The incidence of cancer in humans continues to increase, with recent statistics showing that approximately 38% of women and 45% of men are likely to develop cancer in their lifetime. Therefore, many pet owners have likely had cancer or known someone who has had it. Thus, the veterinary health care team should have a positive, compassionate, and knowledgeable approach to not only pets with cancer but also their owners.

Because pet owners usually understand the importance of nutrition or are willing to learn about it, they are often willing to implement nutritional recommendations that may improve the quality and/or duration of their pets’ lives. In addition, following nutritional recommendations can help pet owners feel like they are participating in their pets’ therapy.

Metabolic Alterations in Patients With Cancer

Patients with cancer may lose weight and have a decrease in body condition due to the location of the tumor (e.g., oral mass), complications of cancer treatment (e.g., radiation of an oral mass), or cancer cachexia. Cancer cachexia is a paraneoplastic syndrome manifested by weight loss and a decrease in body condition despite adequate nutritional intake. Although the numbers of dogs and cats with cancer cachexia are not known, it is imperative for veterinary technicians to remember cachexia when obtaining a patient history and body condition score for pets with cancer.

The metabolic alterations described below have been identified in human and canine cancer patients. Studies evaluating these alterations in cats with cancer have not been published. In humans, these alterations have been associated with cachexia, a decreased response to therapy, a decreased remission rate, and an increased mortality rate.

Alterations in Carbohydrate Metabolism

Research has documented that dogs with lymphoma and many other malignant diseases have a significant alteration in carbohydrate metabolism. Tumors preferentially metabolize glucose (carbohydrate) for energy, forming lactate (lactic acid) as an end product. The host must then expend energy to convert lactate back to glucose, resulting in a net energy gain by the tumor and a net loss by the animal. Consequently, dogs with cancer lose energy to the tumor and have elevated blood lactate and insulin levels (e.g., laboratory evidence of altered carbohydrate metabolism). Veterinary technicians must take care to avoid administering fluids that contain glucose or lactate to pets with cancer.

Alterations in Protein Metabolism

Humans with cancer and weight loss experience a decrease in body muscle mass and an alteration in protein synthesis. Concurrently, skeletal muscle protein breakdown, liver protein synthesis, and whole body protein synthesis

Key Points

- Cancer is one of the most common causes of nonaccidental death in dogs and cats.
- Few diseases evoke as much emotion as cancer, and owners of pets with cancer often feel a loss of control when confronted with their pet’s disease.

*Ms. Burns discloses that she is a consultant for Hill’s Pet Nutrition.
increase to support tumor growth. If protein intake does not keep pace with use, then immune response, gastrointestinal function, and wound healing are affected.

Cytokines such as tumor necrosis factor-α (TNF-α) are also involved in protein catabolism. An increased level of TNF-α does not induce muscle protein catabolism directly but adversely affects important pathways that replenish lost muscle tissue.5,6

One study found that dogs with cancer had altered plasma amino acid profiles compared with normal control dogs.7 These altered profiles did not return to normal after tumors were removed surgically. This finding suggests that cancer induces long-lasting changes in canine protein metabolism.

### Alterations in Fat Metabolism

Catabolism of adipose tissue is the second major feature of cachexia in various chronic diseases, including cancer.5,6,7,8 A decrease in fat synthesis or an increase in lipolysis can deplete fat stores. Studies in animal models suggest that production of lipid-mobilizing factor by tumors may account for loss of body fat, especially when this process is combined with decreased food intake.

Several cytokines alter lipid metabolism. TNF-α is the major cytokine implicated in the catabolism of adipose tissue during cachexia in rodents. Altered lipid profiles in dogs with lymphoma suggest that similar changes may occur in dogs and cats with various cancers.9

Unlike host tissues, some tumor cells have difficulty using lipids as a fuel source compared with soluble carbohydrates and protein.10 This finding has led to the hypothesis that foods relatively high in fat, particularly omega-3 fatty acids, may benefit dogs with cancer compared with foods relatively high in carbohydrates. Cats and dogs in North America receive most of their nutrient intake from commercial dry pet foods. These foods are usually high in soluble carbohydrate (25% to 60%) and relatively low in fat (7% to 25%). These characteristics may make most commercial dry foods unsuitable for nutritional management of cats and dogs with cancer.

### The Ideal Nutritional Profile for Patients With Cancer

Nutritional management of dogs and cats with cancer is part of a multimodal approach to therapy that the veterinary team should consider when initiating treatment. Providing appropriate nutrition may improve quality of life, enhance the effectiveness of treatment, and increase survival time. Alterations in carbohydrate, protein, and fat metabolism precede obvious clinical disease and cachexia in dogs with cancer and may persist in animals with clinical remission of, or apparent recovery from, cancer. Until research results show differently, pathophysiologic and therapeutic principles for cats with cancer should follow those of people and dogs with cancer.1

Key nutritional factors in animals with cancer include soluble carbohydrates, fiber, protein, arginine, fat, and omega-3 fatty acids (TABLE 1). These factors should be incorporated in the nutritional management of every patient with cancer.

#### Soluble Carbohydrates and Fiber

Although most dogs and cats do not require soluble carbohydrates in their diet, ingredients containing these carbohydrates, such as starch, are used in commercial pet food because they are efficient energy sources and have properties that aid in manufacturing and cooking processes. However, soluble carbohydrates may be poorly used by animals with cancer and can contribute to increased lactate production. Thus, in diets for cancer patients, soluble carbohydrates should make up less than 25% of a food’s dry matter content (TABLE 1).

Soluble (fermentable) and insoluble (poorly fermentable) fiber sources are important to help maintain intestinal health, especially in animals undergoing chemotherapy, radiation therapy, or surgery. Increased dietary fiber may help prevent and resolve abnormal stool quality (soft stools, diarrhea) encountered when changing from a high-carbohydrate commercial dry food to a high-fat commercial or homemade food. A crude fiber level greater than 2.5% of dry matter is recommended.

#### Protein and Arginine

Because patients with cancer experience altered protein metabolism, resulting in loss of lean muscle mass (cachexia), dietary protein should be highly digestible and exceed the level normally used for maintenance of adult animals (TABLE 1). The protein level should be 30% to 45% of dry matter in foods for dogs with cancer and 40% to 50% of dry matter in foods for cats with cancer.1

Arginine is an essential amino acid that may have specific therapeutic value in cats and dogs with cancer. The minimum effective level of dietary arginine for animals with cancer is unknown; however, a positive correlation between plasma arginine concentrations and survival in dogs with lymphoma receiving chemotherapy suggests that it is appropriate to provide more than 2.5% arginine on a dry-matter basis.1,12 Arginine has also been shown to improve immune function in cancer patients, promote wound healing, and inhibit tumorigenesis.1 Cats should receive foods with a similar level of arginine (i.e., >2%)
until research discloses a more effective level. L-Arginine can be included in the diet by providing a supplement or a high level of good-quality protein.

**Fat and Omega-3 Fatty Acids**

Omega-3 fatty acids may have a preventive and therapeutic role in cancer therapy. There is epidemiologic evidence supporting the use of omega-3 fatty acids in human patients with cancer.\(^1\)\(^2\) Low cancer rates have been found in populations with high dietary intake of omega-3 fatty acids, which have been shown to reduce the risk of colorectal, prostate, and mammary cancer.\(^1\)\(^2\) Omega-3 fatty acids increase the immunologic response against tumor cells, increase tumor susceptibility to oxidative stress, and decrease TNF-α production. In patients with cancer, a high level of omega-3 fatty acids has many clinical benefits, including reduced tumorigenesis, tumor growth, and metastasis as well as anticatabolic effects.\(^13\)\(^15\)

### TABLE 1  Key Nutritional Factors for Dogs and Cats With Cancer and Levels in Selected Commercial Foods\(^a\)

<table>
<thead>
<tr>
<th>Products</th>
<th>Protein</th>
<th>Soluble Carbohydrate</th>
<th>Fat</th>
<th>Omega-3 Fatty Acids</th>
<th>Arginine</th>
<th>Crude Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hill's Prescription Diet n/d Canine, moist</td>
<td>38%</td>
<td>20%</td>
<td>33.2%</td>
<td>7.3%</td>
<td>2.95%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Hill's Prescription Diet a/d Canine/Feline, moist</td>
<td>44.2%</td>
<td>15.4%</td>
<td>30.4%</td>
<td>2.6%</td>
<td>2.4%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Hill's Prescription Diet p/d Feline, moist (Canada)</td>
<td>49%</td>
<td>16.2%</td>
<td>24%</td>
<td>1%</td>
<td>2.3%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Hill's Prescription Diet p/d Feline, dry (Canada)</td>
<td>39%</td>
<td>24%</td>
<td>29%</td>
<td>1.1%</td>
<td>2.2%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Hill's Science Diet Puppy Healthy Development Savory Chicken Entrée</td>
<td>28.2%</td>
<td>39.2%</td>
<td>23.6%</td>
<td>0.4%</td>
<td>1.8%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Hill's Science Diet Kitten Healthy Development Liver &amp; Chicken Entrée</td>
<td>49%</td>
<td>16%</td>
<td>24%</td>
<td>1%</td>
<td>2.3%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Hill's Prescription Diet m/d Feline, dry</td>
<td>52%</td>
<td>14.7%</td>
<td>22%</td>
<td>0.2%</td>
<td>2.64%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Hill's Prescription Diet m/d Feline, moist</td>
<td>53%</td>
<td>15.7%</td>
<td>19.4%</td>
<td>0.3%</td>
<td>3.2%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Iams Eukanuba Maximum Calorie/Canine &amp; Feline, moist</td>
<td>42%</td>
<td>12%</td>
<td>37%</td>
<td>0.22% (minimum)</td>
<td>NA</td>
<td>0.5%</td>
</tr>
<tr>
<td>Purina CV Feline Formula, moist</td>
<td>42.5%</td>
<td>23%</td>
<td>27%</td>
<td>NA</td>
<td>NA</td>
<td>1%</td>
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<tr>
<td>Purina DM Feline Formula, dry</td>
<td>58%</td>
<td>15%</td>
<td>18%</td>
<td>0.4%</td>
<td>NA</td>
<td>1.3%</td>
</tr>
<tr>
<td>Purina DM Feline Formula, moist</td>
<td>57%</td>
<td>8.1%</td>
<td>24%</td>
<td>0.9%</td>
<td>NA</td>
<td>3.7%</td>
</tr>
<tr>
<td>Royal Canin Veterinary Diet Canine and Feline Recovery RS</td>
<td>53%</td>
<td>2.3%</td>
<td>33%</td>
<td>NA</td>
<td>5.9 g/1000 kcal</td>
<td>3.4%</td>
</tr>
<tr>
<td>Dry grocery-brand dog foods (average)(^b)</td>
<td>25.3%</td>
<td>52.2%</td>
<td>12.3%</td>
<td>&lt;1%</td>
<td>&lt;2%</td>
<td>3.1%</td>
</tr>
<tr>
<td>Dry specialty-brand dog foods (average)(^b)</td>
<td>28.1%</td>
<td>45.1%</td>
<td>16.3%</td>
<td>&lt;1%</td>
<td>&lt;2%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Moist grocery-brand dog foods (average)(^b)</td>
<td>41.2%</td>
<td>19.9%</td>
<td>27.1%</td>
<td>&lt;1%</td>
<td>&lt;2%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Dry grocery-brand cat foods (average)(^b)</td>
<td>34.8%</td>
<td>43.9%</td>
<td>12.3%</td>
<td>&lt;1%</td>
<td>&lt;2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Dry specialty-brand cat foods (average)(^b)</td>
<td>35.3%</td>
<td>37.4%</td>
<td>18.5%</td>
<td>&lt;1%</td>
<td>&lt;2%</td>
<td>2.4%</td>
</tr>
<tr>
<td>Moist grocery-brand cat foods (average)(^b)</td>
<td>51.2%</td>
<td>9.7%</td>
<td>26.6%</td>
<td>&lt;1%</td>
<td>&lt;2%</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

\(\text{NA} = \text{not available from the manufacturer}\)

\(\text{Nutrients are expressed on a percent dry-matter basis unless otherwise indicated. These values were obtained from the manufacturers’ published information.}\)

In clinical trials of dogs with spontaneous cancer, high dietary levels of omega-3 fatty acids (specifically eicosapentaenoic acid [EPA] and docosahexaenoic acid [DHA]) and arginine were shown to benefit dogs with lymphoma, nasal carcinoma, hemangiosarcoma, and osteosarcoma.11,12 In a double-blind, placebo-controlled clinical trial in which dogs underwent chemotherapy, the test food with high levels of omega-3 fatty acids and arginine was shown to reduce lactic acid consistently over a 12-week period compared with the control food.12 Omega-3 fatty acids in conjunction with arginine were shown to influence clinical signs, increase survival time, provide longer remission time, and improve quality of life (BOX 1).12

**Clinical Studies Using Omega-3 Fatty Acids in Patients With Cancer**

Several well-controlled clinical trials have evaluated the use of a high-fat, low-carbohydrate, arginine- and fish oil-supplemented food in healthy dogs and in dogs undergoing chemotherapy for lymphoma or radiation therapy for nasal tumors.16 In healthy dogs, food supplemented with a high level of fish oil increased serum concentrations of EPA and DHA within 1 week. These elevated concentrations persisted for several weeks after dietary supplementation was discontinued.16 In dogs undergoing chemotherapy for lymphoma, omega-3 fatty acid supplementation increased survival time, increased the disease-free interval, improved metabolic abnormalities, and improved quality of life.12 In dogs undergoing radiation therapy for nasal tumors, omega-3 fatty acid supplementation reduced radiation damage to normal tissue.12

Although clinical trials with functional foods have been performed for only a few types of cancer, the underlying metabolic abnormalities caused by cancer have been documented in dogs with many types of tumors.3,4,12 These findings suggest that similar clinical responses (BOX 1) may be expected in animals with various cancers.

Overall, dietary supplementation with a high level of fish oil is safe for dogs. Potential adverse effects include poor wound healing, coagulopathies (platelet dysfunction), gastrointestinal upset (soft stools, diarrhea), pancreatitis, fishy breath odor, and nutrient interactions (e.g., the vitamin E requirement increases with the amount of polyunsaturated fatty acids, including omega-3 fatty acids, in the food).12 Because of the potential for serious bleeding problems, cats with cancer should be closely monitored when given foods supplemented with fish oil or omega-3 fatty acids (TABLE 1).12

**Nutraceuticals**

**Antioxidant Vitamins**

The use of antioxidants in cancer patients is somewhat controversial. Some veterinary professionals think that antioxidants improve the efficacy of cancer therapy, improve immune function, decrease toxicity to normal cells, and reverse metabolic changes contributing to cachexia. Others think that dietary antioxidants may protect cancer cells against damage from chemotherapy or radiation therapy.11,12 It has been reported that many human cancer patients use vitamin supplements as complementary therapy, usually without the recommendation or knowledge of their physician.17–20 It is assumed that owners of cats and dogs with cancer may also commonly provide vitamin supplementation; however, this has not been studied.

The need for vitamin E in the diet is influenced by composition of the food. The vitamin E requirement increases with increasing levels of polyunsaturated fatty acids (including omega-3 fatty acids), oxidizing agents, and trace
minerals and decreases with increasing levels of fat-soluble vitamins, sulfur-containing amino acids, and selenium. Manufacturers of many specialty-brand pet foods have increased levels of antioxidant vitamins such as vitamins E and C because they appear to improve immune function and reduce cell damage in normal animals. However, the role of antioxidant vitamins in animals with cancer is far more complex. Additional studies are needed to determine optimal antioxidant nutrient intake for cats and dogs with cancer. At the present time, if the animal is fed a complete and balanced commercial food, megadose vitamin therapy does not appear to be indicated. The levels of vitamin E and other antioxidant nutrients should be appropriate to the levels of polyunsaturated fatty acids, trace minerals, and oxidants in the food.

**Trace Minerals**

Serum zinc, chromium, and iron concentrations are lower in dogs with lymphoma and osteosarcoma than in normal dogs. The clinical significance of these abnormalities is unknown, especially because serum levels may or may not correlate with tissue levels of trace minerals. To determine the optimal trace mineral intake for cats and dogs with cancer, additional studies are needed. Currently, trace mineral supplementation does not seem to be indicated if the pet is fed a complete and balanced commercial food; however, trace mineral supplementation is essential if the owner feeds a home-prepared food.

**Glutamine**

Glutamine may have specific therapeutic value for cats and dogs with cancer. Glutamine is an essential precursor for nucleotide biosynthesis and an important oxidative fuel for enterocytes. Glutamine has recently been recognized as a conditionally essential amino acid in certain physiologic states, including stress. Glutamine has several important biochemical roles and is a preferred source of energy for cells with rapid turnover, such as lymphocytes, enterocytes, and cancer cells. Glutamine has been shown to stabilize weight loss, improve protein metabolism, improve immune response, and improve gut barrier function in rodent cancer models and in human clinical trials. The optimal glutamine intake for cats and dogs with cancer has not yet been determined. Additional studies are warranted. Glutamine is best supplied by high-quality, high-protein pet foods.

**Tea Polyphenols**

Tea polyphenols, found in the leaves of the tea plant *Camellia sinensis*, protect against cancers induced by chemicals or ultraviolet radiation. Tea polyphenols have also been found to increase chemotherapy efficacy in animal cancer models. Green tea supplements are available, but a dose has not been established for cats and dogs.

**Vitamin A**

Natural and synthetic vitamin A derivatives, also known as retinoids, are currently being studied for their effects on cancer. The functions of vitamin A include growth promotion, differentiation and maintenance of epithelial tissues, and maintenance of normal reproductive and visual functions. Retinoic acid affects differentiation and proliferation of epithelial cells by binding to and activating specific cell nuclear receptors that can modify rates of gene transcription. Human and veterinary studies suggest that retinoids, alone or with other agents, may be effective for treating certain types of malignancies. Retinoids promote cellular differentiation and may enhance the susceptibility of cancer cells to chemotherapy and radiation therapy.

**Conclusion**

Pet owners are acutely aware of cancer in humans; thus, as members of the health care team, veterinary technicians need to remember to approach cats and dogs with cancer and their owners in a positive, compassionate, and knowledgeable fashion. Nutritional therapy and nutraceutical supplementation may influence remission time, survival time, and quality of life of veterinary patients with cancer. Technicians must ensure that clients understand the diagnosis of cancer, what it means for their pets, and the recommendations for treatment. Veterinary technicians have the critical role of educating pet owners about the importance of disease prevention and management.
of nutrition in managing cancer. Veterinary technicians can tell pet owners that nutrition therapy (1) may help their pets live longer and feel better and (2) can help to involve pet owners in their pets’ care and treatment.

References
Article #1 FREE CE Test

The article you have read qualifies for 1.0 credit hour. To receive credit from Alfred State College, choose the best answer to each of the following questions. Take the test online at Vetlearn.com.

1. **Dogs with cancer can have elevated blood levels of**
   a. insulin.
   b. lactate.
   c. neither a nor b
   d. a and b

2. **In humans, metabolic alterations due to cancer are associated with**
   a. increased mortality rates.
   b. cachexia.
   c. a decreased response to therapy.
   d. all of the above

3. **Which cytokine alters protein and fat metabolism in patients with cancer?**
   a. tumor necrosis factor-α
   b. lipoprotein lipase
   c. interleukin-3
   d. prostaglandin F₂α

4. **Key nutritional factors in animals with cancer include**
   a. soluble carbohydrate, protein, and omega-3 fatty acids.
   b. insoluble carbohydrate, polyphenols, and cysteine.
   c. insoluble carbohydrate, polyphenols, and arginine.
   d. insoluble carbohydrate, protein, and calcium.

5. **Many dry foods are not ideal for veterinary cancer patients because these foods tend to be relatively high in _____ and low in ______.**
   a. protein; fat
   b. omega-6 fatty acids; omega-3 fatty acids
   c. fat; arginine
   d. soluble carbohydrate; fat

6. **Some tumor cells have difficulty using _____ as a fuel source.**
   a. carbohydrates c. lipids
   b. lactate d. protein

7. **For dogs with cancer, dietary protein should be _____ digestible and _____ maintenance levels.**
   a. highly; below c. highly; above
   b. moderately; below d. moderately; above

8. **In clinical trials, dogs consuming a diet supplemented with arginine and fish oil (omega-3 fatty acids) while receiving cancer therapy had**
   a. a longer remission.
   b. a longer survival time.
   c. an improved quality of life.
   d. all of the above

9. **In clinical trials of dogs with spontaneous cancer, high levels of omega-3 fatty acids and arginine in food were shown to benefit dogs with**
   a. lymphoma.
   b. nasal carcinomas.
   c. hemangiosarcomas.
   d. all of the above

10. **Which statement(s) regarding vitamin supplementation in dogs is/are true?**
    a. The vitamin E level should be appropriate to the levels of polyunsaturated fatty acids in the food.
    b. Vitamin E can reverse cancer cachexia.
    c. Megadoses of vitamins are recommended for dogs receiving commercial dry food diets.
    d. all of the above