Purina® PRO PLAN® Symposium 2026
Navigating Microbiota Dynamics
Applicable to Pet Nutrition

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symposium

Microbiota Modulation Through the Diet: How Much Do We Know?

ESCG
European Society of Comparative Gastroenterology

Kelly. S. Swanson
University of Illinois Urbana-Champaign

Presentation Overview

- What is “gut health”?
- Modulating gut microbiome
  - Dietary fibers
  - Prebiotics
  - Probiotics
  - Synbiotics
  - Postbiotics
- Ongoing challenges
- Future directions

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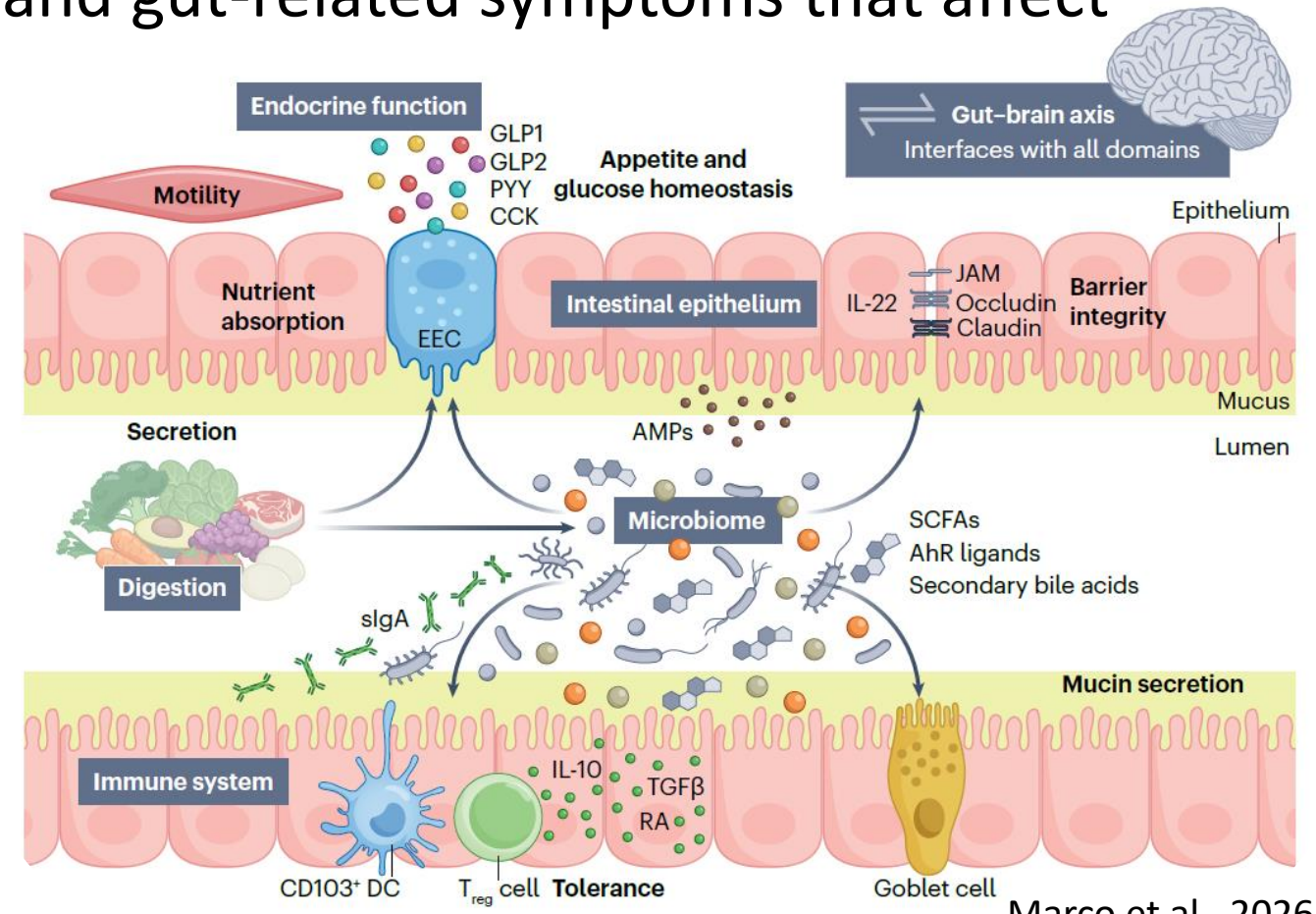
Gut Health

- ISAPP consensus paper:
  - “a state of normal gastrointestinal function without active gastrointestinal disease and gut-related symptoms that affect quality of life”

- Functional domains
  - Digestive physiology
  - Gut microbiome
  - Intestinal epithelium
  - Immune function
  - Endocrine function
  - Gut-brain axis



Marco et al., 2026

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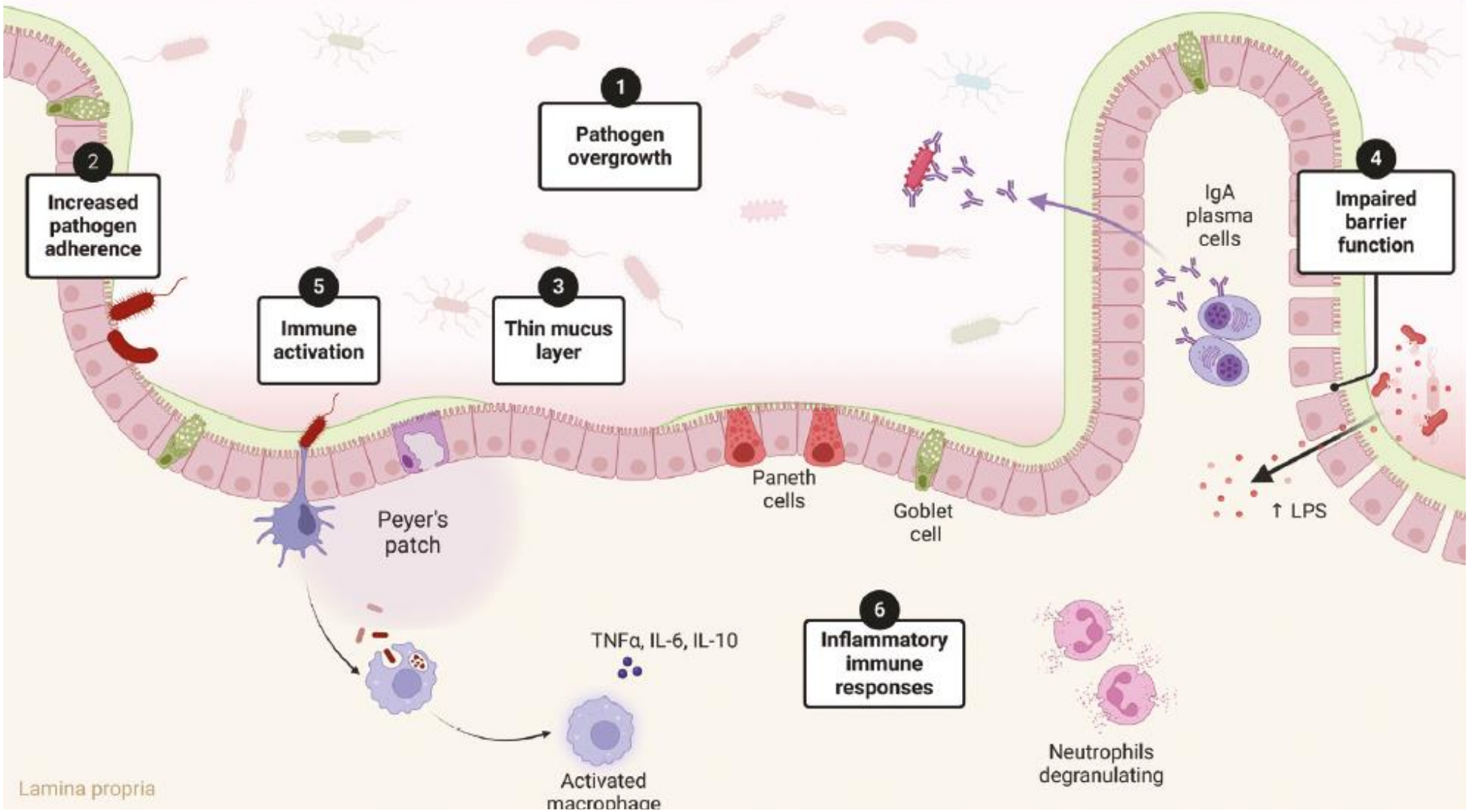
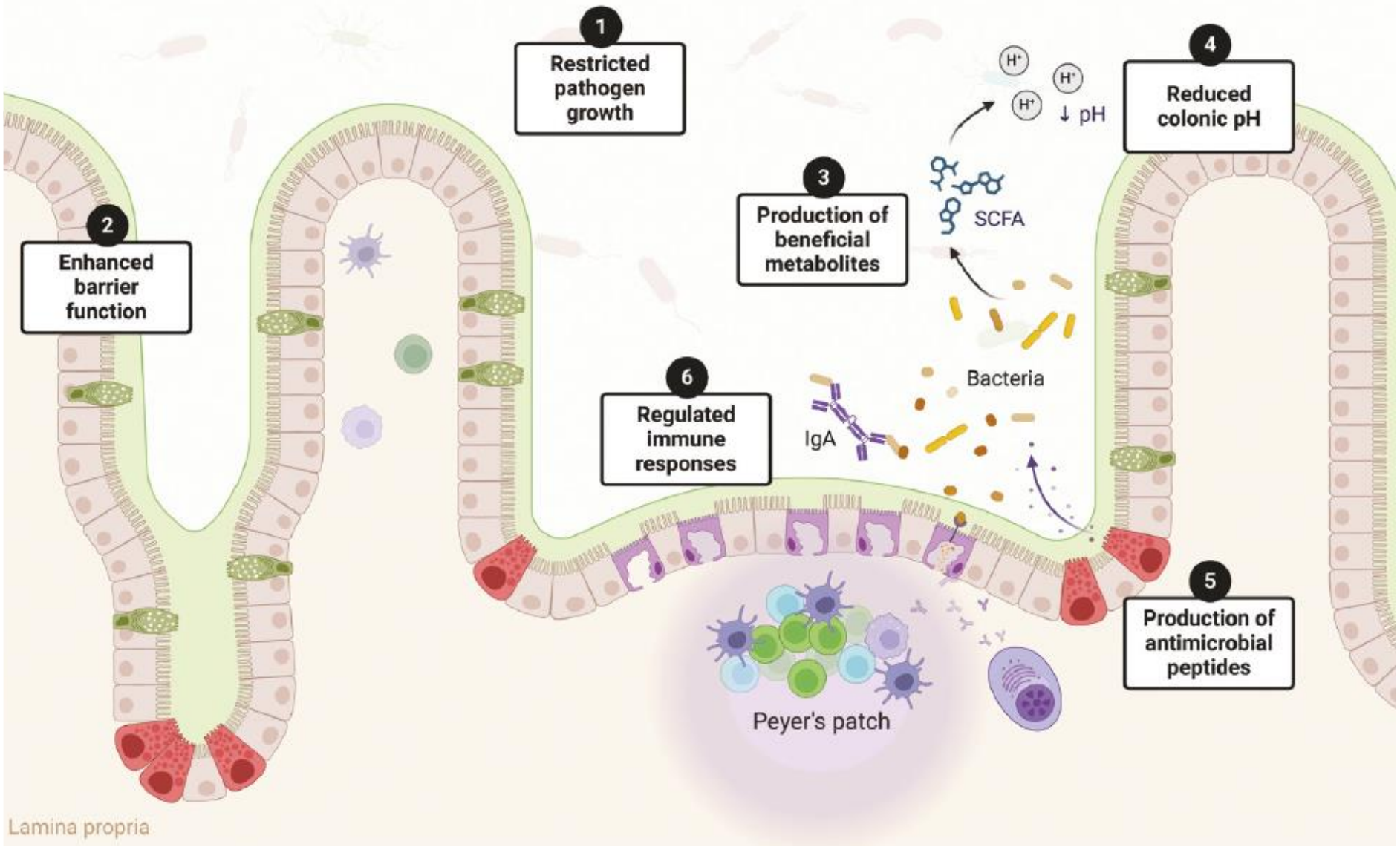
Characteristics of Disease and/or Dysbiosis



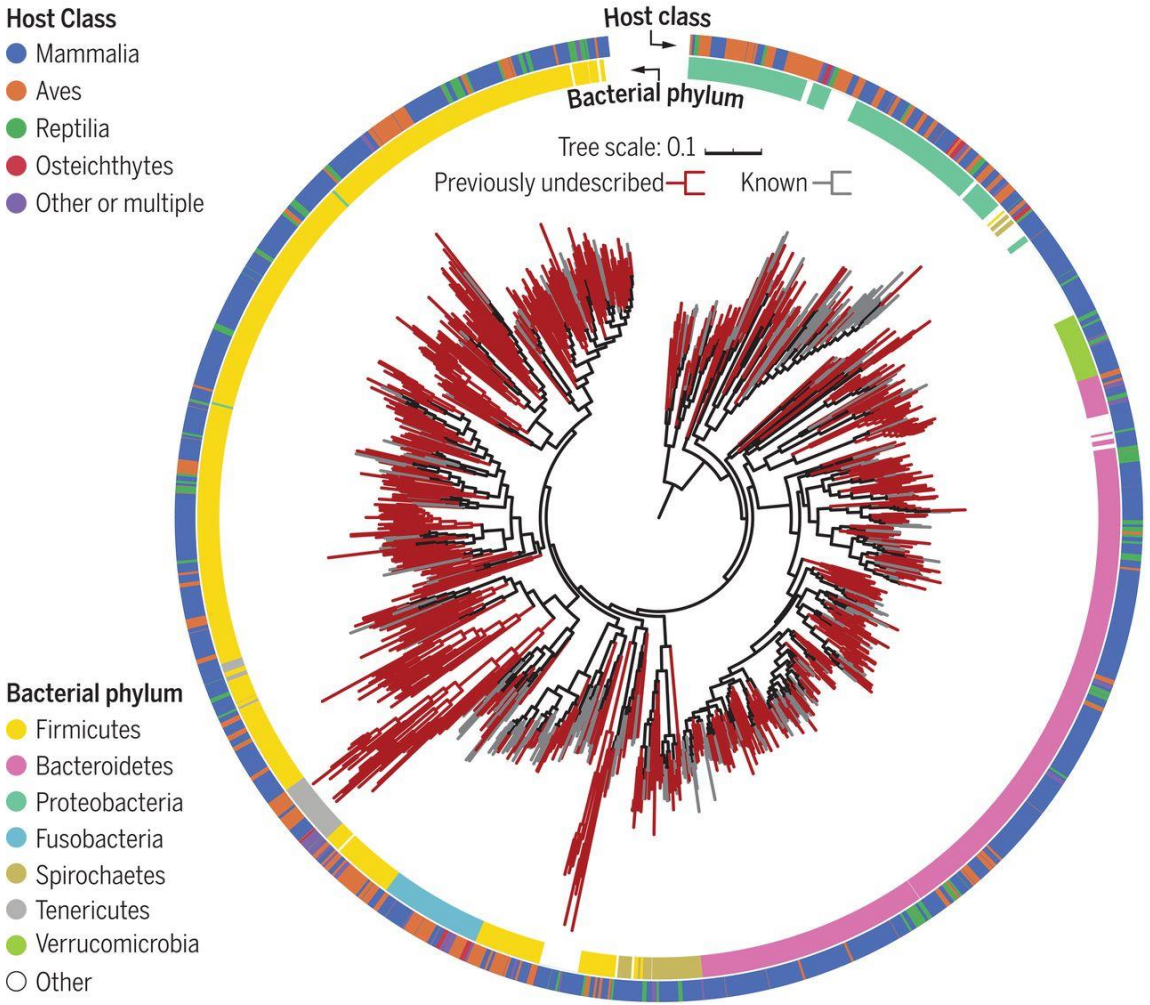
Wilson and Swanson, 2024

Benefits of Supporting the Gut Microbiome



Wilson and Swanson, 2024

Gut Microbiome



Impact of Changes in Gastrointestinal Microbiota in Canine and Feline Digestive Diseases

Anna-Lena Ziese, Dr med vet[a], Jan S. Suchodolski, Dr med vet, PhD[b,*]

Effects of metronidazole on the fecal microbiome and metabolome in healthy dogs

Rachel Pilla[1] | Frederic P. Gaschen[2] | James W. Barr[1] | Erin Olson[2] | Julia Honneffer[1] | Blake C. Guard[1] | Amanda B. Blake[1] | Dean Villanueva[1] Mohammad R. Khattab[1] | Mustafa K. AlShawaqfeh[3] | Jonathan A. Lidbury[1] | Jörg M. Steiner[1] | Jan S. Suchodolski[1]

Article

Effects of Metronidazole on the Fecal Microbiota, Fecal Metabolites, and Serum Metabolites of Healthy Adult Cats

Sara E. Martini [1], Teresa Schmidt [2], Wenyi Huang [2], Amanda B. Blake [2], João P. Cavasin [2], Jan S. Suchodolski [2,*] and Kelly S. Swanson [1,3,4,*]

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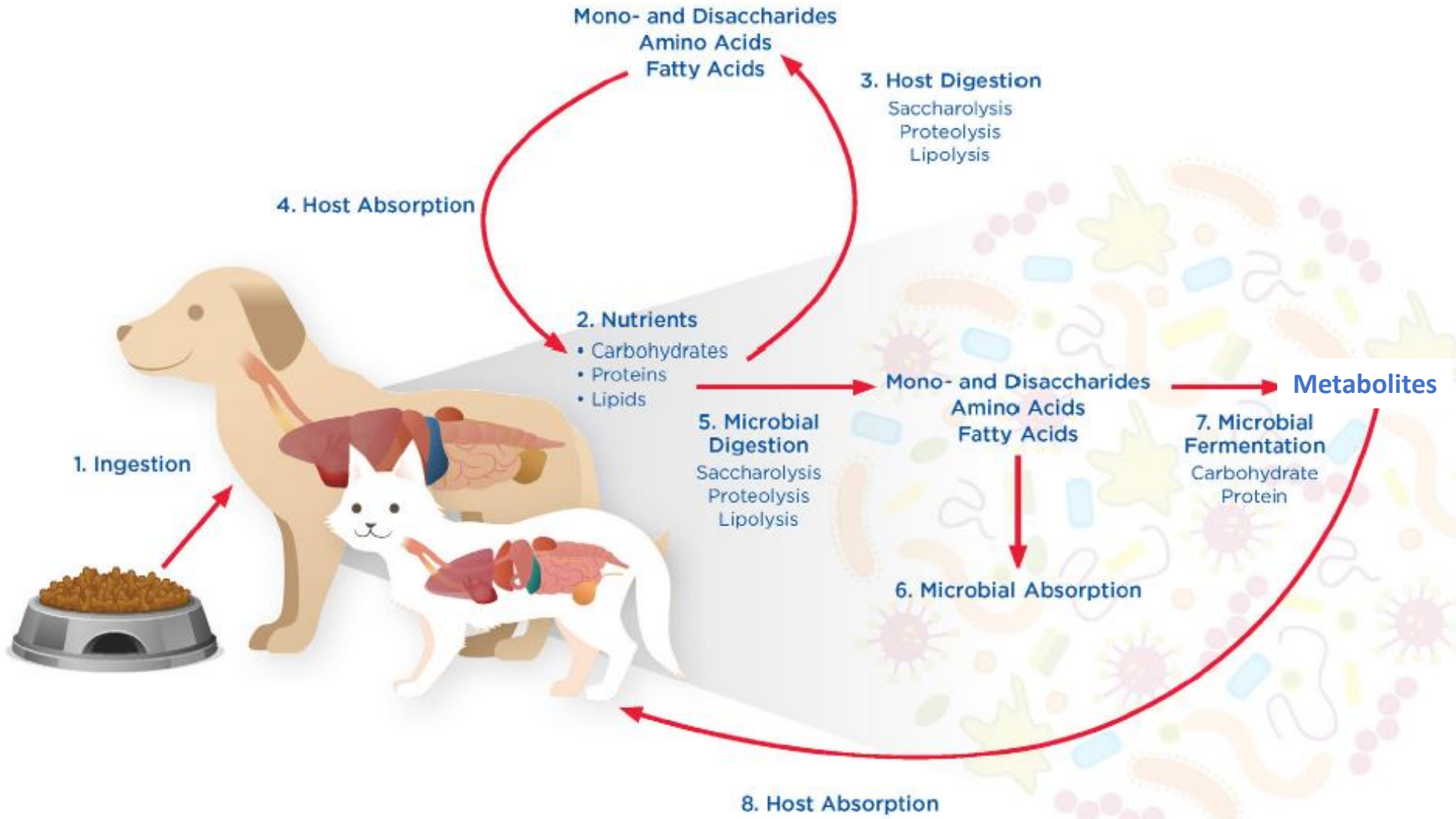
Pilla et al., 2020; Levin et al., 2021; Ziese and Suchodolski, 2021; Martini et al., 2025

Feeding the Gut Microbiome



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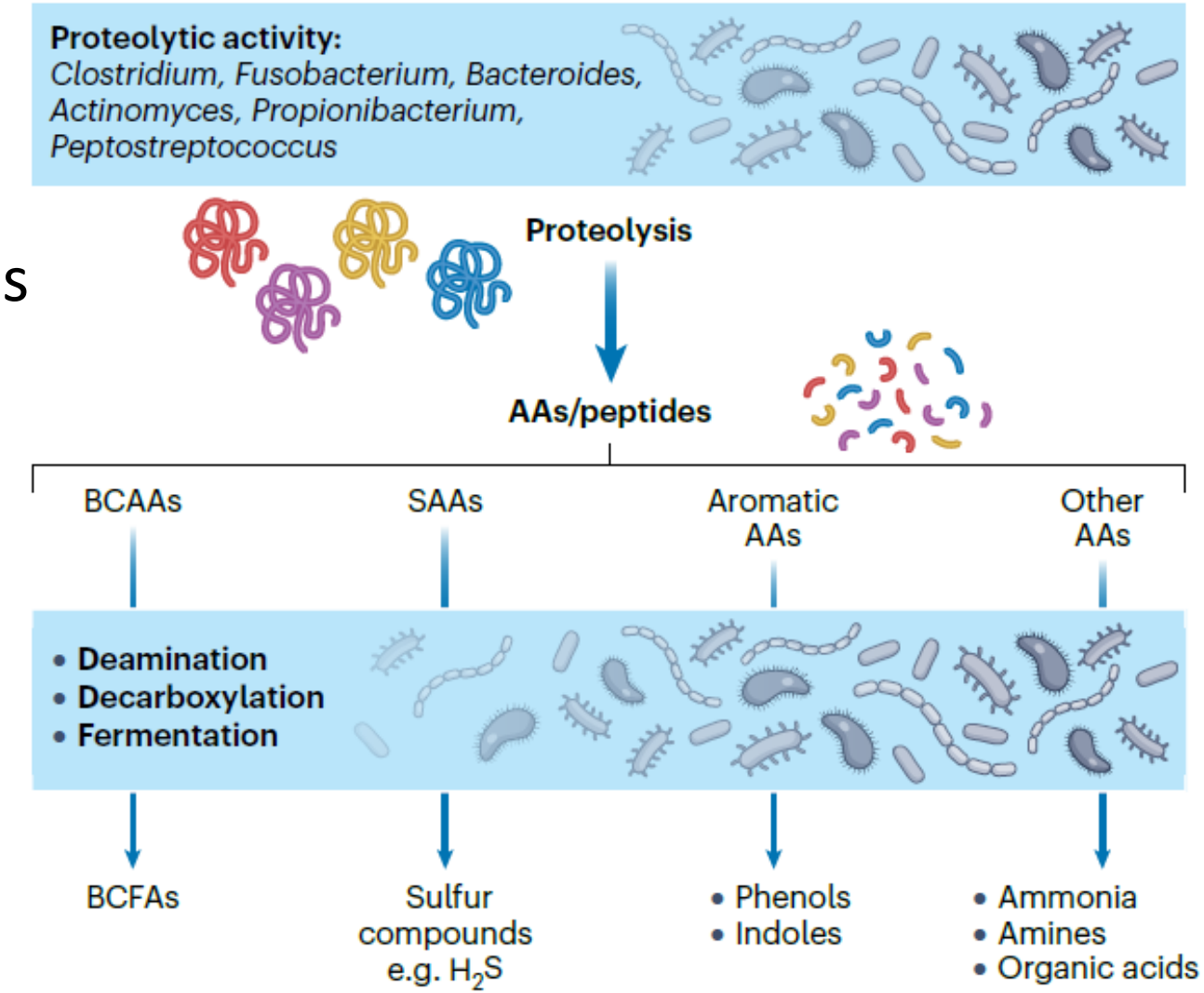
Wernimont et al., 2020

Proteolytic Fermentation

- Dietary proteins
- Endogenous
  - Gastrointestinal secretions
  - Urea
  - Mucins
  - Bacterial cell lysis
  - Sloughed epithelial cells
- Associations
  - Poor stool quality
  - Intestinal disease



Davis et al., 2026

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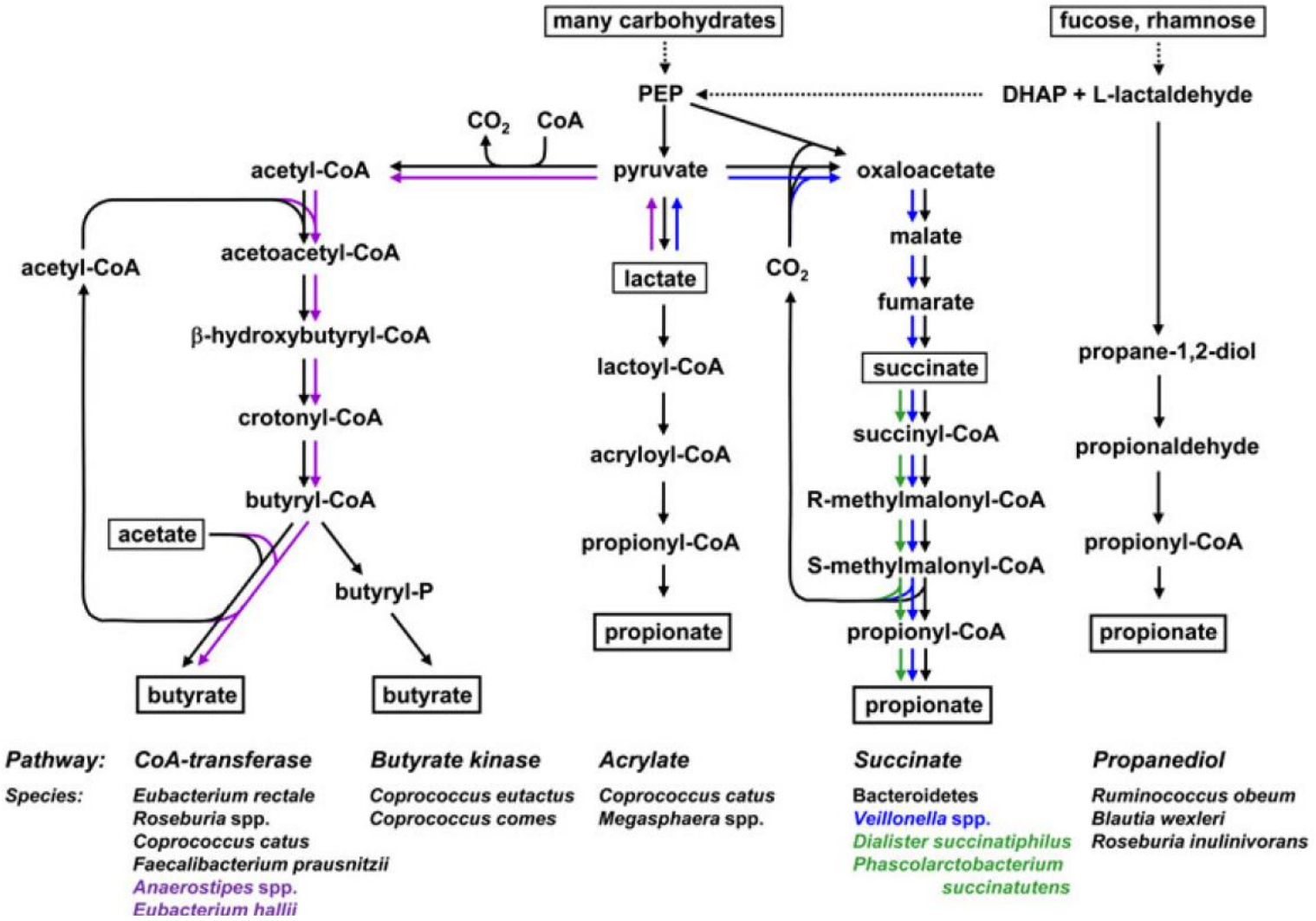
Saccharolytic Fermentation

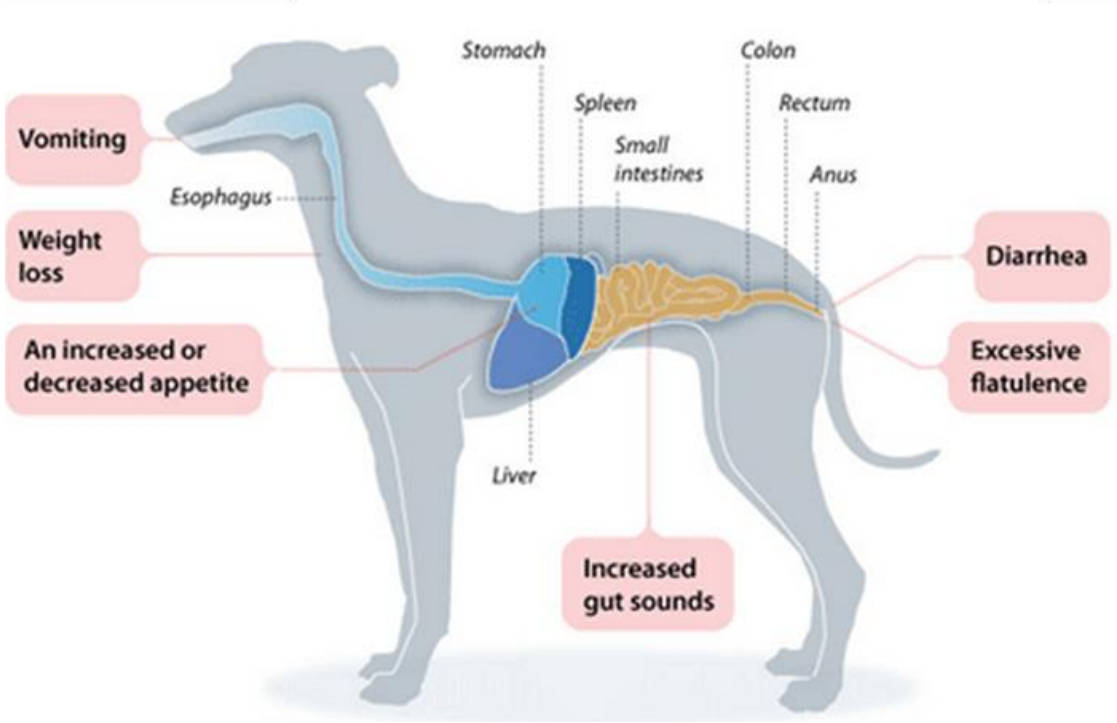
- Substrates
  - Dietary fibers
  - Oligosaccharides
  - Resistant starch
- SCFA benefits
  - Energy
  - Lower pH
  - Gut barrier
  - Immunity
  - Gut peptides



Flint et al., 2012

Strategies to Modulate Gut Microbiome

- Primary options
  - ‘Biotic’ supplements
  - Over-the-counter (OTC) diets
    - Fiber blends; ‘biotics’
  - Therapeutic (prescription) diets
    - Low residue
    - Low residue-restricted fat
    - Fiber-enhanced foods



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Dietary Fiber

- Many definitions in past based on chemistry, physiological responses, or health outcomes

- FDA (2016)
  - Non-digestible soluble and insoluble carbohydrates (with 3 or more monomeric units) and lignin that are intrinsic and intact in plants

  - Isolated or synthetic non-digestible carbohydrates (with 3 or more monomeric units) determined by FDA to have physiological effects beneficial to human health

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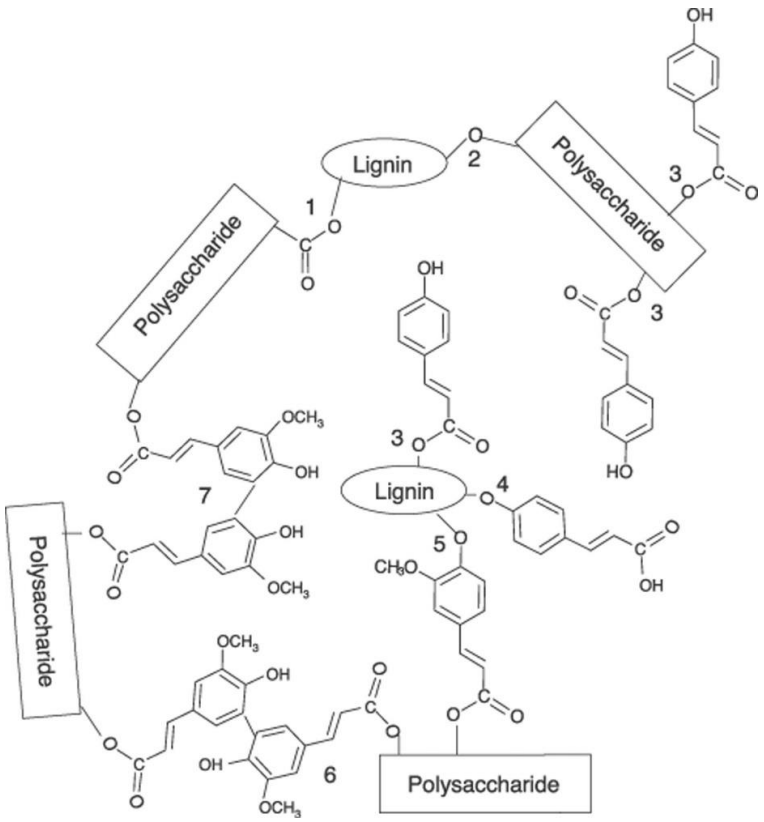
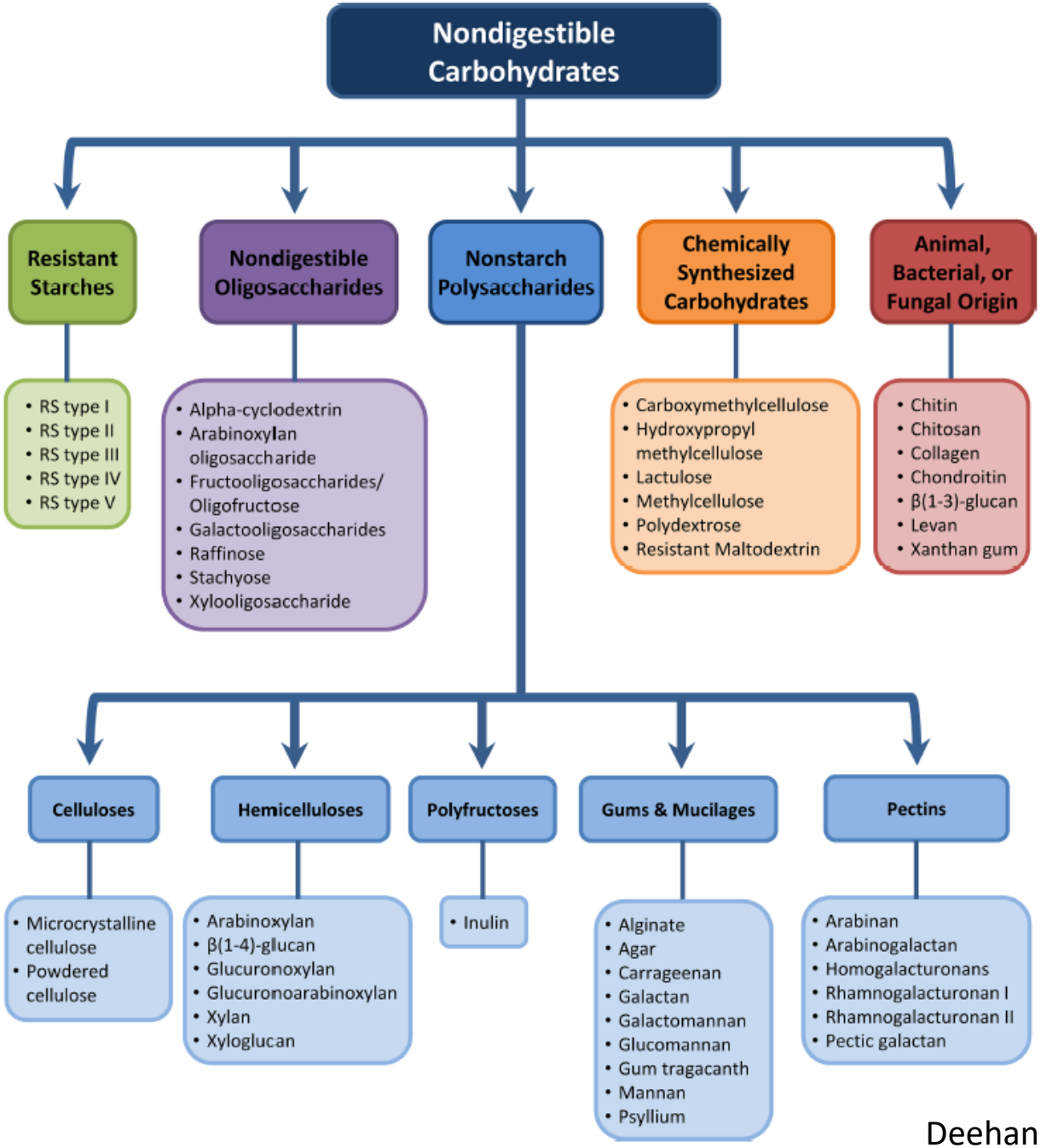
FDA

It's Complicated!





Deehan et al., 2017

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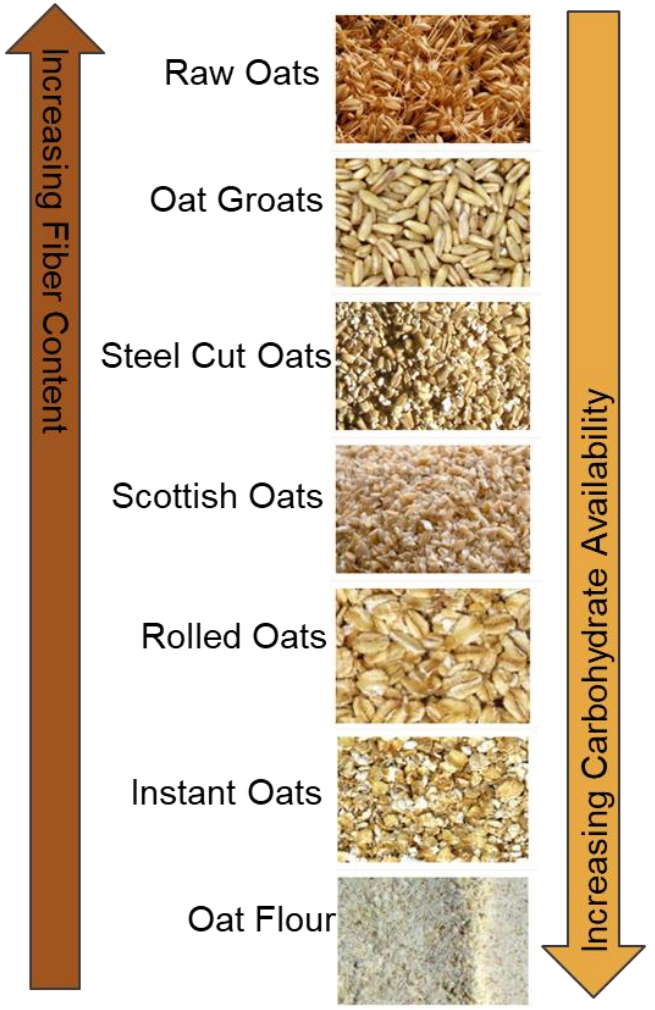
Fiber-Rich Ingredients in Pet Foods

- Beet pulp
- Wood cellulose
- Peanut hulls
- Miscanthus grass
- Grain co-products
  - Wheat bran, wheat middlings, soy hulls, corn fiber
- Pomaces and pulps
  - Apple, carrot, tomato, etc.
- Gums
  - Canned diets



Poutanen et al., 2018

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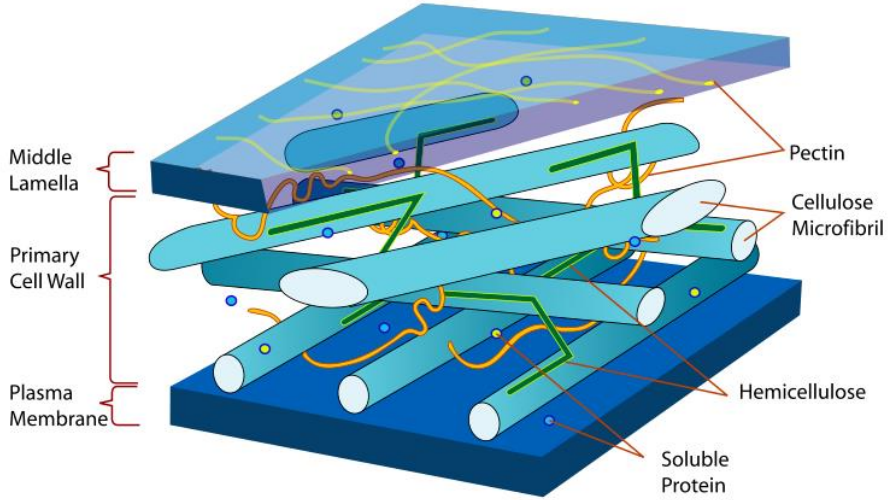
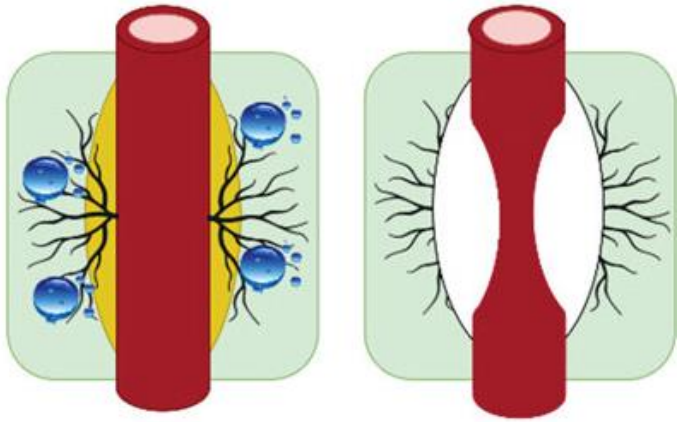
Few Fibers are Pure

- Complex mixtures
  - Fibers, proteins, etc.
- Chemical linkages/MW
- Physicochemical properties
  - Solubility
  - Fermentability
  - Viscosity
  - Water-holding capacity





Gurupranes et al., 2023

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Effects of Fiber on Stomach/Small Intestine

	Dietary fiber type	
Response criteria	Soluble – viscous – fermentable	Insoluble – nonviscous - nonfermentable
Gastric emptying	Delays	Delays or no effect
Transit rate	Decreases	Increases
Transit time	Increases	Decreases
Ileal nutrient digestibility	No effect	No effect
Total tract nutrient digestibility	Decreases protein	Decreases dry matter and protein
Mineral bioavailability	Increases Ca and Mg	Decreases total ash or no effect

Fahey et al., 2004

Effects of Fiber on Large Intestine

	Dietary fiber type	
Response criteria	Soluble – viscous – fermentable	Insoluble – nonviscous - nonfermentable
Wet stool bulk	Increases or no effect	Increases
Fecal moisture	No effect	Decreases or no effect
Defecation frequency	No effect in dogs; increases in cats	Increases
Prebiotic effect	Yes	No
SCFA production	Increases	Slight increase
Colonic weight/length	Increases	No effect
Colonic absorptive area	Increases	No effect

Fahey et al., 2004

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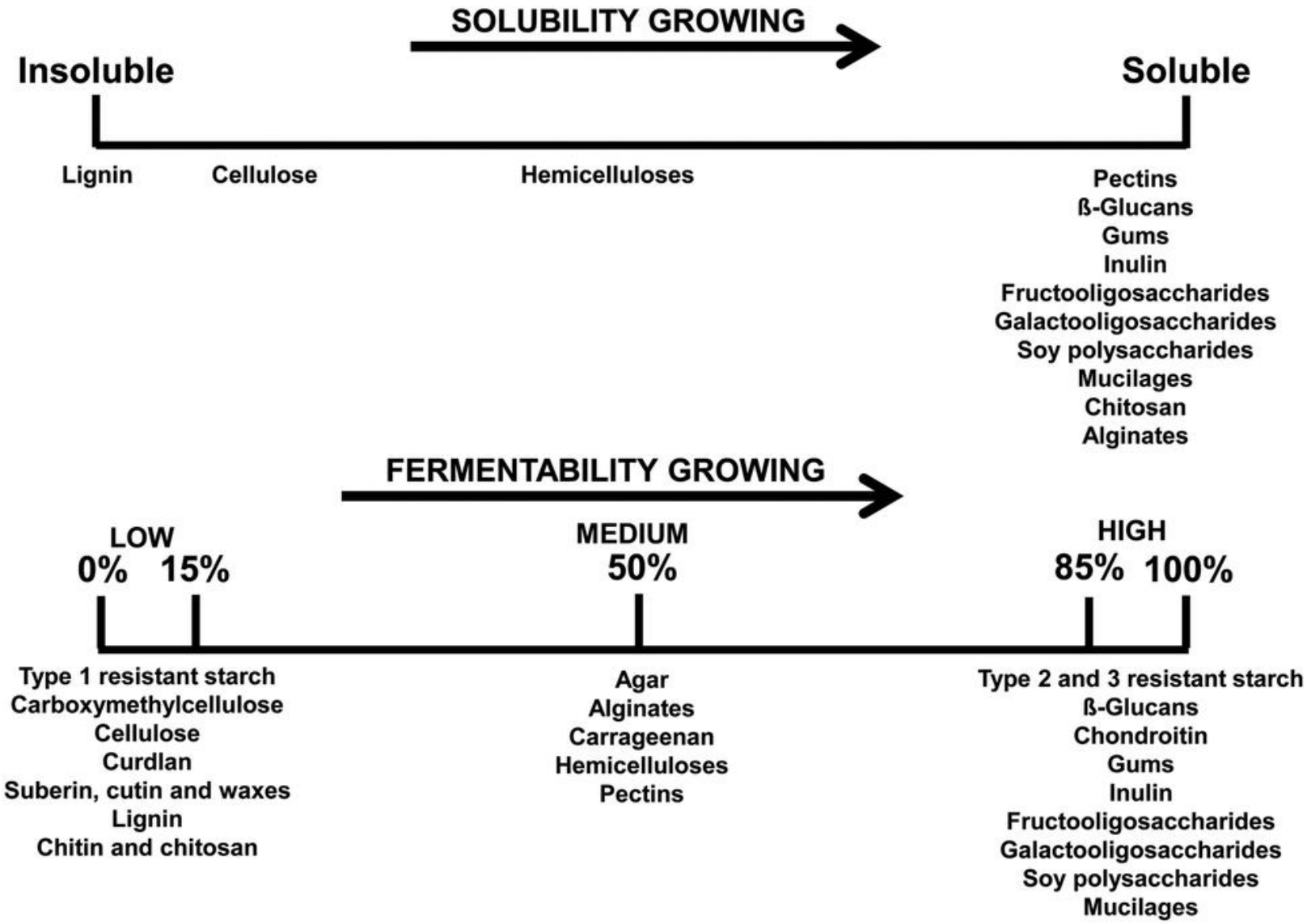
Fiber Solubility and Fermentability

Particle size

Molecular weight

Chemical linkages

Physicochemical properties



Aleixandrea and Miguel, 2016

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Fiber Sources and SCFA-Producing Bacteria

Substrates	Dietary source	Fermenting genera
Resistant starch	Cashew, green banana, white beans, oat and potato	• *Ruminococcus* • *Bacteroides*
Cellulose	Seaweed and cereal bran	• *Bacteroides* • *Ruminococcus*
Hemi-celluloses (xylan and arabinoxylan)	Cereal bran	• *Bacteroides* • *Roseburia* • *Prevotella*
Pectin	Apples, apricots, cherries, oranges and carrots	• *Eubacterium* • *Bacteroides* • *Faecalibacterium*
Fructans (inulin and fructooligosaccharides)	Asparagus, leek, onions, banana, wheat, garlic, chicory and artichoke	• *Bacteroides* • *Faecalibacterium*

Substrates	Dietary source	Fermenting genera
β-Glucan	Oat, barley, wheat, rye, mushrooms and seaweed	• *Eubacterium* • *Atopobium* • *Enterococcus* • *Lactobacillus* • *Prevotella* • *Clostridium* cluster XIVa
Gum arabic	Acacia tree and prepared food additive	• *Bifidobacterium* • *Lactobacillus* • *Ruminococcus*
Galacto-oligosaccharides	Artichoke, beans, beetroot, broccoli, chickpeas, fennel, lentils, lettuce, radicchio and onion	*Bifidobacterium*
Raffinose and stachyose	Cottonseed flour, soy flour, onions, chickpeas, beans, peas and lentils	• *Bifidobacterium* • *Lactobacillus*

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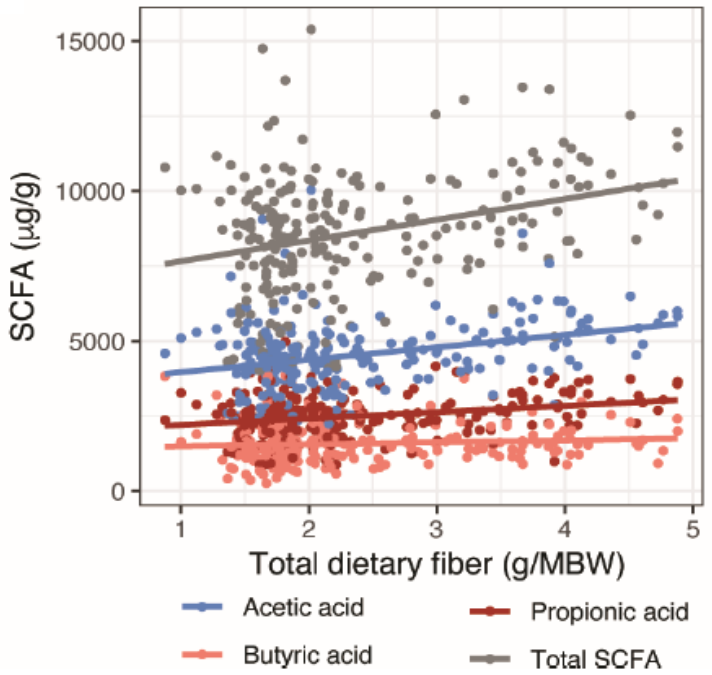
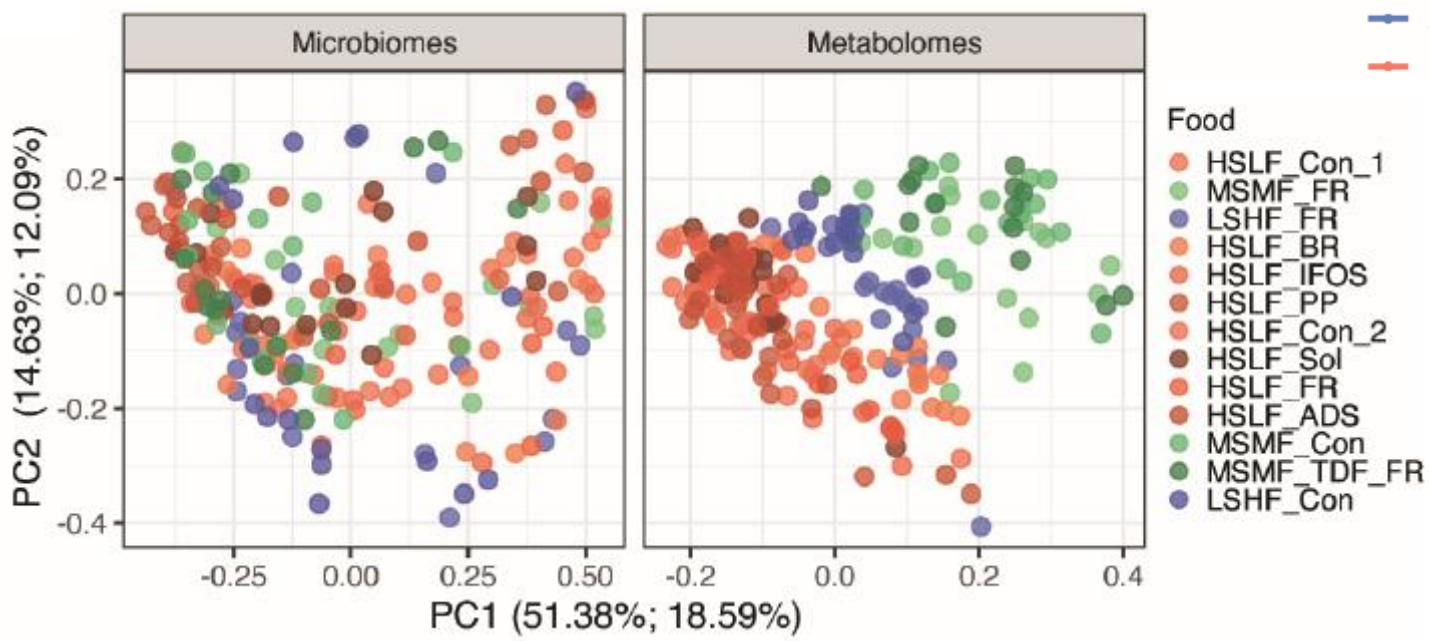
Dalile et al., 2019

Dietary Fiber Responses

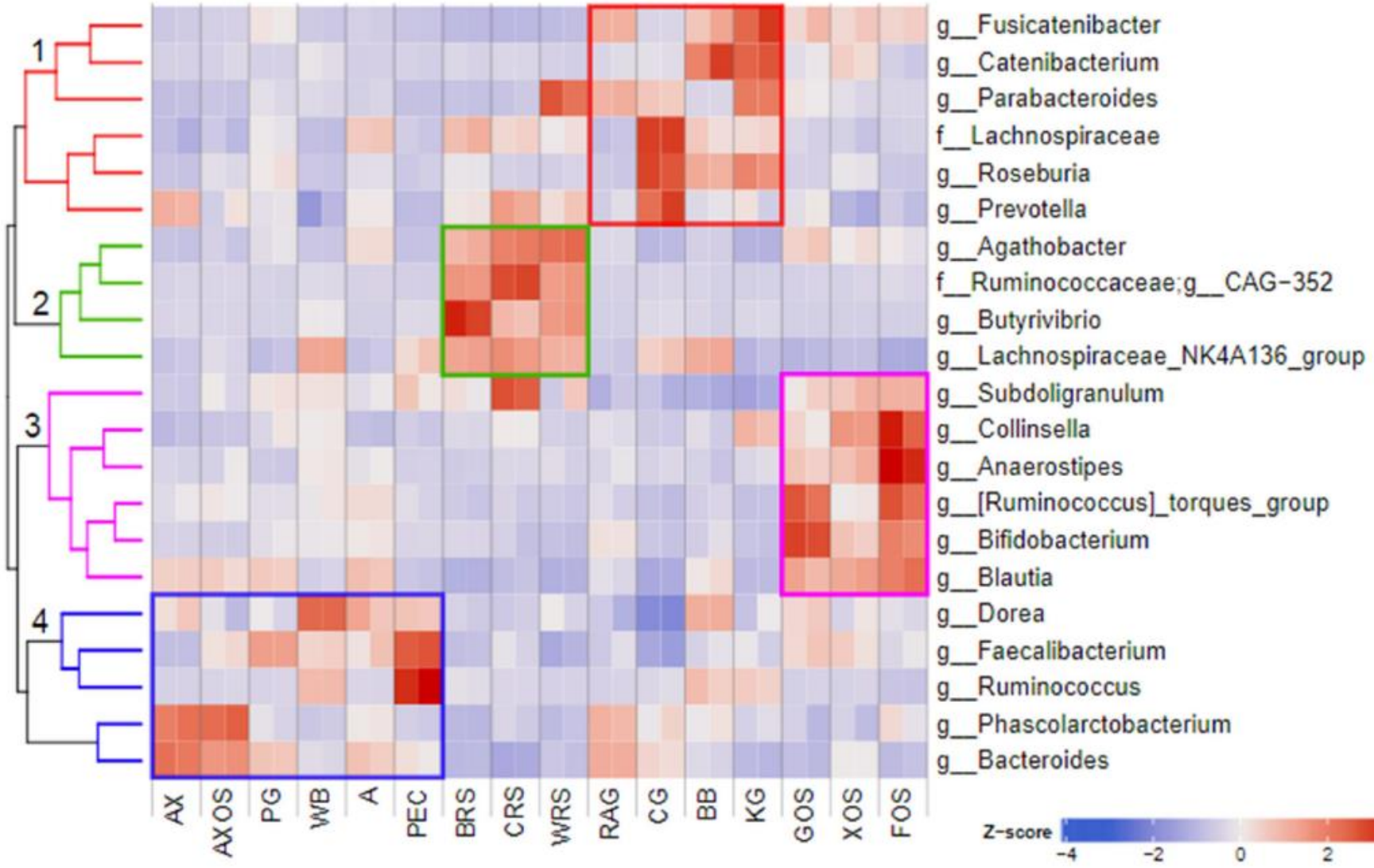
- Laxation and improved stool quality
- Microbial activity often altered
  - Beneficial fecal metabolites shifts
  - Microbiota shifts





Bhosle et al., 2025

Response Depends on Fiber Characteristics



Cantu-Jungles et al., 2025

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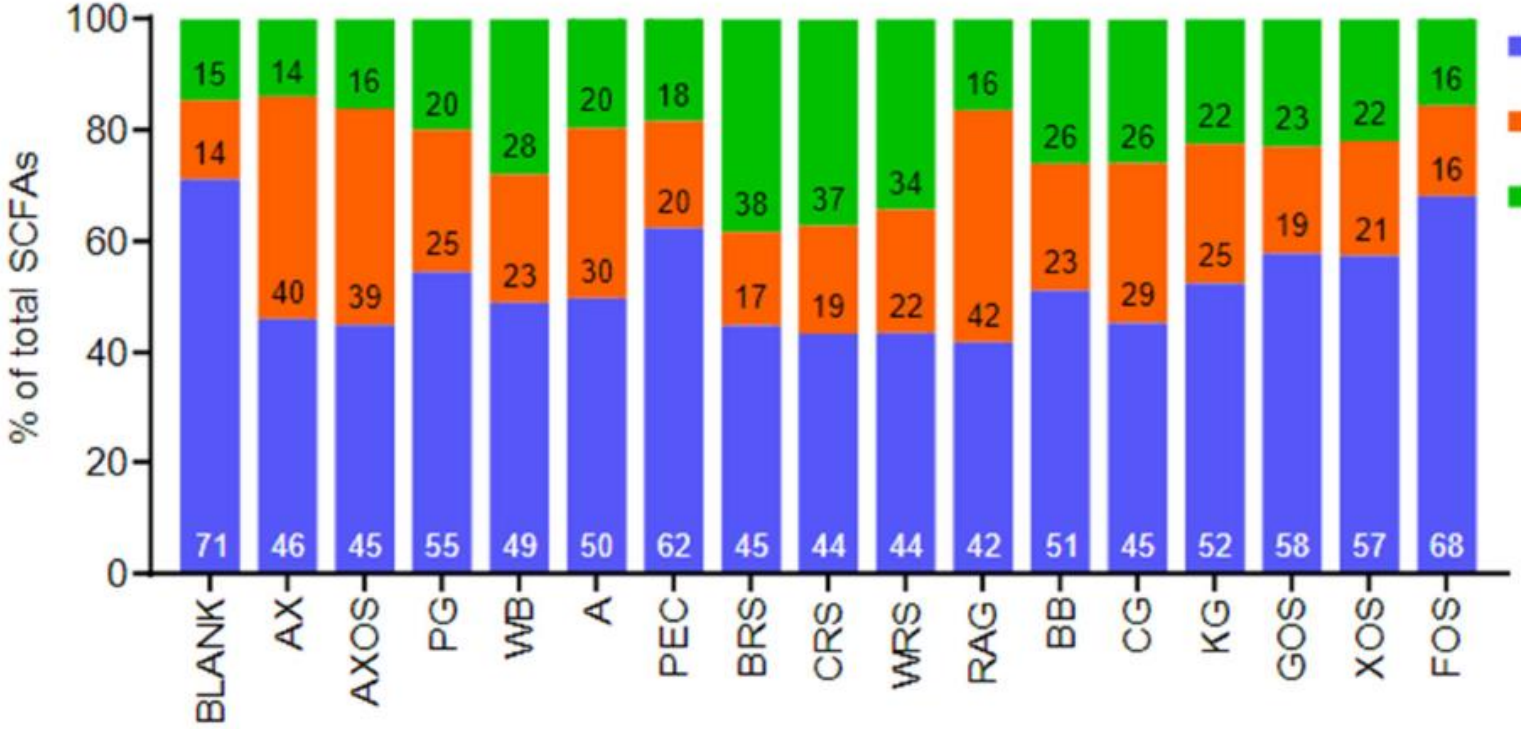
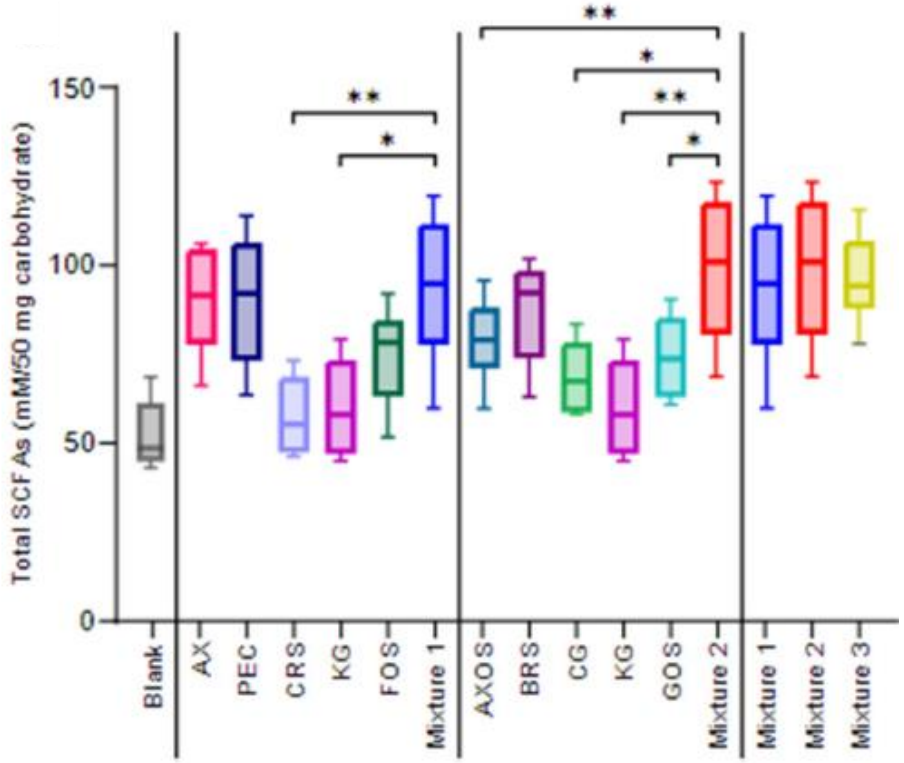
Response Depends on Fiber Characteristics





*Synergistic fiber blends support complementary microbial groups

Cantu-Jungles et al., 2025

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Prebiotics

EXPERT CONSENSUS DOCUMENT

The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics

Glenn R. Gibson[1], Robert Hutkins[2], Mary Ellen Sanders[3], Susan L. Prescott[4], Raylene A. Reimer[5], Seppo J. Salminen[6], Karen Scott[7], Catherine Stanton[8], Kelly S. Swanson[9], Patrice D. Cani[10], Kristin Verbeke[11] and Gregor Reid[12]

"A substrate that is selectively utilized by host microorganisms conferring a health benefit"

Gibson et al., 2017

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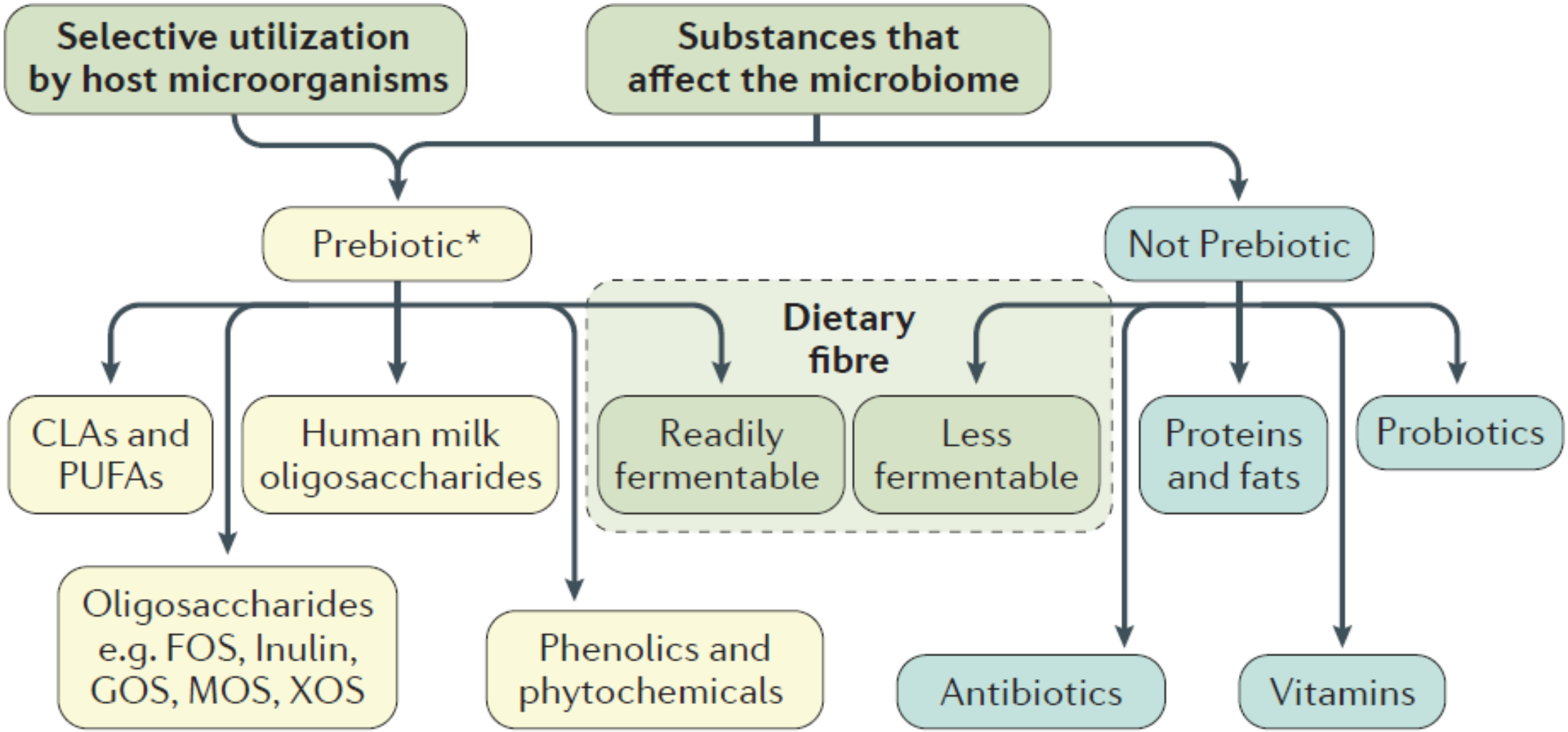
Prebiotic Types



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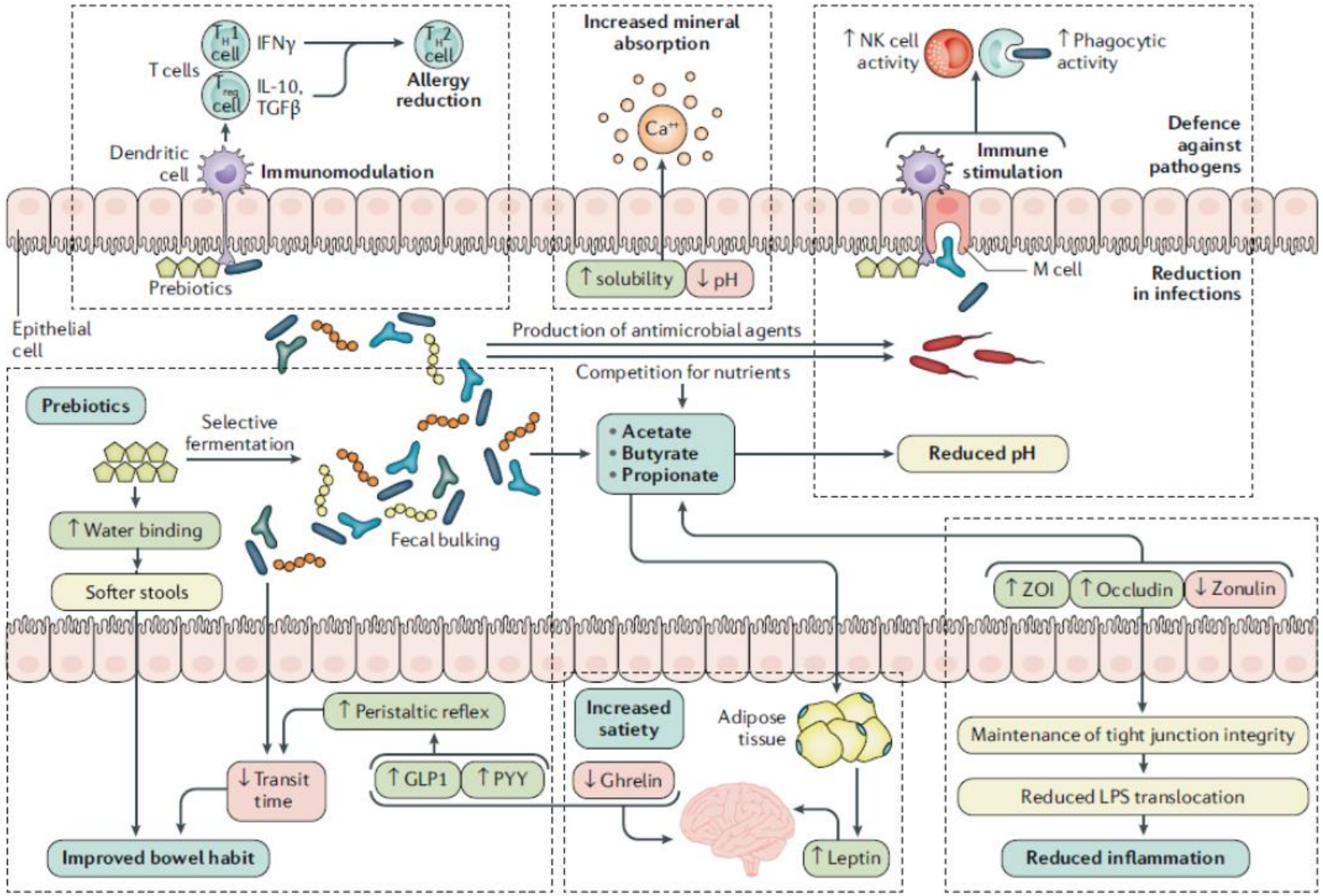
Gibson et al., 2017

Prebiotic Mechanisms

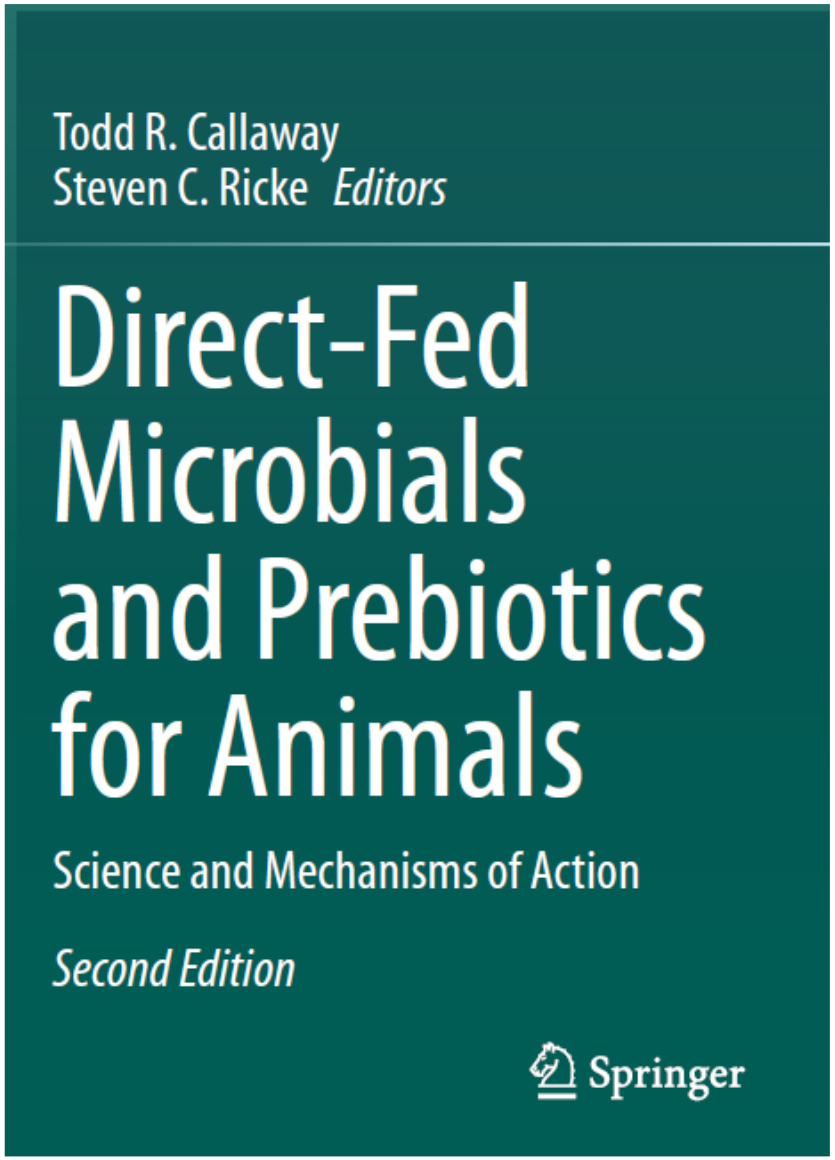


Sanders et al., 2019

Common Prebiotic Responses

Chapter 8
Probiotics and Prebiotics: Application to Pets

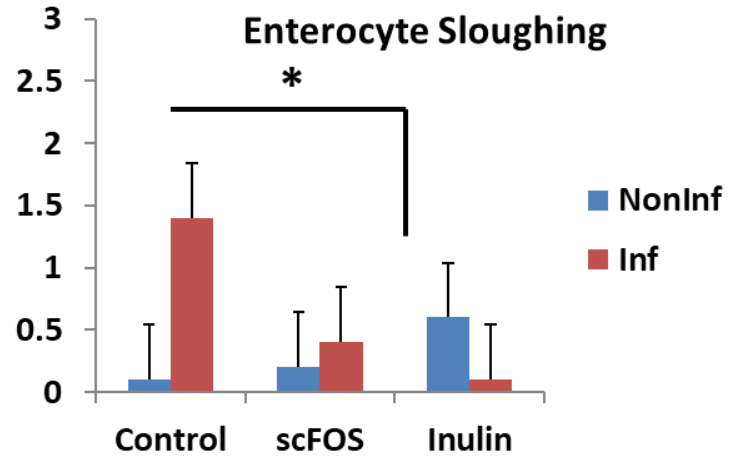
Ching-Yen Lin, Celeste Alexander, Brittany M. Vester Boler, George C. Fahey Jr., and Kelly S. Swanson

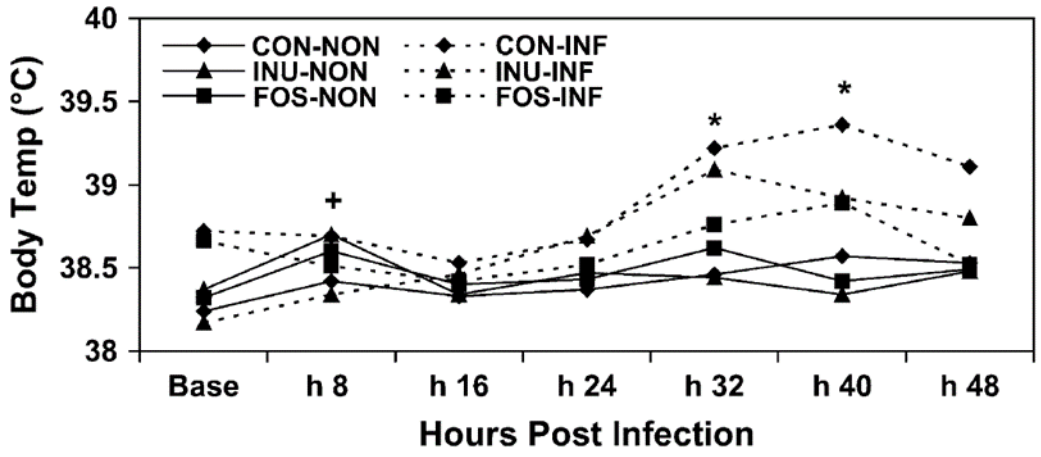


Lin et al., 2023

Common Prebiotic Responses

- Laxation and improved stool quality
- Protection against pathogens
- Microbial activity often altered
  - Beneficially modify fecal metabolites (less odor)
  - Microbiota shifts
    - ↑*Lactobacillus*
    - ↑ *Bifidobacterium*
    - ↑ *Faecalibacterium*
    - ↓*C. perfringens*
    - ↓*E. coli*





Apanavicius et al., 2007; Patra, 2011

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Probiotics

EXPERT CONSENSUS DOCUMENT

The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic

Colin Hill, Francisco Guarner, Gregor Reid, Glenn R. Gibson, Daniel J. Merenstein, Bruno Pot, Lorenzo Morelli, Roberto Berni Canani, Harry J. Flint, Seppo Salminen, Philip C. Calder and Mary Ellen Sanders

"Live microorganisms that, when administered in adequate amounts, confer a health benefit on the host"

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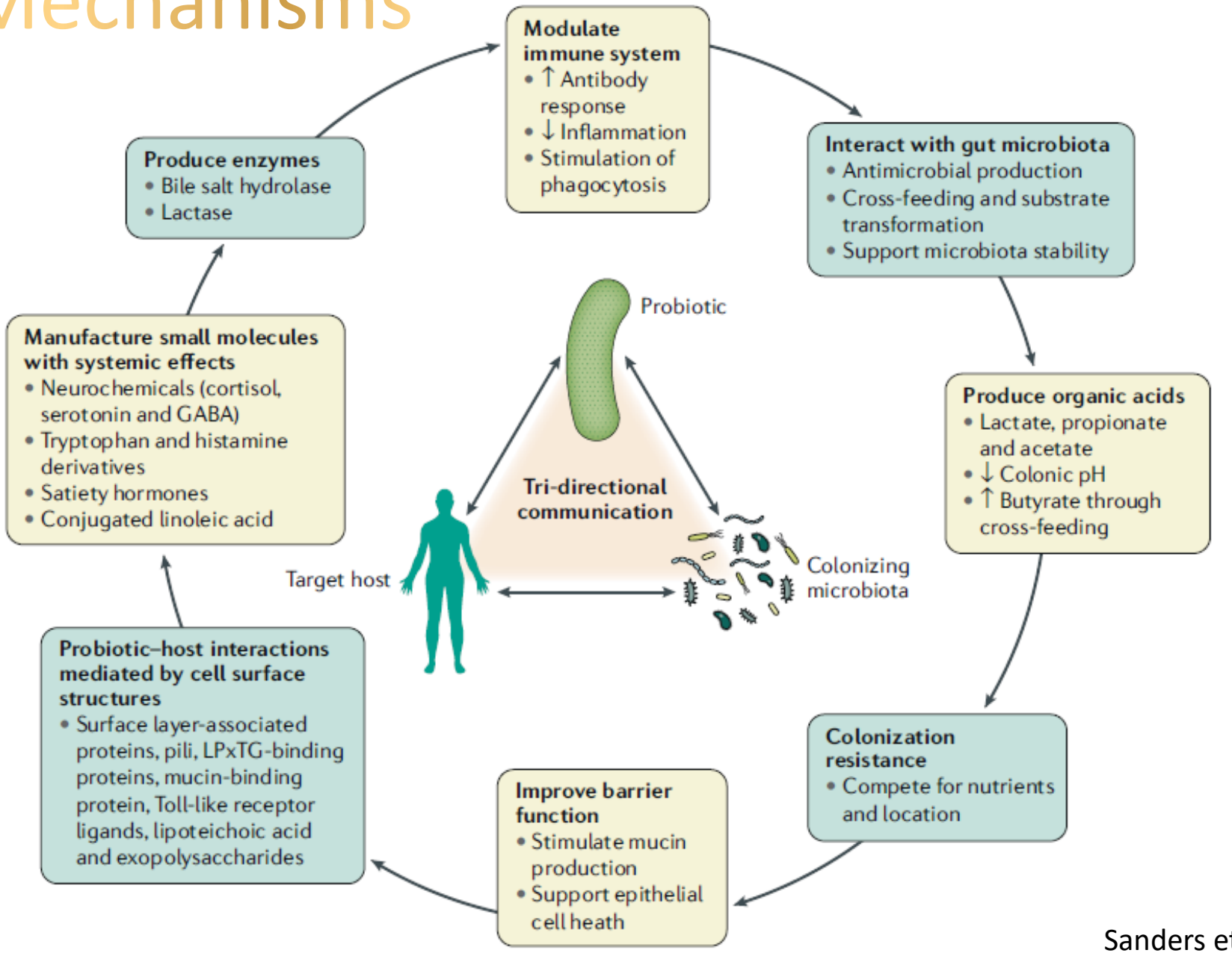
Hill et al., 2014

Probiotic Mechanisms



Sanders et al., 2019

Probiotics

- Common taxa
  - *Bacillus*
  - *Bifidobacterium*
  - *Enterococcus*
  - *Lactobacillus*

- Many forms
  - Powders or capsules
  - Gels, pastes, or liquids
  - In diet, treats, or toppers

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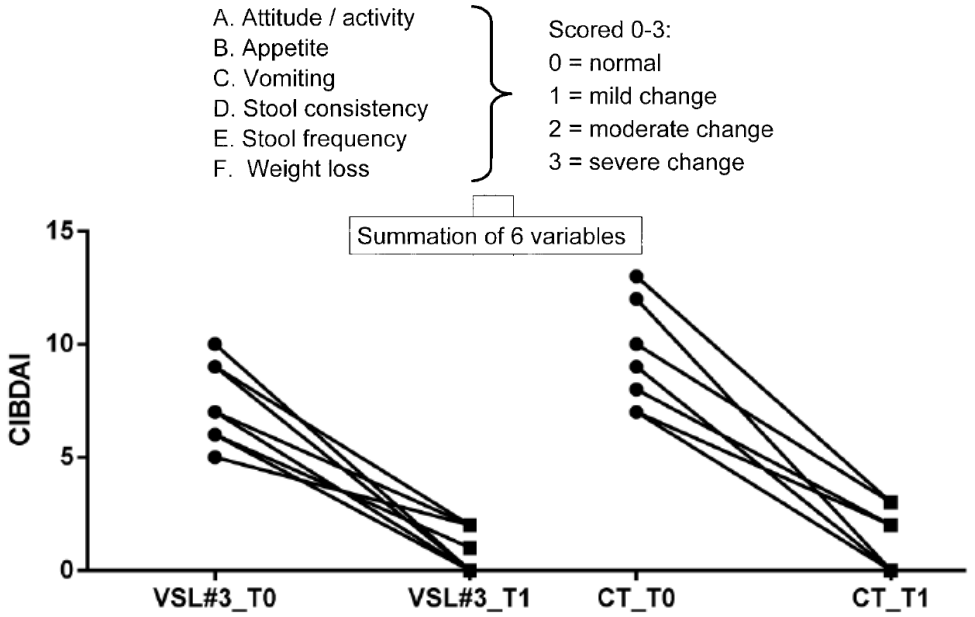
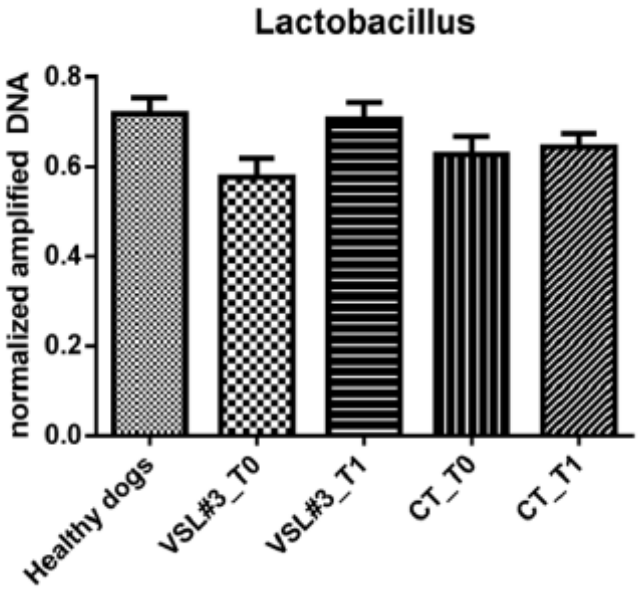
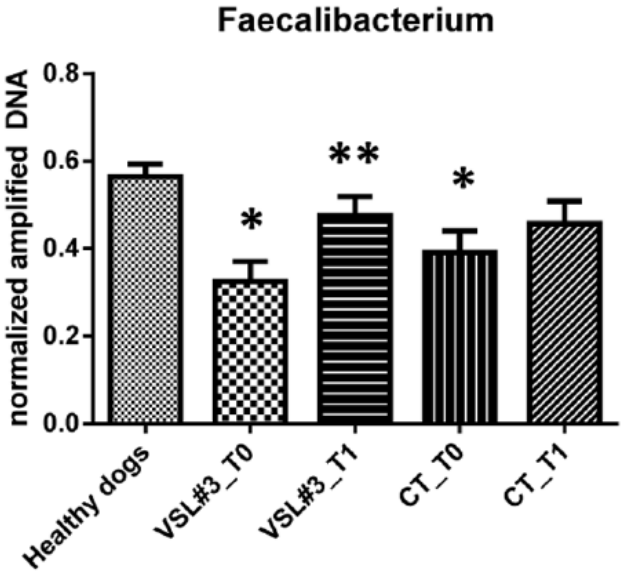
Probiotic Evidence

- Dogs with idiopathic IBD
  - VSL#3: 112 to 225 x 10^9 cfu/10 kg BW for 60 d
  - Drug therapy: metronidazole + prednisone







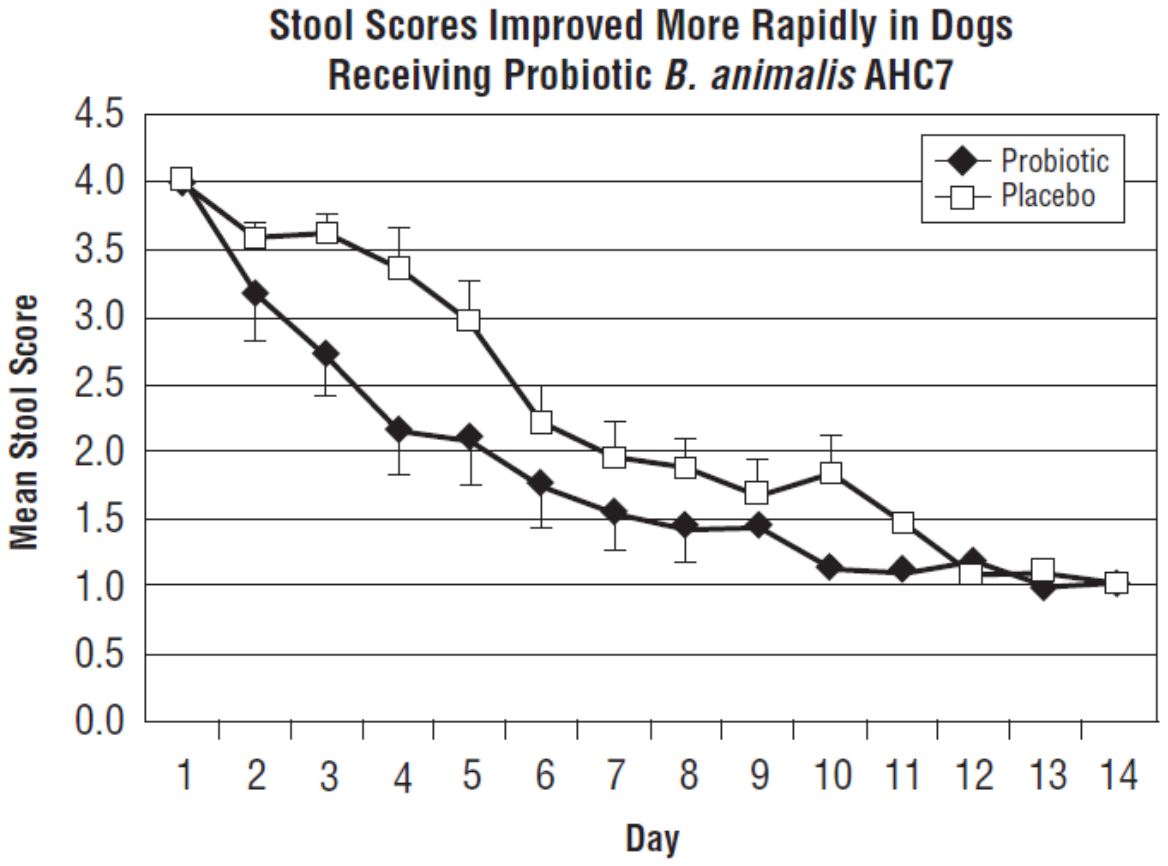
Rossi et al., 2014

Probiotics

- Some of the best evidence
  - Reduced incidence or length of diarrhea
  - Gut microbiota not measured

Clinical Benefits of Probiotic Canine-Derived *Bifidobacterium animalis* Strain AHC7 in Dogs with Acute Idiopathic Diarrhea*

R. L. Kelley, MS[a,†]
Debbie Minikhiem, MS[a]
Barry Kiely, PhD[b]
Liam O'Mahony, PhD[b,‡]
David O'Sullivan, PhD[b]
Tom Boileau, PhD[a]
Jean Soon Park, PhD[a]



Kelley et al., 2009

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Probiotics

- Some of the best evidence
  - Reduced incidence or length of diarrhea
  - Gut microbiota not measured/altered

J Vet Intern Med 2011;25:856–860

Effect of the Probiotic *Enterococcus faecium* SF68 on Presence of Diarrhea in Cats and Dogs Housed in an Animal Shelter

S.N. Bybee, A.V. Scorza, and M.R. Lappin

Effects of a probiotic intervention in acute canine gastroenteritis – a controlled clinical trial

Randomized placebo-controlled trial of feline-origin *Enterococcus hirae* probiotic effects on preventative health and fecal microbiota composition of fostered shelter kittens

Jody L. Gookin[1]*, Sandra J. Strong[2,3], José M. Bruno-Bárcena[4], Stephen H. Stauffer[1], Shelby Williams[5,6], Erica Wassack[5,7], M. Andrea Azcarate-Peril[8], Marko Estrada[9], Alexis Seguin[9], Joerg Balzer[10] and Gigi Davidson[5]

Herstad et al., 2010; Bybee et al., 2014; Gookin et al., 2022

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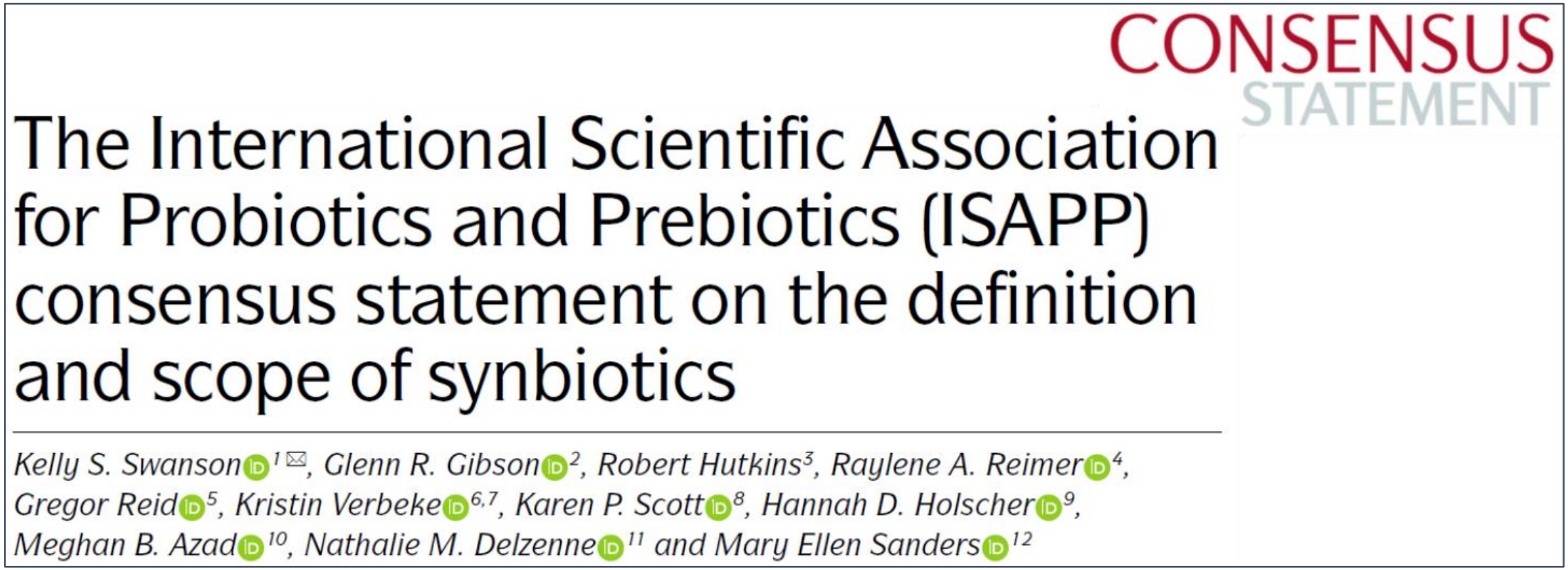
Synbiotics


CONSENSUS STATEMENT

The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of synbiotics

Kelly S. Swanson[1]✉, Glenn R. Gibson[2], Robert Hutkins[3], Raylene A. Reimer[4], Gregor Reid[5], Kristin Verbeke[6,7], Karen P. Scott[8], Hannah D. Holscher[9], Meghan B. Azad[10], Nathalie M. Delzenne[11] and Mary Ellen Sanders[12]

"A mixture comprising live microorganisms and substrate(s) selectively utilized by host microorganisms that confers a health benefit on the host"

Swanson et al., 2020

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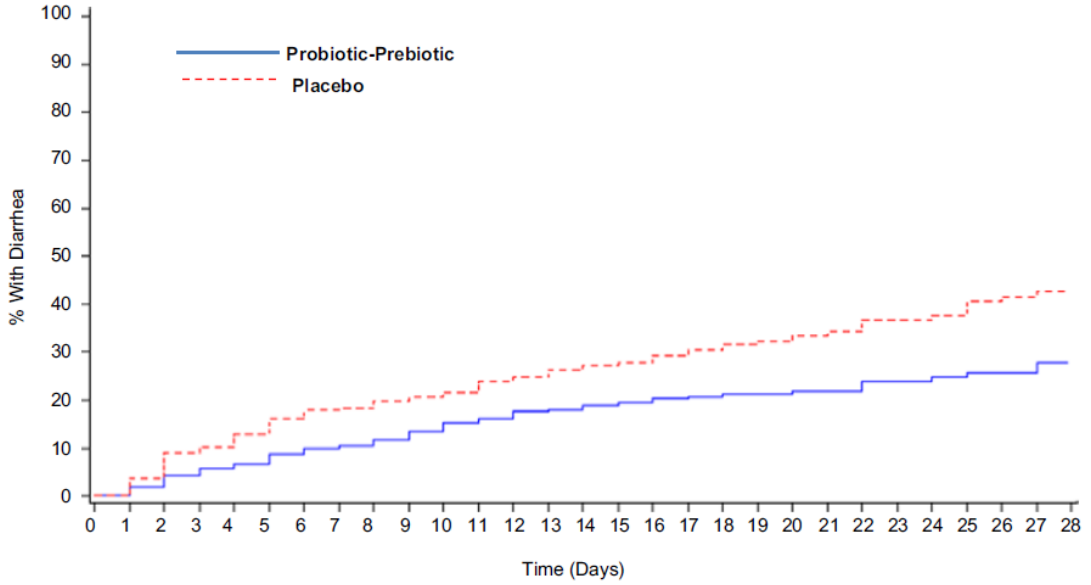
Synbiotics

- Only a few examples

- Beneficial changes to microbiota and metabolites
  - ↑*Lactobacillus*
  - ↑ *Bifidobacterium*
  - ↑ fecal lactate and butyrate
  - ↓ fecal protein catabolites

- Reduced diarrhea incidence
  - Shelter dogs
  - Sled dogs



Swanson et al., 2002; Biagi et al., 2013; Gagné et al., 2013; Rose et al., 2017

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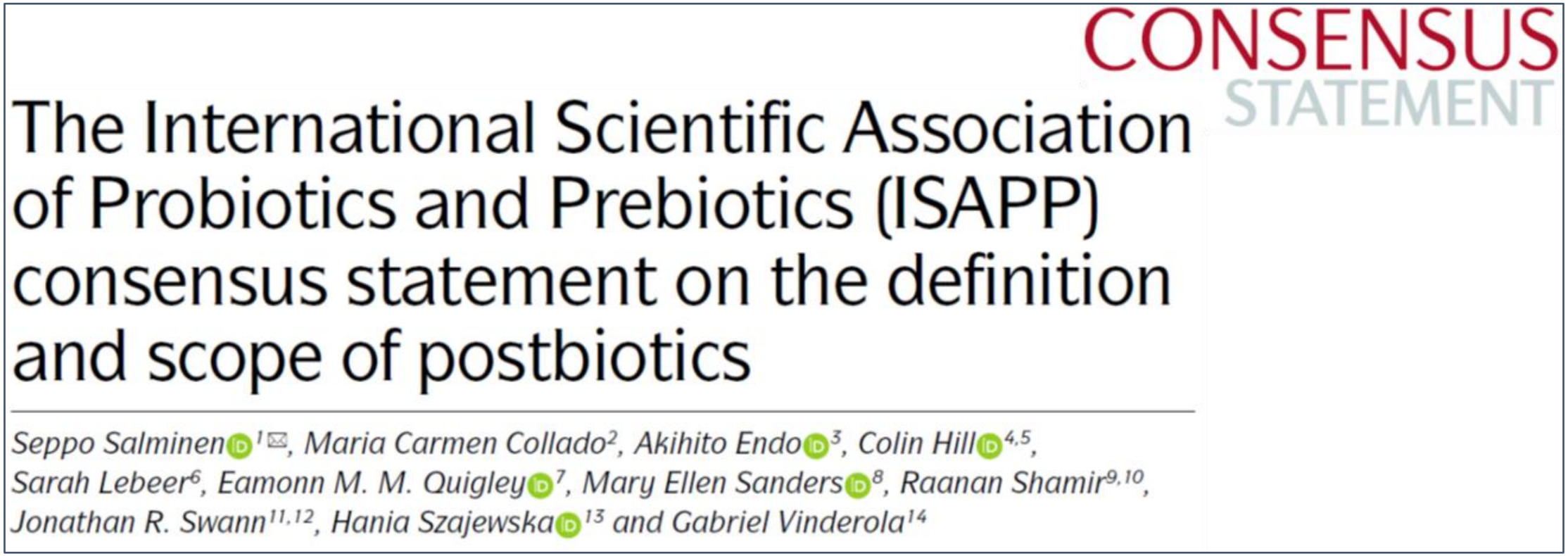
Postbiotics


CONSENSUS STATEMENT

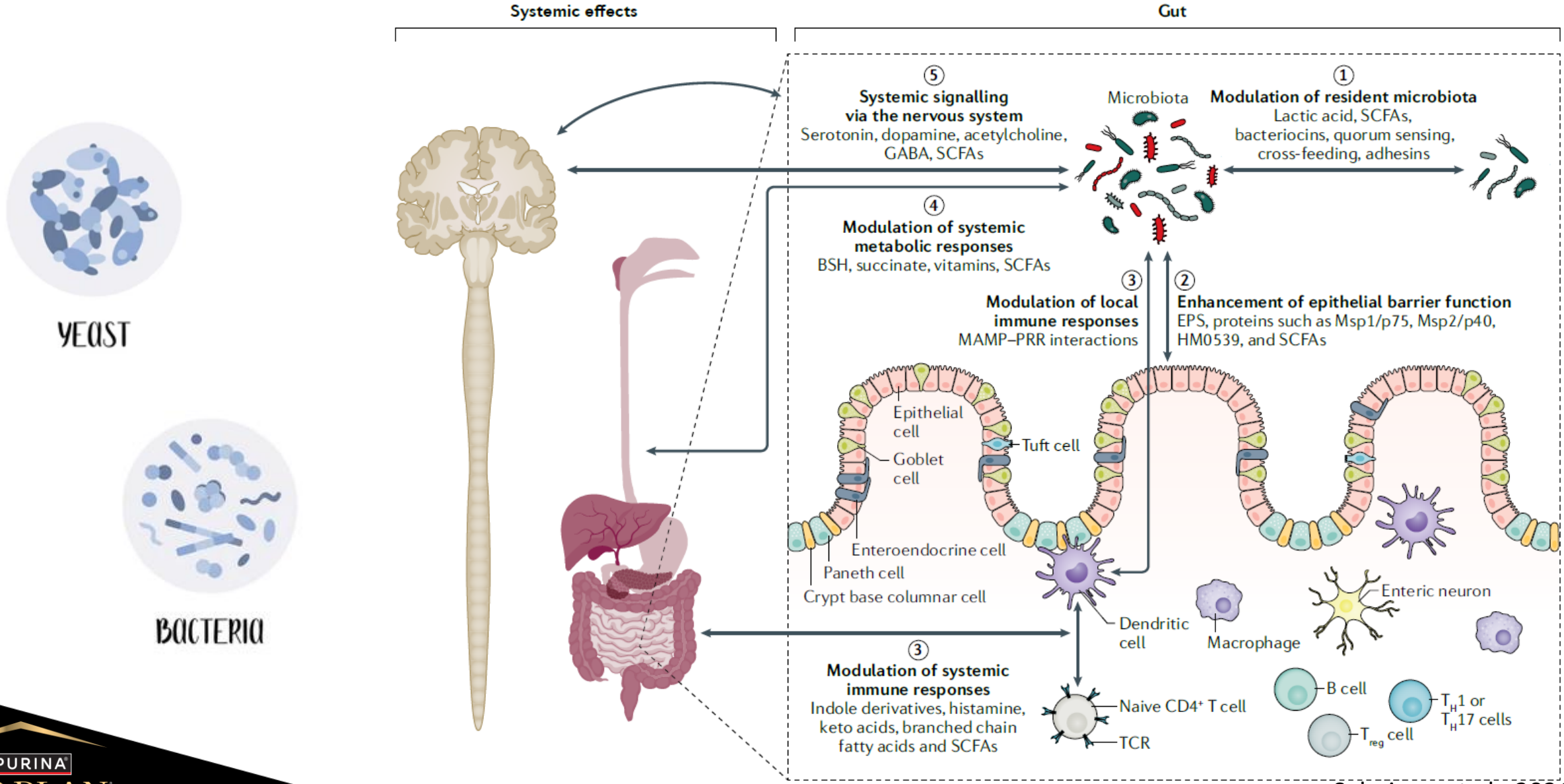
The International Scientific Association of Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of postbiotics

Seppo Salminen[1]✉, Maria Carmen Collado[2], Akihito Endo[3], Colin Hill[4,5], Sarah Lebeer[6], Eamonn M. M. Quigley[7], Mary Ellen Sanders[8], Raanan Shamir[9,10], Jonathan R. Swann[11,12], Hania Szajewska[13] and Gabriel Vinderola[14]

"Preparation of inanimate microorganisms and/or their components that confers a health benefit on the host"

Salminen et al., 2021

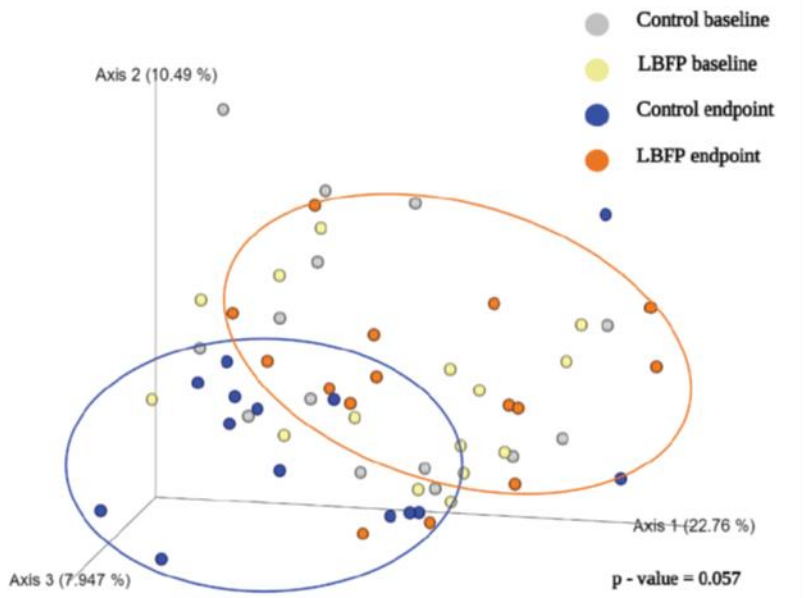
Postbiotic Mechanisms

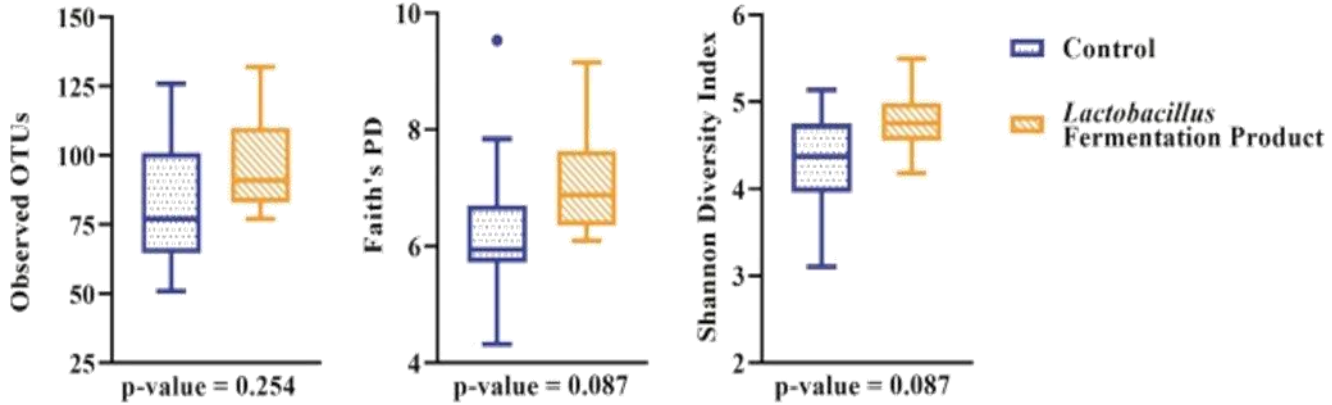


Salminen et al., 2021

Common Postbiotic Responses

- Maintain stool quality
- Modified gut microbiota and reduced fecal odor components
- Increased antioxidant capacity
- Immunomodulation (greater tolerance)





Lin et al., 2019; Koziol et al., 2023

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Existing Challenges

- Lack of consistency (efficacy)
- Unknowns about host microbiome
  - Continued focus on bacterial taxonomy
  - Heavy reliance on fecal samples
- Responders vs. non-responders
- Lack of studies
  - Diseased; life stages
  - Client-owned; breeds

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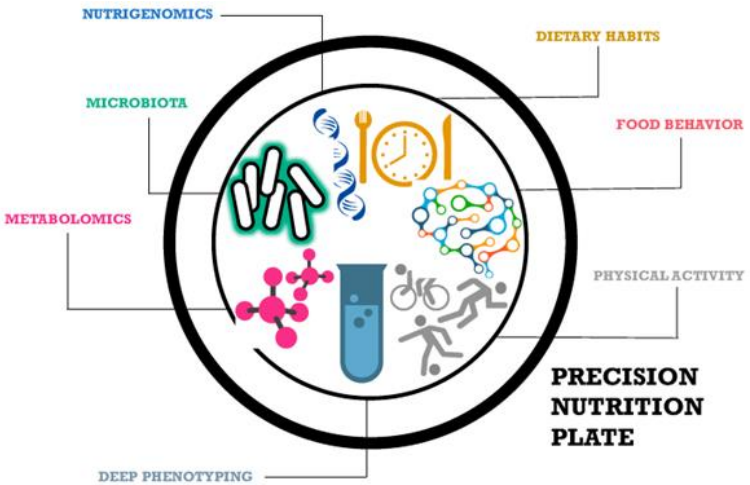
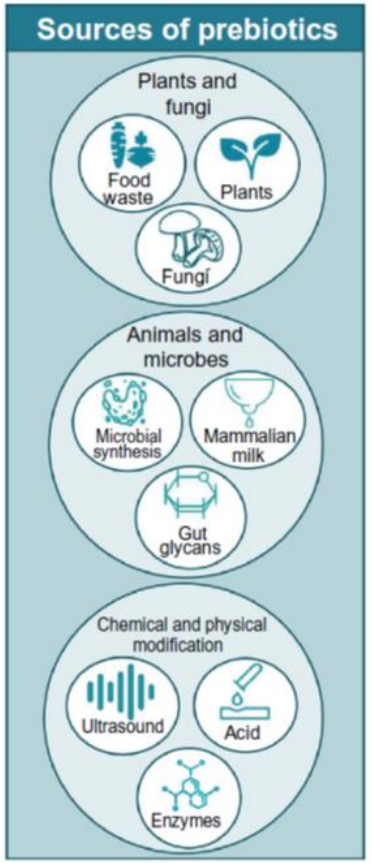
Future Directions

- Microbiome science
  - Host characterization; microbe discovery/characterization
- Laboratory tools and assays
  - Cultivation assays, organoids, omics, robotics
  - Biotic synthesis, screening, characterization
- Machine learning and AI
- Precision and personalization
  - Host and microbiome
  - Diet





Cunningham et al., 2021

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Thank you!

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