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Advancements in pet health research: The role of in vitro models and organoids

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In recent years, pet health research has undergone a profound shift. Traditional research models—once the backbone of veterinary science—are no longer sufficient to address the biological complexity and ethical considerations of studying health and disease conditions in companion animals. As research questions grow more complex and mechanistic, so must the models used to investigate them. Among emerging innovations, in vitro systems such as organoids are rapidly becoming essential tools for understanding physiology, disease, nutrition, and therapeutic response in dogs and cats.

What are organoids? A new frontier in modeling pet health

Historically, veterinary science relied heavily on cell lines and live animal studies. While foundational, these models may not fully reproduce the structural and functional complexities of native tissues, and animal studies come with ethical, logistical, and reproducibility limitations.

Organoids—three-dimensional, self-organizing structures derived from stem cells—address many of these limitations. Developed in the early 2000s after the discovery of adult intestinal stem cells, organoids introduced a transformative way to recreate miniaturized versions of organs in a dish.[1] When provided with appropriate growth factors and a supportive 3D matrix, stem cells differentiate and assemble into structures that closely mimic the architecture and core functions of real tissues. Their multicellular composition and spatial organization make them far more physiologically relevant than flat monolayers.

To support specific research needs, organoid-derived systems can also be adapted into 2D monolayers, providing direct access to epithelial surfaces for mechanistic studies such as nutrient transport, permeability assessment, and inflammatory responses.[2] This flexible format allows controlled apical and basolateral exposures, enabling precise investigations into barrier function and bioactive–tissue interactions.

Of Note

- Organoids are multicellular, self-organizing 3D tissues that better mimic organ structure and function than conventional cell cultures.
- Veterinary organoids can often be generated from clinically indicated samples, supporting ethical sourcing and alignment with the Animal Research 3Rs principles (Replace, Reduce, Refine).
- These models can accelerate nutrition and health research by enabling controlled testing of efficacy, safety, and mechanisms in species-specific tissues.

Initially driven by the development of intestinal organoids for dogs and cats, the field is now rapidly expanding.[3] Organoids from other tissues are beginning to emerge, broadening their applicability in veterinary research.[4] The technology is also widely used in agriculture, where organoids from livestock species—including cattle, pigs, sheep, and poultry—enable the study of nutrient absorption and host–pathogen interactions while reducing reliance on live-animal research.[5]

The inherent self-organization and 3D architecture of organoids provide a biologically relevant environment for examining tissue-specific functions and complex biological processes. This makes them particularly valuable for studies that would otherwise be difficult, invasive, or ethically challenging to conduct in animals.

A new era in veterinary preventive strategy and pet nutrition research

Organoids are reshaping research in pet nutrition and therapeutic development by enabling controlled, high-resolution studies of how bioactives and diets influence health. Specifically, canine intestinal organoids—one

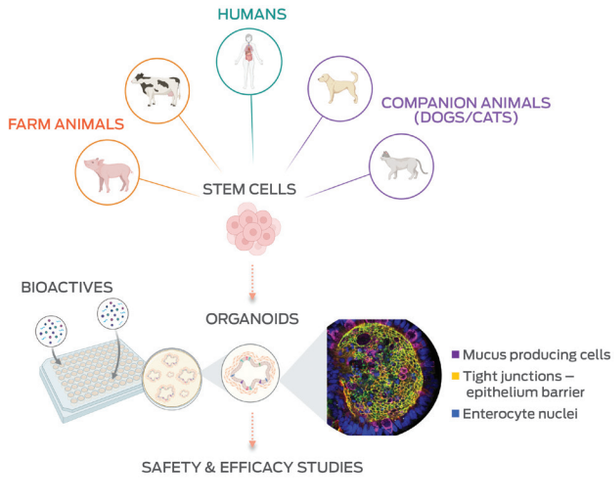

Figure 1. Organoid generation pipeline. Stem cells derived from tissues of humans or companion and farm animals can be expanded and differentiated into organoids such as intestinal organoids, which serve as in vitro models for nutrition and ingredient discovery. The illustration shows a human stem-cell-derived intestinal organoid with a defined lumen, proper apical in-basal out polarization, and multiple differentiated cell types, including enterocytes and mucin-producing goblet cells (magenta). This illustrates key intestinal functions—absorption, secretion, and barrier activity (yellow)—providing a powerful model to study how nutritional ingredients interact with the gut. (Image credit: Nestlé Research Lausanne; Illustration partially created using BioRender (https://biorender.com))

of the earliest veterinary models—offer a powerful platform for examining nutrient absorption, digestive responses, microbiome interactions, and gut barrier function (**Figure 1**).[6]

These cell models allow early assessment of ingredient safety, efficacy, and mechanism of action, helping to refine product development before moving to clinical studies. They also support investigations into probiotics, prebiotics, and functional ingredients, providing a mechanistic basis for nutritional claims. Such insights are increasingly valuable as pet food and supplement markets grow and the demand for solid scientific validation increases.

Beyond nutrition, organoids show promise in the study of complex diseases such as canine chronic enteropathy. Organoid models can provide valuable insights into candidate compounds early in the development process and significantly reduce the need for animal trials. This aligns with evolving regulatory authorities' expectations and the broader movement toward reducing animal use in research as described by the 3Rs Principles for Animal Research (Replace, Reduce, Refine). As organoid collections expand to additional tissues, the potential for investigating a wider range of prevalent conditions will continue to grow.

Collaborative momentum and future directions

The advancement of organoid technology in veterinary science relies on strong collaborations between academia, regulatory authorities, veterinary clinics, and industry. Beyond providing access to relevant stem cells, these partnerships ensure that the models faithfully reflect clinical phenotypes, enable the development of standardized protocols, and support the generation of high-quality datasets. Integrating expertise from biotechnology companies and subject matter experts will accelerate adoption and help overcome challenges such as intellectual property constraints, model acceptance and harmonization.

Conclusion

Organoid technologies are rapidly evolving from promising experimental tools into valuable components of contemporary biomedical research. In veterinary science, they increasingly provide physiologically relevant, ethically sourced, species-specific models that will support deeper mechanistic insight, strengthen preclinical prediction, and help reduce reliance on exploratory animal studies. As the field matures, organoid models are poised to play an expanding role in the next generation of pet nutrition and health innovations, offering a promising platform for developing more precise, science-based solutions. Together, these developments position organoid models as emerging contributors to future progress in companion animal health.

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Multi-omic research and applications in pets

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From central dogma to omics

In 1957, Francis Crick presented the central dogma of life, which states that genetic information flows from the three macromolecules: DNA to RNA to protein.[1] Genetic instructions encoded in genomic DNA sequences are transcribed into messenger RNA (mRNA) and subsequently translated into functional proteins that dictate traits and perform cellular tasks. In 2005, Dr. Schreiber first proposed that small molecules, or metabolites, be included in the central dogma as the central regulators controlling all steps from DNA to traits (**Figure 1**).[2]

Clinical research has significantly advanced our understanding of anatomy, physiology, and how disease disrupts normal physiological processes in companion animals. Research at the molecular level complements the clinical observations and sheds light on the complex molecular interactions governing the health and disease states. Advances in "omics" technologies have revolutionized companion animal research, providing holistic insights of the biological systems on a previously impossible scale. By integrating data from multiple omics layers, multi-omics research provides scientists with the insights to inform understanding of diseases that help clinicians treat those diseases.

Today, some of the commonly used omics techniques include genomics, transcriptomics, proteomics, and metabolomics. Genomics is the study of DNA, including the gene-coding and non-coding regions in an organism. Transcriptomics is the study of the transcriptome, which represents a snapshot of total RNA transcripts in a cell, and their quantity for a specific physiological condition or stage. Since the first publication of human partial transcriptome using expressed sequence tag (EST) in 1991, the field has evolved through a number of techniques, from hybridization-based microarrays to total RNA sequencing (RNA-seq) to single-cell RNA sequencing (scRNA-seq). Proteomics refers to the large-scale study of proteins and their quantities within a cell, tissue, or organism. While the feline or canine genome has ~20,000 protein coding genes, its complement of proteins, the proteome, encompasses over a million different forms. Metabolomics, which studies small molecule metabolites including amino acids, lipids, and sugars, is the closest omics layer to phenotype, bridging genetic information to the environment.

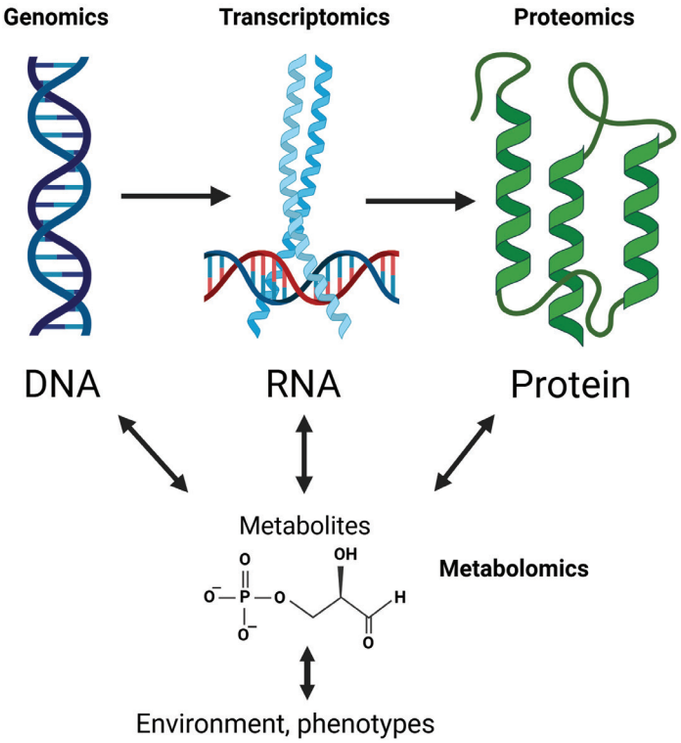
Of Note

- The central dogma of life states that genetic information flows from DNA to RNA to protein. Small molecules or metabolites were later included as the central regulators.
- Some of today's commonly used omics techniques are genomics, transcriptomics, proteomics, and metabolomics. By integrating multiple omics layers, multi-omics offers holistic insights of the biological systems.
- A multi-omics study revealed numerous metabolic changes in dogs with myxomatous mitral valve disease (MMVD). A diet intervention study demonstrated that a nutrient blend designed to address those changes provided cardiac benefits to canine patients with MMVD.

Multi-omics research in canine heart disease

A multi-omics study in dogs employed two omics techniques, serum metabolomics and cardiac tissue RNA-seq transcriptomics, to compare healthy dogs (control) and those with MMVD.[3] Serum samples from MMVD and age and sex-matched control dogs were subjected to metabolomics analysis, and mitral valve and left ventricular free wall tissues were subjected to RNA-seq transcriptomics analysis.[3] Integration of the multi-omics data revealed that the heart increased its reliance on anaerobic glycolysis for fuel in the context of reduced capacity of long-chain fatty acid oxidation, and markers of oxidative stress and inflammation were increased in response to MMVD.

Figure 1. The central dogma of molecular biology and omics. Modified from Schreiber.[2] Created in BioRender.com.



Under normal physiological conditions, approximately 70–90% of ATP generated in the adult mammalian heart results from the oxidation of fatty acids.[4] Because the failing heart is like an engine out of fuel, a nutrient blend was designed to address energy deficits and provide targeted nutrients to support cardiac function.[5] Specifically, medium-chain fatty acids, the hydrolytic products from medium-chain triglycerides (MCTs), provide a potential alternate energy source. MCTs are readily digested and absorbed, and the resulting medium-chain fatty acids can cross the mitochondrial barrier without a requirement for carnitine and are rapidly oxidized. Carnitine or carnitine precursors plus antioxidants can reduce free radical production and quench those that are produced. Taurine, a nutrient required for normal cardiac function, also serves as an antioxidant. Vitamin E, long known as a cellular antioxidant, also has anti-inflammatory properties. Finally, magnesium is an essential mineral for normal cardiac function and provides an antiarrhythmic action. It also helps reduce hypertension and provides antioxidant and anti-hyperlipidemic effects.[6]

A blinded randomized controlled study was conducted to evaluate the clinical impact of the nutrient blend in dogs with early stage MMVD.[5] Supplementation of the nutrient blend helped improve cardiac markers in these dogs. Further, metabolomic analysis using the serum samples from the diet intervention study suggested that the nutrient blend improved markers for energetics, oxidative stress, and inflammation in MMVD dogs.[7]

Future perspectives

The successful application of multi-omics approaches in canine MMVD enabled researchers to apply these powerful tools in other health areas, including feline chronic kidney disease.[8,9] These research endeavors will drive significant breakthroughs in veterinary medicine in the near future.

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Digital tools to improve comprehensive weight loss programs for pets

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Introduction

Obesity is a widespread epidemic in companion animals, and arises from chronic positive energy balance that leads to expansion of adipose tissue and fat deposition in other organs, creating an "obesogenic" environment marked by metabolic, hormonal, and inflammatory dysregulation.[1] These physiologic disturbances contribute to impaired mobility, multiple comorbidities, reduced quality of life, and shortened healthspan.[1] Although obesity is preventable, it remains the most common nutritional disorder in dogs and cats and is associated with significant health consequences. Long-term studies show that even moderately overweight dogs experience earlier morbidity and shorter lifespan, and similar reductions in longevity have been reported in obese cats.[2,3]

Traditional management of obesity focuses on two main principles: calorie restriction ("feed less") and activity modification ("exercise more"). Despite these recommendations, the prevalence of obesity continues to rise. Owner compliance has emerged as a major obstacle to successful weight loss programs.[4] Enhancing owner engagement and accountability is therefore critical to improving obesity outcomes in companion animals.

Human clinical studies demonstrate that technology-enhanced weight loss interventions can significantly improve participant engagement compared to traditional programs.[5] Similarly, incorporating smart devices, such as wearable activity collars, automatic feeders, and litterbox devices that incorporate digital scales, into companion animal weight loss programs may help overcome barriers to owner compliance. These devices offer objective data, automate routine tasks, and reduce the need for frequent veterinary visits. The following sections highlight smart devices that have been utilized successfully in canine and feline weight loss programs

Smart devices used in successful weight loss programs in dogs

Only a limited number of studies have evaluated smart devices within structured weight loss programs for dogs. Wearable activity monitors are increasingly used to assess canine activity patterns. These monitors attach to the dog's collar, record daily activity, and estimate caloric expenditure based on owner-supplied demographic data. At least one of these devices has been validated for tracking physical activity, with strong correlation between activity measurements and canine step counts. However, their accuracy for estimating energy expenditure remains unreliable.[6]

Our research group investigated the utility of one of these activity monitors in obese dogs enrolled in the 24-week AKC Canine Health Foundation-funded Canine SLIM study,[7] which evaluated the effects of fecal microbiota transplants during a structured weight loss program. Throughout the study, participants wore the activity monitors, generating a comprehensive dataset of daily activity. We examined the relationship between recorded activity, Liverpool Osteoarthritis in Dogs (LOAD) scores, and quality-of-life (QoL) scores. We hypothesized that as dogs lost weight, activity levels would increase and owner-perceived mobility and QoL would improve.

Owners completed LOAD surveys every three weeks and QoL surveys every 12 weeks while daily activity was monitored with the device. As dogs lost weight, significant improvements were observed in the physical dimension of QoL from baseline to week 24 and in LOAD scores between weeks 12 and 24. Despite

Of Note

- **Owner compliance remains the primary barrier to successful weight loss in pets.**
- **Technology-enhanced weight loss programs (including wearable activity collars, automatic feeders, and smart litterbox devices that incorporate digital scales) may help improve outcomes for obese pets.**

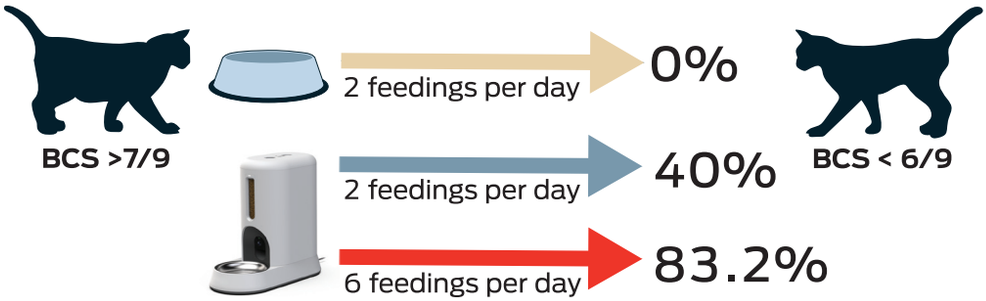

Figure 1. Illustration of results from Witzel-Rollins et al. (2022).[8] Overweight or obese cats on a weight reduction plan were fed twice daily using a regular bowl or fed twice or six times daily using an autofeeder. Cats fed smaller, more frequent meals with the autofeeder were significantly more likely to achieve an ideal body condition.

these improvements in mobility and well-being, no significant changes were found in reported weekly activity. These findings suggest that although weight loss improves mobility and QoL, changes in daily activity may be less easily captured by wearable monitors. Nonetheless, the device provided a user-friendly tool for monitoring activity and may serve as a valuable adjunct in technology-enhanced canine weight loss programs. Further research is needed to determine how such devices might best support owner engagement and adherence.

Smart devices used in successful weight loss programs in cats

More studies have evaluated smart devices in feline weight loss programs, especially in multi-cat households where calorie restriction is difficult to implement. Challenges include food stealing, differing dietary needs, and variable feeding styles among housemates. Technology-enhanced programs may help manage these obstacles by improving portion control and reducing owner burden.

One prospective study of 23 overweight or obese cats compared traditional twice-daily bowl feeding with automatic feeders delivering either two or six meals per day as part of a six-month weight loss program.[8] Cats fed using automatic feeders, particularly those receiving six meals per day, were significantly more likely to reach ideal body condition (**Figure 1**).[8] Owners using automatic feeders reported fewer food-seeking behaviors and found the weight loss plan easier to follow.[8] Another study evaluated a 12-week technology-enhanced program in 15 cats, integrating digital scales, smart feeders, activity monitors, and treat cameras.[9] Owners reported that smart feeders and home scales were particularly valuable, and cats in the technology group achieved greater weekly weight loss than those following traditional dietary restriction alone.[9]

Accurate at-home monitoring of body weight is another essential component of feline weight loss. Smart litterbox devices include integrated scales that automatically record weight during litterbox use; incorporating such passive monitoring tools into weight loss programs may help reduce the frequency of veterinary visits while improving owner compliance.

Conclusions

Obesity is a growing epidemic in companion animals and is associated with significant metabolic, orthopedic, and quality-of-life consequences. While traditional obesity management focuses on calorie restriction and increased activity, incorporating smart devices such as wearable activity monitors, automatic feeders, and smart litterboxes may enhance owner engagement and support successful weight loss. Technology-enhanced programs represent a promising strategy to address the rising prevalence of obesity in dogs and cats.

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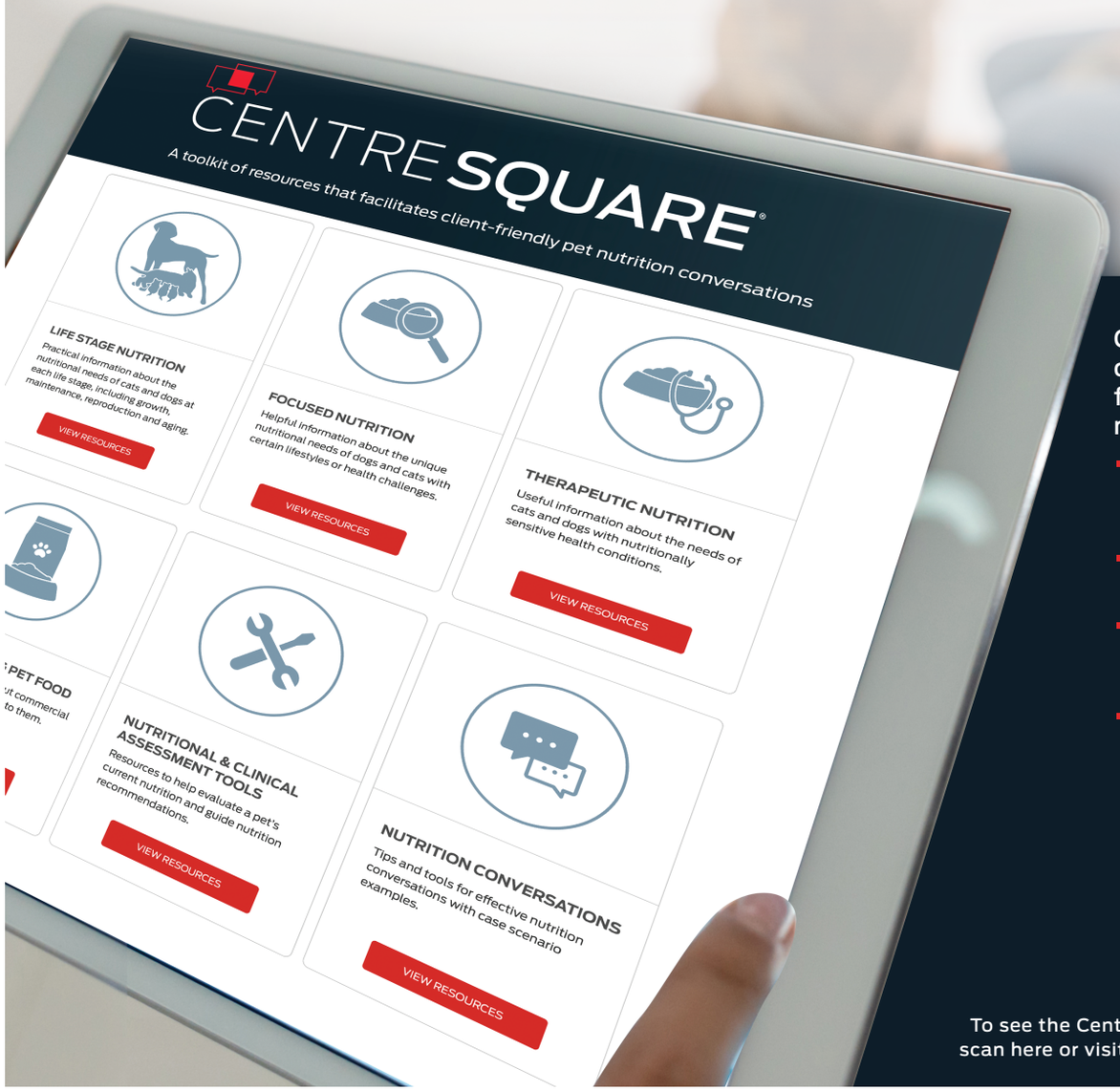

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