The Microbiome and Nutrition

Robin Saar, RVT, VTS (Nutrition)
RAS4Pets
AnimalBiome Veterinary, Lethbridge, Alberta, Canada

Abstract

Research is revealing the important effects that the gut microbiome has on a host’s overall health status as it influences the function of organs and physiologic systems. Compounds or metabolites produced by microbial fermentation of certain nutrients in the gastrointestinal (GI) tract play the largest role in these effects. Appropriately altering the digestibility or type of macronutrients in a pet’s diet can positively affect the pet’s GI microbiome, resulting in improved physiological function and health for the animal. Helping pet owners understand new “alternative” or innovative first-line testing and treatment options is imperative for improving recovery rates in pets with GI dysbiosis.
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twenty years ago, answering the question “Why is pet nutrition important?” has evolved over the last few decades. As the benefits of pharmaceutical agents in treating a disease state have long been understood—for example, insulin to balance blood glucose in a diabetic pet or anti-inflammatories to decrease joint pain associated with obesity—so has nutrition become recognized as a fundamental factor in pet health. Increased research into how nutrients provide energy has led to the use of a wider variety of ingredient sources in pet food and a more thorough understanding of canine and feline digestive and physiologic requirements. This has enhanced the development of formal nutritional guidelines for macro- and micronutrient requirements for pets and a growing variety of diets.

Recently, research in pet nutrition has focused on how nutrients are used by both pets and the microbes living in their gastrointestinal (GI) tract, and how microbial metabolism of these nutrients affects the health of the host.1 The newly recognized organ, the GI microbiome, is particularly important, as it contains over 100 trillion types of bacteria, fungi, archaea, and viruses, including microbial genes, that are able to influence multiple host organ systems, such as the neurologic, hepatic, oral, cardiac, integumentary (skin, hair, nails, and glands), and GI systems.2,4 Multiple factors have been identified as playing roles in altering and supporting these microcommunities, including nutrition.

**Take-Home Points**

- Nutrients provide energy for microbes in the GI tract as well as their host.
- The health of the GI microbiome is a good indicator of the health status of the host. A healthy microbiome contains many microbial species that can aid in promoting host health.
- The GI microbiome is influenced by host factors such as genetics, birth presentation, age, sex, hormonal status, environment, stress, nutrition, and antibiotic use. All of these factors may affect microbiota density and diversity.
- Broad-spectrum antibiotic usage causes the most significant change in the GI microbiome with the longest recovery rate.
- Host nutrition can alter the diversity and density of the GI microbiome, which may affect the metabolism, protective functions, and structural integrity of the GI tract.
- Nutrients that are indigestible by the host are the usual sources of nutrition for the GI microbiome. Fiber is a preferred energy source of many commensal bacteria.
- Fecal microbial testing can provide owners with a visual report of what is happening with their pet’s health compared with “normal” or “healthy” standards.
- When recommending probiotics, veterinary nurses should choose products that are species-specific and are supported by species-specific research.

**WHAT IS A HEALTHY GI MICROBIOME?**

The health status of the GI microbiome is a good indicator of the health status of the host. A healthy microbiome contains numerous types of microbiota that assist in multiple health-promoting functions. A less diverse microbiome in which only a few species are identified is associated with poor health or a disease state.5

Creating a healthy GI microbiome usually starts during the birthing process or soon after birth. Neonates born by vaginal delivery from healthy mothers have an initial exposure to maternal native vaginal microbiota, while those born via cesarean delivery may be initially exposed to the microbiome of the skin or environment. These pioneer microbes help educate and mature the immune system by conditioning the epithelial cells that line the GI tract to decrease their subsequent response to the same types of bacteria, allowing for a future symbiotic relationship.6 Additionally, how and what the neonate is fed can influence exposure to pioneer microbes. Ideally, microbial exposure should be species specific, which is more likely to occur during natural delivery and maternal nursing than during cesarean delivery or artificial nipple or tube feeding. The beneficial microbes that colonize the GI tract are known as commensal microbes.

Continued stabilization of the healthy GI microbiome is influenced by many factors, including host genetics, age, sex, hormonal status, environment, stress,
nutrition, and antibiotic exposure.\(^7\) These factors all affect microbiota density and diversity. However, broad-spectrum antibiotic usage has been identified as causing the most significant shift or change with the longest recovery rate.\(^8\) For example, administration of metronidazole and tylosin has been shown to lead to major, long-lasting alterations in the intestinal microbiome.\(^7\) This is because beneficial anaerobic bacteria in the microbiome are slower to adjust their metabolic process and flourish after antibiotic treatment than facultative bacteria (e.g., *Escherichia coli*), which are able to thrive in an anaerobic or aerobic environment. Once these bacteria have flourished, it can be difficult to rebalance the state of the microbiome back to its preantibiotic “normal” state.\(^9,10\)

**HOW DOES THE GI MICROBIOME AFFECT THE HOST?**

Microbes in the GI tract play a role in host health through 3 main functions (FIGURE 1). First, they perform or aid in the completion of metabolic functions, primarily through metabolite production. Second, they enhance or perform protective functions by controlling the growth of potential pathogens and influencing the immune system—the GI tract contains 80% of the body’s immune cells, which allows the GI microbiota to influence this system.\(^8\) Third, they support the GI tract structure by improving the GI barrier. Each of these functions depends on proper nutrition of both the host and the microbes.

**Metabolite Production and Functions**

Metabolites are chemical compounds resulting from metabolic processes. In the GI setting, they are produced by microbes through fermentation of dietary components that cannot be digested in the small intestine. Different types of bacteria prefer different dietary components (known as preferred nutrients),
and different components produce different metabolites. Each metabolite has different functions for the host, such as providing energy for cells or other microbiota, assisting with host energy metabolism, and aiding in digestion processes.

To flourish and produce necessary metabolites, all commensal microbes require their preferred nutrients. For example, fiber is an important dietary component because it is a preferred nutrient for GI bacteria that produce short-chain fatty acids (SCFAs). SCFAs (butyrate, propionate, and acetate) have multiple beneficial roles, including being energy sources for colonocytes and improving intestinal mucosal barrier functions and glucose metabolism. They also cross the blood–brain barrier to support brain function.

Dysbiosis
An imbalanced microbiome may lead to a state of dysbiosis. Three types of GI microbiome dysbiosis are commonly identified: (1) overgrowth of a pathogenic type of bacteria, (2) absence of key beneficial bacteria, and (3) decrease in the diversity or number of types of bacteria. These types of dysbiosis may be present separately or concurrently. In each case, the imbalance in microbial species affects the type and quantity of metabolites produced by the microbiome, with consequences for the host.

Depending on the type(s) of dysbiosis present, a variety of clinical signs may be observed. Diarrhea is the most commonly identified, but conditions affecting systems and organs other than the GI tract are being identified as correlating with dysbiosis in the GI microbiome. For example, neurologic conditions (e.g., seizure, cognitive dysfunction, anxiety), diabetes, obesity, atopy, and neoplasia have all been associated with a GI microbiome dysbiosis or imbalance. However, it is still unclear if dysbiosis causes disease, if it is a result of the disease state that perpetuates the condition, or how long it takes for signs to appear after dysbiosis develops.

WHAT IS THE ROLE OF NUTRITION IN TREATING DYSBIOSIS?
Veterinary teams can support pets with GI dysbiosis in several ways. One of the most basic is to be aware of all treatment options, including nutritional options, for pets with acute GI or noninfectious conditions in which the GI microbiome may not have been previously considered to play a role, such as atopy, hepatic, and behavior issues. Veterinary professionals should complete a nutritional evaluation for these patients and consider diet as a first-line option. Using 5 main goals, veterinary teams can simplify how they determine and present their nutritional recommendations.

1. Determine Appropriate Calorie Goals
Assess the pet’s body condition score (BCS) and muscle condition score (MCS) and calculate the pet’s energy requirement based on its individual needs. If the pet has an ideal BCS (5/9) and a good MCS, the current diet is likely providing adequate nutrition to meet its basic metabolic needs in its current health state. If the pet is overweight, GI dysbiosis is likely, and a change in diet could aid in improving microbiome diversity.

Calculating the patient’s specific energy requirements supports a healthy body condition and energy function by ensuring that the pet is not being fed excessive calories. The pet’s resting energy requirement (RER) should be calculated using current body weight in kilograms (BWkg) and the formula BWkg0.75 × 70, as this is a more accurate calculation than a linear formula. RER can then be multiplied by a factor of 0.8 to 3 (the average range for most pets) depending on the energy needs of the pet. (Note: For more information on body and muscle scoring and resting energy requirement factors, see the article “Energy Calculations: Gauging the Proper Caloric Intake for Patients” at bit.ly/3f0DRsv.)

2. Choose the Diet
Diet recommendations to support the GI microbiome should be based on 3 main principles:
1. Ensure the diet is complete and balanced and is appropriate for the current life stage of the pet.
2. Improve macronutrient digestibility. Individual macronutrient (protein, fat, carbohydrate) digestibility percentages may be found in pet food product guides or by contacting the pet food company directly. Protein, fat, and simple or digestible carbohydrates ideally have higher digestibility (80% to 90% is very digestible). Fiber is less digestible by the host but important to the GI microbiome. Diets with a high level of fiber will have an overall lower digestibility percentage even though the protein and fat sources in the diet may be highly digestible.
3. Alter the percentage of macronutrients. Is the pet on a diet that contains a higher percentage of a single macronutrient? For example, diets high in fat are correlated with a less diverse microbiome, and obesity is known to be a state of low-grade inflammation that corresponds to GI dysbiosis. Increasing dietary protein or fiber content and reducing fat content provides more preferred

**Basic formulas:**
- Resting energy requirement (RER): \(BW^{0.75} \times 70\)
- Maintenance energy requirement (MER): \(RER \times \text{energy factor}\)
- To increase MER: \([\text{Amount of change} \times (\text{MER} - \text{RER})] + \text{RER}\)

**For a 30-kg dog and an energy factor of 1.4:**
- RER: \(BW^{0.75} \times 70 = 30^{0.75} \times 70 = 897 \text{ kcal/d}\)
- MER: \(RER \times 1.4 = 897 \text{ kcal/d} \times 1.4 = 1256 \text{ kcal/d}\)

**AMOUNT TO FEED IN CUPS** | **AMOUNT TO FEED IN GRAMS**
---|---
**Day 1: 50% RER, 4 meals: 897 kcal/d \times 0.5 = 489 kcal/d / 4 = 122 kcal/meal**<br>122 kcal / 324 kcal/cup = 0.37 kcal/meal (⅓ cup)<br>122 kcal \times 1 kg / 3245 kcal \times 1000 = 39 g/meal

**Day 2: 75% RER, 4 meals: 897 kcal/d \times 0.75 = 673 kcal/d / 4 = 168 kcal/meal**<br>168 kcal / 324 kcal/cup = 0.52 kcal/meal (½ cup)<br>168 kcal \times 1 kg / 3245 kcal \times 1000 = 52 g/meal

**Day 3: 100% RER, 4 meals: 897 kcal/d / 4 = 224 kcal/meal**<br>224 kcal / 324 kcal/cup = 0.69 kcal/meal (⅔ cup)<br>224 kcal \times 1 kg / 3245 kcal \times 1000 = 69 g/meal

**Day 4: 25% increase in calories to reach MER, 4 meals: [0.25 \times (1256 - 897)] + 897 = 987 kcal/d / 4 meals = 247 kcal/meal**<br>247 kcal / 324 kcal/cup = 0.76 kcal/meal (¾ cup)<br>247 kcal \times 1 kg / 3245 kcal \times 1000 = 76 g/meal

**Day 5: 50% increase in calories to reach MER, 4 meals: [0.5 \times (1256 - 897)] + 897 = 1077 kcal/d / 4 meals = 269 kcal/meal**<br>269 kcal / 324 kcal/cup = 0.83 kcal/meal (¾ cup + 1 tablespoon)<br>269 kcal \times 1 kg / 3245 kcal \times 1000 = 83 g/meal

**Day 6: 75% increase in calories to reach MER, 4 meals: [0.75 \times (1256 - 897)] + 897 = 1166 kcal/d / 4 meals = 292 kcal/meal**<br>292 kcal / 324 kcal/cup = 0.9 kcal/meal (¾ cup + 2 tablespoons)<br>292 kcal \times 1 kg / 3245 kcal \times 1000 = 90 g/meal

**Day 7: 100% MER, 4 meals: 1256 kcal/day / 4 meals = 314 kcal/meal**<br>314 kcal / 324 kcal/cup = 0.97 kcal/meal (1 cup)<br>314 kcal \times 1 kg / 3245 kcal \times 1000 = 97 g/meal

**Decrease by 1 meal per day to reach 2 meals per day**
**Day 8: 3 meals: MER / 3 = 1256 kcal/d / 3 = 418 kcal/meal**

**Day 9: 2 meals: MER / 2 = 1256 kcal/d / 2 = 628 kcal/meal**

**FIGURE 2.** Example of an “immediate” feeding plan for starting a pet on a new diet. The patient is a 3-year-old, 30-kg Labrador retriever with a BCS of 5/9, a good MCS, and a recent history of frequent bowel movements of soft stool containing some mucus and fresh blood. The veterinarian has prescribed a gastrointestinal dry diet with fiber that provides 324 kcal/cup (3245 kcal/kg), and the plan is designed to feed to an energy factor of 1.4, ending up at 2 meals per day.

BCS=body condition score; BW=body weight in kilograms; MCS=muscle condition score
nutrients to appropriate commensal microbiota, allowing them to flourish and correct some diversity imbalances. Adding more fiber may also increase satiety and aid in correcting metabolic derangements, as SCFAs are believed to inhibit the accumulation of fat in adipose tissue.¹

3. Create a Feeding Plan
Diet changes should be made gradually. While the generally acknowledged method of switching diets by decreasing the percentage of the existing diet while increasing the percentage of the new diet over several days can be used, a simpler transition plan in which the old diet is stopped and the new diet is started immediately at a lower feeding volume has been successfully used by the author and multiple nutrition clinicians.⁸ This type of plan is usually recommended for any pet that has not met its minimum energy requirements for 3 days or more and may be at risk for refeeding syndrome. However, it is a viable way to provide a pet’s digestive tract sufficient time to adjust to a change in nutrient profile and to allow the appropriate microbes to flourish and properly ferment the indigestible portion of the diet.

This “immediate” plan starts feeding the new diet only on day 1 at 50% of RER, divided into 4 meals. Each day, the total volume of food is increased by 25% of the energy requirement until the pet’s total energy requirement is met by the new diet. Then, the number of meals per day can be reduced until the pet is fed its daily RER or maintenance energy requirement (MER) in 2 or 3 meals per day (FIGURE 2). This plan, which tends to be easier for pet owners to follow, can take anywhere from 4 to 10 days to complete, allowing the GI tract to provide sufficient enzymes for digestion while enabling a smooth microbial shift.⁸

4. Consider Testing and Supplements
Fecal microbial testing can provide owners with a visual reference for what is happening in their pet’s GI tract compared with a “normal” range or dysbiosis index. With the GI microbiome’s ability to influence other systems, this test may be a good indicator of imbalance in more than just the GI tract.³ It can also be used in pets with no signs of disease to provide a baseline.

Supplements such as fecal microbiota transplant capsules (as a form of species-specific probiotics⁴), prebiotics, postbiotics, and bacteriophages are some of the currently available tools to help support the GI microbiome.¹ However, all supplements are not created equally. Probiotics for humans may provide bacteria that do not normally reside in a pet’s GI tract or are not as important in their metabolic functions. When recommending products to support the microbiome, it is important to use only those that have been researched and shown to have a species-specific benefit and to ensure that owners understand the importance of this requirement.

5. Educate Owners
Links to factual sources like the World Small Animal Veterinary Association nutrition tools for pet owners (wsava.org/global-guidelines/global-nutrition-guidelines) and vendor resources are helpful in teaching pet owners about microbiome and nutrition health. Providing owners with reliable information sources allows them to participate more in decisions affecting their pet’s health and improves trust in the veterinary team, strengthening future interactions.

SUMMARY
The body’s microbiomes are diverse microscopic communities that play a role in the health of their host. Their density and diversity can be altered by various factors, including nutrition, with a less diverse microbiome being correlated with poor health and a richly diverse microbiome reflecting a good health status.¹⁴⁻¹⁵ Fecal microbial testing may help identify dysbiosis in pets that are exhibiting clinical signs of disease; it can also be used to obtain a baseline in those that are apparently healthy. Veterinary professionals should be aware of nutrition as a first-line therapy option for pets that may have GI dybiosis and should...
U.S. POSTAL SERVICE STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION

Requester Publications Only (Required by 39 USC 3685)


References


complete a nutritional evaluation for every pet. Providing pet owners with sources of factual information from trusted organizations helps them make educated decisions about their pet’s health and builds trust with the veterinary team. TVN