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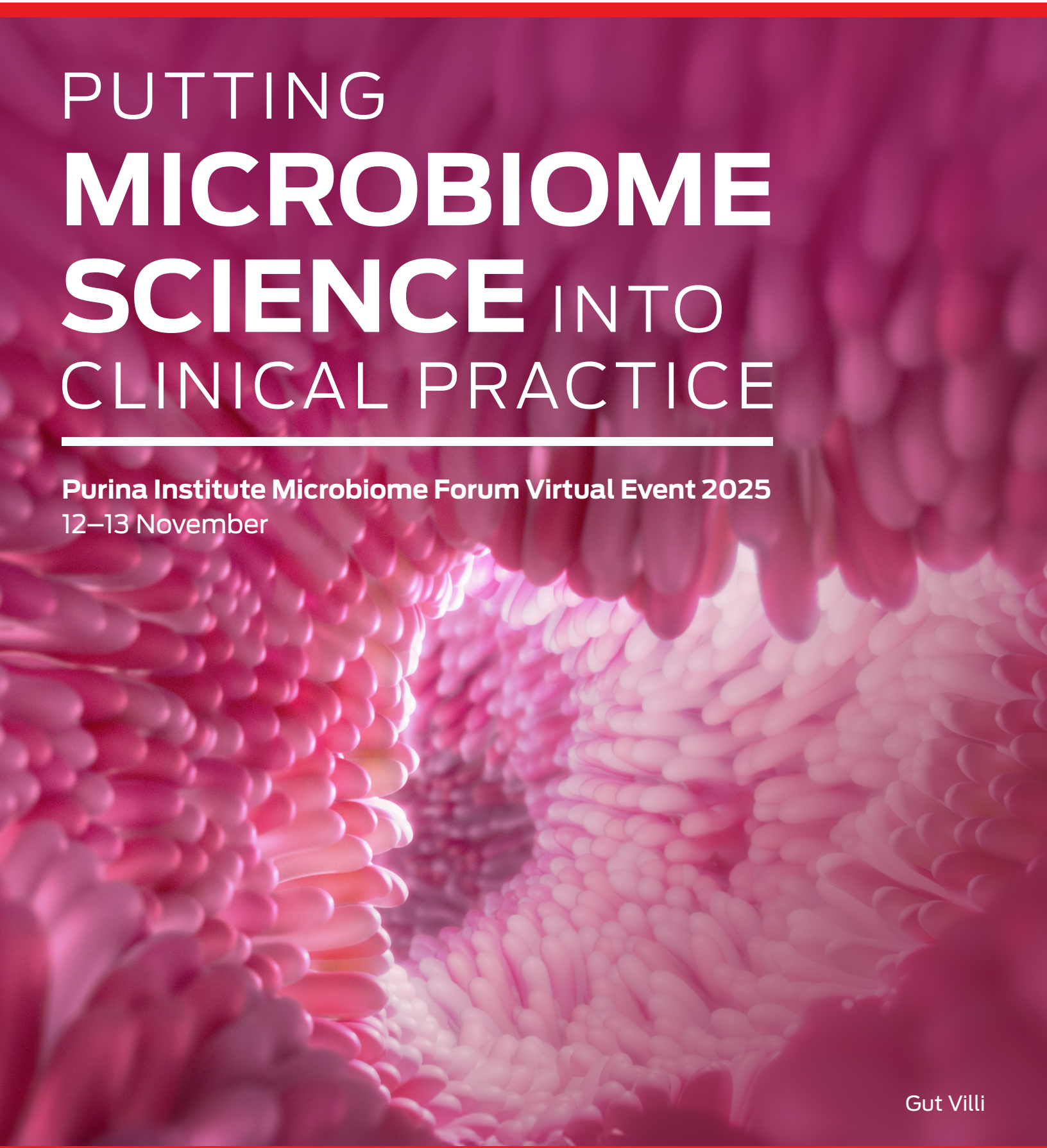
Advancing Science for Pet Health

MICROBIOME FORUM

PUTTING MICROBIOME SCIENCE INTO CLINICAL PRACTICE

Purina Institute Microbiome Forum Virtual Event 2025

12–13 November



Gut Villi

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Scientific Summaries

Microbiome research has generated a wealth of information, but the science can become lost in translation from research to actionable interventions in clinical veterinary practice. The annual Purina Institute Microbiome Forum Virtual Event, the first of which was held in November 2021, is dedicated to providing clinically relevant microbiome science for practicing veterinarians.

The summaries presented here provide an overview of the scientific content as well as guidance for its translation to clinical practice. These summaries were prepared based on AI-generated summaries from the event transcript, further modified by the Purina Institute team based on the content of the presentations and the Q&A and panel discussions, and have been reviewed and approved by the presenters. The summaries present the speakers' perspectives, and do not necessarily reflect the views of the Purina Institute or the Nestlé Purina PetCare Company or its affiliates.

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The Microbiota-Gut-Brain Axis in Health and Disease

Jatin Nagpal, BSc (Hons), MSc, PhD, PG Cert Teaching & Learning in Higher Education

Microbes have existed for billions of years, shaping life on Earth long before humans appeared; if you took all life on Earth and put it on a calendar, with right now as the cusp of a new year, microbes arose in March and dinosaurs emerged in December. Animals, including humans, evolved in a microbial world, resulting in intricate interdependence between host systems and resident microorganisms.

The microbiome consists of trillions of organisms—including bacteria, archaea, viruses, fungi, and protozoa—living on and within the body, with the greatest density in the gastrointestinal tract. Microbial and human cells are of similar order of magnitude in number, and total bacterial biomass in humans has been estimated at roughly ~0.2 kg (wet weight).

The microbiome is not a static entity; it dynamically shapes and is shaped by host physiology across the lifespan. Early life is a sensitive window: initial microbial exposure around birth, feeding mode, antibiotics, infection, diet, and psychosocial stress can all influence community assembly and function. In preclinical models, altering the microbiota (e.g., germ-free rearing, antibiotics, probiotics, or fecal microbiota transfer) can modify stress reactivity and social/anxiety-like behaviours; effects depend on donor/recipient factors, housing, diet, and the behavioural assays used. Notably, several studies report that transferring microbiota from individuals with depression into rodents can induce depression-like phenotypes, supporting a potential causal contribution in some contexts.

The gut–brain connection is ingrained

The gut–brain link is evident in our everyday language (for example, “gut instinct,” “gut feelings,” “gut-wrenching,” “butterflies in the stomach,” feeling “gutted,” “trust your gut”) and deeply rooted in our physiology. The microbiota-gut-brain axis (MGBA) involves bidirectional crosstalk, including bottom-up (gut-to-brain) and top-down (brain-to-gut) communication, in both direct and indirect pathways.

Research has identified the major communication pathways of the MGBA:

- **Vagus nerve** (Cranial nerve X): With a name that means “wandering,” the vagus nerve has multiple connections and provides a major bidirectional communication route between the gut and brain. Visceral sensory signals are relayed to brainstem nuclei with downstream influence over limbic and cortical circuits, while parasympathetic efferents modulate gut motility, secretion, and immune tone. Some microbial metabolites (e.g., short-chain fatty acids and tryptophan-derived metabolites) can engage enteroendocrine and sensory pathways that, in turn, influence vagal activity, mood, and behaviour.
- **Systemic circulation**: The gut microbes act as biochemical factories that transform dietary components into bioactive metabolites (e.g., short-chain fatty acids, bile acid derivatives, indoles, and other tryptophan metabolites). These microbial products—and host-derived mediators they trigger—can enter the circulation and influence blood–brain barrier function, neuroinflammation, and neurotransmission. It is more precise to say microbes modulate host cytokine and hormone signalling, rather than directly “producing” cytokines.
- **Immune system and enteroendocrine signaling**: This includes microbiota–immune cell crosstalk and epithelial sensing pathways, including the functions of enteroendocrine cells. The microbiota help train the developing immune system and shape inflammatory set-points; disruptions can alter host inflammatory mediators (cytokines and chemokines), with consequences for systemic and brain inflammation. Enteroendocrine cells and other gut

sensory epithelial cells act as rapid transducers of luminal cues, releasing hormones and neurotransmitters that can signal locally to nerves and immune cells and systemically to the brain.

- **Hypothalamic-pituitary-adrenal (HPA) axis**: This is the evolutionarily conserved stress axis, mediated by glucocorticoids (cortisol in humans and zebrafish; corticosterone in many rodents). Stress responses via the HPA axis can reshape gut physiology (motility, permeability, and immune activity) and thereby the composition and function of the gut microbiota. Conversely, microbiota manipulations in animal models have been shown to alter HPA reactivity and stress resilience, demonstrating bidirectional control.
- **Barrier systems**: Gut and blood–brain barriers, both vascular and epithelial, regulate microbial metabolite access to the brain. Integrity of these barriers is crucial for neuroprotection.

The exposome shapes the microbiome and gut-brain axis

The exposome refers to the totality of environmental exposures across the life course. Many exposures—diet, medications (especially antibiotics), circadian disruption/sleep, infections, pollutants, psychosocial stress, and the built/social environment—can influence the microbiome and its downstream effects on host physiology. Diet is a major determinant of microbiota composition; broadly, diverse plant-rich diets and fermentable fibre intake are associated with greater microbial diversity and short-chain fatty acid production. Conversely, chronic stress, disrupted sleep/circadian rhythms, and antibiotic use are commonly associated with reduced diversity and altered microbial function. Some lifestyle factors (e.g., contact with animals, social context) have been associated with microbiome differences, but effects are variable and context-dependent.

From the perspective of the gut-brain axis, diet and nutrition allow us to leverage the gut microbiome to benefit brain health and behavior. For example, studies evaluating certain probiotics, prebiotics, postbiotics, and fermented foods have shown these dietary interventions may reduce anxiety, depression, and the stress response, while enhancing cognition.

Are we overselling the microbiome?

Beware of the hype and fads driven by increased public awareness of the gut-brain axis and profit-driven products and programs making unverifiable claims. Thanks to ongoing research, we have strong correlation, but we still need to prove causality, evaluate the mechanisms (including the identification of the mechanisms preserved across species), and perform more rigorous trials. It's a human tendency to look for a "magic bullet" – one easy intervention that solves all of the problems – but we need a multimodal approach because it truly is a complete ecosystem.

Putting the science into practice:

- Gut microbiota profoundly influences brain and behavior through multiple pathways.
- Stress, diet, and antibiotic use can alter microbiota, affecting behavior and immunity.
- Diet and lifestyle are critical levers for microbiota modulation.
- Clinicians, researchers, and other health professionals should consider microbiome-informed strategies (dietary guidance, judicious antibiotic use, and evidence-based biotics where appropriate) alongside established approaches, as part of comprehensive plans for health, well-being, and disease management.

References

Aburto, M. R., & Cryan, J. F. (2024). Gastrointestinal and brain barriers: unlocking gates of communication across the microbiota-gut-brain axis. *Nature Reviews. Gastroenterology & Hepatology*, *21*(4), 222–247. doi: 10.1038/s41575-023-00890-0

Aburto, M. R., Nagpal, J., Majumdar, A., O'Riordan, K. J., Clarke, G., & Cryan, J. F. (2025). Microbiome, exposome, and cognitive development: The known unknowns. *Annual Review of Developmental Psychology, 7*. doi: 10.1146/annurev-devpsych-111323-120638

Anderson, S. C., Cryan, J. F., & Dinan, T. (2019). *The Psychobiotic Revolution: Mood, Food, and the New Science of the Gut-Brain Connection*. Penguin Random House. ISBN: 9781426218460

Belluck, P. (2014, October 11). A promising pill, not so hard to swallow. *The New York Times*. https://www.nytimes.com/2014/10/12/us/a-promising-pill-not-so-hard-to-swallow.html

Borre, Y. E., O'Keeffe, G. W., Clarke, G., Stanton, C., Dinan, T. G., & Cryan, J. F. (2014). Microbiota and neurodevelopmental windows: implications for brain disorders. *Trends in Molecular Medicine*, *20*(9), 509–518. doi: 10.1016/j.molmed.2014.05.002

Braniste, V., Al-Asmakh, M., Kowal, C., Anuar, F., Abbaspour, A., Tóth, M., Korecka, A., …Pettersson, S. (2014). The gut microbiota influences blood-brain barrier permeability in mice. *Science Translational Medicine*, *6*(263), 263ra158. doi: 10.1126/scitranslmed.3009759

Bravo, J. A., Forsythe, P., Chew, M. V., Escaravage, E., Savignac, H. M., Dinan, T. G., Bienenstock, J., & Cryan, J. F. (2011). Ingestion of Lactobacillus strain regulates emotional behavior and central GABA receptor expression in a mouse via the vagus nerve. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(38), 16050–16055. doi: 10.1073/pnas.1102999108

Burokas, A., Arboleya, S., Moloney, R. D., Peterson, V. L., Murphy, K., Clarke, G., Stanton, C., Dinan, T. G., & Cryan, J. F. (2017). Targeting the microbiota-gut-brain axis: Prebiotics have anxiolytic and antidepressant-like effects and reverse the impact of chronic stress in mice. *Biological Psychiatry*, *82*(7), 472–487. doi: 10.1016/j.biopsych.2016.12.031

Chang, H., Perkins, M. H., Novaes, L. S., Qian, F., Zhang, T., Neckel, P. H., Scherer, S., Ley, R. E., Han, W., & de Araujo, I. E. (2024). Stress-sensitive neural circuits change the gut microbiome via duodenal glands. *Cell*, *187*(19), 5393–5412.e30. doi: 10.1016/j.cell.2024.07.019

Chu, C., Murdock, M. H., Jing, D., Won, T. H., Chung, H., Kressel, A. M., Tsaava, T., …Artis, D. (2019). The microbiota regulate neuronal function and fear extinction learning. *Nature*, *574*(7779), 543–548. doi: 10.1038/s41586-019-1644-y

Clarke, G., Grenham, S., Scully, P., Fitzgerald, P., Moloney, R. D., Shanahan, F., Dinan, T. G., & Cryan, J. F. (2013). The microbiome-gut-brain axis during early life regulates the hippocampal serotonergic system in a sex-dependent manner. *Molecular Psychiatry, 18*(6), 666–673. doi: 10.1038/mp.2012.77

Cryan, J. F., & Mazmanian, S. K. (2022). Microbiota-brain axis: Context and causality. *Science (New York, N.Y.), 376*(6596), 938–939. doi: 10.1126/science.abo4442

Diaz Heijtz, R., Wang, S., Anuar, F., Qian, Y., Björkholm, B., Samuelsson, A., Hibberd, M. L., Forssberg, H., & Pettersson, S. (2011). Normal gut microbiota modulates brain development and behavior. *Proceedings of the National Academy of Sciences of the United States of America, 108*(7), 3047–3052. doi: 10.1073/pnas.1010529108

Erny, D., Hrabě de Angelis, A. L., Jaitin, D., Wieghofer, P., Staszewski, O., David, E., Keren-Shaul, H., … Prinz, M. (2015). Host microbiota constantly control maturation and function of microglia in the CNS. *Nature Neuroscience, 18*(7), 965–977. doi: 10.1038/nn.4030

Fülling, C., Dinan, T. G., & Cryan, J. F. (2019). Gut microbe to brain signaling: What happens in vagus…. *Neuron*, *101*(6), 998–1002. doi: 10.1016/j.neuron.2019.02.008

Gacias, M., Gaspari, S., Santos, P. M., Tamburini, S., Andrade, M., Zhang, F., Shen, N., …Casaccia, P. (2016). Microbiota-driven transcriptional changes in prefrontal cortex override genetic differences in social behavior. *eLife*, *5*, e13442. doi: 10.7554/eLife.13442

Gonzalez-Santana, A., & Diaz Heijtz, R. (2020). Bacterial peptidoglycans from microbiota in neurodevelopment and behavior. *Trends in Molecular Medicine*, *26*(8), 729–743. doi: 10.1016/j.molmed.2020.05.003

Hoban, A. E., Stilling, R. M., Moloney, G., Shanahan, F., Dinan, T. G., Clarke, G., & Cryan, J. F. (2018). The microbiome regulates amygdala-dependent fear recall. *Molecular Psychiatry*, *23*(5), 1134–1144. doi: 10.1038/mp.2017.100

Hoban, A. E., Stilling, R. M., Ryan, F. J., Shanahan, F., Dinan, T. G., Claesson, M. J., Clarke, G., & Cryan, J. F. (2016). Regulation of prefrontal cortex myelination by the microbiota. *Translational Psychiatry*, *6*(4), e774. doi: 10.1038/tp.2016.42

Jaglin, M., Rhimi, M., Philippe, C., Pons, N., Bruneau, A., Goustard, B., Daugé, V., Maguin, E., Naudon, L., & Rabot, S. (2018). Indole, a Signaling Molecule Produced by the Gut Microbiota, Negatively Impacts Emotional Behaviors in Rats. *Frontiers in Neuroscience*, *12*, 216. doi: 10.3389/fnins.2018.00216

Kelly, J. R., Borre, Y., O' Brien, C., Patterson, E., El Aidy, S., Deane, J., Kennedy, P. J., ...Dinan, T. G. (2016). Transferring the blues: Depression-associated gut microbiota induces neurobehavioural changes in the rat. *Journal of Psychiatric Research*, *82*, 109–118. doi: 10.1016/j.jpsychires.2016.07.019

Krautkramer, K. A., Fan, J., & Bäckhed, F. (2021). Gut microbial metabolites as multi-kingdom intermediates. *Nature reviews. Microbiology*, *19*(2), 77–94. doi: 10.1038/s41579-020-0438-4

Luczynski, P., Whelan, S. O., O'Sullivan, C., Clarke, G., Shanahan, F., Dinan, T. G., & Cryan, J. F. (2016). Adult microbiota-deficient mice have distinct dendritic morphological changes: differential effects in the amygdala and hippocampus. *The European Journal of Neuroscience*, *44*(9), 2654–2666. doi : 10.1111/ejn.13291

Nagpal, J., & Cryan, J. F. (2021). Microbiota-brain interactions: Moving toward mechanisms in model organisms. *Neuron*, *109*(24), 3930–3953. doi: 10.1016/j.neuron.2021.09.036

Needham, B. D., Kaddurah-Daouk, R., & Mazmanian, S. K. (2020). Gut microbial molecules in behavioural and neurodegenerative conditions. *Nature Reviews. Neuroscience*, *21*(12), 717–731. doi : 10.1038/s41583-020-00381-0

Neufeld, K. M., Kang, N., Bienenstock, J., & Foster, J. A. (2011). Reduced anxiety-like behavior and central neurochemical change in germ-free mice. *Neurogastroenterology and Motility, 23*(3), 255–e119. doi: 10.1111/j.1365-2982.2010.01620.x

Ogbonnaya, E. S., Clarke, G., Shanahan, F., Dinan, T. G., Cryan, J. F., & O'Leary, O. F. (2015). Adult hippocampal neurogenesis is regulated by the microbiome. *Biological Psychiatry, 78*(4), e7–e9. doi: 10.1016/j.biopsych.2014.12.023

Savignac, H. M., Kiely, B., Dinan, T. G., & Cryan, J. F. (2014). Bifidobacteria exert strain-specific effects on stress-related behavior and physiology in BALB/c mice. *Neurogastroenterology and Motility, 26*(11), 1615–1627. doi: 10.1111/nmo.12427

Schneider, E., O'Riordan, K. J., Clarke, G., & Cryan, J. F. (2024). Feeding gut microbes to nourish the brain: unravelling the diet-microbiota-gut-brain axis. *Nature Metabolism*, *6*(8), 1454–1478. doi : 10.1038/s42255-024-01108-6

Schneider, K. M., Blank, N., Alvarez, Y., Thum, K., Lundgren, P., Litichevskiy, L., Sleeman, M., ... Thaiss, C. A. (2023). The enteric nervous system relays psychological stress to intestinal inflammation. *Cell*, *186*(13), 2823–2838.e20. doi: 10.1016/j.cell.2023.05.001

Sender, R., Fuchs, S., & Milo, R. (2016). Are we really vastly outnumbered? Revisiting the ratio of bacterial to host cells in humans. *Cell*, *164*(3), 337–340. doi: 10.1016/j.cell.2016.01.013

Sonnenburg, E. D., Smits, S. A., Tikhonov, M., Higginbottom, S. K., Wingreen, N. S., & Sonnenburg, J. L. (2016). Diet-induced extinctions in the gut microbiota compound over generations. *Nature, 529*(7585), 212–215. doi: 10.1038/nature16504

Thion, M. S., Low, D., Silvin, A., Chen, J., Grisel, P., Schulte-Schrepping, J., Blecher, R., ...Garel, S. (2018). Microbiome Influences Prenatal and Adult Microglia in a Sex-Specific Manner. *Cell*, *172*(3), 500–516.e16. doi: 10.1016/j.cell.2017.11.042

van de Wouw, M., Boehme, M., Lyte, J. M., Wiley, N., Strain, C., O'Sullivan, O., Clarke, G., Stanton, C., Dinan, T. G., & Cryan, J. F. (2018). Short-chain fatty acids: microbial metabolites that alleviate stress-induced brain-gut axis alterations. *The Journal of Physiology*, *596*(20), 4923–4944. doi: 10.1113/JP276431

van de Wouw, M., Walsh, C. J., Vigano, G. M. D., Lyte, J. M., Boehme, M., Gual-Grau, A., Crispie, F., Walsh, A. M., Clarke, G., Dinan, T. G., Cotter, P. D., & Cryan, J. F. (2021). Kefir ameliorates specific microbiota-gut-brain axis impairments in a mouse model relevant to autism spectrum disorder. *Brain, Behavior, and Immunity*, *97*, 119–134. doi: 10.1016/j.bbi.2021.07.004

Vuong, H. E., Pronovost, G. N., Williams, D. W., Coley, E. J. L., Siegler, E. L., Qiu, A., Kazantsev, M., Wilson, C. J., Rendon, T., & Hsiao, E. Y. (2020). The maternal microbiome modulates fetal neurodevelopment in mice. *Nature*, *586*(7828), 281–286. doi: 10.1038/s41586-020-2745-3

Wei, G. Z., Martin, K. A., Xing, P. Y., Agrawal, R., Whiley, L., Wood, T. K., Hejndorf, S., ...Pettersson, S. (2021). Tryptophan-metabolizing gut microbes regulate adult neurogenesis via the aryl hydrocarbon receptor. *Proceedings of the National Academy of Sciences of the United States of America, 118*(27), e2021091118. doi: 10.1073/pnas.2021091118

Youngster, I., Russell, G. H., Pindar, C., Ziv-Baran, T., Sauk, J., & Hohmann, E. L. (2014). Oral, capsulized, frozen fecal microbiota transplantation for relapsing *Clostridium difficile* infection. *Journal of the American Medical Association*, *312*(17), 1772–1778. doi: 10.1001/jama.2014.13875

The Gut-Brain Axis in Veterinary Behavioral Medicine: Evidence and Clinical Practice

Julia Albright, MA, DVM, DACVB

Meet Otis

Otis was a 2-year old Husky mix who presented for aggression toward unfamiliar dogs, He had been adopted form a shelter at 6 weeks of age. Since then, he has been in multiple fights and has sustained injuries that necessitated repeated courses of antibiotics and wound care. His owner also reported that Otis was a "picky eater" and would get diarrhea when he was stressed (fecal score 3-5).

Behavioral evaluation revealed a dog who showed fearful, conflicted and frustrated body language when exposed to other dogs, especially when Otis was on leash. He also had a tendency to pace and pant and was sensitive to noises, hypervigilant, and easily startled even when dogs were not present. Physical findings and bloodwork were within normal limits other than loose stools.

Otis was diagnosed with inter-dog aggression driven by fear and frustration, generalized anxiety disorder, and possible chronic enteropathy. The initial treatment plan included behavior modification and environmental management to create more relaxation and meet his needs without increasing his stress and anxiety; a selective serotonin reuptake inhibitor (SSRI) antidepressant (fluoxetine) for anxiety; and a GI workup for the possible chronic enteropathy. Otis steadily improved with this approach, until his environment changed due to his owner's relationship. With a change from a solely suburban environment to periodic stays in an urban high-rise, he demonstrated relapsed aggression, diarrhea, and hyporexia and once again became a tense, stressed dog. His management was adjusted with the addition of an alpha-2-adrenergic medication (clonidine) before and during anticipated urban visits, as well as a synbiotic (probiotic and prebiotic fiber supplement) and a hydrolyzed diet trial. Otis showed clear improvement and stabilized with this multimodal plan.

Clinical Insights from Otis' case

Why the regression? Did the aggression and GI issues relapse independently, or was there some interaction between these two systems? Or is there a central upstream mechanism affecting both? There is mounting evidence for the latter; the correlation between stress, anxiety, and GI disease suggests shared mechanisms.

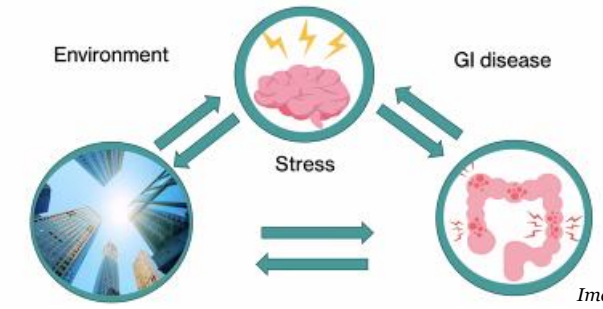

Image provided by Dr. Albright

The gut–brain axis

The gut-brain axis (GBA) is a complex pathway that involves the immune, endocrine, and nervous systems as well as microbial products *(see the summary of Dr. Nagpal's presentation for more*

information). The vagus nerve (Cranial nerve X) appears to play a pivotal role in the behavioral impact of the GBA, and provides parasympathetic balance as well as anti-inflammatory effects.

Chronic stress activates the amygdala and the hypothalamic-pituitary-adrenal (HPA) axis, leading to cortisol and norepinephrine release. This can in turn lead to inflammation, altered GI tryptophan and serotonin metabolism, altered GI motility, dysbiosis, increased enteric permeability, immune dysregulation, vagal withdrawal, and visceral hypersensitivity. This creates further inflammation, turning the gut-brain axis into a continuous inflammatory feedback loop that propagates neuroinflammation and GI disruption.

GBA dysregulation can manifest as both gastrointestinal signs such as diarrhea, constipation, nausea, vomiting, and regurgitation, and CNS signs including hypervigilance, aggression, anxiety, depression, and cognitive decline. In humans, comorbidity of GI and behavioral changes are common in many neurologic conditions such as Alzheimer's disease, epilepsy, and Parkinson's disease and conditions that present as with primary GI symptoms like Irritable bowel syndrome (IBS), inflammatory bowel disease (IBD), and functional dyspepsia (gastroparesis). The latter are known as Disorders of Gut Brain Interaction due to the lack of obvious structural abnormalities and strong correlation between stress, GBA disruption and clinical signs.

Otis' "perfect storm" for GBA dysregulation

The microbiome may also help explain an individual's emotional resilience, or ability to resist the effects of stress or rebound after a stressful experience, and that resilience is heavily impacted by early-life challenges and changes to the microbiome that occur during and individual's development. In addition, microbiome maturation and neurodevelopment are intrinsically linked *(see the summary of Dr. Nagpal's presentation for more on this)*. Otis' known early-life experiences like as premature maternal separation, and psychological stress from the shelter and negative dog interactions, as well as poor nutrition, possible infections, antibiotics, and recurring enteropathy were all factors that created a "perfect storm" for dysbiosis and GBA dysregulation.

Behavioral signs of GI disease

Dogs and cats with GI disease may demonstrate a number of behavior signs, including:

- Altered elimination patterns
- Altered appetite and feeding behaviors including hyporexia or anorexia due to nausea, dental pain, and/or visceral pain
- Stress displacement behaviors such as excessive licking (beyond itching or attention-seeking) of surfaces and "air licking"/"fly biting" behaviors, circling, tail chasing
- Pica
- Altered activity (including pacing)
- Altered social interactions, including separation-related behaviors
- Sleep-wake cycle disturbances
- Irritability and/or aggression, possibly linked to visceral pain and a lower emotional tolerance threshold due to increased cognitive load

Treatment Strategies

Successful management of these cases requires a biopsychosocial approach that addresses anxiety/stress reduction **and** GI health for optimal outcomes.

Medications in the toolbox include antidepressants (SSRIs, SNRIs, TCAs), anti-inflammatories, analgesics (e.g., gabapentin), situational meds (e.g., trazodone, benzodiazepines, clonidine). Recent evidence suggests that the action of antidepressants may be due at least in part their anti-inflammatory effects. Antidepressants may also have an antimicrobial effect, which could potentially improve or worsen dysbiosis. Much more research is needed on the impact of antidepressants on the microbiome.

Microbiome-based interventions include psychobiotics (probiotics that are shown to affect behavior), prebiotics and fiber, synbiotics, postbiotics, and fecal microbiota transplant (FMT).

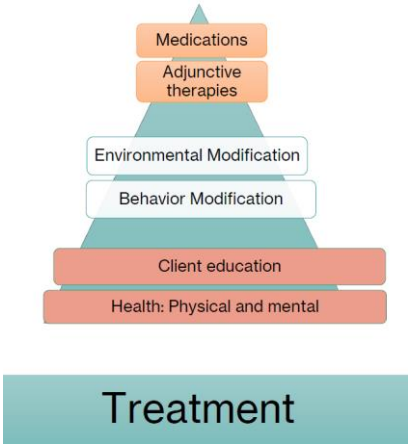

Image provided by Dr. Albright

Other adjuncts include omega-3 fatty acids (EPA/DHA), medium-chain triglycerides, and amino acids/neurotransmitter supplements (e.g., tryptophan, L-theanine, α-casozepine). Vagal nerve stimulation is showing promise to treat GBA dysregulation in people by 'resetting' parasympathetic tone, although little evidence on its use is available in cats or dogs.

Putting the science into practice:

- Behavior problems are almost always a chronic issue, and treatment requires good client communication and education.
- There is a strong association between behavior, emotion, and gut health. Inflammation is a key mediator, and addressing both gut and emotional health is critical for optimal outcome.
- When a GI disease is identified but no organic etiology can be identified, consider the possibility of GBA dysregulation as an inciting cause.
- Early-life stress, poor nutrition, and antibiotic exposure may predispose animals to GBA dysregulation.
- Comprehensive management includes:
  - Addressing comorbidities (such as GI disease)
  - Providing appropriate outlets for species specific behavior (e.g., social interactions, play, and aerobic activity)
  - Identifying triggers of fear or stress, and creating new emotional associations as well as behavior responses through behavior and environmental modifications
  - Pharmaceutical, nutritional, and adjunct therapies are used to facilitate new learning
  - Microbiome modulation through diet, (pre-, pro-, syn-, post)biotics, and FMT

References

Bécuwe-Bonnet, V., Bélanger, M. C., Frank, D., Parent, J., & Hélie, P. (2012). Gastrointestinal disorders in dogs with excessive licking of surfaces. *Journal of Veterinary Behavior, 7*, 194–204. doi: 10.1016/j.jveb.2011.07.003

Craddock, H. A., Godneva, A., Rothschild, D., Motro, Y., Grinstein, D., Lotem-Michaeli, Y., Narkiss, T., Segal, E., & Moran-Gilad, J. (2022). Phenotypic correlates of the working dog microbiome. *NPJ Biofilms and Microbiomes, 8*(1), 66. doi: 10.1038/s41522-022-00329-5

Dalile, B., Van Oudenhove, L., Vervliet, B., & Verbeke, K. (2019). The role of short-chain fatty acids in microbiota-gut-brain communication. *Nature Reviews Gastroenterology & Hepatology, 16*(8), 461-478. doi: 10.1038/s41575-019-0157-3

Drossman, D. A., & Hasler, W. L. (2016). Rome IV—functional GI disorders: disorders of gut-brain interaction. *Gastroenterology, 150*(6), 1257-1261. doi: 10.1053/j.gastro.2016.03.035

Frank, D., Bélanger, M. C., Bécuwe-Bonnet, V., & Parent, J. (2012). Prospective medical evaluation of 7 dogs presented with fly biting. *Canadian Veterinary Journal, 53*, 1279–1284.

Jennings, R., Lilly, M. L., Bohland, K., Rudinsky, A., & Winston, J. (2025). Abstract GI19: Concurrent management of behavioral and gastrointestinal disorders in dogs with early-life trauma improves clinical outcomes. 2025 ACVIM Forum Research Abstract Program. *Journal of Veterinary Internal Medicine, 39*(6). doi: 10.1111/jvim.70258

Keefer, L., Ballou, S. K., Drossman, D. A., Ringstrom, G., Elsenbruch, S., & Ljótsson, B. (2022). A Rome Working Team report on brain-gut behavior therapies for disorders of gut-brain interaction. *Gastroenterology, 162*(1), 300-315. doi: 10.1053/j.gastro.2021.09.015

Kirchoff, N. S., Udell, M. A. R., & Sharpton, T. J. (2019). The gut microbiome correlates with conspecific aggression in a small population of rescued dogs (*Canis familiaris*). *PeerJ,* 7, e6103. doi: 10.7717/peerj.6103

Liu, L., Wang, H., Chen, X., Zhang, Y., Zhang, H., & Xie, P. (2023). Gut microbiota and its metabolites in depression: from pathogenesis to treatment. *EBioMedicine*, *90*, 104527. doi: 10.1016/j.ebiom.2023.104527

Mitrea, L., Nemeş, S. A., Szabo, K., Teleky, B. E., & Vodnar, D. C. (2022). Guts imbalance imbalances the brain: A review of gut microbiota association with neurological and psychiatric disorders. *Frontiers in Medicine, 9,* 813204. doi: 10.3389/fmed.2022.813204

Mondo, E,. Barone, M., Soverini, M., D'Amico, F., Cocchi, M., Petrulli, C., Mattioli, M., …Accorsi, P. A. (2020). Gut microbiome structure and adrenocortical activity in dogs with aggressive and phobic behavioral disorders. *Heliyon, 6*(1), e03311. doi: 10.1016/j.heliyon.2020.e03311

Perez, J., Ford, S., & Lynch, H. (2025). Pica as a clinical sign of a chronic enteropathy in dogs and cats. *Journal of the American Veterinary Medical Association, 263*(8), 1027-1032. doi: 10.2460/javma.25.02.0079

Vanuytsel, T., van Wanrooy, S., Vanheel, H., Vanormelingen, C., Verschueren, S., Houben, E., Salim Rasoel, S., …Tack, J. (2014). Psychological stress and corticotropin-releasing hormone increase intestinal permeability in humans by a mast cell-dependent mechanism. *Gut, 63*(8), 1293-1299. doi: 10.1136/gutjnl-2013-305690

Warrit, K., Boscan, P., Ferguson, L. E., Bradley, A. M., Dowers, K. L., & Twedt, D. C. (2017). Effect of hospitalization on gastrointestinal motility and pH in dogs. *Journal of the American Veterinary Medical Association, 251*(1), 65-70. doi: 10.2460/javma.251.1.65

Woodhouse, S., Hebbard, G., & Knowles, S. R. (2017). Psychological controversies in gastroparesis: a systematic review. *World Journal of Gastroenterology, 23*(7), 1298-1309. doi: 10.3748/wjg.v23.i7.1298

Gut Feelings – The Link Between Gut and Mood

Ulrika Ludvigsson, DVM, Swedish Specialist in Diseases of Dogs and Cats

There is a complex interplay between chronic enteropathy (CE) and emotional health in dogs.

Clinical case examples of the link between gut and mood

Svante was a 3.5-year-old intact male German Shepherd with intermittent diarrhea, weight loss coupled with stress reactivity and hypervigilance. Exocrine pancreatic insufficiency (EPI) and cobalamin deficiency were identified, and successful treatment of the GI disease with pancreatic enzymes, cobalamin supplementation, budesonide, and diet change improved both fecal score and behavior.

Moltas was a 12-year-old intact male Whippet with chronic enteropathy and pancreatitis. Treatment with corticosteroids and cyclosporine led to some improvement, but his GI signs would relapse during stressful events. Emotional modification and treatment with clomipramine reduced his stress-related flare-ups and improved his behavioral response to stress, and his pancreatitis resolved.

Chiva was a 3.5-year old intact female Finnish Lappdog presented for high levels of stress and arousal, barking and lunging at unknown dogs and visitors, and intermittent diarrhea with flare-ups every third week. Initial treatment with a hydrolyzed diet and fiber supplementation improved her fecal score, reduced the number and duration of flare-ups, and allowed her to gain weight. She also became much less reactive, passing other dogs during walks without bursts of barking and lunging.

Svante, Moltas, and Chiva are just three examples. Many dogs with chronic enteropathies are also stressed and demonstrate behavioral issues including hypervigilance, reactivity, fearfulness, anxiety, noise reactivity, and separation-related problems. Successful treatment of their GI disease often improves their behavior, but a subset of dogs with CE continue to show signs of compromised emotional health even after successful management of their GI condition. Treatment response may be improved when both GI and behavioral signs are addressed.

The science to date on the link between gut and mood

There are limited studies on the chronic enteropathy-behavior link in dogs, but there is increasing evidence of this link in humans and in rodent models. Research models of colitis or gastritis demonstrated the development of behavioral changes such as anxiety or depression and identified inflammatory changes in the hippocampus, which plays a critical role in the “emotional brain” limbic system as well as learning and memory. In humans, IBD and psychiatric disorders are common co-morbidities; psychological disorders are more common in people with active disease and are associated with increased risk of flare-ups and a poorer prognosis.

In a 2020 review by Mills et al., 23–82% of behavior cases had suspected concurrent pain, including 27% with suspected GI disease-related pain.

Marchetti et al. (2021) performed a prospective evaluation of behavioral improvements after treatment for chronic enteropathy. Seventy-five percent (75%) of the cases in the study responded to treatment as demonstrated by improved CCEAI scores and behavioral scores using the CBARQ survey also improved – particularly separation-related and contact/attention-related behaviors.

Jennings et al. (2025) recently presented the results of study evaluating 24 dogs with chronic GI signs and concurrent behavioral changes. Twenty-one (86%) of the 24 affected dogs had experienced early-life trauma, and 90% of those dogs experience the trauma between birth and

one year of age. More than three-quarters (76%) of the dogs showed improvement in both GI and behavioral signs once co-managed.

The use of FMT (Toresson et al, 2023) in 41 dogs with chronic enteropathy resulted in a 76% response rate, with improvements in fecal score, activity level, and playfulness/social interaction; the behavioral and GI responses did not always co-occur, underscoring individual variation.

Evaluating emotional health in dogs

Emotions heavily influence dog behavior. There is no precise and generally accepted definition of emotional health in dogs, but the Heath Model of Emotional Health evaluates emotional valence (which emotions are present), emotional arousal (the total intensity of the emotions present, regardless of the valence), and emotional capacity (the individual's threshold for emotion). Valence is based on Panskepp's paradigm that behavior is affected by 7 (now modified to 8) affective systems: the engaging (positive, motivational) affective systems of desire seeking, social play, care, and lust; and the negative (protective, aversive) affective systems of fear-anxiety, frustration, panic-grief, and pain. Negative (protective) emotions are those necessary for survival but if frequent, prolonged, or excessive can compromise welfare and increase the risk of behavioral problems. High arousal, either in duration or intensity, can significantly impact physiological and emotional health. Acute emotional arousal activates the hypothalamic-pituitary-adrenal (HPA) axis, promoting cortisol release.

Further exploring the link between gut and mood

Dr. Ludvigsson presented the findings to date of a study further investigating the link between chronic enteropathy and emotional health, evaluating the hypothesis that dogs with CE have evidence of compromised emotional health compared to healthy control dogs.

The study compared 50 dogs with CE to 50 age- and breed group-matched healthy controls. The Canine Inflammatory Bowel Disease Activity Index (CIBDAI) was used to evaluate their GI signs. Their emotional health was evaluated using a questionnaire that combined the Positive and Negative Activation Scale (PANAS) with questions assessing signs of distress in relation to separation and loud noises as well as the frequency of displacement behaviors (out-of-context behaviors) as an indicator of arousal.

Treatment of the CE dogs in the study included corticosteroids (with or without second generation immunomodulatory drugs) or mycophenolate. Thirty-nine (39) of 50 (78%) had a CIBDAI score of 3 or lower, indicating clinically insignificant disease at the onset of the study. At initial assessment, the CE dogs showed significantly higher negative activation scores compared to healthy controls and their owners reported higher agreement with statements addressing separation-related behaviors and noise reactivity. CE dogs also demonstrated more frequent displacement behaviors compared to controls, indicating higher levels of arousal. Despite low CIBDAI scores and clinically significant CE, significantly reduced emotional health was observed in the CE dogs compared to healthy controls.

Putting the science into practice:

- There is mounting evidence that there is a strong relationship between chronic enteropathy and compromised emotional health in dogs.
  - CE dogs had higher negative emotions, particularly fear and anxiety, as well as more frequent displacement behaviors in stressful contexts and higher owner-reported stress.
  - These behavioral issues were observed even in dogs with well-controlled CE, suggesting a persistent emotional impact and further strengthening the case for addressing the gut-brain axis in CE.
  - This is also an indication that dogs presenting for behavioral signs should be screened for concurrent GI disease.
- Routine emotional health evaluation in dogs with CE, and addressing emotional health concurrently with CE treatment, could be beneficial for improving both CE disease activity and welfare for these dogs.

References

Barberio, B., Zamani, M., Black, C. J., Savarino, E. V., & Ford, A. C. (2021). Prevalence of symptoms of anxiety and depression in patients with inflammatory bowel disease: A systematic review and meta-analysis. *The Lancet. Gastroenterology & Hepatology*, *6*(5), 359–370. doi: 10.1016/S2468-1253(21)00014-5

Bercik, P., Verdu, E. F., Foster, J. A., Macri, J., Potter, M., Huang, X., Malinowski, P., ...Collins, S. M. (2010). Chronic gastrointestinal inflammation induces anxiety-like behavior and alters central nervous system biochemistry in mice. *Gastroenterology*, *139*(6), 2102–2112.e1. doi: 10.1053/j.gastro.2010.06.063

Bisgaard, T. H., Allin, K. H., Keefer, L., Ananthakrishnan, A. N., & Jess, T. (2022). Depression and anxiety in inflammatory bowel disease: Epidemiology, mechanisms and treatment. *Nature Reviews. Gastroenterology & Hepatology*, *19*(11), 717–726. doi: 10.1038/s41575-022-00634-6

Haj-Mirzaian, A., Amiri, S., Amini-Khoei, H., Hosseini, M. J., Haj-Mirzaian, A., Momeny, M., Rahimi-Balaei, M., & Dehpour, A. R. (2017). Anxiety- and depressive-like behaviors are associated with altered hippocampal energy and inflammatory status in a mouse model of Crohn's disease. *Neuroscience*, *366*, 124–137. doi: 10.1016/j.neuroscience.2017.10.023

Heath, S., Dowgray, N., Rodan, I., St Denis, K., & Taylor, S. (2022). 10 years of Cat Friendly: A new model and terminology for understanding feline emotions. *Journal of Feline Medicine and Surgery*, *24*(9), 934–935. doi: 10.1177/1098612X221118762

IsHak, W. W., Wen, R. Y., Naghdechi, L., Vanle, B., Dang, J., Knosp, M., Dascal, J., ...Louy, C. (2018). Pain and depression: A systematic review. *Harvard Review of Psychiatry*, *26*(6), 352–363. doi: 10.1097/HRP.0000000000000198

Jennings, R., Lilly, M. L., Bohland, K., Rudinsky, A., & Winston, J. (2025). Abstract GI19: Concurrent management of behavioral and gastrointestinal disorders in dogs with early-life trauma improves clinical outcomes. 2025 ACVIM Forum Research Abstract Program. *Journal of Veterinary Internal Medicine, 39*(6). doi: 10.1111/jvim.70258

Jergens, A. E., Schreiner, C. A., Frank, D. E., Niyo, Y., Ahrens, F. E., Eckersall, P. D., Benson, T. J., & Evans, R. (2003). A scoring index for disease activity in canine inflammatory bowel disease. *Journal of veterinary internal medicine*, *17*(3), 291–297. doi: 10.1111/j.1939-1676.2003.tb02450.x

Lappin, M. R., Zug, A., Hovenga, C., Gagne, J., & Cross, E. (2022). Efficacy of feeding a diet containing a high concentration of mixed fiber sources for management of acute large bowel diarrhea in dogs in shelters. *Journal of Veterinary Internal Medicine*, *36*(2), 488–492. doi: 10.1111/jvim.16360

Marchetti, V., Gori, E., Mariotti, V., Gazzano, A., & Mariti, C. (2021). The impact of chronic inflammatory enteropathy on dogs' quality of life and dog-owner relationship. *Veterinary Sciences*, *8*(8), 166. doi: 10.3390/vetsci8080166

Mills, D. S., Demontigny-Bédard, I., Gruen, M., Klinck, M. P., McPeake, K. J., Barcelos, A. M., Hewison, L., ...Levine, E. (2020). Pain and Problem Behavior in Cats and Dogs. *Animals*, *10*(2), 318. doi: 10.3390/ani10020318

Neuendorf, R., Harding, A., Stello, N., Hanes, D., & Wahbeh, H. (2016). Depression and anxiety in patients with Inflammatory Bowel Disease: A systematic review. *Journal of psychosomatic research*, *87*, 70–80. doi: 10.1016/j.jpsychores.2016.06.001

Painsipp, E., Wultsch, T., Shahbazian, A., Edelsbrunner, M., Kreissl, M. C., Schirbel, A., Bock, E., Pabst, M. A., Thoeringer, C. K., Huber, H. P., & Holzer, P. (2007). Experimental gastritis in mice enhances anxiety in a gender-related manner. *Neuroscience*, *150*(3), 522–536. doi: 10.1016/j.neuroscience.2007.09.024

Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. Oxford University Press.

Peppas, S., Pansieri, C., Piovani, D., Danese, S., Peyrin-Biroulet, L., Tsantes, A. G., Brunetta, E., Tsantes, A. E., & Bonovas, S. (2021). The brain-gut axis: Psychological functioning and inflammatory bowel diseases. *Journal of Clinical Medicine*, *10*(3), 377. doi: 10.3390/jcm10030377

Sheppard, G., & Mills, D. S. (2002). The development of a psychometric scale for the evaluation of the emotional predispositions of pet dogs. *International Journal of Comparative Psychology, 15*(2), 201–222.

Sudo, N., Chida, Y., Aiba, Y., Sonoda, J., Oyama, N., Yu, X. N., Kubo, C., & Koga, Y. (2004). Postnatal microbial colonization programs the hypothalamic-pituitary-adrenal system for stress response in mice. *The Journal of Physiology*, *558*(Pt 1), 263–275. doi: 10.1113/jphysiol.2004.063388

Toresson, L., Spillmann, T., Pilla, R., Ludvigsson, U., Hellgren, J., Olmedal, G., & Suchodolski, J. S. (2023). Clinical effects of faecal microbiota transplantation as adjunctive therapy in dogs with chronic enteropathies-A Retrospective Case Series of 41 Dogs. *Veterinary sciences*, *10*(4), 271. https://doi.org/10.3390/vetsci10040271

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of personality and social psychology, 54(6), 1063.

Paroxysmal Dyskinesia in Dogs: Response to a Gluten-Free, Hydrolyzed Diet

Prof. Gualtiero Gandini, DVM, PhD, DECVN

Paroxysmal dyskinesia (PD) in dogs involves episodic, self-limiting involuntary movements and is increasingly recognized as a differential diagnosis for epileptic seizures. It is under-recognized and under-diagnosed, often assumed to be Idiopathic Epilepsy (IE), as episodes may be confused with "focal" epileptic seizures. However, its etiology and management are different, making accurate identification critical for effective treatment.

Misdiagnosis can lead to inappropriate use of anti-seizure medications (ASM), which are generally ineffective for PD.

Etiology and characteristics

PD was previously considered a genetic disorder limited to certain breeds (e.g., Cavalier King Charles Spaniel, Jack Russell Terrier, Labrador Retriever, Maltese, Chinook, Soft-coated Wheaten Terrier) and has been described as "episodic falling syndrome," "cramping syndrome," and "Scotty Cramp". Our knowledge of PD has evolved the condition to include non-genetic, reactive forms such as gluten-sensitive PD and idiosyncratic drug reactions as well as PD secondary to structural intracranial lesions. The identification of paroxysmal gluten-sensitive dyskinesia (PGSD) in Border terriers, in which 24-50% of cases have accompanying GI signs, was a critical moment for the realization of the role of the gut-brain barrier in the development and management of PD.

The age of onset of PD is variable but it is more commonly first observed in young adulthood.

From the clinical point of view, PDs are complex episodes characterized mainly by **dystonia** and **tremors.**

> **Dystonia** – sustained muscle contraction that causes postural change – is one of the most commonly observed signs of PD. Simultaneous contraction of extensor and flexor muscles can lead to repetitive movements that can mimic seizure activity. Dystonia can be triggered by voluntary movements.
>
> **Tremors** – involuntary, rhythmic, oscillatory movement of a body part – are also frequently observed with PD.

In Border Terriers, anti-gliadin antibodies (AGA IgG) and anti-canine transglutaminase-2-IgA (TG-2 IgA) have been validated as biomarkers for PD and, in one case series of 6 dogs, their levels decreased when dogs were fed a gluten-free diet. However, antibody levels in other breeds appear to be less reliable as indicators of PD.

Diagnostic challenges

PD often mimics epileptic seizures but differs in key aspects: during PD, dogs remain alert, maintain normal mentation, and lack autonomic signs (urination, hypersalivation, defecation). Video recordings from owners have greatly improved diagnostic accuracy compared to historical reliance on owners' verbal descriptions of "seizures."

	EPILEPTIC GENERALIZED TONIC-CLONIC SEIZURE	PAROXYSMAL DYSKINESIA EPISODE
Duration	Typically 30 secs-3 minutes	Variable Typically 1-5 minutes, but can range from a few seconds to 30 minutes or more
Consciousness	Loss of consciousness	No loss of consciousness, can display expression of discomfort/stress
Posture	Recumbency/inability to stand	Inability to stand/maintain posture
Limbs	Clonic-tonic movement	Sustained contraction in Hyperflexion or hyperextension, abnormal posture (dystonia), tremors
EpiMouth	Contraction of lips, showing teeth	Normal
Autonomic signs	May show hypersalivation and urinate or defecate during seizure	Normal. Possible observation of lack of drops of saliva from the mouth

Diagnostic work up

	IDIOPATHIC EPILEPSY	PAROXYSMAL DYSKINESIA
Neurologic evaluation	Normal	Normal
EEG	Often abnormal	Normal
MRI	Normal	Normal
Response to ASM	Variable – most often good	Very often not responsive

Diet and PD

Dr. Gandini presented the results of a prospective cohort study evaluating the effects of a commercial, soy-based, gluten-free hydrolyzed diet (GFHD) in dogs with PD. The investigators enrolled 23 dogs that had experienced two or more PD episodes in the prior 6 months, normal brain MRI and neurological examination, and no prior gluten-free diet or ASM administration. Assessments included neurological and GI evaluation, bloodwork, abdominal ultrasound, and determination of AGA IgG and TG-2 IgA levels at baseline.

Neurological and GI evaluation and determination of AGA IgG and TG-2 IgA levels were repeated at 3 months, and 6 months.

Seventy-four percent (74%) of dogs showed an excellent to good response to the GFHD, and 26% exhibited partial or poor response.

Feeding a GFHD:

- Significantly improved PD episode frequency
    - The median number of episodes per month significantly reduced from 1.5 (pre-trial) to 0.5
    - The median total number of episodes in a 6-month period significantly reduced from 6 (pre-trial) to 1.5
- Significantly reduced GI signs (vomiting, diarrhea)

AGA IgG and TG-2 IgA titers did not correlate with clinical response and were unreliable as biomarkers of PD. Slightly more than half (52%) of the dogs were positive for one or both antibodies, while 7 dogs (30%) were negative for both antibodies.

Putting the science into practice:

- Consider PD in differential diagnosis for episodic movement disorders and suspected seizures.
- During PD, dogs remain alert, maintain normal mentation, and lack autonomic signs (urination, hypersalivation, defecation).
- Instruct owners to submit video(s) of suspected seizures to facilitate differentiation of IE and PD.
- A gluten-free hydrolyzed diet is an effective treatment for non-genetic PD.
- Routine antibody testing (AGA IgG, TG2 IgA) is not recommended for affected dogs of breeds other than Border Terrier.

References

Black, V., Garosi, L., Lowrie, M., Harvey, R. J., & Gale, J. (2014). Phenotypic characterization of canine epileptoid cramping syndrome in the Border terrier. *Journal of Small Animal Practice, 55*(2), 102-107. doi: 10.1111/jsap.12170

De Risio, L., Bhatti, S., Muñana, K., Penderis, J., Stein, V., Tipold, A., Berendt, M., ...Volk, H. A. (2015). International veterinary epilepsy task force consensus proposal: Diagnostic approach to epilepsy in dogs. *BMC Veterinary Research, 11*, 148. doi: 10.1186/s12917-015-0462-1

Lowrie, M., Garden, O. A., Hadjivassiliou, M., Harvey, R. J., Sanders, D. S., Powell, R., & Garosi, L. (2015). The clinical and serological effect of a gluten-free diet in Border terriers with epileptoid cramping syndrome. *Journal of Veterinary Internal Medicine, 29*(6), 1564-1568. doi: 10.1111/jvim.13643

Lowrie, M., Garden, O. A., Hadjivassiliou, M., Sanders, D. S., Powell, R., & Garosi, L. (2018). Characterization of paroxysmal gluten-sensitive dyskinesia in Border terriers using serological markers. *Journal of Veterinary Internal Medicine, 32*(2), 775-781. doi: 10.1111/jvim.15038

Polidoro, D., Van Ham, L., Santens, P., Cornelis, I., Charalambous, M., Broeckx, B. J. G., & Bhatti, S. F. M. (2020). Phenotypic characterization of paroxysmal dyskinesia in Maltese dogs. *Journal of Veterinary Internal Medicine, 34*(4), 1541-1546. doi: 10.1111/jvim.15804

Rogers, C. B., Meyerhoff, N., & Volk, H. A. (2023). Gluten serological testing in various dog breeds with paroxysmal dyskinesia. *Frontiers in Veterinary Science, 10*, 1119441. doi: 10.3389/fvets.2023.1119441

Stassen, Q. E. M., Koskinen, L. L. E., van Steenbeek, F. G., Seppälä, E. H., Jokinen, T. S., Prins, P. G. M., Bok, ...Lohi, H. (2017). Paroxysmal dyskinesia in Border terriers: Clinical, epidemiological, and genetic investigations. *Journal of Veterinary Internal Medicine, 31*(4), 1123-1131. doi: 10.1111/jvim.14731

Myths and Misperceptions About Pre-, Pro-, and Postbiotics

Gabriel Vinderola, PhD (Chemistry)

The microbes we (and our pets) host influence our health, and common sense, further supported by available evidence, dictates that a diverse ecosystem is beneficial. In the case of the microbiome, reduced diversity is often associated with loss of beneficial bacteria, resulting in functional changes that impact microbiome and host health. Although microbiome research is a rapidly expanding field and certain, we still do not have a fully clear picture of a "healthy microbiome" regarding specific microbial composition.

There are many myths and misconceptions surrounding biotics – probiotics, prebiotics, synbiotics, and postbiotics – that are being propagated, especially on social media. Evidence-based use of these products in veterinary practice is essential.

Definitions

The following definitions are based on scientific consensus documents published by the International Scientific Association for Probiotics and Prebiotics (ISAPP), a non-profit organization dedicated specifically to advancing the science of probiotics, prebiotics, synbiotics, postbiotics and fermented foods.

Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host. Probiotics must be identified by strain (not just genus and species), alive at administration, and supported by evidence. The strain designation is critical, as different strains of the same bacterial species can have different effects. Examples of strain designations:

Genus	Species	Strain
Enterococcus	*lactis*	SF68
Bifidobacterium	*longum*	BL999

Prebiotics are non-digestible ingredients selectively utilized by host microbes to confer health benefits. Examples of prebiotics include inulin, fructooligosaccharide (FOS), galactooligosaccharide (GOS), polyphenols, and resistant starch. Prebiotics have known chemical composition, dose, and health benefit.

Synbiotics are combinations of probiotic(s) and prebiotic(s) and can be complementary (both have independent evidence of efficacy) or synergistic (the components work together without evidence of their individual efficacy).

Postbiotics are preparations of inanimate microorganisms and/or their components that confer health benefits. Postbiotics include dead cells or fragments, not just the metabolites of the microorganisms, and metabolites may or may not be present in the postbiotic (their presence is not required). For example, a combination of heat-inactivated *L. fermentum* LB-f (CNCM I-2998) and *L. delbrueckii* LB-d (CNCM I-4831) is considered a postbiotic and the postbiotic may contain the short-chain fatty acid butyrate in the mixture, but butyrate itself is not a postbiotic.

Separating fact from fiction: Common probiotic and prebiotic myths debunked

MYTH	FACT
All probiotics are created equal, and you can substitute one for another	Probiotic activity is strain-specific
Probiotics must survive the stomach	Probiotics only need to be alive at administration; survival through the gut is not required
Probiotics must colonize the gut	Probiotics do not need to colonize the gut for efficacy
Probiotics colonize the gut permanently	Benefits persist only with continued intake
The more strains, the better	Efficacy depends on strain-specific evidence, not strain quantity
The more colony-forming units (CFU), the better	Efficacy depends on strain-specific evidence, not CFU quantity. Every strain has its own effective dose.
Microbiome testing determines probiotic choice	Probiotics are selected based on clinical condition, not microbiome composition
Probiotics restore gut microbiome after antibiotics	Probiotics can help preserve diversity during antibiotic use, not restore it afterward
Probiotics must be administered AFTER antibiotics	Timing of probiotic administration is based on the probiotic and the antibiotic, the evidence dictates that they are administered together
Probiotics need prebiotics to work	Each can work independently but can also work synergistically as a synbiotic
Fermented foods = probiotics	Fermented foods contain undefined microbial communities, not standardized strains. Probiotics are standardized and fully identified strains with proven efficacy.
You need to intermittently "take a rest" from probiotics	As long as a health benefit is seen, continue administering the probiotic. They are safe.
You need to rotate probiotic strains	As long as a health benefit is seen, continue administering the probiotic
Spore-forming bacteria are more effective as probiotics	Efficacy depends on strain-specific evidence, not spore-forming ability
All fibers are prebiotics	Some prebiotics are fibers, but not all fibers are prebiotics.

Postbiotics: A rapidly evolving landscape

Postbiotics are not new, but there have been at least three different conceptualizations of what comprises a postbiotic, as well as 9 or more terms (including "ghost probiotics," "paraprobiotics," "tyndallized probiotics," etc.) used to describe them and at least 6 different definitions. Variable descriptions of postbiotics in the scientific literature create confusion and challenges when it comes to interpreting the studies and results.

Quantifying postbiotics creates a challenge. Colony-forming units (CFUs) are used for probiotics, but this term only applies to viable microbes, not inanimate microorganisms incapable of reproducing. It is likely that TFU, or Total Fluorescent Units as determined by flow cytometry, will become the standard unit of measure for postbiotics.

Putting the science into practice:

- Probiotics and postbiotics need to be identified to the strain level, need to be alive (probiotics) or intentionally inactivated (postbiotics), and need to have evidence of their safety and efficacy.
- The identity of a prebiotic ingredient must be clear, and evidence of their health benefit and selective utilization by the host microbiome is needed.
- Identifying the probiotic strains, or the inactivation method for postbiotics, in commercial products is still a challenge due to incomplete labelling.
- Choosing biotic products:
  - Market hype and misinformation persist; a critical appraisal of the evidence is essential. Choose biotics based on evidence, not marketing claims.
  - Choose a probiotic or postbiotic according to its evidence of efficacy for the condition you're looking to treat/manage, not the number of strains or CFU. More is not necessarily better.
    - More CFU or multiple strains do not guarantee better outcomes.
  - Check product labelling for the strain designation and dosage matching clinical studies for the target condition.
- Avoid products with minimal prebiotic content marketed as synbiotics—milligrams are insufficient.

References

Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO). (2002). Guidelines for the evaluation of probiotics in food. Available at https://isappscience.org/wp-content/uploads/2019/04/probiotic_guidelines.pdf.

Francavilla, R., Miniello, V., Magistà, A. M., De Canio, A., Bucci, N., Gagliardi, F., Lionetti, E., ...Cavallo, L. (2010). A randomized controlled trial of *Lactobacillus* GG in children with functional abdominal pain. *Pediatrics*, *126*(6), e1445–e1452. doi: 10.1542/peds.2010-0467

Fuller, R. (1989). Probiotics in man and animals. *Journal of Applied Bacteriology, 66*(5), 365-378.

Gibson, G. R., Hutkins, R., Sanders, M. E., Prescott, S. L., Reimer, R. A., Salminen, S. J., Scott, K., ...Reid, G. (2017). Expert consensus document: The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics. *Nature Reviews Gastroenterology & Hepatology*, *14*(8), 491–502. doi: 10.1038/nrgastro.2017.75

Hanieh Hosseini, S., Farhangfar, A., Moradi, M., & Dalir-Naghadeh, B. (2024). Beyond probiotics: Exploring the potential of postbiotics and parabiotics in veterinary medicine. *Research in Veterinary Science, 167*, 105133. doi: 10.1016/j.rvsc.2023.105133

Hernandez, J., Rhimi, S., Kriaa, A., Mariaule, V., Boudaya, H., Drut, A., Jablaoui, A., …Maguin, E. (2022). Domestic environment and gut microbiota: Lessons from pet dogs. *Microorganisms, 10*, 949. doi: 10.3390/microorganisms10050949

Hill, C., Guarner, F., Reid, G., Gibson, G. R., Merenstein, D. J., Pot, B., Morelli, L., …Sanders, M. E. (2014). Expert consensus document. The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nature Reviews Gastroenterology & Hepatology, 11*(8), 506-514. doi: 10.1038/nrgastro.2014.66

Hutkins, R., Walter, J., Gibson, G. R., Bedu-Ferrari, C., Scott, K., Tancredi, D. J., Wijeyesekera, A., & Sanders, M. E. (2025). Classifying compounds as prebiotics - scientific perspectives and recommendations. *Nature Reviews Gastroenterology & Hepatology, 22*(1), 54–70. doi: 10.1038/s41575-024-00981-6

ISAPP handout: Understanding prebiotics and fiber. Available at https://isappscience.org/wp-content/uploads/2019/04/Prebiotic-Fiber-Infographic-Final.pdf.

Joos, R., Boucher, K., Lavelle, A., Arumugam, M., Blaser, M. J., Claesson, M. J., Clarke, G., …Ross, R. P. (2025). Examining the healthy human microbiome concept. *Nature Reviews Microbiology, 23*(3), 192-205. doi 10.1038/s41579-024-01107-0

Kelley, R. L., Minikhiem, D., Kiely, B., O'Mahony, L., O'Sullivan, D., Boileau, T., & Park, J. S. (2009). Clinical benefits of probiotic canine-derived *Bifidobacterium animalis* strain AHC7 in dogs with acute idiopathic diarrhea. *Veterinary Therapeutics, 10*(3), 121-130.

Koziol, S. A., Oba, P. M., Soto-Diaz, K., Steelman, A. J., Suchodolski, J. S., Eckhardt, E. R. M., Swanson, K. S. (2023). Effects of a Lactobacillus fermentation product on the fecal characteristics, fecal microbial populations, immune function, and stress markers of adult dogs. *Journal of Animal Science, 101*, skad160. doi: 10.1093/jas/skad160

Lilly, D. M., & Stilllwell, R. H. (1965). Probiotics: Growth-promoting factors produced by microorganisms. *Science, 147*(3659), 747-748. doi: 10.1126/science.147.3659.747

McFarland, L. V. (2021). Efficacy of single-strain probiotics versus multi-strain mixtures: Systematic review of strain and disease specificity. *Digestive Diseases and Sciences, 66*(3), 694-704.

Merenstein, D., Fraser, C. M., Roberts, R. F., Liu, T., Grant-Beurmann, S., Tan, T. P., Herbin Smith, K., …Kane, M. A. (2021). *Bifidobacterium animalis* subsp. *lactis* BB-12 protects against antibiotic-induced functional and compositional changes in human fecal microbiome. *Nutrients*, *13*, 2814. doi: 10.3390/nu13082814

Oddi, S., Binetti, A., Burns, P., Cuatrin, A., Reinheimer, J., Salminen, S., & Vinderola, G. (2020). Occurrence of bacteria with technological and probiotic potential in Argentinian human breast-milk. *Beneficial microbes, 11*(7), 685–702. doi: 10.3920/BM2020.0054

Oetzel, G. R., Emery, K. M., Kautz, W. P., & Nocek, J. E. (2007). Direct-fed microbial supplementation and health and performance of pre- and postpartum dairy cattle: A field trial. Journal of Dairy Science, 90(4), 2058-2068. doi: 10.3168/jds.2006-484

Ouwehand, A. C. (2017). A review of dose-responses of probiotics in human studies. *Beneficial Microbes, 8*(2), 143-151. doi: 10.3920/BM2016.0140

Rodriguez, J., Hassani, Z., Costa Silva, C. A., Betsov, F., Carraturo, F, Fasano, A., Israelson, M., …Human Microbiome Action Consortium. (2025). State of the art and the future of microbiome-based biomarkers: A multidisciplinary Delphi consensus. *The Lancet. Microbe. 6*(2), 100948. doi: 10.1016/j.lanmic.2024.07.011

Salminen, S., Collado, M. C., Endo, A., Hill, C., Lebeer, S., Quigley, E. M. M., Sanders, M. E., …Vinderola, G. (2021). The International Scientific Association of Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of postbiotics. *Nature Reviews Gastroenterology & Hepatology, 18*(9), 649–667. doi: 10.1038/s41575-021-00440-6

Saxelin, M., Lassig, A., Karjalainen, H., Tynkkynen, S., Surakka, A., Vapaatalo, H., Järvenpää, S., …Hatakka, K. (2010). Persistence of probiotic strains in the gastrointestinal tract when administered as capsules, yoghurt, or cheese. *International Journal of Food Microbiology, 144*(2), 293-300. doi: 10.3168/jds.2006-484

Stelmach, V., Stavrou, G., Theodorou, I., Semertzidou, E., Tzikos, G., Menni, A.-E., …Kotzampassi, K. (2024). Postbiotics: Mapping the Trend. *Nutrients*, *16*(18), 3077. doi: 10.3390/nu16183077

Swanson, K. S., Allenspach, K., Amos, G., Auchtung, T. A., Bassett, S. A., Bjørnvad, C., Everaert, N., …Fahey, Jr., G. C. (2025). Use of biotics in animals: impact on nutrition, health, and food production. *Journal of Animal Science*, *103*, skaf061. doi: 10.1093/jas/skaf061

Swanson, K. S., Gibson, G. R., Hutkins, R., Reimer, R. A., Reid, G., Verbeke, K., Scott, K. P., …Sanders, M. E. (2020). The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of synbiotics. *Nature Reviews Gastroenterology & Hepatology*, *17*(11), 687–701. doi: 10.1038/s41575-020-0344-2

Van Hul, M., Cani, P. D., Petitfils, C., De Vos, W. M., Tilg, H., & El-Omar, E. (2024). What defines a healthy gut microbiome? *Gut, 73*(11), 1893-1908. doi: 10.1136/gutjnl-2024-333378

Vinderola, G., Benkowski, A., Bernardeau, M., Chenoll, E., Collado, M. C., Cronin, U., Eckhardt, E., ...Salminen, S. (2025). Postbiotics: a perspective on their quantification. *Frontiers in Nutrition*, *12*, 1582733. doi: 10.3389/fnut.2025.1582733

Vinderola, G., Sanders, M. E., & Salminen, S. (2022). The concept of postbiotics. *Foods, 11*(8), 1077. doi: 10.3390/foods11081077

Vinderola, G., Sanders, M. E., Cunningham, M., & Hill, C. (2024). Frequently asked questions about the ISAPP postbiotic definition. *Frontiers in Microbiology, 14*, 1324565. doi: 10.3389/fmicb.2023.1324565

Wilson, S. M., & Swanson, K. S. (2024). The influence of 'biotics' on the gut microbiome of dogs and cats. *The Veterinary Record*, *195*(S2), 2-12. doi: 10.1002/vetr.4914

Links Between Early-Life Stressors, Antibiotic Exposure, Gut Barrier Function, and Later-Life Gastrointestinal and Skin Diseases

Prof. Stefan Unterer, DrMedVet, Dr habil, DECVIM-CA

The prevalences of immune-mediated diseases and chronic GI disorders in dogs are rising, and currently about 10–15% of dogs develop chronic GI signs during their lives. This emphasizes the need to be more proactive and catch disease earlier. Genetic predisposition plays a role, with a predisposition to chronic enteropathy (CE) in some breeds such as Yorkies, French Bulldogs, and Boxers. Environmental factors likely play a role, and there is ample evidence that early-life experiences can exert lifelong impacts on gut health and general health.

Normal development optimizes resilience and health

Resilience represents the stability of the microbiome and its resistance to disruption when challenged, as well as its ability to reestablish normality after a challenge. The development of resilience requires normal development of the microbiota and barrier function, which happen in the first year of life. Any disruption of these processes sets the stage for chronic disease(s) later in life.

The intestinal microbiome is an important metabolic organ that impacts development of the intestine and the immune system; the maturation of the immune system is closely related to the maturation of the microbiome. The composition of the microbiome during this critical developmental stage may determine whether the immune system develops a more tolerant programming or if it trends toward intolerance (and potentially allergy) and inflammation. A normal, diverse microbiome is critical for inducing a well-functioning immunoregulatory network; for example, there is a critical level of microbial diversity required to inhibit IgE induction and favor tolerance. Delayed microbiome maturation in the first year of life in humans is a hallmark of pediatric allergic diseases (e.g., food allergy, atopic dermatitis, allergic rhinitis, asthma), underscoring the importance of a healthy microbiome during immune system development. In particular, antibiotic exposure during this phase is strongly linked to later disease.

In humans, an adult-like microbiota profile is typically reached between 2 and 3 years of age. Dogs follow a shorter timeline, reaching near-normal microbiota by 8–12 weeks and full stability by 4–6 months of age. Blake et al (2020) evaluated the puppy microbiome based on the Dysbiosis Index (DI) established by Texas A&M University's GI Lab. The investigators observed that the microbial community in puppies is not yet completely established at the age of 7–9 weeks, with several key bacterial species still absent at earlier stages. This early underdeveloped microbial state is primarily driven by dramatically low levels of *Peptacetobacter hiranonis* (formerly *Clostridium hiranonis*), which begin to increase around 5–6 weeks of age. *Clostridium difficile* is initially increased, but drops to low levels at 7-9 weeks. The "balance" of these two bacteria is relevant because *P. hiranonis* is the primary bacterial species that converts primary bile acids to secondary bile acids (2BA), which are important for suppressing pathobionts; as *P. hiranonis* levels increase and more bile acids are converted to 2BA, *C. difficile* growth and survival reduce.

Barrier development and function are critical to long-term health

The intestinal barrier allows the gastrointestinal tract and microbiome to perform their necessary functions while preventing direct physical contact between the microbiota and host cells. Luminal defense barrier mechanisms degrade antigens and bacteria via gastric acids, biliary secretions,

and pancreatic enzymes; select for holobionts and create a favorable environment for commensal bacteria; and inhibit pathobionts via bacteriocins, bile acids, luminal pH, and competition for nutrients. The mucus layer, which is closely apposed to the intestinal epithelium, consists of a loose outer (luminal) layer containing bacteria and a dense inner layer devoid of bacteria but rich in defensins and IgA; when intact and functional, this mucus layer prevents direct contact between bacteria and the epithelial lining in order to reduce immune stress and preserve tolerance.

The intestinal epithelium is a single layer of cells that serves as a physical barrier, preventing antigen penetration through the cells themselves (transcellular route) or through the intercellular spaces (paracellular route). Tight junction complexes between the cells prevent macromolecular diffusion across the epithelial layer and exclude almost all molecules present in the lumen.

The lamina propria below the epithelium contains immune cells and this region can be divided into two functional compartments. The inductive compartment includes the Gut-Associated Lymphoid Tissue, or GALT, including Peyers patches and lymphoid follicles, which encounter and process antigens. The effector compartment includes antigen-experienced memory cells, intra-epithelial lymphocytes, and lamina propria mononuclear cells and mounts the immune response to antigens.

Intestinal infection and inflammation are associated with disruption of the mucus barrier and barrier function, which may be accompanied by altered innate and adaptive host responses to the microbiota and food components – setting the stage for chronic inflammation and immune dysfunction.

Early-life intestinal barrier dysfunction and dysbiosis increase chronic disease risk

During infancy, the microbiome, immune system and gut barrier are developing and are dynamic and vulnerable. Acute enteritis and antibiotic exposure disrupt microbiota and immune tolerance. Barrier damage allows antigen translocation, triggering chronic inflammation. Although each increases risk on its own, the combination of these factors greatly increases the risk of disease – especially when they occur during early-life and critical developmental stages.

Antibiotic administration induces intestinal dysbiosis and increases the risk of later-life disease. In humans, early-life antibiotic administration impairs microbiota maturation and significantly increases the risk of a number of childhood and lifelong diseases, such as childhood-onset asthma, allergic rhinitis, atopic dermatitis, food allergy, childhood obesity, and autism spectrum disorder. Stavroulaki et al (2023) evaluated the impact of early-life antibiotic administration in cats. Eleven (11%) of ninety-five cats developed chronic diarrhea later in life, and 10 (91%) of those 11 cats had received antibiotics within their first year of life. Cats administered antibiotics in their first year of life were almost 20 times more likely to develop chronic GI disease in adulthood.

Human patients with giardiasis demonstrated a significantly higher prevalence of irritable bowel syndrome (IBS) 3 years later compared to matched control patients (48% vs 14%). Giardiasis affects tight junctions, leading to barrier dysfunction. Metronidazole, commonly administered as treatment for giardiasis in dogs, is well known to induce dysbiosis that persists for weeks (or longer) after discontinuation of the antibiotic. Approximately 30% of dogs that experienced a giardia-associated enteritis in early life developed chronic GI disease later in life, compared to 10% of controls. The long-term effects are not limited to GI disease: more than 30% of these dogs develop chronic pruritic later in life, compared to 10% of controls. A high clinical disease activity index during acute enteritis, combined with metronidazole use, significantly increases the risk for chronic GI disease later in life compared to mild disease or treatment with fenbendazole only.

Canine parvovirus enteritis (parvo) provides a model for the effects of early-life acute intestinal damage in dogs and incorporates both dysbiosis and barrier disruption risks. The virus obliterates intestinal villi, creating severe barrier dysfunction, and antibiotic administration creates dysbiosis. Kilian et al (2018) observed that 42% of parvo survivors developed GI signs later in life, compared to 12% of healthy controls. Sato et al (2022) observed a 57% prevalence of later-life GI signs following parvo, compared to 25% in healthy controls.

Prevention of dysbiosis and barrier dysfunction, particularly during early-life, sets the stage for long-term health and lowers the risk of chronic disease. If either or both develops, treatment programs should include a focus on restoring homeostasis as quickly as possible to mitigate the risks.

Putting the science into practice:

- Early-life experiences have a heavy influence on gut health and general health.
- Dysbiosis and gut barrier dysfunction in early life significantly increase the risk of disease later in life, and the combination of the two poses even greater risk.
- Antibiotic administration remains the biggest cause of dysbiosis. Avoid unnecessary antibiotics; restrict their use to systemic infections.
- Avoid using antibiotics for acute diarrhea. Most cases of acute diarrhea will resolve with supportive care. A more aggressive diagnostic and treatment approach should be performed if the acute diarrhea has not improved within 10 days.
    - Refer to ENOVAT guidelines for antimicrobial use during enteritis. (WSAVA also provides an open-access summary if you cannot access the publication.)
- Incorporate microbiome-modulating approaches (e.g., prebiotics, probiotics, FMT) when treating enteritis.
- Consider feeding hydrolyzed or amino acid-based diets or utilizing parenteral nutrition during the acute phase of enteritis to reduce antigen load and avoid antigen stimulation secondary to severe gut barrier dysfunction.
- When treating enteritis, avoid using drugs that can harm the GI barrier (e.g., NSAIDs, PPIs) unless medically indicated.

References

Aversa, Z., Atkinson, E. J., Schafer, M. J., Theiler, R. N., Rocca, W. A., Blaser, M. J., & LeBrasseur, N. K. (2021). Association of Infant Antibiotic Exposure With Childhood Health Outcomes. *Mayo Clinic Proceedings*, *96*(1), 66–77. doi: 10.1016/j.mayocp.2020.07.019

Cahenzli, J., Köller, Y., Wyss, M., Geuking, M. B., & McCoy, K. D. (2013). Intestinal microbial diversity during early-life colonization shapes long-term IgE levels. *Cell Host & Microbe, 14*(5), 559-570. doi: 10.1016/j.chom.2013.10.004

Gold, M., Bacharier, L. B., Hartert, T. V., & Rosas-Salazar, C. (2024). Use of antibiotics in infancy and asthma in childhood: Confounded or causal relationship? A critical review of the literature. *Journal of Allergy and Clinical Immunology. In Practice*, *12*(10), 2669–2677. doi: 10.1016/j.jaip.2024.06.018

Green, J. E., Wrobel, A., Todd, E., Marx, W., Berk, M., Lotfaliany, M., Castle, D., …Dawson, S. (2025). Early antibiotic exposure and risk of psychiatric and neurocognitive outcomes: Systematic review and meta-analysis. *The British Journal of Psychiatry*, *226*(3), 171–183. doi: 10.1192/bjp.2024.121

Holthaus, D., Kraft, M. R., Krug, S. M., Wolf, S., Müller, A., Delgado Betancourt, E., Schorr, M., …Klotz, C. (2022). Dissection of barrier dysfunction in organoid-derived human intestinal epithelia induced by *Giardia duodenalis*. *Gastroenterology*, *162*(3), 844–858. doi: 10.1053/j.gastro.2021.11.022

Hoskinson, C., Dai, D. L. Y., Del Bel, K. L., Becker, A. B., Moraes, T. J., Mandhane, P. J., Finlay, B. B., …Turvey, S. E. (2023). Delayed gut microbiota maturation in the first year of life is a hallmark of pediatric allergic disease. *Nature Communications*, *14*(1), 4785. doi: 10.1038/s41467-023-40336-4

Kerr, C. A., Grice, D. M., Tran, C. D., Bauer, D. C., Li, D., Hendry, P., & Hannan, G. N (___). Early life events influence whole-of-life metabolic health via gut microflora and gut permeability. *Critical Reviews in Microbiology, 41*(3), 326-40. doi: 10.3109/1040841X.2013.837863

Kilian, E., Suchodolski, J. S., Hartmann, K., Mueller, R. S., Wess, G., & Unterer, S. (2018). Long-term effects of canine parvovirus infection in dogs. *PloS One*, *13*(3), e0192198. doi: 10.1371/journal.pone.0192198

Mueller, R. S., & Unterer, S. (2018). Adverse food reactions: Pathogenesis, clinical signs, diagnosis, and alternatives to elimination diets. *The Veterinary Journal, 236*, 89-95. doi: 10.1016/j.tvjl.2018.04.014

Rasmussen, S. H., Shrestha, S., Bjerregaard, L. G., Ängquist, L. H., Baker, J. L., Jess, T., & Allin, K. H. (2018). Antibiotic exposure in early life and childhood overweight and obesity: A systematic review and meta-analysis. *Diabetes, Obesity & Metabolism*, *20*(6), 1508–1514. doi: 10.1111/dom.13230

Roswall, J., Olsson, L. M., Kovatcheva-Datchary, P., Nilsson, S., Tremaroli, V., Simon, M. C., Kiilerich, P., …Bäckhed, F. (2021). Developmental trajectory of the healthy human gut microbiota during the first 5 years of life. *Cell Host & Microbe*, *29*(5), 765–776.e3. doi: 10.1016/j.chom.2021.02.021

Sato-Takada, K., Flemming, A. M., Voordouw, M. J., & Carr, A. P. (2022). Parvovirus enteritis and other risk factors associated with persistent gastrointestinal signs in dogs later in life: A retrospective cohort study. *BMC Veterinary Research*, *18*(1), 96. doi: 10.1186/s12917-022-03187-7

Scott, K. G.-E., Meddings, J. B., Kirk, D. R., Lees-Miller, S. P., & Buret, A. G. (2002). Intestinal infection with *Giardia* spp. reduces epithelial barrier function in a myosin light chain kinase-dependent fashion. Gastroenterology, *123*(4), 1179–1190. doi: 10.1053/gast.2002.36002

Stavroulaki, E. M., Fosgate, G. T., Moraiti, K. T., Xenoulis, P. G. (2024). Early-life antibiotic exposure and susceptibility to chronic diarrhea during adulthood in cats. (European Society of Comparative Gastroenterology abstract ESCG-O-11). *Journal of Veterinary Internal Medicine, 38*, 745-746. doi: 10.1111/jvim.16930

Walz, K. C., Suchodolski, J. S., Werner, M., Grimm, F., Schnyder, M., Zablotski, Y., & Unterer, S. (2025). Long-term follow-up after acute gastroenteritis caused by *Giardia* infection in juvenile dogs. *Journal of Veterinary Internal Medicine, 39*(4), e70123. doi: 10.1111/jvim.70123

Wensaas, K. A., Hanevik, K., Hausken, T., Eide, G. E., Langeland, N., Mørch, K., & Rortveit, G. (2016). Postinfectious and sporadic functional gastrointestinal disorders have different prevalences and rates of overlap: Results from a controlled cohort study 3 years after acute giardiasis. *Neurogastroenterology and Motility, 28*(10), 1561-1569. doi: 10.1111/nmo.12856

Yamamoto-Hanada, K., Yang, L., Narita, M., Saito, H., & Ohya, Y. (2017). Influence of antibiotic use in early childhood on asthma and allergic diseases at age 5. *Annals of Allergy, Asthma & Immunology, 119*(1), 54–58. doi: 10.1016/j.anai.2017.05.013

Exploring the Gut-Skin Axis: The Role of the Gut Microbiome in the Pathogenesis of Canine Atopic Dermatitis

Ana Rostaher, DVM, DECVD, MRCVS

Atopic dermatitis (AD) is a prevalent chronic inflammatory skin condition, characterized by its lifelong nature and resistance to therapy, presenting significant challenges for both veterinarians and pet owners. The condition significantly impacts the quality of life for both dogs and their owners, creating a cycle of stress and emotional strain. The first documented case of canine AD was published 85 years ago, highlighting the historical significance and long-standing recognition of this condition.[1]

A disease of exclusion

Atopic dermatitis can only be diagnosed through clinical evaluation, which involves assessing the patient's signalment and clinical signs. This process must be followed by the exclusion of differential diagnoses, including sarcoptic mange, infections, hormonal disorders, sebaceous adenitis, and lymphoma. Elimination diet trials and allergen testing are only utilized to identify the triggers such as food, house dust mites, pollens or fungi/yeast.

A multifaceted and evolving condition

Historically, canine AD was primarily associated with IgE antibodies to environmental allergens. Today it is accepted as a hereditary, typically pruritic and predominantly T cell-driven inflammatory skin disease involving an interplay between skin barrier abnormalities, allergen sensitization, and microbial dysbiosis.[2]

Immunological aspects of atopic dermatitis

Atopic dermatitis is characterized by the involvement of various immune cells, including Th1, Th2, Th22, Th17 and T regulatory cells, as well as several cytokines, which are critical in the itch pathways (eg. IL-4, IL-6, IL-13, IL-17, IL-31, IL-33).[3]

Atopic dermatitis breaks down the bricks and mortar of the skin barrier

The skin barrier can be compared to a well-constructed wall made of bricks (proteins such as keratins, filaggrins, along with adhesion molecules) and mortar (lipids such as ceramides) and is compromised in AD. Recent studies have demonstrated that inflammation is the primary driver of barrier disruptions.[4]

Atopic dermatitis is associated with microbiome dysbiosis

The hygiene and biodiversity hypotheses propose an inverse relationship between microbial exposure and the prevalence of immune-mediated diseases, highlighting the critical role of a diverse microbiome in the development and "training" of the host's immune system during early life (early window of opportunity). Furthermore, skin infections are frequently associated with exacerbations of AD. Recent technological advancements have facilitated a more comprehensive investigation of the skin and gut microbiomes and demonstrated that atopic dogs exhibit dysbiosis, with *Staphylococcus pseudintermedius* and *Malassezia* identified as key species associated with this microbial imbalance.[5] However, findings from a birth cohort study involving West Highland White Terrier (WHWT) dogs suggest that the skin microbiota at the age of 3 months, may not serve as the primary driver of AD development in this breed.[6] These insights have prompted further research into the significance of gut microbiota, which has been shown to differ between allergic and healthy dogs.[7]

The gut-skin axis in canine atopic dermatitis

Currently, there is a significant gap in our understanding of the gut-skin axis in canine AD. However, its existence has been demonstrated through basic scientific research in other species.[8] Three primary pathophysiological mechanisms have been identified as key components of the gut-skin axis: short-chain fatty acids (SCFAs) and tryptophan metabolites produced by microbes, beneficial antigenic microbial products (pattern-associated molecular patterns).

Interventions targeting the gut microbiome in canine atopic dermatitis

Microbiome-centric AD approaches include pro-, syn-, and/or postbiotics, leading to some improvements in pruritus and skin lesions and steroid-sparing effects. Fecal microbiota transplant (FMT) represents a broader way to positively manipulate the gut microbiota, as shown in human AD patients.9 A recent randomized placebo-controlled study evaluated the effects of lyophilized FMT as enema and oral capsules in 40 client-owned dogs with AD (article in preparation). The FMT treated dogs showed significantly lower skin lesion intensity, required significantly fewer symptomatic medications and had improvement in life-quality scores after 3 months of treatment.

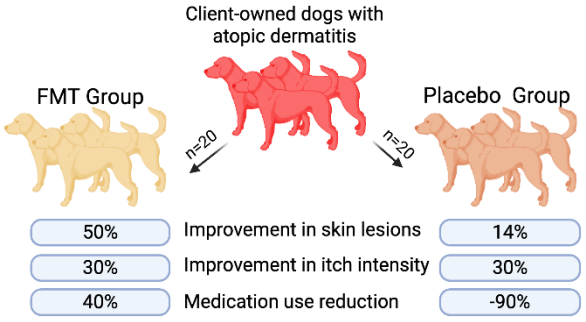

Image provided by Dr. Ana Rostaher

A subsequent unpublished study investigated the potential of fecal microbiota transplantation (FMT) to prevent the development of atopic dermatitis (AD). In this study, Beagle puppies were sensitized to house dust mites after receiving either no treatment, antibiotic administration (metronidazole), or FMT. The groups that received antibiotics or no treatment exhibited significantly higher levels of IgE following sensitization, along with notable increases in pruritus scores, in contrast to the FMT group. These preliminary results are encouraging and indicate that FMT may offer a protective effect against the onset of AD.

Putting the science into practice:

- The diagnosis of AD is strictly clinical; allergy tests are intended to identify specific triggers rather than the disease itself.
- Key components of the gut-skin axis include short-chain fatty acids, tryptophan, and pattern-associated molecular patterns that interact with toll-like receptors.
- AD is a multifactorial condition that requires a multimodal approach, addressing not only immune and barrier dysfunction but also the role of the microbiome.

References

1. Wittich, F. W. (1941). Spontaneous allergy (atopy) in the lower animal: Seasonal hay fever (Fall type) in a dog. *Journal of Allergy, 12*(3), 247-251.
2. Eisenschenk, M. C., Hensel, P., Saridomichelakis, M. N., Tamamoto-Mochizuki, C., Pucheu-Haston, C. M., & Santoro, D. (2024). Introduction to the ICADA 2023 canine atopic dermatitis pathogenesis review articles and updated definition. *Veterinary Dermatology, 35*, 3–4. doi: 10.1111/vde.13183
3. Marsella, R. (2021). Advances in our understanding of canine atopic dermatitis. *Veterinary Dermatology, 32*(6), 547. doi: 10.1111/vde.12965
4. Combarros, D., Cadiergues, M. C., & Simon, M. (2020). Update on canine filaggrin: a review. *Veterinary Quarterly*, *40*(1), 162–168. doi: 10.1080/01652176.2020.1758357
5. Chermprapai, S., Ederveen, T. H. A., Broere, F., Broens, E. M., Schlotter, Y. M., van Schalkwijk, S., Boekhorst, J., …Rutten, V. P. M. G. (2019). The bacterial and fungal microbiome of the skin of healthy dogs and dogs with atopic dermatitis and the impact of topical antimicrobial therapy, an exploratory study. *Veterinary Microbiology*, *229*, 90–99. doi: 10.1016/j.vetmic.2018.12.022
6. Rodriguez-Campos, S., Rostaher, A., Zwickl, L., Fischer, N., Brodard, I., Vidal, S., Brandt, B. W., Favrot, C., & Perreten, V. (2020). Impact of the early-life skin microbiota on the development of canine atopic dermatitis in a high-risk breed birth cohort. *Scientific Reports*, *10*(1), 1044. doi: 10.1038/s41598-020-57798-x
7. Rostaher, A., Morsy, Y., Favrot, C., Unterer, S., Schnyder, M., Scharl, M., & Fischer, N. M. (2022). Comparison of the gut microbiome between atopic and healthy dogs-Preliminary data. *Animals*, *12*(18), 2377. doi: 10.3390/ani12182377
8. Rios-Carlos, M., Cervantes-García, D., Córdova-Dávalos, L. E., Bermúdez-Humarán, L. G., & Salinas, E. (2024). Unraveling the gut-skin axis in atopic dermatitis: exploiting insights for therapeutic strategies. *Gut microbes*, *16*(1), 2430420. doi: 10.1080/19490976.2024.2430420
9. Mashiah, J., Karady, T., Fliss-Isakov, N., Sprecher, E., Slodownik, D., Artzi, O., Samuelov, L., …Maharshak, N. (2022). Clinical efficacy of fecal microbial transplantation treatment in adults with moderate-to-severe atopic dermatitis. *Immunity, Inflammation and Disease*, *10*(3), e570. doi: 10.1002/iid3.570

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Nutrition for Skin Health: Leveraging the Gut-Skin Axis for Optimal Skin Health

Emanuela Kayser, DVM, PhD

By supporting gut health, we are setting a good foundation for overall health, including skin health. The gut and skin are not only complex organs, but both serve as barriers between the external and internal environment.

Skin health is a key indicator of overall health

The skin is a critical barrier and indicator of overall health. Signs of a disrupted skin barrier include dryness, flaking or scaling, greasy skin, dehydration, erythema, sensitivity, inflammation, alopecia or poor hair growth, and even local and systemic secondary infections.

Skin and coat changes often signal underlying systemic disorders (e.g., kidney disease). Skin health can also be a sentinel for nutritional disorders.

Gut health and skin health are intrinsically linked

A healthy gut enables nutrient absorption essential for skin health. Dysbiosis is a shift in the diversity of the gut microbiota, and the severity of dysbiosis is an indicator of the severity of disruption of the microbiome and gut function – with potentially far-reaching effects on host health. For example, gut dysbiosis is linked to skin disorders such as atopic dermatitis (*see the summary of Dr. Rostaher's presentation for more information*). Improving gut health improves skin health and overall health.

Non-invasive tools help assess skin health

Non-invasive techniques facilitate the evaluation of skin health in response to interventions and include measurement of hydration, transepidermal water loss, sebum, and skin pH. Microbiome samples from the feces as well as skin swabs allow further exploration of the microbiota.

From a clinical perspective, validated scales such the Pruritis Visual Analog Scale (PVAS) and the Canine Atopic Dermatitis Extent and Severity Index (CADESI) provide repeatable measures. Recording subjective assessment of coat gloss and texture is also helpful for patient records.

Nutrition is essential for skin health

The skin needs sufficient protein and nutrients for health, and even small dietary changes can impact skin and coat health.

Essential fatty acids

Essential fatty acids (e.g., linoleic acid, arachidonic acid) are critical for barrier function, cell membrane integrity, overall skin structure, and water permeability. Dogs and cats cannot synthesize linoleic acid; therefore, it must be provided in adequate amounts in the diet. Cats also cannon synthesize arachidonic acid, and therefore require a dietary source.

Protein

Protein plays a critical role in skin structure and also supports hair growth and wound healing. Protein comprises 95% of hair, and the skin's protein needs account for up to 30% of the pet's daily protein requirement. Consequences of protein deficiency include dull, brittle hair; poor hair growth; delayed wound healing; and increased risk of infection.

The skin's protein needs account for up to 30% of the pet's daily protein requirement.

Vitamins and minerals

Vitamins A and E and minerals like zinc are vital for skin integrity. Vitamin A supports cellular growth and the keratinization process. Cats cannot produce Vitamin A from β-carotene, and therefore require dietary Vitamin A. Vitamin E has antioxidant activity and serves as a free radical scavenger. Vitamin E can be depleted by appropriate or prolonged food storage.

B vitamin needs are generally met by food and the gut microbiome's metabolic activity, but long-term antibiotic use can lead to gut dysbiosis and vitamin B deficiency. Avidin, found in raw egg whites, binds to biotin and prevents its absorption – leading to a deficiency that impacts skin and coat health.

Zinc is a cofactor for DNA and RNA polymerase. It is also essential for the synthesis of fatty acids. Although zinc deficiencies have occurred historically, they are rare today.

Omega-3 fatty acids

Omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) reduce inflammation and improve coat quality. Fish oil is a common source of EPA and DHA, and fish oil supplementation resulted in clinical improvement in dogs with atopy and flea allergies.

Innovative Ingredients

Palmitoylethanolamide (PEA) is a bioactive lipid that has shown promising results to date. Supplementation with PEA reduced itching and lesions in dogs with dust mite allergy and delayed the recurrence of clinical signs after allergen exposure.

Botanicals like curcumin support skin and gut health, likely through immunomodulation (e.g., suppression of inflammatory cytokine production). Other botanicals may have antioxidant and anti-inflammatory properties.

Incorporate the microbiome into your skin health nutrition plan

Gut health and skin health are intrinsically linked, and microbiome-centric approaches leverage the gut microbiome to improve skin health. Pre-, pro-, and postbiotics are valuable nutritional approaches. Clinical improvements have been reported in the scientific literature associated with administration of probiotic strains of *Lactobacillus sakei* (Kim et al., 2015)*, Lactobacillus rhamnosus* (Marcella, 2009)*, and Lactobacillus paracasei K71* (Ohshima-Terada et al., 2015).

Fecal microbiota transplantation (FMT) is a rapidly expanding field of research showing clinical benefits for gut health and skin health *(see the summaries of Dr. Rostaher's and Dr. Lotti's presentations for more information).*

Putting the science into practice:

- Proper nutrition is key for healthy skin, with increasing focus on understanding and supporting the gut-skin connection.
- Skin and coat changes often signal underlying systemic disorders (e.g., kidney disease). Skin health can also be a sentinel for nutritional disorders.
- Skin health reflects systemic health, and nutrition plays a pivotal role.
- The gut-skin axis offers new therapeutic opportunities to leverage diet and nutrition to improve skin health.
- Omega-3 fatty acids – primarily EPA and DHA – improve skin health.

References

Cobiella, D., Archer, L., Bohannon, M., & Santoro, D. (2019). Pilot study using five methods to evaluate skin barrier function in healthy dogs and in dogs with atopic dermatitis. *Veterinary Dermatology*, 30(2), 121-e34. doi: 10.1111/vde.12723

Combarros, D., Castilla-Castaño, E., Lecru, L. A., Pressanti, C., Amalric, N., & Cadiergues, M. C. (2020). A prospective, randomized, double blind, placebo-controlled evaluation of the effects of an n-3 essential fatty acids supplement (Agepi® ω3) on clinical signs, and fatty acid concentrations in the erythrocyte membrane, hair shafts and skin surface of dogs with poor quality coats. *Prostaglandins, Leukotrienes, and Essential Fatty Acids, 159*, 102140. doi: 10.1016/j.plefa.2020.102140

Guidi, E. E. A., Gramenzi, A., Persico, P., Di Prinzio, R., Di Simone, D., & Cornegliani, L. (2021). Effects of feeding a hypoallergenic diet with a nutraceutical on fecal dysbiosis index and clinical manifestations of canine atopic dermatitis. *Animals*, *11*(10), 2985. doi: 10.3390/ani11102985

Hill, P., Lo, A., Eden, C. A. N., Huntley, S., Morey, V., Ramsey, S., ... & Williams, V. (2006). Survey of the prevalence, diagnosis and treatment of dermatological conditions in small animals in general practice. *Veterinary Record*, *158*(16), 533-539. doi: 10.1136/vr.158.16.533

Kim, H., Rather, I., Kim, H., Kim, S., Kim, T., Jang, J., Seo, J., Lim, J., & Park, Y.-H. (2015). A double-blind, placebo controlled-trial of a probiotic strain *Lactobacillus sakei* probio-65 for the prevention of canine atopic dermatitis. *Journal of Microbiology and Biotechnology, 25*, 1966–1969. doi: 10.4014/jmb.1506.06065

Logas, D., & Kunkle, G. A. (1994). Double-blinded crossover study with marine oil supplementation containing high dose eicosapentaenoic acid for the treatment of canine pruritic skin disease. *Veterinary Dermatology, 5*, 99–104. doi: 10.1111/j.1365-3164.1994.tb00020.x

Marchegiani, A., Fruganti, A., Spaterna, A., Dalle Vedove, E., Bachetti, B., Massimini, M., ... & Cerquetella, M. (2020). Impact of nutritional supplementation on canine dermatological disorders. *Veterinary Sciences*, *7*(2), 38. doi: 10.3390/vetsci7020038

Marsella, R. (2009). Evaluation of *Lactobacillus rhamnosus* strain GG for the prevention of atopic dermatitis in dogs. *American Journal of Veterinary Research, 70*, 735–740. doi: 10.2460/ajvr.70.6.735

Marsella, R., Joyce, J., Nicklin, C., & Lopez, J. (2005). Evaluation of the effects of palmitoylethanolamide on clinical signs in house dust mite allergic high IgE Beagle dogs using a randomized, double blinded. *Veterinary Dermatology, 6*, 202. doi: 10.1111/j.1365-3164.2005.00458.x

Marsh, K. A., Ruedisueli, F. L., Coe, S. L., & Watson, T. G. D. (2000). Effects of zinc and linoleic acid supplementation on the skin and coat quality of dogs receiving a complete and balanced diet. *Veterinary Dermatology*, *11*(4), 277-284. doi: 10.1046/j.1365-3164.2000.00202.x

McKnight, G., Shah, J., & Hargest, R. (2022). Physiology of the skin. *Surgery (Oxford)*, *40*(1), 8-12. doi: 10.1016/j.mpsur.2021.11.005

Noli, C., della Valle, M.F., Miolo, A., Medori, C., Schievano, C.,& The Skinalia Clinical Research Group. (2015). Efficacy of ultra-micronized palmitoylethanolamide in canine atopic dermatitis: An open-label multi-centre study. *Veterinary Dermatology, 26*, 432–e101. doi: 10.1111/vde.12250

Ohshima-Terada, Y., Higuchi, Y., Kumagai, T., Hagihara, A., & Nagata, M. (2015). Complementary effect of oral administration of *Lactobacillus paracasei* K71 on canine atopic dermatitis. *Veterinary Dermatology, 26*, 350–e75. doi: 10.1111/vde.12224

Patel, J. R., Patil, S. S., Pawar, M. M., & Modi, C. P. (2021). Nutritional approaches for healthy skin and coat in pet dogs. *Indian Farmer*, *8*, 43-47.

Rostaher, A., Morsy, Y., Favrot, C., Unterer, S., Schnyder, M., Scharl, M., & Fischer, N. M. (2022). Comparison of the gut microbiome between atopic and healthy dogs—preliminary data. *Animals*, *12*(18), 2377. doi: 10.3390/ani12182377

Saseendran, A., George Sherin, G., Banakar, P. S., Rajkumar, G., Jayaprakash, G., Sheethal, C., & Saseendran, A. (2016). Skin disease in companion animals: a nutritional impact. *Indian Journal of Natural Sciences*, *6*(36), 10923-10931.

Szántó, M., Dózsa, A., Antal, D., Szabó, K., Kemény, L., & Bai, P. (2019). Targeting the gut-skin axis—Probiotics as new tools for skin disorder management? *Experimental Dermatology*, *28*(11), 1210-1218. doi: 10.1111/exd.14016

Watson, T. D. (1998). Diet and skin disease in dogs and cats. *Journal of Nutrition, 128*(12 Suppl), 2783S-2789S. doi: 10.1093/jn/128.12.2783S

FMT Made Practical: How I Implemented FMT into Daily Practice

Francesco Lotti, DVM, MSc, ECVIM-CA (Internal Medicine), Specialist in Small Animal Internal Medicine

Fecal Microbiota Transplantation (FMT) is the transfer of fecal matter from a healthy donor into the GI tract of a patient in order to restore gut microbiome balance in dysbiosis-related disease. To date, FMT has been shown effective in dogs and cats with chronic enteropathy, refractory GI signs, parvovirosis, or antibiotic-induced dysbiosis. FMT research is a rapidly evolving field.

Chronic enteropathy has a complex etiology

Chronic enteropathy (CE) results from a combination of multiple pathological events that disrupt the intestinal structure and the microbiome, including degradation of the mucus layer, increased levels of pathobionts, villus atrophy, mucosal remodeling, dysfunction of tight junctions, and increased permeability. The consequences of GI barrier dysfunction include inflammation, maldigestion/malabsorption, dysbiosis, and functional changes in bile acid, lipid, and carbohydrate metabolism.

Dysbiosis and intestinal structural changes lead to altered GI function – the higher the Dysbiosis Index (DI), the more severe functional changes are present. Altered bile acid metabolism is one of the more consequential aspects of dysbiosis. *Peptacetobacter hiranonis* (formerly *Clostridium hiranonis*) is the primary converter of primary bile acids to secondary bile acids in dogs and cats, and its depletion is associated with far-reaching health effects. Secondary bile acids, when present in physiological levels, suppress potential pathogens such as *C. difficile, C. perfringens*, and *E. coli*.

Not every dog or cat with CE has dysbiosis; there is a subset of CE cases without dysbiosis. This subset may represent earlier stages of CE that may progress to a dysbiotic state unless appropriate management is instituted.

A complex etiology demands a multimodal approach

Due to the complexity of CE etiology, a multimodal approach is necessary to optimize treatment outcomes. The overarching strategy for treatment includes controlling inflammation, supporting GI function, and restoring the GI microbiota and balance. Tools available to the clinician include diet, biotics, drugs to control inflammation, and FMT.

CE is not the only inducer of dysbiosis

Dysbiosis can be induced by a number of GI disruptors, including poor diet quality, enteropathogens, proton pump inhibitor (PPI) administration, antimicrobial therapy, and CE.

Diet should always be the first approach to CE

Dietary changes remain the most effective means of CE management in the majority of cases, and dietary trials should always be the first-line approach in clinical practice. A thorough diet history should be obtained and the information used to determine diet choice. One dietary trial may not be sufficient; in many cases, 3 or more diet trials may be attempted before one proves effective. Fiber supplementation, hydrolyzed diets, novel antigen diets, and amino acid-based diets are among the tools available for diet trials.

FMT is simple, cost-effective, and evidence-based

Fecal microbiota transplantation (FMT) is the transfer of fecal matter from a healthy donor to a recipient. It can be delivered via enema (recommended method) or orally via capsules. Recently, the FMT Consortium released FMT guidelines for veterinarians (Winston et al., 2024).

EQUIPMENT AND SUPPLIES

- Donor feces
- Mixer/blender or a zip bag
- Strainer
- Saline solution
- Scale
- Catheter for enema
- Catheter-tipped syringe (20-60mL)

DONOR SELECTION & SCREENING

- Clinically healthy
- Adult (12 or more months of age)
- No raw diet
- No antimicrobials in previous 6 months
- No medications
- Normal behavior
- Negative for pathogens
- (Cats) Indoor cat

Screening: Dysbiosis Index; negative for *Salmonella, C. jejuni, Giardia*, Crypto, intestinal parasites; in cats, add *Tritrichomonas foetus*, enteric coronavirus, FIV-FeLV

Rescreen every 6 months.

- If acute GI episode, wait 3 months before next use as a donor
- If antimicrobials administered, wait 6 months before next donation
- If PPI administered, wait 2 weeks before next donation

PREPARATION AND STORAGE

Preparation:

- Process feces within 2-6 hours of voiding
- Use 2.5-5 gm donor feces per kg of recipient body weight
- Mix feces with saline
- Strain
- Draw up in catheter-tipped syringe and attach catheter

Storage:

- Freshly prepared FMT: stable at 4°C (39°F) for up to 1 day, or for 1 month at -20°C (-4°F)
- For longer storage, add glycerol to make 10% solution (for each 100 gm feces, add 100 mL saline solution and 10 mL glycerol)
    - Stable for up to 3 months at -20°C (-4°F), thaw before use

ADMINISTRATION

1. Measure catheter length needed by measuring from base of tail to sternum
2. Attach appropriate-length catheter to catheter-tipped syringe
3. Push material into catheter until comes out the tip (to avoid air transplantation)
4. Feed catheter all the way into the colon
5. Administer FMT material

Post-administration care:

- Repeat dose if patient defecates within 20-30 minutes of FMT
- Withhold food for 4-6 h post-FMT in dogs
- For cats, recommend 4-6 h hospitalization

Frequency of administration:

- Repeat 2-3 times, 10-14 days apart

Clinical cases demonstrate the value of FMT

Camillo was a 4 year old, intact male Miniature Poodle presented for lifelong GI signs of chronic morning vomiting, intense nausea, poor appetite, and abdominal pain despite normal stool and stable body weight. Previous treatments included probiotics, several different diet types and resulted in only partial clinical improvement. He had a CIBDAI score of 5 (moderate disease). Abdominal ultrasonography detected mild signs of non-specific enteropathy. Camillo's Dysbiosis Index (DI) was 4.7, indicating severe dysbiosis, with depletion of *P. hiranonis*. Multimodal treatment was instituted to target his nausea (with maropitant) and hypocobalaminemia; FMT (3 FMTs by enema, 10 days apart) was performed. This treatment regime resulted in clinical improvement: his CIBDAI score reduced to 0, his appetite greatly improved, and his DI improved. In addition, his *P. hiranonis* levels went from 1.7 log DNA pre-FMT to 6.2 log DNA (normal range 5.1-7.1) 45 days after FMT

Cesira was a 7 year old, spayed female French Bulldog referred for refractory and severe chronic enteropathy of 6 months duration. Her clinical signs included morning nausea, reduced appetite, and mixed-bowel diarrhea. GI histopathology showed mild to moderate lymphoplasmacytic inflammation. Prior to referral, attempted therapies included several diet trials (hydrolyzed soy diet, single protein source diet, home-prepared diet), several courses of antimicrobials, and steroids – none of which provided acceptable improvement. Her CIBDAI score was 7, indicating moderate to severe disease. Her DI was 4, with depletion of *P. hiranonis* (0.1 log DNA, normal 5.1-7.1 log DNA), indicating severe dysbiosis which was likely due to a combination of antimicrobial use and underlying GI disease. Three FMTs were administered 10 days apart, along with B12 supplementation to address hypocobalaminemia, and the steroids were tapered to be discontinued. Cesira showed clinical improvement after FMT despite persistent severe dysbiosis. She continued to have episodes of relapse every 2-3 months, necessitating repeated FMTs; however, she did show and maintain clinical remission even when the medications were discontinued.

Cleo was a 9 month old, spayed female Domestic Shorthair cat with refractory diarrhea with hematochezia since she was adopted at 3 months of age. She maintained good weight and appetite, but her diarrhea showed no improvement with diet trials (easily digestible diet, novel protein diet, hydrolyzed salmon diet) or a multistrain probiotic. Despite the chronicity of her disease, she was not dysbiotic. A high-fiber diet produce partial improvement of her diarrhea. FMT was performed as a series of 3 FMTs 10 days apart. She developed normal feces after the first FMT.

FMT is safe and effective

Retrospective and prospective studies of FMT for CE show 70-85% response rate (Toresson et al., 2023; Vecchiato et al., 2025). Long-term success is linked to lower initial DI and better bile acid profiles.

Side effects of FMT are minimal and self-limiting and may include mild diarrhea, flatulence, and straining.

Immunocompromise is not a contraindication for FMT. For example, FMT improves treatment outcome in canine parvoviral enteritis.

Predictors of response to FMT include the severity of dysbiosis (higher DI indicates worse dysbiosis and increases likelihood of a poorer response to FMT) and the ratio of primary bile acids and secondary bile acids at baseline (higher primary bile acids indicate a poorer response is

likely). Dr. Lotti anecdotally reported that young German Shepherd dogs with severe diarrhea tend to be poor responders.

Putting the science into practice:

- Diet should always be the first-line approach for CE, but FMT is an excellent next approach.
- A very high Dysbiosis Index (DI) more likely indicates advanced disease – the more dysbiotic the patient, the more severe the functional changes.
    - A high DI is also an important prognostic indicator: severe and/or persistent dysbiosis is associated with higher risk of relapse, and repeated courses of FMT may be necessary. If relapses occur, try to time FMT earlier to avoid flare-ups and maintain clinical remission.
- Clinical remission is not always equivalent to functional recovery or resolution of underlying pathology.
- FMT is simple and cost-effective
    - A screened donor and simple equipment are enough to start using FMT in your practice
- FMT is evidence-based and effective
    - FMT can reduce the need for medications to manage CE
    - FMT is probably more effective in early disease
    - FMT can help achieve clinical remission, especially in young animals or those with antibiotic-induced dysbiosis
    - FMT as part of a multimodal strategy can help even when diarrhea is not the main clinical sign
    - Best used as part of multimodal therapy, not just a last resort.
- Indications for FMT include:
    - Patient with a history of GI signs secondary to antimicrobial use
    - Management of canine parvoviral enteritis
    - CE unresponsive to diet, fiber, and probiotics
    - Multimodal treatment in refractory CE
- Practical FMT tips
    - A compounded lidocaine suppository may help (allow 15min for effect) if severe colitis is present
    - Cats: give 50-100 mg gabapentin 90 minutes before FMT
- Follow-up is essential; some patients need repeated protocols for sustained remission.

References:

AlShawaqfeh, M., Wajid, B., Minamoto, Y., Markel, M., Lidbury, J., Steiner, J., Serpedin, E., & Suchodolski, J. (2017). A dysbiosis index to assess microbial changes in fecal samples of dogs with chronic inflammatory enteropathy. *FEMS Microbiology Ecology*, *93*(11). doi: 10.1093/femsec/fix136

Chaitman, J., & Gaschen, F. (2021). Fecal microbiota transplantation in dogs. *Veterinary Clinics: Small Animal Practice, 51*(1), 219–233. doi: 10.1016/j.cvsm.2020.09.012

Chen, C.-C., et al. (2025). Microbial gene profiling and targeted metabolomics in fecal samples of dogs with chronic enteropathy with or without increased dysbiosis index. *Journal of Veterinary Internal Medicine, 39*(5), e70199. doi: 10.1111/jvim.70199

Martini, S. E., Oba, P. M., Suchodolski, J. S., & Swanson, K. S. (2025). Effects of dietary and fecal microbial transplant treatments on fecal characteristics, metabolites, and microbiota of adult cats treated with metronidazole. *Pets, 2*(3), 27. doi: 10.3390/pets2030027

Pereira, G. Q., et al. (2018). Fecal microbiota transplantation in puppies with canine parvovirus infection. *Journal of Veterinary Internal Medicine, 32*(2), 707–711. doi: 10.1111/jvim.15072

Pérez-Accino, J., Salavati, M., Glendinning, L., & Salavati Schmitz, S. (2025). Effect of a single rectal fecal microbiota transplantation on clinical severity and fecal microbial communities in dogs with chronic inflammatory enteropathy. *Journal of veterinary internal medicine*, *39*(1), e17264. https://doi.org/10.1111/jvim.17264

Rojas, C. A., Entrolezo, Z., Jarett, J. K., Jospin, G., Martin, A., & Ganz, H. H. (2024). Microbiome Responses to Oral Fecal Microbiota Transplantation in a Cohort of Domestic Dogs. *Veterinary sciences*, *11*(1), 42. https://doi.org/10.3390/vetsci11010042

Rojas, C. A., et al. (2024). Microbiome responses to oral fecal microbiota transplantation in a cohort of domestic dogs. *Veterinary Sciences, 11*(1), 42. doi: 10.3390/vetsci11010042

Suchodolski, J. (2023). Assessing and managing the gut microbiome in canine and feline practice. In *Purina Institute Handbook of Canine and Feline Clinical Nutrition* (2nd ed., pp. 113–118). Embark Consulting Group, LLC.

Suchodolski, J. S. (2022). Analysis of the gut microbiome in dogs and cats. *Veterinary Clinical Pathology, 50*(Suppl 1), 6–17. doi: 10.1111/vcp.13031

Toresson, L., et al. (2023). Clinical effects of faecal microbiota transplantation as adjunctive therapy in dogs with chronic enteropathies—a retrospective case series of 41 dogs. *Veterinary Sciences, 10*(4), 271. doi: 10.3390/vetsci10040271

Toresson, L., Ludvigsson, U., Olmedal, G., Hellgren, J., Toni, M., Giaretta, P. R., … & Blake, A. B. (2025). Repeated fecal microbiota transplantation in dogs with chronic enteropathy can decrease disease activity and corticosteroid usage. *Journal of the American Veterinary Medical Association*, online ahead of print, 1-10. doi: 10.2460/javma.25.08.0563

Tuniyazi, M., et al. (2022). Canine fecal microbiota transplantation: Current application and possible mechanisms. *Veterinary Sciences, 9*(8), 396. doi: 10.3390/vetsci9080396

van Lienden, M., et al. (2025, July/August). Multimodal treatment approach to dogs with chronic diarrhea and the role of the microbiome. *Today's Veterinary Practice*. https://todaysveterinarypractice.com/gastroenterology/multimodal-treatment-approach-to-dogs-with-chronic-diarrhea-and-the-role-of-the-microbiome

Vecchiato, C. G., et al. (2025). Effect of faecal microbial transplantation on clinical outcome, faecal microbiota and metabolome in dogs with chronic enteropathy refractory to diet. *Scientific Reports, 15*(1), Article 96906. doi: 10.1038/s41598-025-96906-7

Wang, S., Martins, R., Sullivan, M. C., Friedman, E. S., Misic, A. M., El-Fahmawi, A., De Martinis, E. C. P., O'Brien, K., Chen, Y., Bradley, C., Zhang, G., Berry, A. S. F., Hunter, C. A., Baldassano, R. N., Rondeau, M. P., & Beiting, D. P. (2019). Diet-induced remission in chronic enteropathy is associated with altered microbial community structure and synthesis of secondary bile acids. *Microbiome*, *7*(1), 126. doi: 10.1186/s40168-019-0740-4

Winston, J. A., et al. (2024). Clinical guidelines for fecal microbiota transplantation in companion animals. *Advances in Small Animal Care, 5*(1), 79–107. doi: 10.1016/j.yasa.2024.06.006

Disentangling canine chronic enteropathies and microbiome dysbiosis: Purina-Texas A&M partnership advances understanding of this complex condition

A partnership between Nestlé Purina PetCare and the Gastrointestinal Laboratory at Texas A&M University's School of Veterinary Medicine & Biomedical Sciences is driving advances in research that are facilitating a deeper understanding of canine chronic enteropathies (CE) and the role of diet and the microbiome, with the ultimate goal of improving patient outcomes. Three recent veterinary journal publications supported by this partnership provide novel insights into the mechanisms of this important group of GI conditions.

CE has been previously associated with dysbiosis (altered gut microbial composition and function) in a subset of CE dogs, and researchers at the TAMU GI Lab developed a Dysbiosis Index (DI) that measures the severity of dysbiosis based on the absolute abundance (levels) of key bacteria in the feces. In research settings, commonly used next generation sequencing approaches have a major limitation as they only provide information on the relative abundance of microbial species, as the data for individual species is expressed as a percentage of total. In contrast, the DI utilizes independent quantification of key bacteria affected in dysbiosis; this indicates the severity of dysbiosis, which has important clinical relevance as shown in the studies below.

Chen et al[1] compared the fecal microbiome and metabolome from clinically healthy dogs and dogs with CE with and without increased DI. The findings show that CE is a heterogenous disease, as dogs with increased DI had more functional changes compared to CE dogs that had a normal DI. This study also revealed that malabsorption of nutrients is a major component of CE and drives dysbiosis, as increased amounts of fatty acids and carbohydrates were observed in dogs with CE, and particularly those that had an increased DI. Dogs with CE with increased dysbiosis index had also reduced abundance of *Peptacetobacter hiranonis* (previously called *Clostridium hiranonis*), a gut bacterial species responsible for the conversion of primary bile acids to secondary bile acids, with accompanying disruption of bile acid metabolism.

Although diet remains the frontline approach to canine CE and multiple diet trials may be necessary to achieve a response, a number of dogs with CE do not achieve clinical remission with diet alone and may require additional therapy in the form of microbiota modulation such as probiotics or fecal microbiota transplantation (FMT) and/or immunomodulatory or other medications. Toresson et al[2] evaluated the outcome of a repeated FMT protocol in 39 dogs with CE. Twenty-eight of the 39 (72%) dogs clinically responded to FMT, and 20 of those 28 (71%) were long-lasting responders who improved and remained clinically stable for 6 months or longer. Following FMT, corticosteroid dose had been decreased by a median of 34% in 11 dogs and corticosteroids were discontinued in 2 dogs – indicating that FMT can have a steroid-sparing effect. When long-lasting responders were compared to non-responders and short-term responders, two baseline parameters stood out as indicators of no or only short-term response: the severity of dysbiosis as indicated by an increased DI, and the degree of bile acid dysmetabolism (as indicated by lower percentage of secondary bile acids compared to primary bile acids in the feces). This study underscores the safety and benefits of FMT for CE in dogs as well as providing important information for setting realistic expectations when communicating with owners of CE dogs: dogs with increased DI can clinically benefit from FMT, but likely will relapse sooner and require repeated courses of FMT.

A very small subset of CE that responds poorly to diet, immunomodulation, and FMT likely represents more severe and chronic underlying gut damage and dysbiosis and requires more aggressive treatment. Toresson et al[3] focused on dogs with CE non-responsive to diet and partially responsive or non-responsive to immunosuppressive therapy and FMT. These dogs with no response to these combined treatments received bile acid sequestrants– medications that bind bile acids so they are excreted instead of absorbed – to their current treatment regimen. Bile acid sequestrants improved the clinical signs and clinical outcomes of CE in these dogs, suggesting that some dogs with poor or no response to diet and immunosuppressive therapy and FMT may benefit from treatment with bile acid sequestrants. The majority of these dogs responding to bile acid sequestrants again had persistent marked dysbiosis as measured by an increased DI and severe depletion of *P. hiranonis*.

In summary, CE appears to be a gradual disease leading in some dogs to mucosal remodeling with loss of transporters and therefore malabsorption of carbohydrates, lipids, and amino acids. These increased luminal substrates are available for bacteria leading to dysbiosis. A more severely increased DI, especially with depletion of the key bacterium *P. hiranonis*, may therefore serve as a marker for more severe functional changes. Based on these studies, an increased DI can serve potentially as a staging marker for CE, as these dogs are less likely to achieve full resolution, and have an increased likelihood of the need for repeated and lifelong treatment, as was demonstrated in these studies.

These findings further explain and emphasize that diet needs to be the cornerstone therapy of canine CE, as highly digestible diets together with fiber and changes in other nutrients will have the largest impact in modulating the abnormal luminal environment due to malabsorption in CE.

These studies, combined with ongoing research supported by this partnership, clearly demonstrate that CE is a heterogeneous condition and cannot be treated with a one-size-fits-all approach; successful management of CE requires a multimodal approach focused on addressing the underlying pathophysiologic processes as well as host and microbiome function. As further research continues to shed light on these processes, veterinarians will be able to customize their treatment approach to achieve greater clinical success and improve the health and quality of life of their patients.

For a more detailed synopsis of each manuscript, please see the Study Summaries that follow.

References:

1. Chen, C.-C., Pilla, R., Toresson, L., Sung, C.-H., Blake, A. B., Lopes, B. C., Turck, J., Jergens, A. E., Summers, S. C., Unterer, S., Ishii, P. E., Giaretta, P. R., Tolbert, M. K., & Suchodolski, J. S. (2025). Microbial gene profiling and targeted metabolomics in fecal samples of dogs with chronic enteropathy with or without increased Dysbiosis Index. *Journal of Veterinary Internal Medicine, 39*, e70199. doi: 10.1111/jvim.70199
2. Toresson, L., Ludvigsson, U., Olmedal, G., Hellgren, J., Toni, M., Giaretta, P. R., Blake, A. B., & Suchodolski, J. S. (2025). Repeated fecal microbiota transplantation in dogs with chronic enteropathy can decrease disease activity and corticosteroid use. *Journal of the American Veterinary Medical Association,* online ahead of print. doi: 10.2460/javma.25.08.0563
3. Toresson, L., Blake, A. B., Sung, C.-H., Olmedal, G., Ludvigsson, U., Giaretta, P. R., Tolbert, M. K., & Suchodolski, J. S. (2025). Fecal and clinical profiles of dogs with chronic enteropathies treated with bile acid sequestrants for 5-47 months: A retrospective case series. *Journal of Veterinary Internal Medicine, 39*, e70206. doi: 10.1111/jvim.70206

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The Dysbiosis Index (DI) is an assay that measures the severity of dysbiosis – altered microbial composition and function – of the gut microbiome based on the abundance (levels) of key bacteria in the feces. The higher the DI, the more severe the shift in the composition and function of the gut microbiome. Chronic enteropathy (CE) may be associated with dysbiosis, and the abnormal microbiota can contribute to the clinical signs.

This study evaluated the microbiome and fecal metabolome from 74 clinically healthy dogs with a normal DI and 115 dogs with CE. Of the CE dogs, 57 dogs had a normal DI (<0) and 58 dogs had dysbiosis (DI>0).

Dogs with increased DI had significantly reduced abundance of *P. hiranonis* (the main bile acid converting bacteria in dogs) and significantly increased fecal primary bile acid levels compared to healthy dogs and CE dogs without dysbiosis. These dogs also had significantly higher fecal levels of primary bile acids and significantly lower levels of secondary bile acids and the cholesterol metabolite coprostanol compared to healthy dogs and CE dogs without dysbiosis. These parameters in CE dogs without dysbiosis were closer in value to those of healthy dogs than to CE dogs with dysbiosis. No significant differences were observed when the CE dogs were compared by their CE category instead of the DI.

Metabolomic analysis identified altered metabolic pathways – particularly those associated with lipid and carbohydrate metabolisms – in CE dogs with increased DI compared to healthy dogs and CE dogs with normal DI. A subset of CE dogs with increased DI showed increased carbohydrate degradation-related pathways and fecal transporter-dependent carbohydrate concentrations as well as reduced carbohydrate biosynthesis-related pathways, possibly indicating a subset of CE that may benefit from altered carbohydrate intake. An additional subset of CE dogs with increased DI demonstrated alterations to several amino acid pathways, increased abundance of *E. coli* and *Streptococcus,* and reduced abundance of *P. copri* and *C. mitsuokai*, which may reflect intestinal amino acid malabsorption.

Collectively, these findings suggest that dogs with CE accompanied by dysbiosis also have altered host and microbial metabolic functions and that the pathophysiology of CE with dysbiosis differs from that of CE without dysbiosis. Overall these findings indicate that malabsorption is a key component of CE, and is associated with dysbiosis.

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This prospective study evaluated 39 dogs with CE who had received 2-3 fecal microbiota transplantations (FMTs) via enema in a 1-month time period. The dogs' Canine Inflammatory Bowel Disease Activity Index (CIBDAI) scores and fecal microbiomes were assessed at baseline and for the following 6 months.

Twenty-eight (28) of the 39 dogs (72%) clinically responded to FMT, as demonstrated by increased activity level, improved fecal scores, decreased stool frequency, and weight gain in previously

underweight dogs. Eight of those 28 (29%) dogs had a short-lasting response – they improved after the first FMT, but showed no further improvement with subsequent FMTs. The 20 long-lasting responders (LLRs) demonstrated significant improvements in CIBDAI scores and Dysbiosis Index (DI) compared to baseline, while nonresponders (N) and short responders (SR) did not. Median *P. hiranonis* was higher, *E. coli* was lower, and the percentage of secondary bile acids was higher at baseline in LLRs than N and SR groups combined. CIBDAI scores at baseline were not associated with response to FMT.

At 6 months, maintenance corticosteroid (CCS) dose had been decreased by a median of 34% (range, 25-63%) in 11 LLR dogs and had been stopped in 2 LLR dogs. Prior to FMT, attempts to taper CCS were unsuccessful.

The presence of marked dysbiosis and bile acid dysmetabolism before and after FMT was associated with short-lasting or no clinical response to FMT. Dogs with severe dysbiosis may still benefit from FMT, but are less likely to respond and may require repeated FMT; this underscores the importance of setting realistic expectations prior to therapy. These results confirm that FMT is a safe and valuable adjunctive treatment option in dogs with refractory or partially refractory CE, associated with decreased disease activity and a CCS-sparing effect in the majority of responders.

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Bile acids (BA) have numerous critical roles in metabolism and health, and impaired BA metabolism has been shown to occur in some dogs with chronic enteropathies (CE). This retrospective case series evaluated the veterinary medical records of 24 dogs with CE (based on the Canine Inflammatory Bowel Disease Activity Index, CIBDAI) receiving BA sequestrants – medications that bind BA so they are excreted instead of absorbed – as adjunctive therapy due to inadequate or no response to diet change and immunosuppressive therapy. Fecal BA concentrations and Dysbiosis Index results in these dogs were compared to those of 18 healthy dogs and also within the CE group based on their response (responder vs non-responder) to BA sequestrant therapy.

Sixteen (67%) of the 24 dogs with CE responded to BA sequestrants with improved fecal and CIBDAI scores. Dogs that responded to BA sequestrants had higher concentrations of fecal primary BAs, lower concentrations of secondary BAs, higher DI, and low abundance of *Peptacetobacter hiranonis* (formerly *Clostridium hiranonis*; this is the primary BA-converting bacterial species) compared to non-responders and healthy dogs. Nine (64%) of 14 dogs treated with corticosteroids were able to have their dosages reduced by 33-67%, which had not been possible prior to BA sequestrant administration. Adverse effects of the BA sequestrants were observed in some dogs, and more common in the non-responder group, but tended to be mild. Long-term follow-up on the dogs showed that 4 of 16 (25%) of the responder group had been euthanized due to their enteropathy, compared to 4 of 8 (50%) of the non-responder group; the remaining responders alive at the time of manuscript preparation had maintained their improved clinical status.

The authors concluded that treatment with BA sequestrants may benefit some dogs with CE that do not respond, or only partially respond, to dietary intervention and immunosuppressive therapy, particularly when those dogs have higher dysbiosis index, higher levels of fecal primary bile acids and depleted *P. hiranonis*. The study also shows that clinical remission does not mean there is resolution of the underlying pathology.

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