Welcome to the world of gut microbiome

Iveta Becvarova, DVM, MS, DACVN

Have you been wondering why the word microbiome has been an increasingly popular topic in human and veterinary medicine?

This is because scientists began to uncover that the microbes living on and in the body are not just a random cluster of microorganisms originating from the environment that can make an individual sick. In fact, the gut microbiome is a living ecosystem that is responsible for the health of the gastrointestinal tract and even many distant organs. Research is clear that harboring a healthy microbiome in the gut offers lots of health benefits. What do we know about the gut microbiome, what are its benefits and why does it matter to our dogs and cats?

Gut microbiome is the entire habitat of living microorganisms, including not only anaerobic and aerobic bacteria but also archaea, fungi, protozoa and viruses. They have been evolving for billions of years and there are thousands of diverse species known.

It is estimated that the intestine of mammals contains approximately 10^{10} to 10^{14} microorganisms which is ten times more than that number of cells within the body.

Due to their small size and presence in high density, the microbial mass is not as large and heavy when compared to the rest of the body. The total bacterial counts increases along the GI tract of dogs and cats, with numbers being lowest in the stomach and highest in the colon.

The colon has a slow flow of ingesta which provides the ideal environment for the microbes to grow and multiply, and replenish those excreted in the feces. Their growth is influenced by multiple factors but the major determinant is the type of substrate that is available for their nourishment, such as residuals of undigested food, sloughed mucosal cells, enzymes released into the gut lumen and dietary fiber which they skillfully digest.

Altogether, gut microbes use these substrates for their own benefit and growth. In return, they manufacture and release many compounds called postbiotics, with some of them providing benefits to the host. This interaction between mammal and gut microbial cells is a great example of the symbiotic relationship, with microbial bioactive metabolites (postbiotics) acting as major mediators of the dialogue between the gut and the host.

Since the metabolism of gut microbes is influenced by the diet, there is a great opportunity for dietary intervention to selectively alter microbial production of molecules to promote dog and cat health and prevent disease.

The best strategy for lasting and positive impact on intestinal microbiome is to include prebiotic fibers into the food. Not every prebiotic is created equal. Fibers with prebiotic benefits commonly found in pet foods include beet pulp, flaxseed, fruit fiber, rice fiber, oats or barley.

Postbiotics play an important role in dog and cat health and disease. They arise from the transformation of specific dietary components by select species of microbes that express the necessary enzymes to act on these components. Microbes produce unique enzymes that are not synthesized by the mammalian body.

Although there are differences in microbial species between individual dogs or cats, the metabolic end products are surprisingly similar between individuals. This is because several members of the microbial community are able to perform similar functions, and if one microbial group is displaced, other members of the community are capable to substitute that function and stabilize the entire ecosystem. Since the health benefits are mostly linked to the postbiotics produced, knowing what microbial species are present becomes less important than measuring type and concentration of microbial metabolites.

Let's look into a few of the most relevant "diet – microbiota – host interactions" and why they are important to dogs and cats.

GUT MICROBES REGULATE DEVELOPMENT AND ACTIVITY OF IMMUNE SYSTEM

Puppies and kittens are born with a sterile gastrointestinal (GI) tract which is colonized by microorganisms from the birth canal and from the environment within 24 hours. Those microbes are necessary to the newborn to establish an oral tolerance to commensal bacteria and food antigens, which ensures that the gut immune system will ignore them and will not initiate inflammatory response.

Throughout the life, a balanced intestinal ecosystem continues to collaborate with immune system and serves as the defense against invading intestinal pathogens. This ecosystem balance is established via various cooperative strategies that microbes developed and is even capable to competitively exclude potentially pathogenic bacteria.

GUT MICROBES PROVIDE IMPORTANT NUTRITIONAL BENEFITS

Intestinal microbes harvest otherwise inaccessible nutrients, sources of energy and fiber-bound plant polyphenols from the food, and synthesize vitamins (vitamin K, water soluble B vitamins). Polyphenols are molecules with antioxidant and disease modulating properties, and are found in fruits and vegetables. Plants produce them as defense mechanism against UV light and pathogens, and they possess their bioactive roles after ingestion.

The major metabolic products generated by canine and feline intestinal microbiota are short chain fatty acids (SCFAs) acetate, propionate and butyrate. They are mainly products of carbohydrate and fiber fermentation by microbes with saccharolytic function.

Acetate and propionate are energy substrates for microbial growth but are also absorbed from the colon of the dog and provide a source of energy for the body.

Butyrate is an important energy fuel for colonocytes. Interestingly, up to 7% of the metabolic energy of dogs, and to a lesser extent in cats, is produced by microbial fermentation in the colon. Without the presence of gut microbes, these energy substrates would never form and the energy would remain trapped within the fiber and lost in the feces.

It is generally accepted that carbohydrate and fiber fermentation results in beneficial effects for the host due to generation of SCFAs but what about protein fermentation? Anaerobic degradation of undigested protein in the colon is a process called putrefaction. Bacterial proteases and peptidases break the protein down to peptides and amino acids, and release of NH_3 through deamination. Although SCFAs are the major end products from carbohydrate fermentation, they are also produced from many amino acids.

Other metabolites of proteolysis include branched chain fatty acids (BCFAs) from fermentation of branched amino acids, phenolic and indolic compounds from aromatic amino acids, and hydrogen sulfide (H_2S) from sulfur containing amino acids. Finally, decarboxylation of amino acids results in the appearance of amines in the gut.

Researchers at Hill's Pet Nutrition did show that feeding dogs food enriched with fiber-bound polyphenols improved fecal stool quality, increased saccharolytic postbiotic concentration, decreased microbial putrefaction and decreased polyamine concentration, when compared to dogs fed food without fiber-bound polyphenols. In conclusion, while some postbiotic products from protein fermentation are beneficial, others can be potentially harmful. Inclusion of fiber-bound polyphenols appears to promote healthy gut microbiome in dogs.

GUT MICROBES INFLUENCE GASTROINTESTINAL TRACT AND DISTANT ORGANS

Dysbiosis occurs when the bacterial populations within the gut become imbalanced. Dysbiosis is commonly observed in dogs and cats with acute or chronic GI disease. Dysbiosis has also been observed in atopic infants and after administration of antibiotics.

Evidence is accumulating to consider the gut microbiome as a central player in the gut-kidney axis. Microbiome products, such as advanced glycation end products, phenols, and indoles, are absorbed into the circulation but are cleared by normal-functioning kidneys. In chronic kidney disease, these products then become toxic and contribute to the uremic load and increased morbidity.

Bacteria in the gut also play a role in whether or not an individual becomes obese. This is linked to the ability of the intestinal biome to extract additional energy from undigested food and to the role of gut microbes in regulation of energy expenditure and storage.

Evidence increases that there is a gut microbe and the brain communication. Neuroscientists are probing the idea that intestinal microbiota might influence brain development and behavior, and anxiety.

CONCLUSION

Gut microbiome is an important living ecosystem within the dogs' and cats' body, which influences both gut health and extraintestinal organs. Gut microbes metabolize and ferment substances that travel to the hindgut in the form of undigested substrate. The composition of the intestinal microbiota ecosystem and postbiotics produced are strongly affected by dietary patterns. Composition of the diet and inclusion of prebiotic fiber represent a long-lasting strategy to maintain a healthy balance of gut microflora and promote health.