related to health benefits.[8] It is the manufacturer's responsibility to ensure that a food supplement marketed within the EU is safe, compliant with regulations, and that they have proper justifications for health claims and commercial statements about the product. However, the lack of systematic review policies and standardized reporting methods makes it extremely challenging to evaluate each existing product in the EU market.

While various regulations apply in different regions, dietary supplements, unlike drugs, do not require strict demonstration of efficacy to be marketed. The growing commercial interest, paired with a vague regulatory framework and the ease with which pet owners can

purchase human supplements for their pets, creates a challenge for veterinary professionals in making informed decisions about pet supplements.

ASSESSING AND GIVING ADVICE ON DIETARY SUPPLEMENTS

Safety, efficacy, and quality should be the primary criteria for selecting a dietary supplement. However, it can be challenging to find reliable data on these aspects. Many substances marketed as veterinary dietary supplements often lack quality control, safety, and clinical efficacy data.[9] It is important to discuss these criteria with clients, as they may have their own opinions on the matter. In human pediatrics, for example, families do not always communicate their interest in nutraceuticals to health care providers, and physicians often do not ask about it.[10]

Starting the conversation

Owners often administer certain dietary supplements in response to cancer diagnoses in dogs and chronic kidney disease in cats. While veterinarians are the most common source of information, pet shops, social media groups, and blogs are also highly prevalent sources.[11-13]

To properly assess dietary risks, a nutritional assessment that includes a thorough diet history should be conducted. For more detailed information, the reader is referred to other sections of this publication.

Whenever owners give a dietary supplement, it is important to inquire about the reasons behind that decision, the sources of information they have consulted, or who recommended the supplement. Understanding the owner's motivation is crucial for initiating a conversation about the appropriate use of supplements.

The first and most important message from the veterinary health care team is the importance of a complete and balanced diet tailored to the pet's life stage and health condition. Dogs and cats fed a complete and balanced diet do not need additional food supplements that supply extra nutrients. Unlike human nutrition, pet nutrition provides complete and balanced (complete) diets that, when given according to recommendations, meet all nutritional requirements appropriate for the pet's life stage and health status.

If a dog or cat is already on an adequate diet, providing reassurance and information about the benefits of their diet can help avoid unnecessary supplementation. For pets on non-specific, unknown, or unbalanced diets, a transition to a more suitable complete and balanced diet may be recommended. Furthermore, it is essential to communicate the risks of harmful effects caused by imbalances in nutrient intake and the potential toxicities linked to arbitrary supplementation. For example, excessive dietary calcium during the growth phase of large breed dogs may increase the risk of orthopedic diseases.[14]

If a dietary supplement is being given to address clinical signs in the pet, the owner must be informed of the medical nature of the condition and the need for a proper diagnosis and treatment.

COMMUNICATION TIP

Veterinary dietary supplements can be implemented alongside various therapeutic approaches for patients. However, safety, quality, and efficacy must be guaranteed. Given the uncertain regulatory framework, supplements should be carefully selected from reputable manufacturers.

Safety concerns

Product safety is the most critical concern when evaluating supplements. There is often a lack of safety studies for many substances used in pet supplements. While products that have been on the market for extended periods may lend some trust regarding the harmlessness of certain compounds at their recommended dosages, new products, substances, and dosages used in different species still carry risks. This is particularly true for botanical extracts, which should be evaluated cautiously due to their potential toxic effects on dogs and cats.

While scientific literature and regulatory bodies such as the FDA and European Food Safety Authority (EFSA) may provide safety data for some substances, specific safety studies in dogs and cats are limited. Responsible producers should ensure the safety of the compounds in their products when used at the recommended doses.

In addition to the risks posed by active compounds, raw materials used in supplements may also contain contaminants, such as heavy metals found in certain fish oils[15] and mineral[16] supplements. Responsible producers should be aware of these risks and conduct appropriate tests to ensure product safety.

Beyond contaminants, some raw materials may contain additional molecules (vitamins, minerals, etc.) that result in uncontrolled extra amounts of nutrients or other compounds being ingested. For instance, some fish oils can have high doses of fat-soluble vitamins A and D.[17]

For human supplements administered to pets, clinicians must verify that both the product and the dosage are safe. Human multivitamin supplements can lead to toxicity from vitamin D. Additionally, some products may contain high levels of alpha-lipoic acid,[18] stimulants (such as caffeine and ephedrine),[19] or xylitol,[20,21] all of which can cause toxic effects in dogs and cats. In addition to these concerns, human supplements do not have demonstrated efficacy in pets.

Supplement quality implications

Supplements can vary in concentration, which can affect both their efficacy and adequacy. For instance, fish oil supplementation is commonly used to provide EPA and DHA omega-3 fatty acids; however, there are many fish oil products available that offer widely differing concentrations (see **Figure 1**). These variations can influence the amount of fat and energy supplied daily by the supplement, as well as the economic cost for the pet owner.

Claims made about the specific functions of a supplement should indicate that the product contains an amount of the active substance that is realistic for achieving efficacy at the recommended doses. Some products have been reported to contain only minimal amounts of a nutraceutical or ingredient, allowing them to make a claim despite insufficient quantities for effectiveness.[22] Additionally, there are instances where supplements fail to provide the amounts listed on their labels or may not even contain the stated substances when analyzed.[17,23] To avoid low-quality products, it is advisable to use products from reputable manufacturers with adequate quality control systems.

The intended target of the supplement should also be considered. For example, veterinary multi-nutrient supplements are typically formulated for dogs and cats that are fed a complete and balanced diet, resulting in low nutrient concentrations to prevent toxicity. These supplements are not suitable for complementing home-cooked diets or other types of foods. There are specifically formulated supplements available in the market that cater to complete home-cooked diets, and specialists in canine and feline care can provide guidance on the appropriate supplements for these purposes.

Supplement efficacy

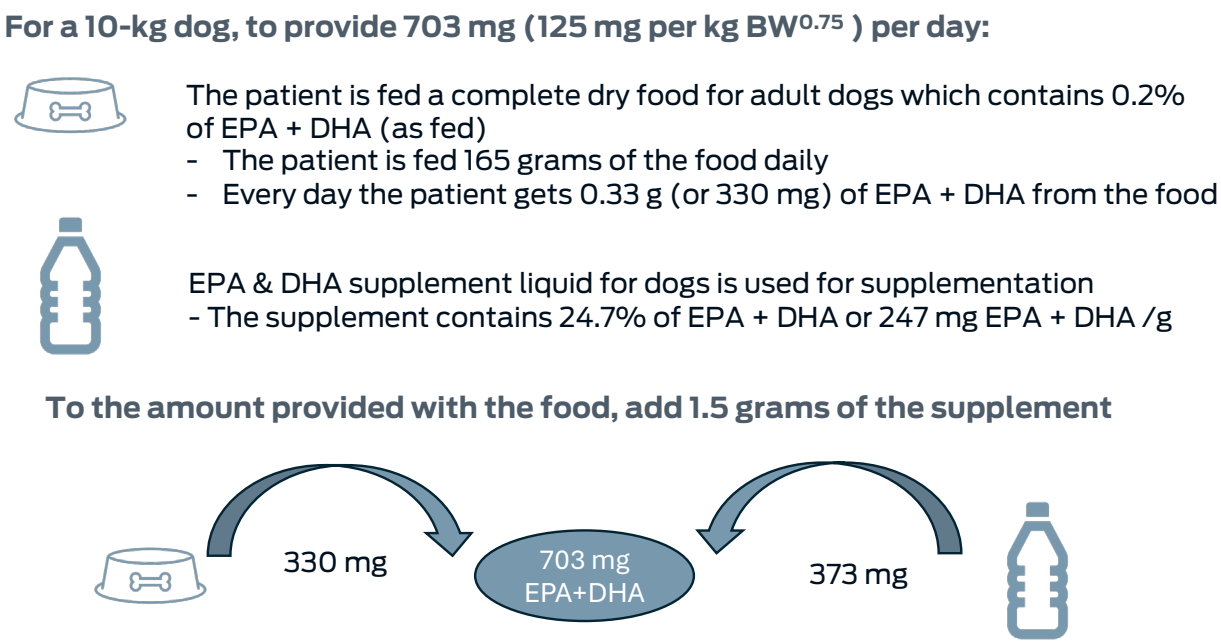
Proving the efficacy of a supplement requires rigorous and often expensive testing. Studies evaluating the effects of supplements in dogs or cats with clinical conditions are not always available. Producers are responsible for providing any supportive documentation

Figure 1. EPA and DHA veterinary supplements and implications of different concentrations



EPA & DHA supplement capsules for cat and dog	Fish oil supplement liquid for cat and dog	EPA & DHA supplement liquid for cat and dog
Content per capsule 99 mg EPA 66 mg DHA	Content per 100 g 3 g EPA 5 g DHA	Content per 1.5 ml pump 400 mg EPA 250 mg DHA
For a 10-kg dog, to provide 703 mg (125 mg per kg BW $^{0.75}$) per day:		
4 capsules per day should be provided Equivalent to 4 g of fish oil	8.8 g per day should be provided	1.6 ml per day should be provided Equivalent to 1.5 g of supplement

Figure 2. Calculating daily amounts of EPA and DHA with different products



of efficacy. The level of evidence supporting efficacy can vary. The most robust products to recommend are those supported by peer-reviewed, blinded, controlled clinical trials using the amount recommended by the producer. Weaker levels of evidence may include studies conducted in vitro, on laboratory animals, or in species other than dogs or cats; non-controlled studies; studies with a small number of animals; or non-peer-reviewed research.[24] Systematic reviews and meta-analyses assessing available information about a nutraceutical in target species can also provide solid evidence of its efficacy—or lack thereof.

The concentration of functional nutrients included in products must also be considered. The amount of the active ingredient(s) provided by the supplements should be those proven effective in studies to achieve the claimed benefits. When calculating the daily amount of a nutraceutical, it is important to consider that some complete and balanced diets may already include the nutraceutical in their composition, meaning the total daily dose comes from both the diet and the supplement (**Figure 2**).

Some studies evaluate the efficacy of supplements containing more than one nutraceutical, which makes it difficult to assess efficacy separately, as the synergy among substances may impact effectiveness. Proven efficacy in such studies can only be expected for the specific nutraceutical combination that was studied, as is the case with products containing various probiotic strains or synbiotics.[25]

Similar products do not necessarily share the same efficacy, especially among probiotics, which are widely recommended by clinicians. The efficacy of probiotics is strain-specific, disease-specific,[26] and dose-specific.[27] Therefore, it is crucial for clinicians to ensure that the recommended probiotic has been proven effective for the disorder being treated at that specific dose; this information should be provided by the manufacturer.[28]

Veterinary dietary supplements can be implemented alongside various therapeutic approaches for patients. However, safety, quality, and efficacy must be guaranteed. Given the uncertain regulatory framework, supplements should be carefully selected from reputable manufacturers based on published scientific data and used within an individualized care context.

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PRACTICAL TOOL: INCORPORATING MICROBIOME SCIENCE INTO GENERAL PRACTICE

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IMPORTANCE OF THE INTESTINAL MICROBIOME

Physiological function of the gastrointestinal tract (GIT) relies on both the host and the intestinal microbiome. Dietary nutrients are broken within the GIT into smaller compounds, which are then absorbed at the brush border of the small intestine. Many of these dietary compounds (e.g., fiber, protein, and fat) are also metabolized by bacteria present in the intestinal lumen. Additionally, some host-derived molecules (e.g., primary bile acids) are metabolized by bacteria. The resulting microbial-derived metabolites are beneficial for the host, whether for energy, for immune responses, regulation of gut motility, and/or intestinal barrier function. Certain beneficial core bacteria (**Table 1**) are found in greater abundance in healthy animals compared to those with intestinal diseases.[1] For example, *Faecalibacterium* ferments dietary carbohydrates into beneficial short-chain fatty acids (SCFAs). The keystone species *Peptacetobacter hiranonis* is the major bile acid converter in dogs and cats and converts primary bile acids from the liver into secondary bile acids in the colon. These secondary bile acids act as immune-modulating signaling molecules and/or suppress pathobionts such as *Clostridium perfringens* and *Escherichia coli*.

CHANGES IN THE INTESTINAL MICROBIOME

The intestinal microbiome reacts to the environment along the intestinal epithelium, while also responding to dietary substrates or medications (i.e., antibiotics, proton-pump inhibitors) within the intestinal lumen.[2] As a result, changes in the intestinal environment can alter the composition of the microbiota. Shifts in the intestinal microbiota can be assessed in individual patients using a commercial assay, the Dysbiosis Index, which has been validated for dogs and cats.[3,4]

Observed shifts in the microbiome can be mild, for example, in response to poorly digestible and/or low fiber diets,[5] and are more severe after antibiotic use or because of architectural changes in chronic enteropathies.[1] Severe shifts in the microbiome lead to functional changes, as a decrease in beneficial core bacteria will also lead to decreased SCFAs and altered conversion of bile acids, which are crucial for intestinal health. Consequently, this altered microbiota may contribute to clinical signs and also create a pro-inflammatory state in the gut.

MODULATION OF THE INTESTINAL MICROBIOME

Modulation of the intestinal microbiome often requires multimodal management. Various approaches exist, with each of them addressing a different mechanism

Table 1. Important core bacteria

	Function	Change in dysbiosis
Faecalibacterium	Anti-inflammatory, production of SCFAs	↓
Turicibacter	Production of SCFAs, serotonin-signaling	↓
Fusobacterium	Production of SCFAs	↓
Peptacetobacter hiranonis	Conversion of primary to secondary bile acids	↓
Streptococcus	Overgrowth associated with maldigestion	↑
E. coli	Pro-inflammatory	↑

Table 2. Modulation of the microbiome

Treatment	Potential mechanism	Potential side effects
Dietary modulation	High macronutrient digestibility leads to less residual substrate available for bacterial overgrowth	None when no food sensitivity
Prebiotics/fibers	Growth of beneficial bacterial (e.g., *Faecalibacterium*); converted to SCFAs; some fibers known to bind deleterious bacterial metabolites	Can initially cause flatulence, diarrhea in higher doses
Probiotics	Can improve barrier function; immunomodulatory effects	Only rare side effects; because of strain-specific function, it is often unclear which patient would benefit most from which strain
Antibiotics	Reduction in total bacterial load and/or mucosa-adherent bacteria	Long-term negative changes in microbiota; when stopped, there is often regrowth of bacteria; increased antimicrobial resistance; some animals develop antibiotic-associated GI signs
Fecal microbiota transplantation (FMT)	Alters luminal microbiota and metabolites	Rarely side effects; long-lasting normalization after antibiotic-induced dysbiosis; recurrence of dysbiosis when chronic intestinal dysfunction present in CE

(**Table 2**). The approach will also depend on whether the animal is healthy or if a dysbiosis is present due to an underlying chronic enteropathy. In the latter, dysbiosis often persists even when clinical symptoms improve, in part due to chronically abnormal GIT function. This generally requires long-term management with diet, fibers, and, eventually, repeated fecal microbiota transplantations (FMTs). For healthy animals, maintaining a healthy and stable microbiome is important to optimize nutrition and overall health and minimize risk factors associated with dysbiosis and a pro-inflammatory gut environment.

Dietary modification is the most effective way to modulate the microbiome and intestinal environment. Of major importance is that diets contain highly digestible protein and fat. This helps with nutrient digestion and reduces undigested food compounds in the intestinal lumen, thereby avoiding bacterial overgrowth and/or production of deleterious bacterial metabolites. The addition of prebiotics and insoluble fiber sources promote the growth of beneficial bacteria and also beneficial metabolites such as SCFAs (**Table 1**).

Probiotics, which are live beneficial bacteria, can have an adjunct benefit as some strains are immunomodulatory or can strengthen intestinal barrier function. Their efficacy depends on the bacterial strain used, and products from reputable sources that have demonstrated benefits in clinical studies should be prioritized.

Antibiotics should be avoided, unless there is a clear indication for their use, as they disrupt the microbiota. In a subset of animals, long-term dysbiosis (increased Dysbiosis Index) has been observed, lasting for several weeks to months.

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PRACTICAL TOOL: USEFUL CALCULATIONS IN NUTRITION

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Making nutrition recommendations can involve many different calculations, but the most frequently used are those that estimate feeding amounts. To calculate feeding amounts, it is necessary to calculate energy requirements and, in some dogs and cats, target body weight. Once an animal's maintenance energy requirement—the number of kilocalories of metabolizable energy (ME) needed per day—has been calculated based on current or target weight, the amount of the appropriate diet to feed can be determined with knowledge of the energy density of the chosen diet(s) and other foods included in the nutrition plan.

Please note that there are multiple ways to calculate energy requirements.[1] The methodology discussed here is one example. Since energy requirements are estimates and the different calculation methods yield similar results, alternative equations can be used.

CALCULATING ENERGY REQUIREMENTS FOR ADULT DOGS AND CATS

There are multiple equations that can be used to estimate a dog or cat's energy requirement.[1] All equations are starting points and estimate the average energy requirement for an animal of a certain weight. Monitoring the patient to ensure weight maintenance (or weight loss or gain, if desired) is essential as there are animals that need more or less energy than the calculation suggests. In addition, the energy requirements of individual patients with acute or chronic illnesses may vary more significantly from these equations than the requirements of healthy pets.

Resting Energy Requirements (RER)

The RER is the basic amount of energy that is used in a day by a pet remaining at rest. RER, expressed in kilocalories (ME) per day, can be estimated with an exponential equation for dogs and cats.[1]

$$RER\ (kcal/day) = 70 \times (body\ weight\ in\ kg)^{0.75}$$

Current weight is most frequently used in the RER equation, but for some patients, target weight can be used in the equation to provide energy requirements for weight loss or gain.

Maintenance Energy Requirements (MER)

RER is used as a starting point to calculate MER, which more accurately estimates the actual daily energy requirements of a dog or cat. The daily energy needs of individual dogs and cats are affected by many different variables, including age and life stage, breed, activity level, reproductive status, environment, and health status. For an individual animal, the MER provides an initial estimate of energy requirements, and ongoing assessment of body weight, BCS, and other health parameters should then be used to adjust food intake as needed.

To calculate MER, expressed in kilocalories (ME) per day, begin with the equation for RER shown above. Use current or target weight as directed below. Then, individual variables must be accounted for by multiplying RER by a specific MER factor.[1-3]

$$MER\ (kcal/day) = RER \times MER\ Factor$$

Commonly used MER factors are listed in **Table 1**. This is not an all-inclusive list—different factors would be required for sporting dogs, for example. These factors are estimates and patient monitoring is required to ensure weight maintenance, loss, or gain as desired.

ESTIMATING TARGET WEIGHT

It is often necessary to estimate target weight for animals that are not in ideal body condition. It is important to remember that target weight equations provide estimates–the calculations, especially for underweight animals, are not completely accurate for every individual dog or cat due to variations in activity level and other variables. Target weight is based on BCS and current body weight and is calculated by multiplying the pet's current weight by a target weight factor as described below.

$$Target\ weight = current\ weight \times factor\ based\ on\ current\ BCS$$

Table 1. Selected MER factors for dogs and cats[3]

Description of animal	Current or target weight	MER factor (MER = RER x factor)
Neutered adult dog	Current	1.6
Intact adult dog	Current	1.8
Obese-prone or inactive adult dog	Current	1.2-1.4
Obese adult dog	Target or current*	1.0
Underweight adult dog	Target	1.4-1.6
Puppies, weaning to 4 months	Current	3.0
Puppies, 5 months to adult	Current	2.0
Canine gestation	Current	First half of gestation, 1.8 Second half of gestation, 2.5-3.0
Canine lactation	Current	3.0-6.0
Neutered adult cat	Current	1.2
Intact adult cat	Current	1.4
Obese-prone adult cat	Current	1.0
Obese adult cat	Target or current*	0.8
Underweight adult cat	Target	1.2-1.4
Kittens, weaning to 4 months	Current	3.0
Kittens, 5 months to adult	Current	2.0
Feline gestation	Current	At breeding, 1.6 Increase to 2.0 as parturition nears
Feline lactation	Current	2.0-6.0

* Target weight is often used to determine calorie intake for weight loss. However, current weight can be used if target weight is difficult to determine or if there is concern for drastic calorie restriction leading to nutrient deficiencies or unwanted begging behaviors.

The factors are derived from research indicating that each BCS point above ideal accounts for approximately 10-15% of body weight.[4-6] For overweight patients, the factors (**Table 2**) are described in the 2014 AAHA Weight Management Guidelines.[7]

For underweight patients, the target weight factors are not as well researched or validated, but the ones listed in **Table 3** are calculated similarly to the overweight patient target weight factors.

The target weight factors for both overweight and underweight patients assume the pet's ideal body condition score is 5/9. Some dogs, such as canine athletes and orthopedic patients, may have an ideal BCS of 4/9. If the dog's ideal body condition score is 4/9, the percent overweight increases by 10% and the percent underweight decreases by 10%. To calculate target body weight for a dog with an ideal body condition of 4/9, the target weight factor should be adjusted accordingly. Monitoring during weight gain or weight loss plans is essential.

Table 2. Target weight factors for overweight patients

Body condition score	Percent overweight*	Target weight factor (Target weight = current weight x factor)
6/9	10%	0.9
7/9	20%	0.8
8/9	30%	0.7
9/9	40%	0.6

*This is a starting point for calculations. Please keep in mind that it is an estimate. Each patient should be evaluated closely during a weight loss plan to avoid nutrient deficiencies and excessive food restriction.

Table 3. Target weight factors for underweight patients

Body condition score	Percent underweight*	Target weight factor (Target weight = current weight x factor)
4/9	10%	1.1
3/9	20%	1.2
2/9	30%	1.3
1/9	40%	1.4

*This is a starting point for calculations. Please keep in mind that it is an estimate. Each patient should be evaluated closely during a weight gain plan.

CALCULATING ENERGY REQUIREMENTS FOR GROWING PUPPIES AND KITTENS

Puppies and kittens have higher energy requirements than adult dogs and cats per unit of body mass. Energy requirements per metabolic body weight ((BW in kg)$^{0.75}$) are initially quite high (after weaning), and then decline as the puppy or kitten reaches their adult weight.[3] Puppies and kittens require approximately 3.0 x RER for current weight after weaning up to 4 months, including large and giant breed dogs, and energy requirements will gradually decline to approximately 2.0 x RER for current weight after 4 months.[3] Spay and neuter surgery decrease energy requirements and will likely necessitate downward adjustment of feeding amounts.

Overall, it is most important to maintain the puppy or kitten in ideal body condition.[8] This is especially important for large breed puppies, since their risk of developmental orthopedic disease is higher if they gain weight too quickly. Rapid growth can be associated with obesity and other health problems later in life.[9-11] Free choice feeding should be avoided for dogs. Some puppies can benefit from receiving multiple small meals per day. This is especially relevant for puppies who can become hypoglycemic between meals. It can be safe to feed young kittens free choice, but their food intake should be monitored carefully. This can be more difficult in multi-cat households. If meal-fed, kittens should receive multiple small meals per day and should be fed more often than twice daily.

CALCULATING ENERGY REQUIREMENTS FOR GESTATION

For female dogs, energy requirements will gradually increase starting after week 5 of gestation and until parturition. Energy requirements increase to up to 3.0 x RER during gestation, with large breed female dogs requiring a bigger increase in energy.[3] Queens require more energy versus maintenance throughout gestation, starting at breeding, and gain weight linearly.[3] Calorie intake should be increased to 1.6 x RER at breeding and then to 2.0 x RER as parturition nears to allow for steady weight gain.[3]

CALCULATING ENERGY REQUIREMENTS FOR LACTATION

Lactation is a huge energy demand on the female, and energy requirements can be so high that it can be difficult for the female to consume enough energy to maintain ideal body condition.[3] The energy needed during lactation depends on the number of puppies and kittens in the litter and the week of lactation, and usually falls between 3.0-6.0 x RER for female dogs and between 2.0-6.0 x RER for queens.[3] Energy demands become higher as the puppies or kittens grow, and having a larger litter is more demanding. Solid food should start to be introduced to the puppies or kittens during the third week of lactation to help reduce the energy demands on the female.

The female's body condition should be monitored to ensure she does not fall below ideal body condition, and food intake should be adjusted if her BCS changes rapidly or if her MCS decreases. Queens lose a significant amount of body weight during lactation and should be weighed at least weekly to ensure weight loss occurs gradually. Body weight should not dip below pre-breeding weight for both female dogs and queens. Energy intake for lactating dogs and cats should be free choice if significant weight loss occurs. Preweaning puppies and kittens should be weighed daily to ensure slow, steady weight gain.

SUMMARY

Because calculating energy requirements provides an estimate, it is important to notate every dog or cat's body weight, BCS, and MCS in the pet's medical record at every visit. It can also be helpful to teach pet owners to monitor BCS so they can alert the veterinary health care team if the pet's BCS changes.

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NUTRITIONAL ASSESSMENT

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KEY TAKEAWAYS

- Nutritional assessment is vital for maintaining the health and welfare of dogs and cats as well as for disease management.
- The screening nutritional assessment, comprised of diet history, body weight, body condition score, muscle condition score, skin and coat health examination, and dental examination, adds little time and no cost to a veterinary consultation, and provides great benefits for pets and for their owners.
- An extended nutritional examination should be performed when risk factors are found or suspected.

INTRODUCTION

Nutritional assessments are critical for maintaining pets' health and their optimal response to disease and injury. The World Small Animal Veterinary Association (WSAVA) has established guidelines for nutritional assessment as the 5th vital assessment incorporated into the standard anamnesis and physical examination.[1] The nutritional assessment requires little time and no cost, is greatly beneficial for pets, and enhances the bond between owners and the veterinary team.

The standardized assessments include:

1. temperature
2. pulse
3. respiration
4. pain assessment
5. nutritional assessment

COMPONENTS OF A NUTRITIONAL ASSESSMENT

Nutritional assessment includes consideration of animal-specific factors, diet-specific factors, feeding management, and environmental factors.[1]

Animal-specific factors include age, life stage, activity, and nutrient-sensitive disorders requiring specific dietary management (e.g., chronic kidney disease, obesity).

Diet-specific factors include the safety and appropriateness of the diet and include nutrient imbalances, spoilage, and contamination. Feeding an unbalanced homemade or poor-quality commercial diet is within this part of the assessment.

Feeding and management factors include the frequency, timing, location, and method of feeding. Feeding management includes over- or under-feeding, treats/snacks/human foods, scavenging, and hunting. Environmental factors include the pet's housing, presence of other animals, access to the outdoors, and environmental enrichment.

Owner factors and the owner's relationship with their pet should also be taken into consideration (**Figure 1**). Good communication with owners is vital and is addressed elsewhere.

Nutritional assessment is a two-part process comprising a screening evaluation and, when needed, an extended evaluation (**Figure 2**).[1]

Screening evaluation

The screening evaluation should be part of routine history taking and physical examination at every veterinary visit. It includes the diet history, body weight, body condition score (BCS), muscle condition score (MCS), and evaluation of the coat and oral health.

Diet history, body condition score, and muscle condition score are covered elsewhere.

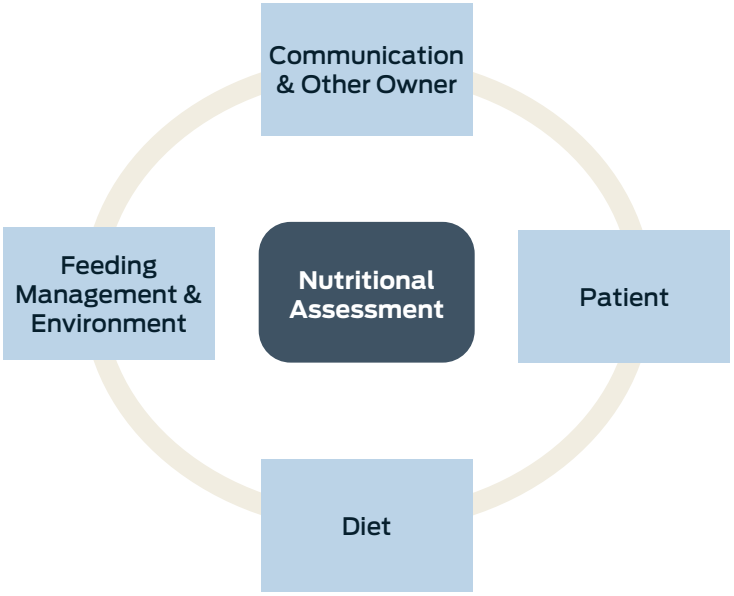
Body condition scores using a 9-point scale show good repeatability.[2,3] Lower BCS numbers indicate underweight and higher numbers indicate overweight/obesity. For dogs, a BCS of 4/9 to 5/9 is ideal. A score of 4/9 would be appropriate for typically leaner breeds (e.g., Greyhounds) or working dogs. For cats, a BCS of 5/9 is generally considered ideal, with a BCS of 6/9 being ideal for some cats.[4] Middle-aged or senior cats and those with chronic disease conditions (e.g., kidney or heart disease) may have better survival times with a BCS of 6/9 rather than < 5/9 or > 7/9.[4–6]

Body condition charts include profile and "top-down" pictures with written descriptions. Body condition is determined using a combination of visual appearance, e.g., if there is a waist apparent looking down on the pet and an abdominal tuck visible from the side profile, and palpation of the fat cover over the ribs. The owner should be shown how to palpate their pet, placing their hands gently in a flat position over the pet's ribs (**Figure 3**).

The BCS evaluates body fat; however, it is possible for a pet to have excess fat but still have muscle loss (e.g., diabetic cats and other ill or aged pets). Acute or chronic disease can cause loss of muscle mass disproportionate to the loss of fat due to cytokine and neurohormonal effects on metabolism.[7] Muscle mass scoring systems are based on palpation of skeletal muscle over the skull, scapulae, spine, and pelvis.[1] Animals are scored as having normal or mild, moderate, or severe muscle wasting.

Every pet owner should leave the hospital or appointment with a written dietary recommendation

Figure 1. Screening evaluation factors including owner communication



Patient factors include age, life stage, activity, and nutrient-sensitive disorders requiring specific dietary management.

Diet factors include safety and appropriateness of the diet and include nutrient imbalances, spoilage, and contamination.

Feeding management and environmental factors include feeding frequency, timing, location, and method of feeding; over- or under-feeding; extra foods; housing; presence of other animals; access to the outdoors; and environmental enrichment.

Communication and other owner factors include the owners' lifestyle (e.g., work and family commitments), members of the household, beliefs about pet food and feeding, relationship with the pet, and their communication styles with the veterinary team.

Figure 2. Flow chart for screening and extended nutritional assessments

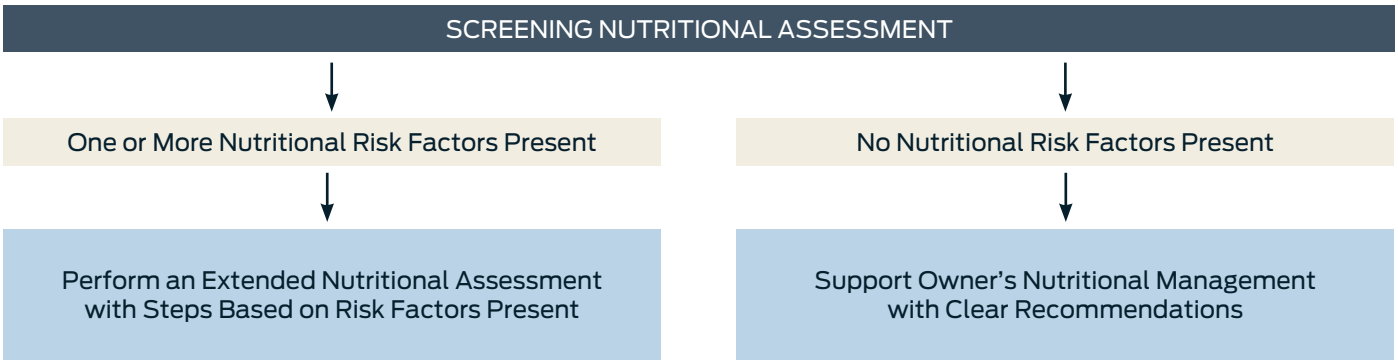


Figure 3. Demonstration of palpation of the ribs of a cat for a body condition score



on a discharge sheet along with any other instructions, e.g., for medication. If no change is recommended, the owners should be advised that the current diet and management are appropriate.

Extended evaluation

An extended evaluation should be performed if nutrition-related risk factors are found or suspected on the screening evaluation or medical assessment. A checklist for indications for an extended evaluation is available from the WSAVA website.[8] The items on the checklist are discussed below.

RISK FACTORS INDICATING EXTENDED EVALUATION

Animal risk factors indicating an extended evaluation include over or under ideal BCS, unintentional weight gain or loss, decreased muscle condition, changes in food intake or feeding behavior, changes in the coat or skin (e.g., dryness or alopecia), altered gastrointestinal function (e.g., vomiting, diarrhea, nausea, flatulence, constipation), dental abnormalities or disease, and new or previous or ongoing medical conditions/disease. Growing puppies and kittens and queens or bitches in gestation or lactation may also require an extended evaluation.

Abnormalities in the serum chemistry profile (e.g., high or low glucose, albumin, total protein, electrolytes, urea, creatinine, or thyroid hormone), urinalysis, fecal examination, or other diagnostic tests should also trigger an extended evaluation and medical diagnostic workup.

Dietary risk factors include medications and/or supplements, unconventional diets (e.g., raw, homemade, vegetarian, grain free), a diet unfamiliar to the clinician, hunting or scavenging, begging, extra foods (e.g., snacks, treats, human foods) comprising more than 10% of total calories, and any concerns with food safety.

Feeding management concerns include multiple pet households (e.g., potential competition for or guarding of food), inappropriate location of food and water bowls, inadequate feeding frequency, decreased or increased spontaneous activity level, environmental stressors, and inadequate or inappropriate housing.

EXTENDED NUTRITIONAL ASSESSMENT

The extended evaluation depends upon what risk factors are suspected or found.

Diet factors in an extended evaluation may include caloric density, food ingredients, and supplements. Treats, human foods, food given to administer medications, and successful hunting or scavenging should be evaluated for their effect on diet balance and caloric intake. If disease conditions exist which may be due to contamination of the food, food testing should be performed. Raw foods carry a higher risk of bacterial contamination than those that are cooked.

Diets should be appropriate for the pet's nutritional life stage (i.e., growth, adult, reproduction). There is no unique life stage nutritional profile for senior or geriatric cats or dogs. They are included as "adults," but they should be fed as individuals as no single type of diet is suitable for all older pets.

Diets should be formulated to meet FEDIAF,[9] AAFCO,[10] or NRC[11] nutrient requirements. Commercial pet food companies usually use FEDIAF or AAFCO requirements

as they are adapted for use in commercial diets. Ideally, appropriate feeding trials of commercial diets will have been performed to demonstrate they are nutritionally replete. The quality control protocols, reputation, and research of the company are also important factors.

Homemade diets should be checked to determine if they are complete and balanced. The owner may need to be referred to a board-certified veterinary nutritionist for homemade diet analysis or formulation.

COMMUNICATION TIP

Small animal clinics have reported an improvement in consistency of the total examination process, more discussion on nutrition, and better wellness care after implementation of nutritional assessments.

Therapeutic diets may be indicated, and the use of the correct diet should be assessed. Not all patients with a disease (e.g., hepatic, renal, cardiac disease) need to be on a commercial therapeutic diet labeled for that disease. A concurrent disease may take precedence over the one for which the diet is being fed, or the diet may not be appropriate for that individual pet. For example, for pets in early stages of chronic kidney disease, an early renal diet may be more appropriate than a severely protein-restricted diet.[12,13]

Extended evaluation feeding management factors include multiple pets, resulting in either competition or pets receiving an inappropriate diet (e.g., all household pets inappropriately fed a renal diet meant for one pet, puppies fed adult foods). Environmental factors include the pet's activities; living indoors, outdoors, or both; availability and accessibility of clean water (e.g., an arthritic dog unable to climb stairs to the bowl); and, for inside cats, access to a clean litter box (e.g., a cat guarding the box or infrequent litter box cleaning). Stress due to other animals within the household or outside the house, negative interactions with family members, or being left alone for long periods of time have an impact on the pet's health. Pets may show competitive eating, coprophagy, or obesity due to environmental factors. For example, indoor confinement and physical inactivity are risk factors for overweight in cats whereas feeding balls or interactive toys increase activity and decrease food intake.

HOW TO INCORPORATE A NUTRITIONAL ASSESSMENT INTO PATIENT APPOINTMENTS AND EXAMINATIONS

Nutrition and nutritional assessment ideally should include all of the health care team, including receptionists, veterinary technicians/nurses, and care assistants as well as veterinarians. An awareness of the clients' desires to have nutrition information from the veterinary team as well as the importance of nutrition for pet health should be discussed at a team meeting. Veterinary team members sometimes feel their nutrition knowledge is inadequate to provide guidance to pet owners. The WSAVA Global Nutrition Toolkit and WSAVA Academy Nutrition Modules can provide the education and confidence to incorporate nutrition into clinic consultations.[14]

Sending diet history forms to owners prior to the consultation or having them come to the clinic a bit early to fill them out saves time in the examination room. They can then be screened for any dietary risk factors that need to be discussed with the client.

Creating templates in the objective part of SOAP (subjective, objective, assessment, plan) examination record provides a stimulus for including and recording BCS and MCS as well as body weight, and dermatological and dental assessments.[15] These should either have no default or default to zero if not performed rather than to normal or good. A scan of the record then shows if the assessment has been omitted. Charts for BCS and MCS should be available in the records and/or easily seen in the examination room. Performing a BCS, MCS, coat, and dental assessment adds very little time to the physical examination process.

The assessment part of the SOAP record would include nutritional assessment of the current diet. The plan includes a recommendation to continue with the current diet and management of any changes recommended. If risk factors are found on the screening assessment, another appointment for an extended assessment may be beneficial.

After nutritional assessment has been incorporated into the clinic, follow-up reviews will determine if the staff needs any changes to help implement the program. Small animal clinics have reported an improvement in consistency of the total examination process, more discussion on nutrition, and better wellness care after implementation of nutritional assessments.[15]

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OBTAINING A COMPREHENSIVE NUTRITIONAL HISTORY

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KEY TAKEAWAYS

- Obtaining a comprehensive nutritional history is the foundation for performing a nutritional assessment and should be completed as part of every veterinary assessment.
- A comprehensive nutritional history is comprised of 1) patient factors, 2) diet factors, 3) environmental factors, and 4) human factors.
- When obtaining a nutritional history, the veterinary healthcare team should utilize a combination of verbal and written communication strategies, such as open-ended inquiries and nutritional history forms.

IMPORTANCE OF A COMPREHENSIVE NUTRITIONAL HISTORY

Obtaining a comprehensive nutritional history is fundamental to assessing patient wellness. According to the World Small Animal Veterinary Association (WSAVA), the "five vital assessments" should be performed at each veterinary assessment and include 1) temperature, 2) heart rate, 3) respiratory rate, 4) pain assessment, and 5) nutritional assessment.[1] Over a decade ago, the WSAVA Global Nutrition Committee published Nutritional Assessment Guidelines that highlight the nutritional assessment as the "fifth vital assessment," of which obtaining a comprehensive nutritional history is a key component.[1]

DEVELOPMENTS IN OBTAINING A COMPREHENSIVE NUTRITIONAL HISTORY

Performing a nutritional assessment is an iterative process that begins by screening each patient for nutritional risk factors, which includes the patient's nutritional history, medical history, and physical examination findings.[1,2] The comprehensive nutritional history is comprised of a detailed evaluation of 1) patient factors, 2) diet factors, 3) environmental factors, and 4) human factors.[2] Previously, the recommendation of the American College of Veterinary Nutrition was to focus on "the circle of nutrition" (see **Figure 1**), which lacked specific emphasis on human factors.[3] Given the role humans play in provision of nutrition to domesticated cats and dogs, adding a fourth category to focus solely on "human factors" in the 2021 American Animal Hospital Association (AAHA) Nutrition and Weight Management Guidelines for Dogs and Cats was an important step.[2]

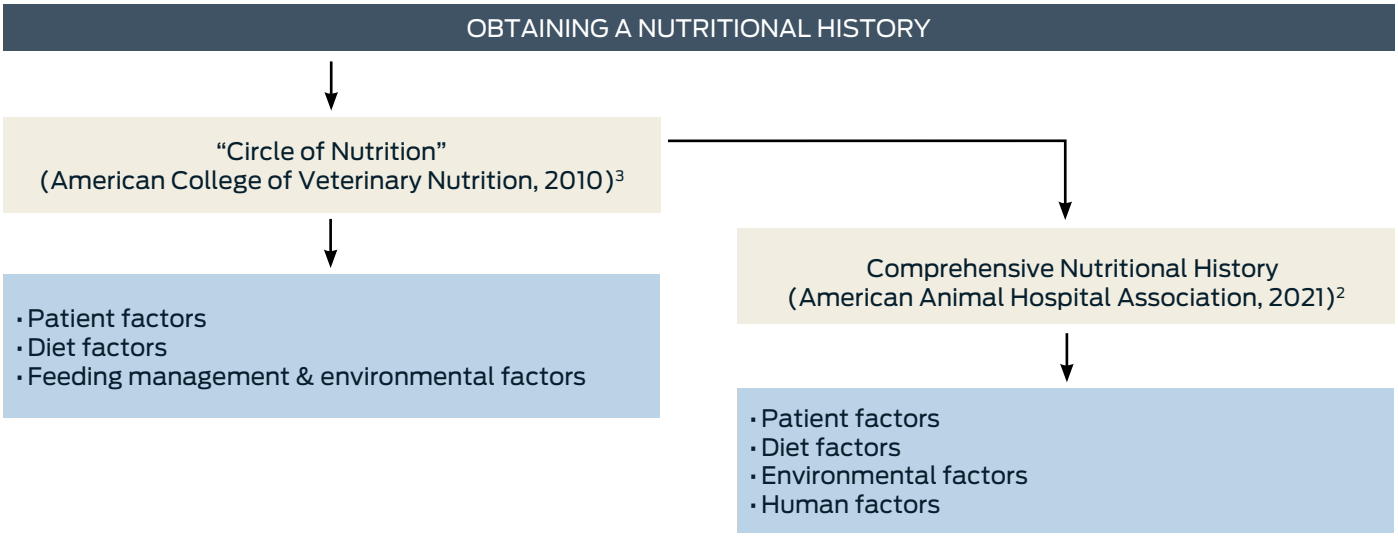
A SYSTEMATIC APPROACH: THE FOUR FACTORS

The four factors of the comprehensive nutritional history serve as the framework for the systematic approach to gathering this pertinent information. Detailed examples of information to be gathered for each of the factors is shown in **Box 1**.[1-5]

OBTAINING A COMPREHENSIVE NUTRITIONAL HISTORY

Communication strategies are not only important when it comes to the efficiency of obtaining a nutritional history, but also to ensure the information is comprehensive. An efficient approach involves a combination of both verbal (incorporating interpretation of nonverbal cues from pet owners) and written communication strategies by the veterinary healthcare team.[6] Gathering a comprehensive

Figure 1. Development of factors included in obtaining a comprehensive nutritional history. Both sets of factors are meant to be iterative processes. In other words, the factors are assessed and then reassessed as needed.



nutritional history is a process that can build rapport and trust with pet owners through openness and empathy on the part of the veterinary healthcare team.

For efficiency, the process should begin with having the main person caring for the patient complete a written nutritional history form at home and then either bringing/emailing the form to the clinic prior to the patient's scheduled assessment (see **Box 2** for examples).[6] Collecting this detailed information requires sufficient time for it to be useful to the veterinary healthcare team, so forms should be provided at least 1 week in advance of scheduled assessments. Providing this form in advance improves the completeness of the nutritional history, especially if the main person caring for the patient cannot attend the veterinary assessment. Additionally, information gathered on the form assists with efficient medical record keeping and provides a starting point for the veterinary healthcare team to ask clarifying questions during the veterinary assessment. This written form does not replace verbal communication, which is essential for building rapport and trust with pet owners.

To initiate the verbal component of gathering a comprehensive nutritional history, gauge the owner's willingness to discuss their pet's nutritional history by asking for example, ***"As part of assessing your cat's overall wellness, I would like to discuss her nutrition and activity. Would it be alright if we go over this in detail?"***[2] Pet owners are usually receptive when asked for permission.[2] If a pet owner is apprehensive, as demonstrated either via verbal or nonverbal cues, use this as an opportunity to demonstrate respect by offering to set up a follow-up consultation at a later date/time. If the pet owner outright declines, move on with the remainder of the consultation given this pet owner is not likely to be responsive to nutrition discussions at this time.[2]

Open-ended inquiries should initially be utilized to allow for more efficient and complete information gathering rather than starting with closed-ended questions that often prompt one-word answers.[2,6-8] The use of open-ended inquiries has consistently demonstrated that a more comprehensive nutritional history is obtained when compared with use of "what-prefaced" questions, such as "What food are you feeding your dog?"[7] Utilizing "what-prefaced" questions often yields brief answers that tend to be restricted to only the commercial brand and subtype (i.e., kitten food) as responses.[8] Comparatively, asking, ***"Tell me everything your dog eats throughout a day, starting from first thing in the morning right through to the end of the day"*** is less restrictive, and provides a clinician with more information.[2,7] After initially using open-ended inquiries, funnel down to more specific questions, including closed-ended questions, to clarify any missing information.[2,6] For further examples, please review: Gathering a Comprehensive Nutrition History (aaha.org).[2]

After reviewing the patient's comprehensive nutritional history, the final step is to check in with the pet owner

Box 1. Detailed information to be gathered for each patient using the four factors of the comprehensive nutritional history

FACTOR 1 – PATIENT FACTORS:

- Patient signalment:
  - Age (i.e., growth, adult maintenance, senior, geriatric)
  - Breed and consideration of known breed predispositions (e.g., obesity in Labrador Retrievers)
  - Sex (i.e., intact, spayed, neutered)
- Physical examination:
  - Current weight and weight trends over time (i.e., increasing, stable, or decreasing weight over time)
  - Body condition score (BCS) using the 9-point scale[5]
  - Muscle condition score using normal muscling, mild muscle loss, moderate muscle loss, or severe muscle loss[5]
- Medical history:
  - Patient's past and current medical conditions, including if the patient is over-conditioned (BCS > 5/9) or under-conditioned (BCS < 4/9 for dogs, < 5/9 for cats)
  - Current prescribed medications including monthly preventatives
  - Current recommended supplements (e.g., probiotics, fat supplements, joint support supplements, vitamin and mineral supplements, etc.)
  - Daily appetite (e.g., polyphagic, hyporexic, anorexic) and any begging behaviors (i.e., begging for food in the middle of the night)
  - Fecal scores using the 7-point Purina Fecal Scoring System, number of bowel movements daily, and any changes
  - Other gastrointestinal signs including nausea, vomiting including trichobezoars, regurgitation, eructation, borborygmi, flatulence, anal gland issues, etc.
    - If vomiting or regurgitation is present determine the time of day in relation to timing of meals (i.e., before, during, immediately after, several hours after), any known triggers, the appearance, etc.
  - Issues with dietary indiscretion or pica (e.g., grass/leaves/sticks, another pet's food, garbage/compost, pieces of bone/toys/socks, etc.)
  - Urination frequency and volume (e.g., polyuria, oliguria, etc.) and any changes or concerns (e.g., hematuria, dysuria, etc.)

FACTOR 2 – DIET FACTORS:

- Determine the base foods the patient is eating or being offered:
  - Commercial base food examples:
    - Shelf-stable dry (e.g., extruded or baked kibbles, semi-moist foods)
    - Shelf-stable wet (e.g., cans, pouches, etc.)
    - Shelf-stable mixers (i.e., cooked animal proteins and oils/fats are typically added to these products in an attempt to make a balanced food)
    - Perishable cooked (e.g., bowls, pouches, tubes, etc. that require storage in the freezer/refrigerator)
    - Perishable raw (uncooked/lightly cooked) (e.g., pouches, tubes, bags, etc. that require storage in the freezer/refrigerator and may have undergone high pressure pasteurization, had bacteriophages added, or been washed in acid (e.g., peracetic acid), etc. for pathogen control)

Box 1. *Continued*

- Homemade base foods (either cooked/uncooked):
  - No recipe is being followed
  - Recipe is being followed from an unknown source
  - Recipe is being followed from a source without the training required to balance the recipe
  - Recipe is being followed and was formulated by a MSc or PhD Animal Nutritionist with training in balancing diets for cats and dogs
  - Recipe is being followed and was formulated by a Board-Certified Veterinary Nutritionist® with training in balancing diets for cats and dogs

- For all commercial base foods determine the following for the past 12 months:
  - Brand and full product name (e.g., [Brand name] Complete Adult Dry Dog Food with Real Beef)
    - Ideally have the owner provide the weblink to the product for clarity
  - Amount and frequency (e.g., 2 cups twice daily, 126 grams daily over 3 meals)
    - If a volumetric measuring device (e.g., measuring cup, scoop, etc.) is being used, have the owner provide a picture for clarity
  - Fed since (e.g., June 2019)
- For all homemade base foods (either cooked/uncooked) determine the following for the past 12 months:
  - Specific ingredients being fed and how they are prepared (e.g., pan-browned, 95% lean/5% fat ground turkey or boiled long-grain brown rice)
  - Amounts being included (e.g., ½ cup once daily, 85 grams twice daily)
  - Supplements being added (e.g., vitamin and mineral supplements, salt, etc.)
  - Fed since (e.g., June 2019)
- For all commercial treats (e.g., biscuits, chews, bones, pill administration treats, etc.) determine the following for the past 12 months:
  - Brand and full product name (e.g., [Brand name] Chicken Flavor Moist Treats)
    - Ideally have the owner provide the weblink to the product for clarity
  - Amount and frequency (e.g., 2–3 treats twice daily)
  - Fed since (e.g., June 2019)
- For all homemade treats (either cooked/uncooked) determine the following for the past 12 months:
  - Specific ingredients being fed and how they are prepared (e.g., roasted boneless skinless chicken breast or raw baby carrots)
  - Amount and frequency (e.g., 3 baby carrots daily)
  - Fed since (e.g., June 2019)
- Patient preferences:
  - Determine what foods/treats the patient prefers
  - Determine what foods/treats the patient does not readily consume or does not tolerate

FACTOR 3 – ENVIRONMENTAL FACTORS:

- Day in the life of the patient:
  - Determine the patient's daily schedule from the time they wake up until the time they go to bed (i.e., Please tell me about a day in the life of your pet)

Box 1. *Continued*

- Where does patient spend most of their time (e.g., indoors, outdoors)? If outdoors, how is the patient secured (e.g., fenced yard, enclosed catio, etc.)?

- Other pets in the home:
  - Are there other pets in home? If so, determine the specific pets and types of interactions, especially those that impact food intake or feeding management (e.g., one parrot that drops food frequently for the patient)
  - Does the patient have access to another pet's food?
  - Does the patient eat out of another pet's bowl/dish/feeder?
  - Does the patient have access to trash/compost/dishwasher?
  - Is there competition for food between pets?
- Activity:
  - Determine the patient's daily activity (e.g., 1 hour of walking per day, 5 minutes of chasing the ball in the yard, etc.)
  - Determine the type of work or exercise (if any) patient does on average per week (e.g., agility training 2 days per week for 1 hour each)
  - Determine any routine outings (if any) that involve activity (e.g., doggie daycare 3 days per week with playgroups for several hours each day)

FACTOR 4 – HUMAN FACTORS:

- Physical Examination:
  - Does the owner consider their pet to be over-conditioned, ideal, or under-conditioned? Does this match the veterinary healthcare team's assessment?
  - Does the owner have any concerns regarding their pet's physical condition (i.e., lameness, dry skin/coat, bad breath, etc.)?
- Medical History:
  - What past/current medical conditions is the owner most concerned about?
  - Are prescribed medications being given properly by the owner?
  - Are recommended supplements being given properly by the owner?
- Nutritional History:
  - What are the owner's primary concerns related to nutrition?
- Human Environment:
  - Who feeds the patient meals? Is there more than one person?
  - Who gives the patient treats? Is there more than one person?(e.g., children in the home dropping food from highchairs for the patient to eat)
  - How many adults and children are in the home? (e.g., 1 adult and 2 children ages 3 years and 5 years)
  - Are there any challenges in the home related to feeding the patient? (e.g., grandmother with dementia that forgets how often she is feeding the patient)
  - Is there any care provided by people outside the home? (e.g., dog walker)

COMMUNICATION TIP

Open-ended inquiries should initially be utilized to allow for more efficient and complete information gathering rather than starting with closed-ended questions that often prompt one-word answers.

to determine if they have any concerns regarding their pet's nutrition.[2,6] For example, ***"Now that we have reviewed your pet's history, please tell me about any concerns you have regarding his nutrition."*** Clarifying any concerns the pet owner expresses through active listening (i.e., making eye contact and not rushing the client) and paraphrasing the concerns expressed are critical steps to ensure the pet owner feels heard.[2,6]

Lastly, obtaining a comprehensive nutritional history takes time. Booking follow-up telehealth appointments via phone or videoconferencing platforms, or telling clients to expect a longer appointment and scheduling time for the comprehensive nutritional history, helps reduce the tendency to rush pet owners during nutrition conversations and ensures the veterinary healthcare team stays on schedule.

Box 2. Nutritional history form examples

- American College of Veterinary Internal Medicine (Nutrition):[9] https://bit.ly/Nutrition-diet-form
- Purina Institute CentreSquare:[10] https://www.purinainstitute.com/sites/default/files/2024-02/screening-evaluation.pdf
- World Small Animal Veterinary Association Global Nutrition Committee Nutrition:[11] https://wsava.org/wp-content/uploads/2020/01/Diet-History-Form.pdf

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TAKING A TEAM APPROACH TO NUTRITION

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KEY TAKEAWAYS

- All veterinary health care team (VHCT) members have a role to play in increasing utilization of nutrition in a veterinary hospital.
- The majority of the nutrition portion of a veterinary consultation is within the veterinary team's scope of practice.
- Nutrition can be easily integrated into existing practice protocols.

OVERVIEW

Nutrition has been recognized globally as the fifth vital assessment,[1] alongside temperature, pulse, respiration, and pain. Nutrition provides the base fuel for all species, with the potential for malnutrition to cause catastrophic effects on the patient's overall function and quality of life. Nutrition should be the cornerstone of both health maintenance and disease treatment, utilized independently or synergistically with other modalities of care. Nutrition assessments and recommendations should be provided by the veterinary team as a component of every visit, even if compliance is incomplete. When nutrition is neglected by their veterinary teams, clients will resort to less-reputable sources of information without the benefit of professional guidance.[2,3] A survey by the American Animal Hospital Association found that clients both trust and value veterinary insight on their pet's food, yet they often perceive a lack of a strong nutrition recommendation from their veterinarian.[4]

Time is a limited resource in general practice, presenting a potential barrier to effective nutrition assessments and consultations. Within the confines of the scheduled appointment, the general practitioner must manage a thorough assessment of all body systems while formulating and implementing a plan to maintain or manage health. Add in the challenges of a normal day such as staffing shortages, seasonal pressures, unscheduled emergencies, and an overburdened schedule, and it is easy to understand why nutrition may be neglected or omitted by even the most dedicated practitioner.

A further challenge in practice are the staggering rates of burnout in veterinary medicine, affecting all members of the health care team. In a recent survey, Kogan et al.[5] found that over half of veterinary technicians were suffering from burnout. Affected team members may be unable to perform to their full potential, require a period of absence, resign from their position, or leave the profession entirely. This can lead to a shortage of veterinarians and team members, adding further strain to an already overburdened practice.

Incorporating nutrition assessments and recommendations into routine clinical care can actually help provide solutions to some of these issues,

COMMUNICATION TIP

By working together, the veterinary health care team can ensure that all patients receive the best opportunity to be fed nutrition that will fuel and optimize life.

as team members are more satisfied in their roles when they feel that their skills and knowledge are fully utilized.[5] Veterinary technicians report increased job satisfaction, lower rates of mental health strain, and overall improvement in workplace experience when they perceive their role as adding value to the practice while fully utilizing their skills and being provided with opportunities for professional development.[5–7] Further, increased revenue from an improved nutrition program can help to fund competitive wages and allow for the recruitment of additional team members. Food

sales offer an alternative income stream with relatively low overhead when compared with the costs of other therapeutic modalities. The time commitment to the team is minimal when compared with interventions such as surgery.

Veterinary health care teams (VHCTs) are highly skilled, knowledgeable professionals with training in a variety of species' biological and psychological needs. Through extensive training and practical experience, team members understand patients' needs in health and illness, including confounding factors like environment, genetics, or life stage. Along with the veterinarian, members of the VHCT understand the nuanced requirements of both the healthy and ill animal and are prepared to implement a new nutrition protocol. Many team members have at least a foundational knowledge of wellness nutrition while registered veterinary technicians (RVT, or team members with similar qualifications) have a more advanced knowledge base. Within a practice, the entire VHCT plays a role in supporting the needs of the client, patient, and business. Many aspects of the nutrition assessment and consultation are already in place in other aspects of care. Minor modification of roles and responsibilities would minimally tax the individual while allowing for the implementation of an optimal nutrition protocol across the team. Most importantly, even the busiest practice can ensure that the needs of all patients are met in every appointment.

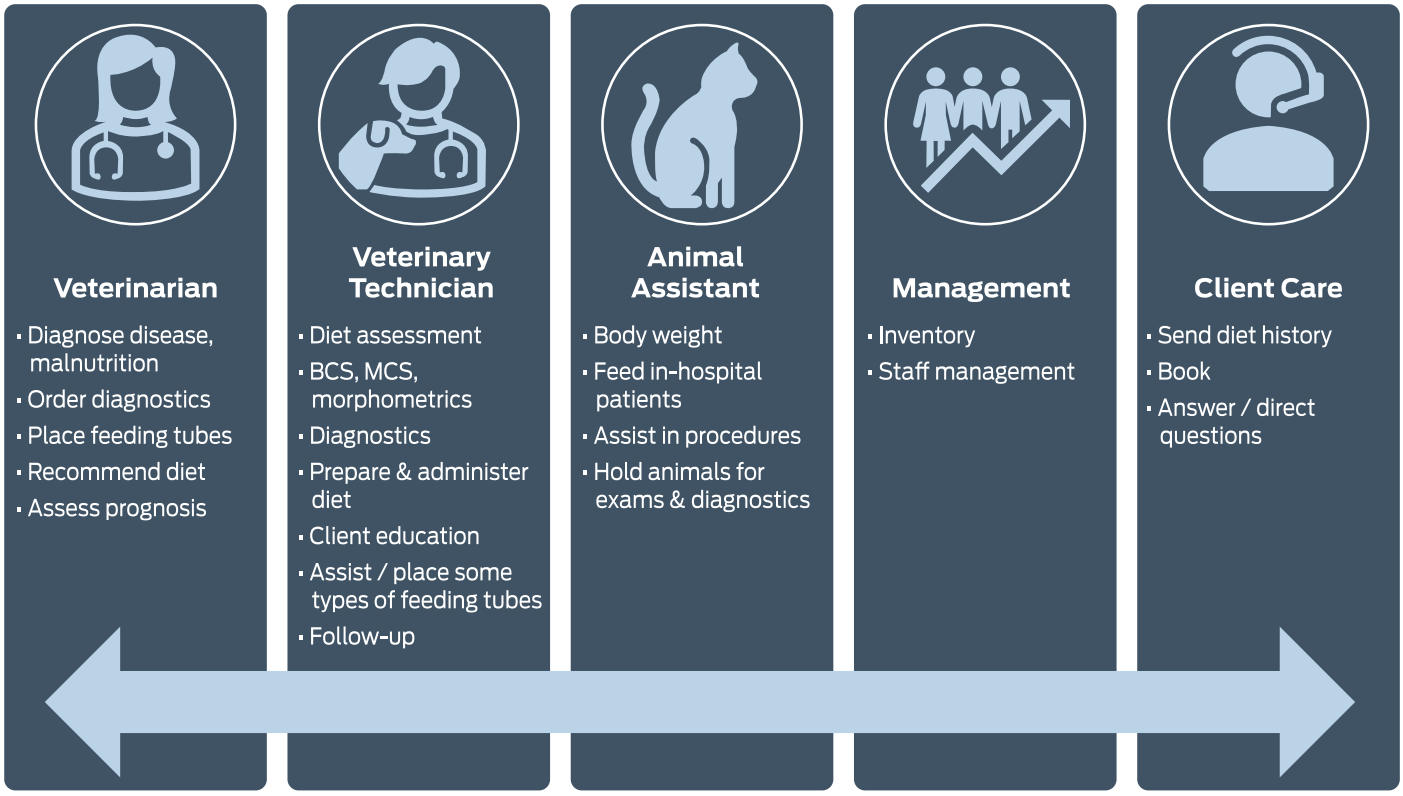
SCOPE OF PRACTICE (FIGURE 1)

The general practitioner may perceive that the entire nutrition consultation is their responsibility without allowing team members to assist within their abilities. A general review of the scope of practice can help recognize the potential expansion of nutrition services. As a focused guideline for nutrition implementation, this is not by any means an exhaustive list of all professional skills. Specific guidelines and laws may vary according to regulating bodies within countries, states, and provinces and should be verified. Individual comfort, knowledge, and skill will also play a role in maximizing the role of the team in nutrition. Additionally, the importance of professional development and continuing education for all team members should never be underestimated.

Veterinarian[8]

The veterinarian is the only team member who may diagnose; prescribe, order, or modify treatments or diagnostics; and perform surgery. As such, these duties

Figure 1. Scope of practice in a veterinary hospital



should be the priority for the veterinarian, and all other needs of the client and patient should be delegated to maximize team efficiency.

- Assessing patient through evaluation of history, physical exam findings, and diagnostics
- Ordering and interpreting of diagnostics
- Diagnosing and assessing prognosis
- Formulating of treatment plan
- Prescribing
  - Diet selection
  - Feeding plan
  - Surgical intervention
  - Medical management
- Reassessing patient to ensure successful management
- Performing surgery
  - Collecting biopsy samples
  - Placing feeding tubes
  - Surgical repair of digestive system

Veterinary technician[9]

The RVT may also be recognized as an animal health technician or technologist (AHT), licensed veterinary technician (LVT), certified veterinary technician (CVT) or registered veterinary nurse (RVN). The term RVT will be used to encompass all licensed, credentialed veterinary technicians for the purpose of this chapter. They must meet the criteria set by their regulating body to achieve and maintain this title and may be self-regulated. Providing a wide array of technical skills, services, and assessments under the supervision or direction of a veterinarian, they assist veterinarians with complex procedures and the collection of diagnostic images and samples. They may also administer medications and nonsurgical treatments to patients. Their expertise in a broad expanse of veterinary topics also makes them prime candidates for client communication.

- Performing initial patient assessment, presenting findings to veterinarian for interpretation and discussion
  - Conducting nutrition assessment
  - Assessing body condition score (BCS)
  - Assessing muscle condition score (MCS)
  - Collecting morphometric measurements
  - Obtaining history
- Collecting, preparing, and processing samples for diagnostic assessment
- Obtaining diagnostic images
- Carrying out nonsurgical intervention under veterinary direction or supervision
  - Nasogastric or nasoesophageal feeding tube placement and general feeding tube management
  - Orogastric tube placement for emergency decompression or feeding
  - Gastric lavage
  - May include a new diet recommendation or modifications
  - Obesity management
- Performing veterinary calculations
  - Energy requirements
  - Feeding amounts
  - Ideal body weight
- Educating and communicating with clients
- Supporting diet transition
- Follow-up

Management

Clinic managers may also be veterinarians or veterinary technicians, or they strictly have managerial or business training and experience. Their scope of practice may vary, but examples of roles surrounding nutrition are described below.

- Inventory management
  - Sourcing of diets
  - Managing returns
  - Assessing inventory turnover
  - Managing supply interruptions and replacement items
  - Selecting which diets to stock and special order (with RVT/DVM)
  - Managing the web store for direct-to-client sales and automatic shipping
- Team management
  - Developing and implementing the nutrition program

Box 1. Veterinary Technician Specialist (VTS) in Nutrition

- Registered veterinary technicians with a passion for veterinary nutrition can further develop their careers by pursuing certification as a veterinary technician specialist in nutrition. These specialists will be required to pursue additional training in both practical skills and advanced knowledge beyond the expectations of a credentialed veterinary technician. They must demonstrate their expertise to the Academy of Veterinary Nutrition Technicians through an application process and exam. For more information, visit nutritiontechs.org.

  - Identifying and nurturing potential nutrition leaders
  - Providing professional development opportunities
  - Communicating with company representatives

Client care

Client care professionals, office administrators, or receptionists may have formal academic training specific to veterinary care. They may also have received formal training for human medical practice or practically acquired training. Their skills in client communication are superb, and they may often fill the need for a veterinary assistant. Individual comfort level and scope of practice may vary based on their training and experience.

- Managing diet sales +/- inventory
- Reinforcing veterinary recommendation
- Addressing and directing additional client questions and communication
- Distributing and collecting diet history form via hard copy or digital
- Educating clients +/- RVT
- Follow-up +/- RVT

Animal assistant

Animal care attendants or veterinary assistants may be formally academically trained or may have achieved their skills from practical, on-the-job training. If they have graduated from a National Association of Veterinary Technicians in America (NAVTA) program and successfully passed the exam, they may earn the title of approved veterinary assistant (AVA). They may also be veterinary technicians who are not licensed or students of a veterinary program. Their individual scope of practice and comfort level may vary.

- Weighing patients
- Feeding hospitalized patients +/- RVT
- Monitoring food consumption
- Fecal scoring

PUTTING IT INTO PRACTICE

When implementing a new or improved nutrition protocol, the best formula is to build from the success that the team has already established throughout all areas of practice. Rather than reconfigure individual responsibilities and roles, integrate nutrition into established responsibilities to better ensure a seamless implementation of the new program. Although all clinics are unique in their own needs and strengths, some basic principles can help to establish a successful program in a wide array of clinics, both large and small.

Existing within each practice is an established flow of client care touch points. First consider the existing distribution of established touch points within a practice. Each of these interactions can be highlighted as potential opportunities for the integration of nutrition, often with minimal additional time commitment.

Patient Care Touch Points

1) Booking and admission
2) History
3) Assessment
4) Treatment and discharge
5) Follow-up

Compare these touch points to the base structure of the nutrition consultation and consider where these steps could be integrated within existing protocols. Slight modification may be needed to fit the scope of practice of each team member.

Nutrition Consultation Steps

1) History
   a. Diet history
   b. Medical history

2) Assessment
   a. Patient: Identify nutrition risk factors
   b. Diet: Establish suitability of the current diet to the patient
3) Treatment: Modify or reinforce diet plan
   a. Discussion and formulation of plan with client
   b. Diet selection
   c. Feeding management: Amount, frequency, feeding method
   d. Communication of nutrition plan
      i. Diet features
      ii. Amount, duration, method
      iii. Transition
4) Follow-up
   a. In person
   b. Virtual
   c. Telephone
   d. Text

If each of the above steps are carried out by a single individual independent of other care needs, the nutrition consultation would certainly exceed practical time limitations. Instead, integrate the nutrition consultation within the team's existing patient touch points to maximize efficiency and minimize additional individual obligations.

AN EXAMPLE (FIGURE 2)

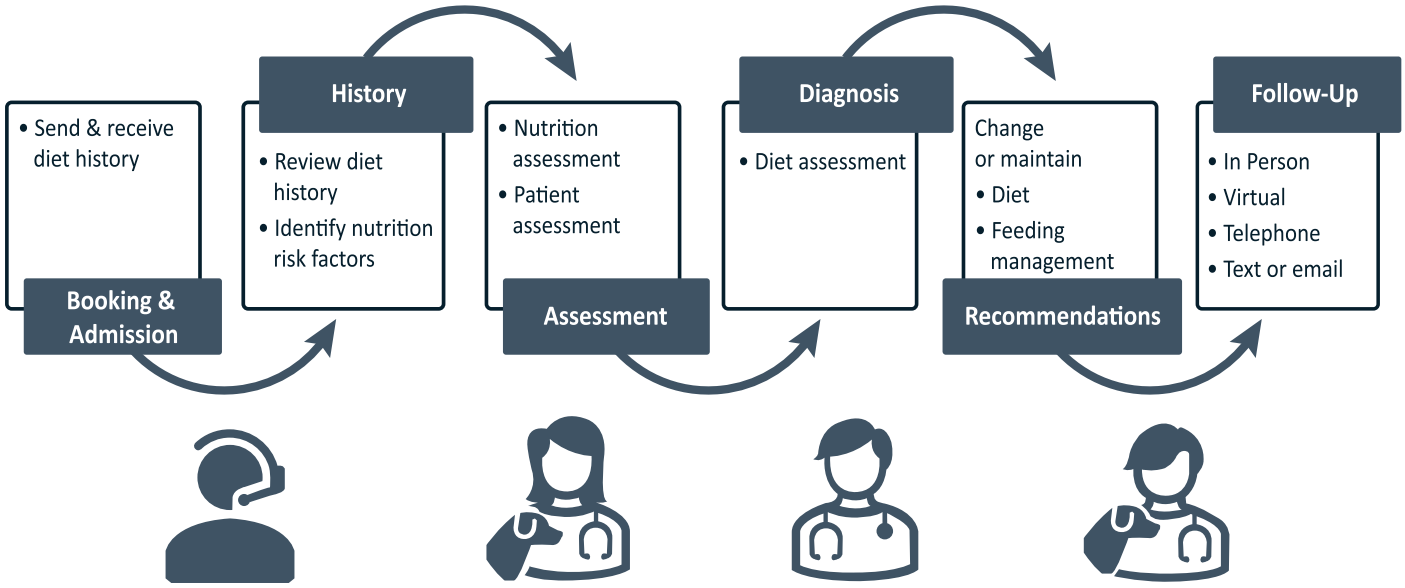
The client care team would distribute and collect the completed diet history prior to the consultation. When the patient arrives, they are admitted by the client care or animal care team who will obtain an updated body weight.

Prior to or during the appointment, the veterinary technician reviews the diet history form alongside the history and highlights risk factors such as changes in appetite or gastrointestinal function. The veterinary technician assesses and records BCS and MCS and performs relevant calculations.

The veterinarian can then integrate nutrition risk factors from the combined history into the overall patient assessment. If a new disease is diagnosed or suspected, a specific diet and feeding plan could be recommended with the treatment and diagnostic plan for the patient. If no diet change is indicated, this should be highlighted as well to encourage continued compliance.

Under the direction of the veterinarian, the veterinary technician can collect, prepare, or complete relevant diagnostics. If advanced nutrition intervention such as initiating feeding with feeding tubes is required, the RVT can assist or even place certain feeding tubes, calculate refeeding plans, and commence feeding. Nutrition management in the hospital can

Figure 2. Veterinary appointments tend to follow a general patient care protocol. Each of these touch points provides an opportunity to split the nutrition consultation into steps which can be seamlessly shared with the team.



Box 2. Establish a nutrition plan B

- A successful veterinary team is flexible! If a team is short staffed due to illness, vacation, or is occupied by an emergency, be prepared to shift responsibilities within appropriate scopes of practice.
- A separate appointment may be booked to address nutrition in exceptional situations, such as an unscheduled emergency interrupting the appointment. It also may be necessary to spend more focused time on nutrition, which may be to address misinformation or advanced nutrition plans. Consider booking these as a technician appointment via telehealth or in person to allow clients the additional time they need or consider including nutrition in a scheduled follow-up appointment. Some conditions, such as weight loss, may require a series of nutrition rechecks.
- Management tip: If the need to schedule these appointments is frequent, it may indicate a need for a nutrition block in the schedule, longer appointment times, or additional team members.

be implemented and managed by the RVT. They can educate clients on a change to the diet or feeding management, including gradual transition techniques, and address client concerns. The RVT can follow up with the client to answer additional questions, assess diet transition success, and review patient progress. This can be done along with other patient follow-up in collaboration with the veterinarian.

CONCLUSION

The ideal nutrition program will not overly tax any single individual on the team, but rather make sure that all members are able to contribute. By working together, the veterinary health care team can ensure that all patients in all appointments, on even the busiest day, receive the best opportunity to be fed nutrition that will fuel and optimize life.

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PRACTICAL TOOL: GUIDELINES ON SELECTING SUPPLEMENTS

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The National Academy of Sciences–National Research Council (NAS/NRC) defines a pet supplement as "any substance for oral consumption by horses, dogs, and cats, whether in/on feed or offered separately, intended for specific benefit to the animal by means other than provision of nutrients recognized as essential or for provision of essential nutrients for intended effect on the animal beyond normal nutritional needs, but not including legally defined drugs."[1]

In the United States, the Food and Drug Administration Center for Veterinary Medicine (FDA-CVM) regulates both food and drugs but does not currently maintain a separate category for "supplements" for animals.[2] In many other parts of the world, including Europe, supplements for dogs and cats are sold as complementary pet food. Regardless of the way supplements are regulated, it can be difficult to find specific guidance for veterinarians for use when considering use of specific supplements. However, the World Small Animal Veterinary Association Global Nutrition Committee maintains multiple resources that can aid practitioners in finding information about supplements for animals.[3] The United States Pharmacopeia (USP) Dietary Supplement Verification Program is also an excellent resource.[4]

While there are rigorously tested and efficacious supplements from reputable manufacturers, regulation for supplements is not as strict as for drugs or food. Having less oversight can lead to ingredients being fed to pets that are not needed, ineffective, contaminated, or products that fail to meet label claims. For example, in one study, most of the products purported to contain probiotics failed to meet the label claim.[5] In one recent meta-analysis, the data failed to find support for use of chondroitin-glucosamine, one of the most frequently recommended supplements for pets in many countries.[6]

Box 1 contains a 6-point practical checklist that owners or veterinarians should consider using before feeding a supplement. The veterinary health care team is the primary source of information, and each veterinarian should use the resources discussed and review the scientific literature prior to using a supplement in their patients.

Box 1. Supplement selection checklist

1. Is the manufacturer reputable?
2. Is there is a known need for each ingredient in the supplement?
3. Is the amount of ingredient being provided safe for the species (more may not be better!) and not already provided by the dog's or cat's complete and balanced diet?
4. Can the company selling the product provide some form of quality assurance?
5. If the supplement contains a probiotic, can the company provide data showing that the suggested minimally effective bacterial count is present at the end of the suggested shelf life of the product?
6. Can some level of evidence be provided showing that the supplement being considered has benefit to the species in question? The following are listed as highest to lowest evidence.
   a. Meta-analysis including at least the ingredient but preferably the specific product
   b. Peer-reviewed, published placebo-controlled trial
   c. Peer-reviewed, published open trial
   d. Company performed trial provided to consumers for scientific review
   e. Wide support by veterinarians on social media
   f. Company data on file, but not shared for scientific review

If the answer is NO to any of the checklist questions, that supplement should not be recommended or fed. If there are multiple supplements available in a category, preference should be given to the specific products that have been used in peer-reviewed clinical trials.

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PRACTICAL TOOL: A HOLISTIC VIEW OF SUSTAINABILITY IN PET FOOD

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The sustainability movement has made its way into the pet food industry, with pet owners increasingly seeking products that offer sustainability claims. However, a critical question arises: What is sustainability, and what role does each stakeholder play in achieving it?

Sustainability is based on three main pillars: environmental, social, and economic. These pillars interact to ensure that present needs are met without compromising the ability of future generations to meet their own needs.[1] In the context of pet food, nutritional sustainability specifically refers to the capacity of food systems to provide sufficient energy and essential nutrients to maintain health without hindering future generations' ability to fulfill their nutritional needs.[2]

To understand our role in this mission, we must evaluate the entire life cycle of a product, from ingredient selection to end-of-life disposal. Raw material sourcing has garnered significant attention, with by-products that do not compete with the human food supply chain (e.g., animal meals) often viewed as sustainable options, and plant-based ingredients generally considered more sustainable than animal-based ones.[3,4] Alternative protein sources, such as insect meals, have gained traction due to their nutritional quality and theoretical lower environmental impact.[5] However, sustainability is multifaceted, and the absence of standardized measures remains a challenge for ingredient suppliers and the pet food industry.

Carbon footprint analysis has become a popular method for assessing environmental impact by measuring both direct and indirect total greenhouse gas emissions associated with a product or organization. However, other metrics such as land use, water depletion, and nitrogen management should also be considered, as narrow focus on carbon emissions alone may not adequately reflect an ingredient's or product's overall environmental impact.[6] Nutrient supply, particularly protein, also affects sustainability.[3] Oversupplying nutrients above a pet's needs is not sustainable. Bioavailable amino acids (coming from protein in the diet) beyond physiological needs cannot be used for protein synthesis and are instead oxidized, leading to nitrogen excretion in urine—resources that could otherwise feed more animals.[7] Additionally, protein quality should be a key consideration in sustainability efforts, and recent work has begun considering it as a part of life cycle assessments for ingredients.[8]

Packaging often takes center stage in sustainability discussions, as it offers a visible and easily communicated aspect to pet owners.[3,9] However, sustainability extends far beyond packaging. For example, a pet food company may excel in sustainability efforts related to ingredient selection and packaging, but if the product fails to resonate with consumers due to cost or other market demands, those sustainability efforts fall short of their ultimate goal.[9] This highlights the interconnectedness of the three pillars of sustainability. To ensure a product's overall sustainability, all stakeholders must collaborate to align efforts across environmental, social, and economic dimensions.

The actions of pet owners play a critical role in sustainability once the product is in their hands. Therefore, educating pet owners should be a central focus of sustainability efforts.

In summary, sustainability is a multifaceted endeavor that goes beyond raw material selection and packaging, which tend to be the main focus of consumers. A holistic understanding of sustainability is essential. It is not just about using alternative protein sources; it is also about optimizing feeding management. Educating pet owners on their role in sustainability is crucial to ensuring that all players contribute meaningfully to the bigger picture. Sustainability remains a complex topic requiring further standardization and effort; however, we must not overlook the fundamentals: nutrient oversupply and pet owner education have a profound impact on sustainability and should be integral components of our strategies.

Box 1. Ways pet owners can be involved in nutritional sustainability efforts

- Key considerations include proper food storage to prevent oxidation and waste and mindful use of energy-intensive appliances such as refrigerators and freezers. Most importantly, responsible feeding practices are essential.
- Overfeeding is unsustainable, and with the rising obesity epidemic in pet dogs and cats in some countries,[10] veterinarians should address this issue not only as a health concern but also within the context of broader sustainability efforts. Pet owners should monitor their pet's body condition between veterinary visits. Discussions around the oversupply of nutrients, in addition to calories, should also be prioritized.
- The increasing trend of supplement use in the pet food industry can create a false sense of environmental awareness among pet owners. They may choose a complete and balanced diet with a lower environmental footprint, only to offset these benefits by purchasing additional supplements and treats without considering their cumulative impact.
- Focusing on a single ingredient in a complete and balanced diet as a way to anecdotally classify a product as sustainable may be deceiving.

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PRACTICAL TOOL: DIET HISTORY FORM

PURINA Institute
Advancing Science for Pet Health

Owner's name: _____ Date form completed: _____

Pet's name: _____ Species: _____ Breed: _____

Age: _____ Gender: ☐ Male ☐ Female Neutered/Spayed: ☐ Yes ☐ No

1. What proportion of time does your pet spend indoors or outdoors?

_____ % Indoors _____ % Outdoors When outdoors, is your pet supervised? ☐ Yes ☐ No

2. How active is your pet?

☐ Very active ☐ Moderately active

☐ Not very active ☐ Mostly inactive

3. How would you describe your pet's weight?

☐ Overweight ☐ Ideal weight

☐ Underweight

4. Please list below the brands and product names (if applicable) and the amount of *all* foods, treats, snacks, dental hygiene products, rawhides and any other foods that your pet currently eats, including foods used to administer medications. If homemade diet(s), please provide recipe(s).

Food and Treats (brand, flavor)	Form (dry/wet)	Amount* Per Meal	Frequency	Fed since
*If feeding by volume, what size measuring device do you use?				

5. Do you give your pet any supplements (e.g., vitamins, minerals, probiotics, fish oil, glucosamine, etc.) or other food items not listed above?

☐ Yes ☐ No If yes, please list types and amounts given. _____

6. Have you made any changes to your pet's diet in the last 4 weeks?

☐ Yes ☐ No If yes, please note what change was made and why. _____

7. Do you have any questions about feeding or nutrition for your pet?

For a fillable PDF form, go to: https://www.purinainstitute.com/sites/default/files/2024-02/screening-evaluation.pdf

BODY CONDITION SYSTEM

TOO THIN



1 Ribs visible on shorthaired cats; no palpable fat; severe abdominal tuck; lumbar vertebrae and wings of ilia easily palpated.

2 Ribs easily visible on shorthaired cats; lumbar vertebrae obvious with minimal muscle mass; pronounced abdominal tuck; no palpable fat.



3 Ribs easily palpable with minimal fat covering; lumbar vertebrae obvious; obvious waist behind ribs; minimal abdominal fat.

4 Ribs easily palpable with minimal fat covering; noticeable waist behind ribs; slight abdominal tuck; abdominal fat pad absent.

IDEAL



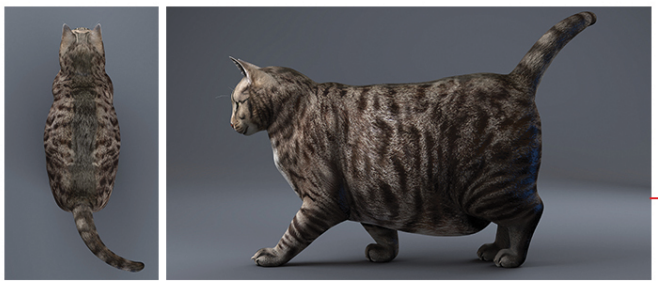
5 Well-proportioned; observe waist behind ribs; ribs palpable with slight fat covering; abdominal fat pad minimal.

TOO HEAVY



6 Ribs palpable with slight excess fat covering; waist and abdominal fat pad distinguishable, but not obvious; abdominal tuck absent.

7 Ribs not easily palpated with moderate fat covering; waist poorly discernible; obvious rounding of abdomen; moderate abdominal fat pad.



8 Ribs not palpable with excess fat covering; waist absent; obvious rounding of abdomen with prominent abdominal fat pad; fat deposits present over lumbar area.

9 Ribs not palpable under heavy fat cover; heavy fat deposits over lumbar area, face and limbs; distension of abdomen with no waist; extensive abdominal fat deposits.

The BODY CONDITION SYSTEM was developed at the Nestlé Purina Pet Care Center and has been validated as documented in the following publications:

Laflamme, D. P. (1997). Development and validation of a body condition score system for cats: A clinical tool. *Feline Practice, 25*(5-6), 13-18.
German, A. J., Holden, S. L., Moxham, G. L., et al. (2006). A simple, reliable tool for owners to assess the body condition of their dog or cat. *Journal of Nutrition, 136*(7 Suppl), 2031S-2033S. doi: 10.1093/jn/136.7.2031S
Bjornvad, C. R., Nielsen, D. H., Armstrong, P. J., et al. (2011). Evaluation of a nine-point body condition scoring system in physically inactive pet cats. *American Journal of Veterinary Research, 72*(4), 433-437. doi: 10.2460/ajvr.72.4.433

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BODY CONDITION SYSTEM

TOO THIN





1 Ribs, lumbar vertebrae, pelvic bones and all bony prominences evident from a distance; no discernible body fat; obvious loss of muscle mass.

2 Ribs, lumbar vertebrae, pelvic bones easily visible; no palpable fat; some evidence of other bony prominence; minimal loss of muscle mass.

3 Ribs easily palpated and may be visible with no palpable fat; tops of lumbar vertebrae visible; pelvic bones becoming prominent; obvious waist and abdominal tuck.

IDEAL



4 Ribs easily palpable, with minimal fat covering; waist easily noted when viewed from above; abdominal tuck evident.

5 Ribs palpable without excess fat covering; waist observed behind ribs when viewed from above; abdomen tucked up when viewed from the side.

TOO HEAVY





6 Ribs palpable with slight excess fat covering; waist is discernible viewed from above, but is not prominent; abdominal tuck apparent.

7 Ribs palpable with difficulty; heavy fat cover; noticeable fat deposits over lumbar area and base of tail; waist absent or barely visible; abdominal tuck may be present.

8 Ribs not palpable under very heavy fat cover, or palpable only with significant pressure; heavy fat deposits over lumbar area and base of tail; waist absent; no abdominal tuck; obvious abdominal distension may be present.

9 Massive fat deposits over thorax, spine and base of tail; waist and abdominal tuck absent; fat deposits on neck and limbs; obvious abdominal distension.

The BODY CONDITION SYSTEM was developed at the Nestlé Purina Pet Care Center and has been validated as documented in the following publications:

Laflamme, D. P. (1997). Development and validation of a body condition score system for dogs: A clinical tool. *Canine Practice, 22*(4), 10-15.

Mawby, D. I., Bartges, J. W., d'Avignon, A., et al. (2004). Comparison of various methods for estimating body fat in dogs. Journal of the American Animal Hospital Association, 40(2), 109-114. doi: 10.5326/0400109

German, A. J., Holden, S. L., Moxham, G. L., et al. (2006). A simple, reliable tool for owners to assess the body condition of their dog or cat. *Journal of Nutrition, 136*(7 Suppl), 2031S-2033S. doi:10.1093/jn/136.7.2031S

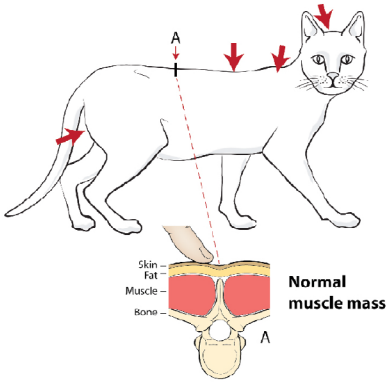
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WSAVA
Global Nutrition
Committee

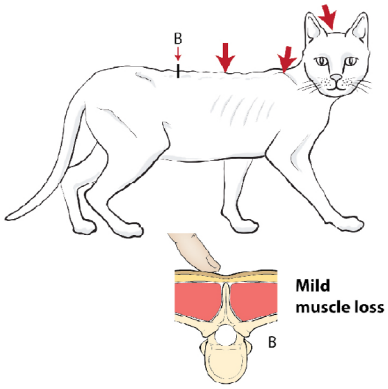
Muscle Condition Score

Muscle condition score is assessed by visualization and palpation of the spine, scapulae, skull, and wings of the ilia. Muscle loss is typically first noted in the epaxial muscles on each side of the spine; muscle loss at other sites can be more variable. Muscle condition score is graded as normal, mild loss, moderate loss, or severe loss. Note that animals can have significant muscle loss even if they are overweight (body condition score > 5/9). Conversely, animals can have a low body condition score (< 4/9) but have minimal muscle loss. Therefore, assessing both body condition score and muscle condition score on every animal at every visit is important. Palpation is especially important with mild muscle loss and in animals that are overweight. An example of each score is shown below.

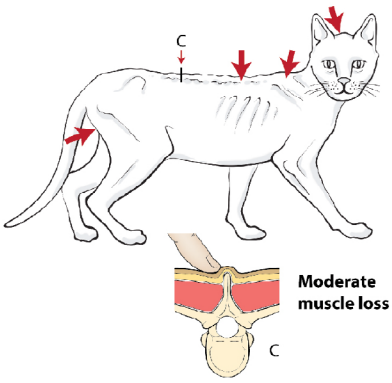
Normal muscle mass



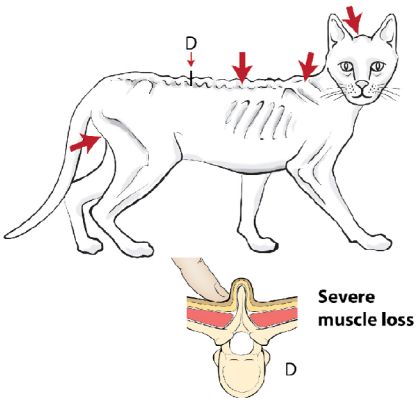
Mild muscle loss



Moderate muscle loss



Severe muscle loss



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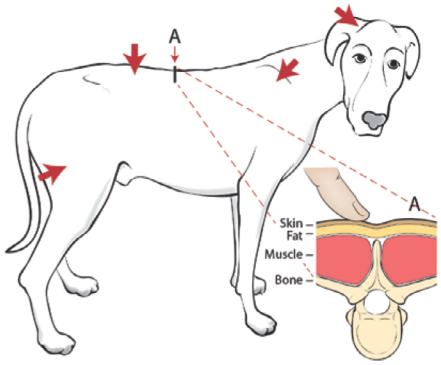
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WSAVA
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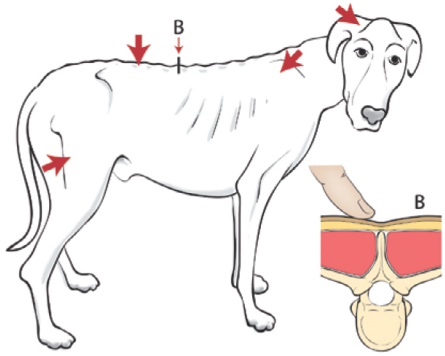
Muscle Condition Score

Muscle condition score is assessed by visualization and palpation of the spine, scapulae, skull, and wings of the ilia. Muscle loss is typically first noted in the epaxial muscles on each side of the spine; muscle loss at other sites can be more variable. Muscle condition score is graded as normal, mild loss, moderate loss, or severe loss. Note that animals can have significant muscle loss if they are overweight (body condition score > 5). Conversely, animals can have a low body condition score (< 4) but have minimal muscle loss. Therefore, assessing both body condition score and muscle condition score on every animal at every visit is important. Palpation is especially important when muscle loss is mild and in animals that are overweight. An example of each score is shown below.

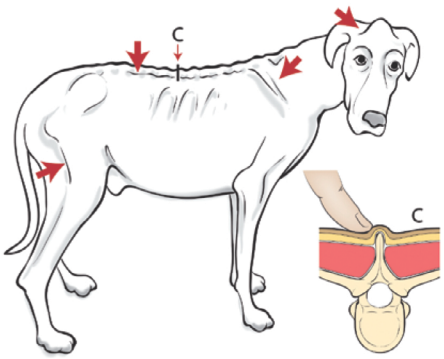
Normal muscle mass



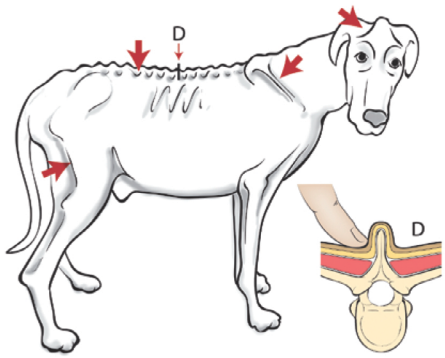
Mild muscle loss



Moderate muscle loss



Severe muscle loss



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WSAVA
Global Nutrition Committee



Updated on 10 March 2021

WSAVA Global Nutrition Committee:

Guidelines on Selecting Pet Foods

Pet food labels include a lot of required and useful information for veterinary teams and pet owners. They may also include marketing images and phrases that are designed to promote product sales rather than relay nutritional information. This means that some of the information, including unregulated terms such as 'holistic' or 'premium', is of little practical value for nutritional assessment. The veterinary team has a vital role in helping pet owners make informed decisions on the optimal diet for their dog or cat.

What to look for in a brand

1. Do they employ a Nutritionist?

- Appropriate qualifications are either a PhD in Animal Nutrition or Board Certification by the American College of Veterinary Nutrition (ACVN) or the European College of Veterinary Comparative Nutrition (ECVCN).
- What are the Nutritionist's name, qualifications and employment status? Consultants may have limited influence compared to a staff Nutritionist.

2. Who formulates the diet?

- Is the recipe developed by an experienced pet food formulator (MS or PhD in Animal Nutrition), a veterinarian, or a pet owner/breeder/trainer?
- Recipe development is a complex process requiring knowledge of nutrition, raw materials, and processing not taught in veterinary school programs.
- Trained and experienced formulators may have a degree (MS/PhD) in food science and technology to help guide ingredient selection and nutrient levels for health or disease management.
- An individual with Board Certification by ACVN or ECVCN may also be cross-trained in pet food formulation or work in collaboration with experienced pet food formulators to help guide ingredient selection and nutrient levels.

3. What is the quality control process for ingredients and finished products?

- Diets formulated to meet Association of American Feed Control Officials (AAFCO) or European Pet Food Industry Federation (FEDIAF) guidelines should meet their nutrient profiles. Does the diet meet the profile based on analysis using a nutrient database or on chemical analysis of the finished product?
- Manufacturers and pet food providers should have adequate quality control to ensure companion animal and owner safety. This should include ingredient (food and supplement) validation, final diet nutrient analysis, toxicology, bacteriology, and packaging/shelf-life screenings prior to, during, and after manufacturing.

4. What kind of product research or nutrition studies have been conducted? Is it published in peer-reviewed journals?

- Pet food companies are not required to conduct or sponsor nutritional research in order to produce and sell a food, but when they do, it indicates a commitment to animal health and wellness.

What to look for on a label

1. Nutrition Adequacy Statement?

- Is it a complete diet? Foods should be labeled to indicate if they provide a "complete" diet with all required nutrients. The label might also specify if this was determined via life stage feeding trials vs formulation to meet requirements. Those labeled as intended for "short-term", "intermittent", or "complementary" feeding should only be fed as a small portion of the diet (10% or less), or under veterinarian supervision if feeding a therapeutic diet.
- Does the food match the nutritional needs of the individual dog or cat? AAFCO and FEDIAF provide pet food manufacturers with recommended nutrient levels for different life-stages (reproduction, growth, and adult) for healthy dogs or cats. Diets labeled "for all life-stages" are formulated for reproduction and growth.

2. How many calories per gram or serving of food?

- Obesity prevalence is increasing in pets in many areas of the world. Having access to accurate pet food caloric content can help prevent unintended overfeeding. Calorie information is only required on pet food labels in the US. Where it is not provided on the label it should be available by contacting the manufacturer or calculating from label nutrient analysis.

3. Does the company provide immediate contact information such as a phone number or email address?

- Company representatives should be easily accessible for additional questions, such as the level of specific nutrients not on the label. Pet food companies should be able to provide an "average" or "typical" analysis for all essential nutrients in their food.

4. Who makes the food?

- Companies may make their own food (i.e.,"Made by") or use a third- party manufacturer (i.e.,"Made for" or "Distributed by").

If the manufacturer cannot or will not provide any of this information, veterinarians and owners should be cautious about feeding that brand.

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PRACTICAL TOOL: PURINA FECAL SCORING CHART

Fecal consistency is primarily a function of moisture in stool and can be used to identify changes in colon health and other problems. In a healthy dog or cat. stools ideally should be firm but not hard, pliable, segmented and easy to pick up (Score 2).

Score	Specimen	Characteristics
1		■ Very hard and dry ■ Often expelled as individual pellets ■ Requires much effort to expel from the body ■ Leaves no surface residue when picked up
2		■ Firm, but not hard; pliable ■ Segmented appearance ■ Leaves little or no surface residue when picked up
3		■ Log shaped; moist surface ■ Little or no visible segmentation ■ Leaves surface residue, but holds form when picked up
4		■ Very moist and soggy ■ Log shaped ■ Leaves surface residue and loses form when picked up
5		■ Very moist, but has a distinct shape ■ Present in piles rather than logs ■ Leaves surface residue and loses form when picked up
6		■ Has texture, but no defined shape ■ Present as piles or spots ■ Leaves surface residue when picked up
7		■ Watery ■ No texture ■ Present in flat puddles

PURINA Institute

Advancing Science for Pet Health

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GLOSSARY OF NUTRITION TERMINOLOGY

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A

AA – see arachidonic acid

AAA – see aromatic amino acid

AAFCO – see Association of American Feed Control Officials

AAHA – see American Animal Hospital Association

Absorption – the passage of nutrients and/or substrates into and/or across tissues and cells.

Action – stage of readiness to change where the caregiver is intentionally making changes, for example, to manage their pet's weight.

Acute diarrhea – one or more episodes of diarrhea lasting less than 3 weeks.

Adipokines – hormones secreted from adipose (fat) tissue, many of which can contribute to mild inflammation and oxidative stress; examples include leptin, adiponectin, resistin, TNF-alpha.

Ad libitum (feeding) – free or unrestricted access to food and/or drink; also called free choice.

Adenosine triphosphate (ATP) – an energy-providing substrate that drives metabolic processes in living cells.

Adherence – the degree to which an informed patient or owner will correctly follow the prescribed treatment or advice.

Adipose tissue – also known as fat tissue; can be classified as white adipose, brown adipose, or beige/brite adipose (each with different characteristics and functions).

Aerobic (metabolism) – a metabolic process utilizing oxygen; examples include tricarboxylic acid (TCA) cycle, glycolysis, pentose phosphate pathway (indirectly), and electron transport chain (ETC).

Allergens – any particle (antigen) that can cause an immunogenic/allergic response in an individual; induces an IgE-mediated hypersensitivity reaction.

Aldosterone – a mineralocorticoid released from the adrenal glands that helps to regulate electrolyte and water balance.

Alopecia – the abnormal loss of hair (partial or complete) from where it is normally present.

Alpha-amylase – an enzyme in saliva that initiates starch digestion. Present in dogs, absent in cats.

Alpha-linolenic acid – an essential omega-3 polyunsaturated fatty acid (PUFA) with 18 carbons and 3 double bonds.

(DL)-alpha-lipoic acid – a cofactor for mitochondrial respiratory chain reactions. Supplementation may improve mitochondrial function but can be toxic if too much is ingested. Cats are more susceptible to toxicity than dogs.

Altricial – completely dependent on maternal support for survival.

American Animal Hospital Association (AAHA) – a non-profit professional organization that acts as an accreditation body for companion animal veterinary facilities in North America.

Amino acid – an organic (carbon-containing) compound containing an amino and carboxyl group; the building block for all proteins.

Ammonia (NH_3) – a product of protein metabolism and the precursor of urea; exists as a colorless alkaline gas.

Ammoniagenic – ammonia-forming.

Amyloid – a pathologic protein that is comprised of misfolded proteins; deposits on tissue resulting in damage and subsequent dysfunction.

Anaerobic (metabolism) – a metabolic process that does not utilize oxygen; examples include lactic acid/Cori cycle, creatinine phosphate pathway.

Angiotensin – a family of hormones that act as vasopressors; angiotensin I (formed via renin acting

on angiotensinogen) is the inactive precursor to the powerful vasopressor, angiotensin II.

Anogenital stimulation – rubbing the neonate's bottom after feeding with a warm and damp cotton swab or cloth to stimulate defecation and urination.

Antioxidant – a substance that either prevents formation of, or eliminates, oxygen free radicals. Examples include vitamin E, vitamin C, selenium, alpha-lipoic acid, carotenoids, and flavonoids.

Anxiety – a generalized emotional and physiological response in anticipation of a potential threat.

Arachidonic acid (AA) – an omega-6 polyunsaturated fatty acid with 20 carbons and 4 double bonds; considered as essential in cats due to their lack of delta-6-desaturase enzyme.

Arginine – an essential amino acid that is key to the appropriate function of the urea cycle in hepatocytes.

Arginine vasopressin (AVP) – also known as antidiuretic hormone (ADH); a hormone secreted in response to dehydration, which acts on aquaporin 2 channels in the renal collecting ducts to concentrate urine.

Aromatic amino acid (AAA) – an amino acid containing an aromatic (e.g., benzene) ring. Examples include tryptophan, phenylalanine, and tyrosine.

Ascites – the abnormal accumulation of fluid in the abdominal cavity; if severe, may lead to abdominal distention.

Ash (crude) – incinerated residue or inorganic matter (i.e., minerals).

Asking permission – a special form of signpost that gains the other person's consent before moving the conversation forward in a certain direction.

Association of American Feed Control Officials (AAFCO) – a United States non-governmental organization that develops pet food regulatory guidelines and standards that may be adopted by the State Departments of Agriculture. AAFCO guidelines may also be used in countries besides the United States.

ATP – see adenosine triphosphate

Atwater (factors) – numerical values used to estimate energy/caloric content of energy-providing macronutrients in standard foods; does not account for species-specific digestibility (see modified Atwater factors).

B

Basal energy requirement (BER) – the number of calories required for maintaining basic life functions while the animal rests quietly in a thermoneutral environment, in a fasted state. Synonymous with basal metabolic rate in humans.

B vitamins – see vitamin (B)

(vitamin) B1 – see thiamine

(vitamin) B2 – see riboflavin

(vitamin) B3 – see niacin

(vitamin) B9 – see folate

(vitamin) B12 – see cobalamin

BBB – see blood-brain barrier

BCAA – see branched-chain amino acid

BCS – see body condition score

Behavioral disorder – an expansive label including disorders of fear, anxiety, stress, conflict, panic (collectively, FASCP), impulsivity, phobia, and undesirable behaviors.

BER – see basal energy requirement

Beta carotene – a form of vitamin A from plant sources that can be converted into retinol via intestinal dioxygenase enzyme; cats lack sufficient enzymes, making retinol essential.

Beta oxidation – the catabolism of fatty acids within the mitochondria, resulting in the production of energy.

Bioactive – any ingredient or metabolite that can impart a biological effect on a cell, tissue, and/or organism.

Bioavailability – the degree to which a nutrient is available to the target tissue/cells after consumption.

Biological age – a reflection of the physiological and functional status of the individual. While chronological age is the length of time an individual has been alive, biological age is an indication of how well an individual is aging.

Birch sugar – an alternate name for xylitol (see xylitol).

Bitch – a female, breeding dog.

Blood-brain barrier (BBB) – a semipermeable and selective layer of cells acting as a barrier between circulating blood and the extracellular fluid of the central nervous system.

Body condition score (BCS) – an assessment of a pet's body composition, primarily body fat, using a combination of visual and tactile skills.

Bradytocia – problems/dysfunction with widening of the birth canal.

Branched-chain amino acid (BCAA) – an amino acid with an alkyl side chain and methyl group branch. Examples include leucine, isoleucine, and valine.

Breeding (period) – the period of time where a breeding male and female mate with the goal of producing offspring.

Butyrate – one of the short-chain fatty acids (SCFAs) produced via fermentation of dietary fibers; the major fuel source for colonocytes.

C

Cachexia – a multifactorial process characterized by loss of fat and muscle tissue and associated with disease. It involves increased inflammatory cytokines, oxidative damage, inadequate delivery of nutrients, and impaired clearance of metabolic waste products, resulting in increased energy requirements and, often, increased protein degradation (lean tissue loss). Examples of causes include renal disease, cancer, and cardiac disease.

Calcification – the deposition of calcium onto tissues. Normal with bone and teeth formation; however, significantly detrimental if associated with metastasis or dystrophic mineralization, where calcium is deposited on soft tissues.

Calculus – an aggregation of minerals formed within the body, such as that formed in the oral cavity (tartar), kidney, or urinary bladder.

calorie – the energy required to raise the temperature of 1 gram of water by 1 degree Celsius.

Calorie (kilocalorie or kcal) – the energy required to raise the temperature of 1 kilogram of water by 1 degree Celsius; 1 Calorie = 1000 calories; 1 kcal is equivalent to 4.184 kilojoules (see Joule).

Calorie density – see energy density

Cancer – see neoplasia

Capability – the physical and psychological ease or ability of the client to perform the behavior, including having the necessary knowledge and skills.

Carbohydrate (CHO) – a derivative of a poly (multi) hydric alcohol (usually an aldehyde or ketone), containing carbon, hydrogen, and oxygen. Typically, hydrogen and oxygen atoms are in appropriate proportions to form water after combustion. Examples include starches, fibers, and sugars.

Carbon footprint – an assessment of environmental impact by measuring (directly and indirectly) total greenhouse gas emissions associated with a product or organization.

Carnivore – a classification of animals that require the ingestion of animal products in order to meet their essential nutrient needs.

Catabolic/catabolism – the cellular metabolic process that degrades or breaks down complex nutrients and molecules into smaller units.

Cataracts – a condition where the lens of the eye becomes opaque, resulting in loss of eye sight; can be associated with natural aging processes, trauma, nutritional deficiencies, genetics, and/or disease processes.

Central nervous system (CNS) – the portion of the nervous system containing the brain and spinal cord.

Cereal – grasses or grains with edible seeds; a type of carbohydrate ingredient from the phylogenetic family Poaceae.

Check in – a process of eliciting questions and assessing understanding and readiness to move forward.

CHO – see carbohydrate

Cholecalciferol (Vitamin D3) – a fat-soluble vitamin that is critical for optimal bone health, via calcium and phosphorus metabolism, and immune function. Must be supplied in the diet as it cannot be synthesized in dogs and cats.

Cholesterol – a subclass of lipids (sterols) found in animal tissues; essential for cell membrane structure.

Choline – a nutrient found in most tissues with many functions including formation of phospholipids and transport of fats/lipids.

Chondroitin sulfate – a building block/component of glycosaminoglycans.

Chronic kidney disease (CKD) – abnormal and irreversible decrease in renal function.

Chronological age – the number of years an individual has lived since birth.

Citric acid cycle – a series of mitochondrial reactions to release energy after the oxidation of calorie-providing nutrients; also known as Krebs cycle or tricarboxylic acid (TCA) cycle.

CDS – see cognitive dysfunction syndrome

CKD – see chronic kidney disease

Closed-ended inquiry – a question that results in a specific, often brief, response.

CNS – see central nervous system

Cobalamin – a water-soluble nutrient that is essential for many metabolic processes (e.g., formation of DNA and red blood cells); also known as vitamin B12.

Coenzyme – a particle/molecule that must bind to an enzyme in order for that enzyme to be bioactive.

Cognitive dysfunction syndrome (CDS) – a combination of behavioral changes resulting from neurodegeneration associated with aging. Observed behaviors may include anxiety, spatial/temporal disorientation, alterations of family interactions, and changes to sleep-wake cycle.

Coitus – another term for mating.

Colitis (stress colitis) – inflammation of the colon, typically resulting in soft stool/diarrhea; can be triggered by many things, including stressful events.

Colostrum – the first "milk" produced by a dam within the first 24–72 hours after parturition, providing a high concentration of nutrients (protein and fat), growth factors, and maternal antibodies; has a different nutrient composition compared to regular milk and is species-specific.

Communication content – what is being communicated, representing the substance of questions and answers.

Communication perception – what is being felt or thought during communication, representing feelings, thought processes, beliefs, assumptions, etc.

Communication process – how information is communicated, representing the verbal and nonverbal skills used.

Comorbidity – the presence of two or more diseases/medical conditions simultaneously.

Complete (diet) – FEDIAF terminology for a diet containing all essential nutrients in the appropriate concentrations and proportions for the individual being fed (see complete and balanced diet).

Complete and balanced (diet) – AAFCO terminology for a diet containing all essential nutrients in the appropriate concentrations and proportions for the individual being fed (see complete diet).

Complex carbohydrate – a polysaccharide with complex, long chains of sugars strung together; more energy is required for digestion, and thus, release of glucose.

Compliance – the process describing how well a patient or owner carries out their prescribed therapy or recommendations.

Comprehensive nutrition history – exploration of all animal-, diet-, environment-, and human-related factors associated with a dog's or cat's nutrition.

Concomitant (disease) – a disease/condition that typically occurs (or is associated with) another disease process, illness, or condition.

Concordance – a process of informed communication between the client and their pet's health care team, leading to an agreed-upon treatment and ongoing assessment plan.

Conditionally essential (amino acid) – a non-essential amino acid that becomes essential in certain circumstances, such as pregnancy or disease conditions.

Constipation – a reduced defecation frequency and/or difficulty in passing feces.

Contemplation – stage of readiness to change where the caregiver acknowledges a problem or a need for change, for example, with respect to their pet's weight, yet is caught in deliberating the advantages and disadvantages leading to a static state of not changing.

Copulation – another term for mating.

CoQ10 – see ubiquinone

Cystitis – inflammation of the urinary bladder

D

Deficiency – inadequate nutrient concentration/ingestion resulting in impaired physiologic and metabolic functions.

Degenerative joint disease (DJD) – any disorder/disease associated with progressive deterioration of a joint, articular surface, or articular cartilage (see osteoarthritis).

Developmental orthopedic disease (DOD) – any orthopedic disorder in puppies or kittens (or young dogs or cats) causing malformation or deterioration of a joint as the pet grows associated with either a genetic anatomic anomaly and/or growth defect. More common in large and giant breed puppies, DOD is typically seen with inappropriate diet, rapid/uncontrolled growth rate, and/or genetic predisposition.

DHA – see docosahexaenoic acid

DI – see dysbiosis index

Diabetes mellitus (DM) – the presence of persistent hyperglycemia, resulting from either insufficient insulin secretion from pancreatic beta cells and/or insufficient response of insulin receptors to insulin to maintain blood glucose concentrations in the normal range. Often seen with clinical signs, especially polyuria, polydipsia, weight loss, and polyphagia.

Diarrhea – an abnormal alteration in stool consistency characterized by increased water content, with increased frequency, volume, and/or weight of feces.

Digesta – the term for food particles once they have entered the GI tract and begun the digestion process.

Digestibility – the proportion of nutrients released from food following both mechanical and enzymatic digestion. Digestibility is influenced by both exogenous/dietary and endogenous/host factors.

DJD – see degenerative joint disease

DM – see diabetes mellitus

Docosahexaenoic acid (DHA) – an omega-3 polyunsaturated fatty acid with 22 carbons and 6 double bonds; typically used for its anti-inflammatory properties. Considered essential during growth for its role in nervous system and retinal development.

DOD – see developmental orthopedic disease

Dysbiosis – a reduction in microbial diversity (i.e., reduction in the number of different species) and/or changes in bacterial abundances that lead to altered production of bacteria-derived metabolites.

Dysbiosis Index (DI) – a commercially available, analytically validated, PCR-based assay that is a marker of dysbiosis in individual patients.

Dyslipidemia – a condition associated with dysregulation of lipids resulting in increased presence and circulation of cholesterol, triglycerides, or both; often associated with underlying endocrine/metabolic conditions.

Dystocia – difficult or abnormal labor.

E

EAA – essential amino acid; see essential nutrient.

EFA – essential fatty acid; see essential nutrient.

Eicosanoid – a cell signaling compound derived from polyunsaturated fat metabolism. Examples include prostaglandins, leukotrienes, thromboxanes, and lipoxins.

Eicosapentaenoic acid (EPA) – an omega-3 polyunsaturated fatty acid with 20 carbons and 5 double bonds; typically used for its anti-inflammatory properties.

Electron transport chain (ETC) – the final stages of aerobic nutrient metabolism (oxidative phosphorylation) resulting in the production of ATP; occurs in the inner mitochondrial membrane.

Embryo – the term for an organism following initial cell division up until the fetal stage; ~ 30 days in dogs and cats.

Embryotrophe – a nutritive substance that provides nutritional support to the embryo prior to full maturation and functionality of the placenta.

Endocrinopathy – a disease or syndrome associated with abnormal function of any endocrine organ.

Endogenous – originating from within the body.

Endurance (athlete) – prolonged duration of activity; fueled by fats/lipolysis.

Energy – the power required to support a living organism; in animals, provided via food in the form of Calories (see Calorie) or Megajoules.

Energy density – energy (kcal or kJ) per unit weight of food; for pet food this is provided as metabolizable energy.

Enostosis – growing pains.

Enrichment – methods of enhancing an animal's emotional and cognitive well-being by modifying its environment.

(chronic) Enteropathy – a term referring to any disease/pathology of the intestine, but often used to describe a group of idiopathic diseases resulting in persistent or intermittent chronic gastrointestinal signs; subclassified into food-responsive or immunosuppressive-responsive, depending on the response to treatment.

EPA – see eicosapentaenoic acid

Epigenetics – behavioral and environmental factors that cause changes in gene expression.

Erythropoiesis – formation, production, and release of new red blood cells. While this is a normal process, increased erythropoiesis can be triggered by hypoxic events (see hypoxia).

Essential nutrient (e.g., amino acids, fatty acids, etc.) – those nutrients that the body cannot make, or make in ideal/appropriate concentrations, and thus must be provided in the diet.

Estrous (cycle) – the repetitive reproductive phases in female mammals, consisting of hormonal and physiologic changes to prepare said female to become pregnant if mated during the appropriate phase.

Euglycemia – blood glucose within normal ranges for an individual.

Euhydration – appropriate hydration.

European Pet Food Industry Federation – see Fédération Européenne de l'Industrie des Aliments pour Animaux Familiers (FEDIAF)

Exogenous – originating from outside of the body.

F

FASCP – see behavioral disorder

Fat – a macronutrient that provides fatty acids (mainly in the form of triglycerides); also provides the highest calorie/energy content of any macronutrient; often increases palatability.

Fat-soluble – see vitamin (fat-soluble)

Fatty acid (FA) – a carboxylic acid defined by its carbon chain length and the degree of hydrogen saturation. Fewer hydrogens mean more double bonds in the carbon chain, resulting in either mono- (one double bond) or polyunsaturated fatty acids.

FDA – see Food and Drug Administration

Fear – an emotional and physiological response to an imminent perceived threat.

Fecal (microbiota) transplant (FMT) – the transfer of stool from a healthy donor into the gut of a recipient via oral capsules, endoscopy, or enema; also known as transfaunation.

Fédération Européenne de l'Industrie des Aliments pour Animaux Familiers/European Pet Food Industry Federation (FEDIAF) – the trade association representing Europe's pet food industry. FEDIAF has produced nutritional guidelines that members follow. Countries outside of Europe may also use FEDIAF guidelines.

FEDIAF – see Fédération Européenne de l'Industrie des Aliments pour Animaux Familiers

Fel d 1 – a major allergen produced in feline saliva, and to a smaller extent, in sebaceous, lacrimal, urine, and

anal gland secretions. Known to be the main source of human allergies to felids; able to be neutralized via anti-Fel d 1 IgY immunoglobulins added to cat's diet.

Felidae – the phylogenetic family to which all cats (both wild and domestic) belong.

Feline idiopathic cystitis (FIC) – a diagnosis of exclusion, where there is irritation or inflammation of the urinary bladder that has no known cause.

Feline lower urinary tract disorder/disease (FLUTD) – any disease affecting the lower urinary tract in felines; clinical signs typically manifest as dysuria, hematuria, pollakiuria, etc.

Feline lower urinary tract sign(s) (LUTS) – clinical signs associated with lower urinary tract disorders in cats; potential signs include dysuria, hematuria, pollakiuria, periuria, and urethral obstruction.

Fermentability – the ease of which a fiber is able to undergo microbial digestion/fermentation.

Fermentable (fiber) – a complex carbohydrate that resists mammalian enzymatic digestion but is able to undergo microbial digestion or fermentation within the gut.

Fetus – the final phase of intrauterine growth of an organism, after the embryonic stage until parturition.

Fiber – a complex carbohydrate that is resistant to mammalian digestion and intestinal absorption; can be classified as soluble or insoluble, viscous or non-viscous, and non-fermentable or fermentable.

FIC – see feline idiopathic cystitis

Flatulence – excessive production of gases in the gastrointestinal tract.

Flushing (feeding) – feeding a higher amount of food prior to conception with the goal of increasing ovulation rate.

FLUTD – see feline lower urinary tract disorder(s)/disease(s)

FMT – see fecal (microbiota) transplant

Folate – vitamin B9; essential for DNA synthesis and repair, making it critical during growth and reproduction life stages.

(United States) Food and Drug Administration – the regulating body within the United States government responsible for regulation of foods, food additives, cosmetics, and drugs.

Frailty – general weakness associated with a decline in multiple organ systems; associated with aging and medical conditions and, among other things, results in decreased resilience and increased vulnerability.

Free choice (feeding) – see ad libitum

Functional dietary ingredient or functional ingredient – an ingredient added to a diet for a specific purpose, without being required to make a diet complete and balanced.

G

GABA – gamma aminobutyric acid; the primary inhibitory neurotransmitter in the mammalian brain.

GAGs – see glycosaminoglycans

Geriatric – a term used to describe dogs and cats with advanced age, at or beyond the pet's expected life span. Geriatric patients often require extra attention to ensure health, adequate food intake, and maintenance of body and muscle condition.

Gestation (period) – also known as pregnancy; the period of time between conception and birth of the fetuses, typically lasting approximately 2 months (~ 65 days) in dogs and cats, and divided into three (3) trimesters.

GI(T) – gastrointestinal (tract).

Glutamine – a conditionally essential amino acid and a preferred energy source for rapidly dividing cells such as enterocytes; also plays a crucial role in the urea cycle as a transporter of nitrogen.

Glycogen – a polysaccharide, multi-branched storage form of glucose.

Glycogenolysis – the metabolic process of breaking down glycogen stores.

Glycolysis – the metabolic process of breaking down glucose for energy.

Glycosaminoglycans (GAGs) – compounds containing both polysaccharides and amino groups; often associated with connective tissues.

Gluconeogenesis – the metabolic process of creating glucose from another source (such as glucogenic amino acids).

Glucokinase – one of two hepatic enzymes responsible for the metabolism of glucose. Has a low affinity for glucose and thus typically functions optimally at higher concentrations of blood glucose; poor/limited activity in the cat, resulting in poor tolerance to high levels of circulating glucose.

Glucosamine – a building block/component of glycosaminoglycans.

Gonadectomized – surgically altered to remove sex organs (specifically ovaries and testicles, in females and males, respectively).

Growth chart – mapping the growth pattern of a puppy or kitten from 8–12 weeks of age until adulthood, to monitor healthy growth or detect unusual growth early.

Growth (period) – the period of time that a pediatric patient is accreting tissues up until adulthood.

Gum – a type of soluble and fermentable fiber that is often used as a thickening agent, e.g., guar gum, gum Arabic, xanthan gum, agar-agar.

H

Hepatic lipidosis – a syndrome associated with protein-calorie malnutrition resulting in excessive accumulation of lipid within hepatocytes leading to hepatic dysfunction.

Hexokinase – one of two hepatic enzymes responsible for the metabolism of glucose. Has a high affinity for glucose and thus typically functions optimally at lower concentrations of blood glucose.

Homeostasis – maintaining balance or stability; can describe an animal's environment, metabolism, etc.

Hyaluronic acid – a glycosaminoglycan synthesized by chondrocytes and synovial cells; a component of joint fluid and articular cartilage, providing the joint with lubrication and shock absorption.

Hydrolysis – any chemical reaction where water is used to break chemical bonds; essential for digestion, metabolism, etc.

Hyperadrenocorticism – an endocrine disease characterized by an abnormal, sustained increased release of cortisol, with associated clinical signs; can be associated with primary disease of the pituitary or the adrenal glands; also called Cushing's disease.

Hypercholesterolemia – an increased concentration of cholesterol in the blood.

Hyperglycemia – an increased concentration of glucose in the blood.

Hyperlipidemia – an increased concentration of lipids (i.e., triglycerides, cholesterol, or any combination thereof) in the blood; see hypertriglyceridemia; see hypercholesterolemia.

Hyperparathyroidism – a condition where parathyroid hormone (PTH) levels are elevated; can be primary, due to a functional tumor of the parathyroid gland, or secondary, due to malnutrition and nutrient deficiencies, nutrient excesses, or chronic kidney disease.

Hypersalivation – excessive saliva production.

Hyperthermia – an increased body temperature above what is considered normal for the species/patient (overheating); most often seen in performance/working dogs with an inability to adequately cool themselves via panting; not synonymous with febrile (having an elevated body temperature associated with illness or disease).

Hypertriglyceridemia – an increased concentration of triglycerides in the blood.

Hypoalbuminemia – a low concentration of albumin in the blood; can be associated with a disease process that results in loss, reduced production, or both of albumin.

Hypoglycemia – a low concentration of glucose in the blood. Can be associated with certain disease processes. In healthy pets, hypoglycemia is seen most often in small and toy-breed puppies due to limited glycogen stores.

Hypometabolic – changes associated with lowered metabolism and lowered energy requirements.

Hypothyroidism – nutritionally, often associated with deficiency in iodine; also associated with autoimmune conditions resulting in destruction of the thyroid gland.

Hypothermia – a common condition in neonates, often due to poor husbandry, resulting in a body temperature lower than is considered normal or appropriate for that species.

Hypoxia – low (partial pressure of) blood oxygen; seen in cases of altitude stress in working and performance dogs.

I

Immunoglobulins – another term for antibodies; produced by B cells to recognize and fight antigens.

Inflammatory bowel disease (IBD) – a group of diseases associated with gastrointestinal mucosal and/or submucosal inflammation without evidence of a specific cause (see also chronic enteropathy). The disease is thought to arise from a combination of factors including genetic, intestinal microbiota, dietary, environmental, and immune function dysregulation.

Ingredient – a component of food that provides nutrients.

Inorganic – a component of food that is not originally derived from a living source, e.g., mined salt.

Inquiry funnel – a process for gathering information, which at its widest part involves the use of broad open-ended statements or questions to invite wide-ranging details on a topic. These are then followed by more focused open-ended inquiries as the funnel narrows to explore specific areas in greater detail. Finally, specific closed-ended inquiries (i.e., questions often resulting in one-word answers) are used to confirm or clarify any remaining details at the bottom of the funnel.

Insoluble fiber – an indigestible complex carbohydrate that does not disperse in water and that can increase fecal bulk and GI motility; examples include cellulose, lignin, and hemicellulose. Often used in the nutritional management of hairballs in cats.

Insulin – a hormone produced and released from pancreatic beta cells in response to increased blood glucose levels; promotes storage/utilization of glucose, electrolytes, and amino acids.

International Renal Interest Society (IRIS) – an association of nephrology-focused veterinarians with the goal to help veterinary practitioners diagnose, understand, and treat renal disease in companion animals.

In vitro – referring to an experiment performed in a controlled laboratory setting, not involving a living animal/organism; results may not always reflect natural processes in a living animal. In vitro experiments may be used to help reduce the use of animal models.

In vivo – referring to an experiment performed on/within a living organism.

IRIS – see International Renal Interest Society

Inulin – a type of soluble fiber, often derived from chicory root, that functions as a prebiotic (food for beneficial bacteria); often added to commercial diets to support GIT health.

J

Joule (J) – a unit of measurement describing the amount of energy that is released when food is metabolized; one joule is equivalent to 0.239 calories.

(kilo)Joule (kJ) – 1,000 joules; 1 kilojoule is equivalent to 0.239 kilocalories (see Calorie).

K

Ketogenesis – the metabolic process of forming ketone bodies.

Ketone – an organic molecule produced from triglyceride (i.e., fat) metabolism; also called ketone body. Examples include beta-hydroxybutyrate, acetoacetate, and acetone.

Key nutrients (of concern) – nutrients and their targeted ranges; dependent on the dog or cat and life stage in question.

Krebs cycle – see citric acid cycle

L

LA – see linoleic acid

Lactation (phase) – the period of time when a dam produces milk for her offspring.

LBM – see lean body mass

L-carnitine – a nonessential amino acid–related compound that improves mitochondrial function and is required for mitochondrial lipid metabolism; acts as a water-soluble vitamin-like substance.

LCFA – see long-chain fatty acid

Lean body mass – also known as lean muscle mass, or muscle tissue; excludes adipose tissue and bone mass.

Legume – a classification of vegetables that produce seeds in a pod; examples include beans, lentils, peas, and peanuts.

Leukotrienes – formed through the lipoxygenase pathway, leukotrienes are eicosanoids derived from 20 carbon PUFAs (arachidonic and eicosapentaenoic acids) and are involved in inflammatory and immune pathways.

Limiting (amino acids) – an essential amino acid (EAA) that is present in the food in the lowest proportion to an animal's biologic need.

Linoleic acid – an omega-6 polyunsaturated fatty acid with 18 carbons and 2 double bonds; essential in both dogs and cats.

Lipemia – circulating fat or lipid in the blood.

Lipolysis – the metabolic breakdown of endogenous fat stores.

Long-chain fatty acid (LCFA) – a fatty acid comprised of 16 to 22 carbons (see fatty acid).

LT – see leukotrienes

LUTS – see feline lower urinary tract signs

Lymphangiectasia – the dilation of lymphatic vessels in the mucosa and/or submucosa of the intestine and one of many causes of protein-losing enteropathy (PLE).

M

Macromineral – see mineral (macro)

Macronutrient – a nutrient that is required in large amounts (typically grams per 100 kcals or 100 grams of food consumed); includes energy-providing nutrients (protein, fat, and carbohydrates) and water.

Maintenance – stage of readiness to change where the caregiver continues to work on sustaining changes (such as to manage their pet's weight) and avoid relapse.

Maintenance (period) – the longest period of an animal's life, from the end of the growth period up until a need for nutrition modulation arises.

Maintenance energy requirement (MER) – the actual amount of energy required by a pet for weight loss, gain, or maintenance, depending on body condition score and patient goals. MER depends on life stage, spay/neuter status, age, activity level, and other factors and includes energy required for obtaining, digesting, and absorbing food and energy for activity. MER in kcal/day is calculated in different ways. One calculation is RER x MER Factor; this equation is not exact but estimates the actual energy requirements of a dog or cat. MER is also called daily energy requirement or DER.

Malabsorption – impaired intestinal absorption of nutrients.

Maldigestion – impaired digestion of food, due to exocrine pancreatic dysfunction and/or intestinal brush border enzyme deficiency.

Malnutrition – an abnormal state of nutrition, including deficiencies and excesses of nutrients and/or calories.

Marine – referring to a species or ingredient that is found in the ocean.

MCFA – see medium-chain fatty acid

MCS – see muscle condition score

MCT – see medium-chain triglyceride

ME – see metabolizable energy

Medium-chain fatty acid (MCFA) – a fatty acid comprised of 8 to 12 carbons; has a higher ketogenic yield compared to a long-chain fatty acid (LCFA). Examples include caprylic acid (C8; also called octanoic acid), capric acid (C10; also called decanoic acid), and lauric acid (C12); see fatty acid.

Medium-chain triglyceride (MCT) – a triglyceride comprised of medium-chain fatty acids; see triglyceride; see medium-chain fatty acid.

Megaloblastic (anemia) – an anemia characterized by abnormally large, immature red blood cells; associated with iron deficiency, folate deficiency, and cobalamin deficiency.

MER – see maintenance energy requirement

Metabolic flexibility – the ability of a body to switch between different fuel sources without untoward consequences.

Metabolizable energy – the usable energy available from food, after removing losses via urine and feces.

Metalloenzyme – an enzyme that uses certain metals as a cofactor.

(Matrix) Metalloproteases (MMP) – enzymes that degrade the extracellular matrix in cartilage (specifically affecting collagen, elastin, and gelatin).

(gut/intestinal) Microbiome – the collection of all microorganisms (or their genes) within the gastrointestinal (GI) tract.

Micronutrient – required in small quantities (typically in mg or microgram per 100 kcal consumed); categorized into vitamins and minerals.

Milk replacer – species-specific products that are designed to replace a mother's milk in the event a neonate is orphaned or if nursing is not an option.

Mineral – inorganic elements that are essential for various physiologic functions; are divided into macrominerals and trace minerals or elements.

Mineral (macro) – minerals required in relatively large amounts (typically milligrams per 100 kcal consumed); include calcium, phosphorus, potassium, chloride, sodium, and magnesium.

Mineral (trace) – minerals required in small amounts (typically micrograms or nanograms per 100 kcal consumed); include iron, zinc, copper, manganese, iodine, and selenium. Also called trace elements.

MMP – see matrix metalloproteases

Modified Atwater factors – numerical values used to estimate energy/caloric content of energy-providing macronutrients in standard pet foods; accounts for pet food processing.

(dietary) Moisture content – water content/concentration in a diet.

Morbidity – developing a disease or medical condition; often described as a rate of disease development.

Mortality – death; often used to describe rate of death.

Motivation – the drive, energy, or intent to perform a behavior, including habits, emotions, and thoughts.

Mucilage(s) – a viscous, jelly-like substance created by plants and certain microorganisms; comprised of polysaccharides mixed with water.

Muscle condition score (MCS) – an assessment of a pet's body composition—specifically, lean muscle tissue—using a combination of visual and tactile skills.

Myopathy – nutritionally, a muscle weakness or dysfunction associated with certain vitamin and/or mineral deficiencies (e.g., vitamin E deficiency).

N

National Research Council (NRC) – an organization that compiles and collects research pertaining to different topics. Functions as the working branch of the National Academy of Sciences.

Neonatal period – the first 2–3 weeks of a dog's or cat's life; considered the most critical for determining and supporting survival.

Neophilic – liking something "new," as opposed to something familiar; often used to describe a response to diet, toys, environment, etc.

Neophobic – preferring the familiar over something "new"; often used to describe a response to diet, toys, environment, etc.

Neoplasia – growth of tissues due to abnormal proliferation; can be benign or malignant; also known as cancer.

Neurohormonal – typically in reference to hormones secreted by neuroendocrine cells, but that do not require synapses to send messages (rather utilizing the bloodstream); examples of hormones secreted include AVP/ADH, oxytocin, epinephrine, etc.

Neurotransmitter – a chemical/hormone/etc. that transmits a signal from one nerve cell to another, utilizing synapses (junction between two neurons); biologic signals can be characterized as modulatory, inhibitory, or excitatory.

Niacin/nicotinic acid – a form of vitamin B3; an essential nutrient.

NRC – see National Research Council

Nuclear sclerosis – thickening of the center (nucleus) of the lens in the eye, resulting in a cloudy, opaque

appearance; *may* impact vision; also called lenticular sclerosis.

Nutraceuticals – foodstuffs that provide both nutritional and other benefits.

Nutrient – a metabolically useful component of ingredients and food; can be classified as essential or nonessential.

Nutrient density – nutrient-to-calorie ratio of a particular diet.

Nutrient profile – the unique nutrient composition of a particular diet.

Nutritional assessment – an evaluation that includes consideration of animal-specific factors, diet-specific factors, feeding management and environmental factors, and human factors; performed in addition to medical evaluation, it includes body weight, body condition score (BCS), muscle condition score (MCS), and a comprehensive nutritional history.

O

OA – see osteoarthritis

Obesity – excess storage of body fat, resulting in increased body weight and body condition score (BCS) with potentially deleterious effects on health.

Obligate – mandatory or required; e.g., obligate carnivore (see carnivore).

Obstipation – severe constipation with an inability to pass feces.

OHI – see Oral Health Index

Oligosaccharide – a carbohydrate containing multiple simple sugar molecules (monosaccharides) bonded together; typically between 3 and 10 sugars in length.

Omega/(n)-3 fatty acid – a fatty acid where the first double bond occurs between the 3rd and 4th carbon from the methyl terminal carbon. Examples include eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

Omega/(n)-6 fatty acid – a fatty acid where the first double bond occurs between the 6th and 7th carbon from the methyl terminal carbon. Examples include linoleic acid (LA) and arachidonic acid (AA).

Omnivore – used to describe the eating patterns of an animal that consumes both animal- and plant-based foods; often used to describe dietary flexibility.

Open-ended inquiry – a statement or question that draws out a broad, wide-ranging response.

Opportunity – the social factors as well as the environment around the client and patient which either promote or impede a behavior.

Oral health index (OHI) – an index that estimates the severity of periodontal disease; includes evaluation of plaque and calculus accumulation, gingival health, stain and malodor, and regional lymph nodes.

Organic – 1) referring to a carbon-containing compound; 2) referring to a living organism; 3) regarding foods and products, must adhere to governmental guidelines in a specific country for organic products.

Orphan – a neonatal dog or cat that is not receiving maternal care (either due to abandonment, illness, losing the mother, etc.).

Osteoarthritis (OA) – a progressive degeneration of diarthrodial synovial joints which results in articular chondrocyte death, synovial inflammation, loss of normal joint fluid and cartilage, subchondral bone sclerosis, osteophyte and enthesophyte formation, and ultimately loss of joint function and chronic maladaptive pain (see degenerative joint disease).

Osteochondritis – a type of DOD involving inflammation of the cartilage and subsequent damage to the underlying bone.

Osteochondrosis – a type of DOD; results in disturbed/abnormal development of cartilage but does not yet involve the bone.

Osteomalacia – inappropriate calcification and subsequent softening of bone(s) often due to malnutrition, typically deficiencies of calcium, phosphorus, and/or vitamin D; may also be referred to as rickets when present in a growing puppy or kitten.

Osteomegaly – a type of DOD resulting in abnormal enlargement or excessive growth of bones; often associated with high calcium intake particularly in large-breed puppies.

Overweight – weighing more than is considered "normal"; while increased percentage of adipose tissue is implied, it is important to note that its qualifier does not in fact distinguish between tissue type. To determine if a pet has excess adipose tissue, a body condition score must be combined with measurement of body weight.

Ovulation (period) – the period of the estrous cycle where ovulation (release of egg) occurs, in response to luteinizing hormone surges; cats are induced ovulators (requiring copulation to occur).

Oxidation – chemical process that occurs when there is a transfer (in this case loss) of electrons by a molecule; in contrast, reduction results when a molecule gains an electron.

Oxidative damage – occurring when a molecule is exposed to oxygen free radicals/reactive oxygen species (ROS), resulting in cellular damage, ultimately resulting in reduction or loss of cell function.

Oxygen free radical – oxygen molecules with uneven numbers of electrons, resulting in instability and the likelihood of reacting with other molecules.

P

Palatability – the state of being acceptable to taste; regarding trials, the preference of food measured by standard testing methods.

Palliative care – patient care/support that emphasizes comfort and quality of life.

Pancreatitis – an inflammatory condition of the pancreas.

Parturition (partum) – birth of the neonate.

Periodontal disease – a collection of diseases within the oral cavity, the majority of which are preventable with appropriate husbandry and care.

Periuria – urinating in inappropriate locations (i.e., outside of the litter box).

PG – see prostaglandin

Phagocytes – a classification of immune cells that engulf and eat (phagocytize) pathogens, antigens, and other cells.

Pharmaceutical – a medicinal drug; medication.

Phosphatidylserine – a type of phospholipid (complex fat) that plays a crucial role in the activation of signaling pathways associated with the immune system.

Phosphocreatine system – also known as creatinine phosphate system, is a type of anerobic pathway designed to supply energy during fast bursts of exercise (e.g., sprint).

Pica – eating or desiring to eat unnatural foreign materials.

Placentation – the formation of the placenta, which develops during pregnancy to provide nutrients and waste removal from the developing fetuses and the mother.

Pollakiuria – abnormally frequent urination.

Polyestrous (seasonally) – e.g., queens; referring to animals that experience multiple estrous/heat cycles within a year; seasonality indicates that the heat cycles are associated with particular seasons/times of year.

Polyphagia – excessive eating.

Polyphenol – one of a family of organic compounds characterized by multiple phenol units; often used as a functional ingredient for antioxidant properties.

Polysaccharide – a carbohydrate containing multiple sugar molecules bonded together.

Polyunsaturated fatty acid (PUFA) – a long-chain fatty acid with two or more double bonds.

Portion-controlled feeding – a type of feeding strategy where a pre-measured amount of food is given at scheduled times.

Post-prandial – after eating.

Postbiotic – a preparation of inanimate microorganisms and/or their components that confers a health benefit on the host.

Postpartum (period) – the period of time immediately after birthing one's offspring.

Prebiotic (fiber) – a substrate that is selectively utilized by host microorganisms conferring a health benefit on the host; typically, indigestible carbohydrates that promote growth of beneficial microorganisms; can be divided into soluble/insoluble and fermentable/non-fermentable fibers.

Precontemplation – stage of readiness to change where the caregiver lacks awareness of a specific issue (e.g., why their pet's weight is a problem) or does not see the reason, or have a willingness, to change.

Pregnancy – see gestation

Prehension – the act of picking up food and transferring it to the mouth.

Preparation – stage of readiness to change where the caregiver commits to making a change (e.g., to manage their pet's weight), yet is only in the early steps or has not taken steps to make the change.

Pre-prandial – prior to eating.

Probiotic – a preparation of live microorganisms that, when administered in adequate amounts, confers a health benefit on the host.

Prostaglandin – formed through the cyclooxygenase pathway, prostaglandins are eicosanoids derived from 20 carbon PUFA (arachidonic and eicosapentaenoic acids), and are involved with inflammatory and immune pathways; examples include thromboxane A2, PGE2, etc.

Protein – a macronutrient which provides a source of amino acids and nitrogen for various physiologic functions; also a source of energy.

Protein-energy malnutrition – malnutrition resulting from severe energy and protein deficiency.

Proteolysis – protein (muscle) breakdown.

Providing options – presenting a range of diagnostic or treatment options.

Pruritus – itching.

PUFA – see polyunsaturated fatty acid

Pulse – a type of legume (see legume) that includes edible seeds that are typically dried; examples include beans, chickpeas, peas, lentils.

Pyridoxine – also known as vitamin B6; essential for many functions, especially in carnivores, including glucose regulation, protein metabolism, red blood cell formation, and immune function.

Q

Queen – a female, breeding cat.

R

RA – see recommended allowance

Rancidity – spoilage, typically in reference to a fat.

Ration – measured feed for a pet or patient.

Readiness to change – pet owners can progress through a series of stages, or levels, of readiness, indicative of their willingness or ability to make changes (e.g., designed to help their pet lose weight). The stages are often referred to as precontemplation, contemplation, preparation, action, and maintenance.

Recommended allowance – the known amount of a nutrient recommended/required to meet the nutritional needs of an animal; species-, life stage-, and nutrient-specific.

Refeeding syndrome – a condition that typically occurs when a patient with prolonged starvation is fed more nutrients than their body can assimilate, often resulting in fluid and electrolyte shifts (specifically phosphorus, magnesium, and potassium), thiamine/B1 deficiency, and altered glucose, fat, and protein metabolism (among other clinical signs).

Relative supersaturation (RSS) – a mathematical calculation/ratio that predicts the ability of crystals to form or dissolve in urine with a given diet.

Renin-angiotensin aldosterone system (RAAS) – an integrated hormone system responsible for controlling sodium (and other electrolyte) excretion to maintain sodium and water balance in healthy animals.

Reproduction (phase) – in reference to life stages, the period of time in an intact female's life that encompasses mating, gestation, parturition, and lactation.

RER – see resting energy requirement

Resting energy requirement (RER) – the number of calories required for maintaining homeostasis while the animal rests quietly in a thermoneutral environment. RER is often calculated as 70 x $BW_{kg}^{0.75}$, although other equations exist as well.

Retinol – a fat-soluble vitamin crucial for optimal vision, immune function, and skin health. Retinol is the active form of vitamin A; while dogs can convert beta-carotene to retinol, cats cannot (see beta-carotene).

Riboflavin – vitamin B2; essential for energy production and the metabolism of fats, medications, and steroids.

RSS – see relative supersaturation

S

S-adenosyl-L-methionine (SAMe) – a potent antioxidant and precursor to glutathione that improves cell membrane integrity and rebalances monoamine neurotransmitter levels.

Safe upper limit – the maximum amount of a single nutrient that can be present in a pet food or that is safe for an animal to consume. For diets, the nutrient concentration must not have been associated with an adverse effect in healthy pets for which the diet is designed.

SAMe – see S-adenosyl-L-methionine

Sarcopenia – a complex syndrome characterized by the severe loss of lean body mass and strength that may be seen as a feature of aging.

Satiety – a state of feeling full/satiated.

SCFA – see short-chain fatty acid

Senescence – the irreversible inability for cells to proliferate and regenerate, resulting in progressive loss of function and organ deterioration.

Senior – a term to describe aging pets; while other life stages (including growth, reproduction, and maintenance) are well-defined, "senior" is not, and is dependent on the species, size, breed, etc. Often used synonymously with aging and/or geriatric.

Short-chain fatty acid (SCFA) – a fatty acid containing 2 to 6 carbons (see fatty acid). Produced in the colonic lumen by bacteria from fermentable fibers. Examples include butyrate, propionate, and acetate. Also called volatile fatty acids.

Signpost – a transition statement that signals where the conversation has been and/or where the conversation is going next.

Solubility – regarding fiber, the ability of a fiber to dissolve in (and absorb) water.

Soluble carbohydrate – a sugar or starch that requires little energy to digest and assimilate; a simple carbohydrate.

Soluble fiber – a fiber that disperses in water. Some soluble fiber absorbs luminal water. Examples include psyllium, guar gum, and inulin.

Sprinting – referring to activities or athletes that partake in short bursts of intense energy; fueled by carbohydrates; anaerobic metabolism is often prioritized during these activities.

Starch – a carbohydrate that contains an alpha-glycosidic bond; able to be enzymatically broken down in the GI tract into simple carbohydrates.

Stranguria – an inability to urinate or passing only small amounts of urine despite repeated attempts; typically indicates a physical or functional urethral obstruction and is usually accompanied by pain or discomfort.

Supplement – a substance for oral consumption, whether in or on feed or offered separately, often intended for specific benefit to the animal by means other than provision of nutrients recognized as essential or for provision of essential nutrients for intended effect on the animal beyond normal nutritional needs. Does not include legally defined drugs.

Sustainability – regarding pet food manufacturing, describes the global, social, economic, and environmental impact of producing, processing, distributing, consuming, and discarding the product.

Synbiotic – a mixture comprising live microorganisms and substrate(s) selectively utilized by host microorganisms that confers a health benefit on the host.

T

Taurine – a beta-sulfur-containing free amino acid that has important physiological roles in bile acid conjugation, cardiac and skeletal muscle, retinal function, and the central nervous system; considered an essential nutrient in cats as they cannot synthesize it from precursor amino acids (methionine and cysteine).

TCA cycle – see citric acid cycle

Therapeutic diet – food/diet designed to address the physiological compromises and clinical signs caused by disease, but rarely to cure the underlying disease.

Thermoregulation – the process of maintaining an individual's internal/core temperature; must be within a narrow (and defined) range.

Thiamine – also known as vitamin B1; essential for carbohydrate metabolism and optimal neural function.

Time-restricted meal – food is offered at specific times of the day and left available for the pet to eat within a limited time.

Tocopherol – a form of vitamin E; a fat-soluble vitamin that functions as a potent antioxidant, not only protecting cells from oxidative damage but enhancing immune and skin health. There are several tocopherols that vary in their antioxidant potency.

Topper – a food, treat, or enhancement that can be added to a patient's diet (typically on top or mixed in) to enhance flavor, aroma, palatability, etc. with the goal of encouraging and/or optimizing food intake. It is recommended that no more than 10% of a patient's daily caloric intake is provided in the form of treats and/or toppers.

Trace mineral – see mineral (trace)

Transition (dietary) – a period of time when gradually changing from one diet to another with the goal of minimizing risk for developing gastrointestinal and/or metabolic intolerance. Duration is based on the individual's unique tolerance and any underlying conditions.

Treat – a high-value food product that is fed to incite a particular response from a pet; common uses are for training and for showing affection. While treats can be complete and balanced, the majority are not, and use can potentially unbalance an otherwise complete and balanced diet. As with toppers, the total additional foods should not be more than 10% of the patient's daily calorie intake.

Triglyceride (also known as triacylglycerol) – an ester consisting of a glycerol backbone attached to three fatty acids.

Tricarboxylic acid cycle (TCA) – see citric acid cycle

Tryptophan – an essential amino acid; functions include acting as precursor to serotonin and melatonin, as well as niacin (in dogs). Considered a functional ingredient, often used for helping to reduce stress in both dogs and cats by increasing serotonin levels.

Tuber – a plant/vegetable whose root systems are consumed due to their starch content; examples include potatoes, yams, cassava, and sweet potato.

Tyrosine – an amino acid; functions include serving as precursor of dopamine, norepinephrine, and epinephrine.

U

Ubiquinone – also known as CoQ10, a powerful antioxidant that plays a key role in cellular energy metabolism; currently used to support cognitive and cardiac health.

United States Department of Agriculture (USDA) – the United States governmental agency primarily responsible for domestic food production inspections, inspection of imported foods, and animal disease prevention in the United States.

Urea cycle – a series of reactions in hepatocytes that remove ammonia from circulation by producing blood urea nitrogen for ultimate urinary excretion.

Urethral obstruction – a blockage of the urethra, which conveys urine out of the body from the urinary bladder.

Urolithiasis – the macroscopic accumulation of crystalloid material (uroliths or "stones") in the urinary tract.

USDA – see United States Department of Agriculture

V

Veterinary health care team (VHCT) – a team of highly skilled, knowledgeable professionals with training in a variety of species' biological and psychological needs; includes veterinarians, veterinary technicians or nurses, assistants, client care representatives, practice managers, and other professionals.

Veterinary professionals – trained and/or licensed individuals working in the veterinary field; includes doctors/clinicians, technicians, nurses, assistants, specialists, practice managers, as well as customer service representatives.

VHCT – see veterinary health care team

Viscosity – refers to thickness of the gel formed by fiber; viscosity influences digestion, absorption, and GI health.

Veterinary Oral Health Council (VOHC) – a program developed by the American Veterinary Dental College to a) establish guidelines for treats and pet foods labeled to reduce plaque, tartar, and/or dental calculus and to b) independently review and evaluate claims of said products. Products containing the VOHC seal have demonstrated approval of the claim.

Vitamin – organic compounds essential for growth, metabolism, and general health; can be classified into fat-soluble and water-soluble.

Vitamin A – see retinol and beta-carotene

Vitamin B – water-soluble vitamins; include B1, B2, B3, B5, B6, B7, B9, and B12.

Vitamin B1 – see thiamine

Vitamin B2 – see riboflavin

Vitamin B3 – see niacin

Vitamin B9 – see folate

Vitamin B12 – see cobalamin

Vitamin C – a water-soluble vitamin and antioxidant that is synthesized endogenously in dogs and cats, making it non-essential; however, during times of extreme stress or illness, it may become conditionally essential.

Vitamin D3 – see cholecalciferol

Vitamin E – see tocopherol

Vitamin (fat-soluble) – transported via fat absorption and stored in the body's fatty tissues and liver; includes A, D, E, and K.

Vitamin K – a fat-soluble vitamin that is essential for coagulation factors and bone health. Due to adequate production via intestinal microbiota, supplementation is usually not required in companion pets but can be conditionally essential in some disease states. Includes phylloquinone (K1), which is found in leafy green vegetables; menaquinone (K2), which is produced by GI microbiota; and menadione (K3), which is synthetically produced and added to foods or used in cases of deficiency.

Vitamin (water-soluble) – does not require fat for absorptive transport, but rather is absorbed with water; minimal to no storage in the body (depending on the individual vitamin); includes the B vitamins and vitamin C.

VOHC – see Veterinary Oral Health Council

Volatile sulfur compounds (VSC) – malodorous molecules containing sulfur that in veterinary patients are most often associated with halitosis (bad breath); odors produced include rotten egg smell.

Vomiting – the forceful projection of stomach contents through the mouth; also known as emesis.

VSC – see volatile sulfur compounds

W

Water-soluble – see vitamin (water-soluble)

Weaning (period) – typically starting between 3–4 weeks of age through 6–9 weeks of age, the period of transitioning a pediatric patient off a mother's milk onto a solid food.

Weight trend – the trajectory of a veterinary patient's weight over time, based on measurements at two or more time points.

Well-pet diet – a diet that can be purchased at retailers without a veterinary recommendation, designed to support healthy pets based on their respective life stages.

World Small Animal Veterinary Association (WSAVA) – a global federation representing more than eighty veterinary medical associations around the world, with goals to promote animal health and welfare and advance quality and availability of medical and surgical care.

WSAVA – see World Small Animal Veterinary Association

X

Xylitol – an artificial sweetener that is toxic to pets, leading to hypoglycemia and potential hepatic damage; also called birch sugar.

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