Nutrition and Gut Microbiota

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Outline

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- What is a "Healthy" Gut Microbiota?
- Diet as a Primary Modulator of the Gut Microbiota.
- Dietary Patterns and Microbiota Signatures.
- Gut Microbiota in GI Diseases: Mechanistic Links.
- Nutritional Strategies to Modulate the Microbiota.
- Future Directions & Takeaways for Gastroenterologists.

Introduction

- The gut microbiota, also known as the gut microbiome, is a complex community of bacteria, fungi, viruses, and other microorganisms that live in the digestive system.
- The hidden metabolic organ is not a single, easily identifiable organ, but rather a complex ecosystem with profound effects on overall health.
- The gut microbiota plays a crucial role in health and disease, with **dysbiosis** linked to obesity and inflammatory bowel disease, and metabolic disorders.

Valencia S, et al. Human Gut Microbiome: A Connecting Organ Between Nutrition, Metabolism, and Health. *Int J Mol Sci*. 2025;26(9):4112.

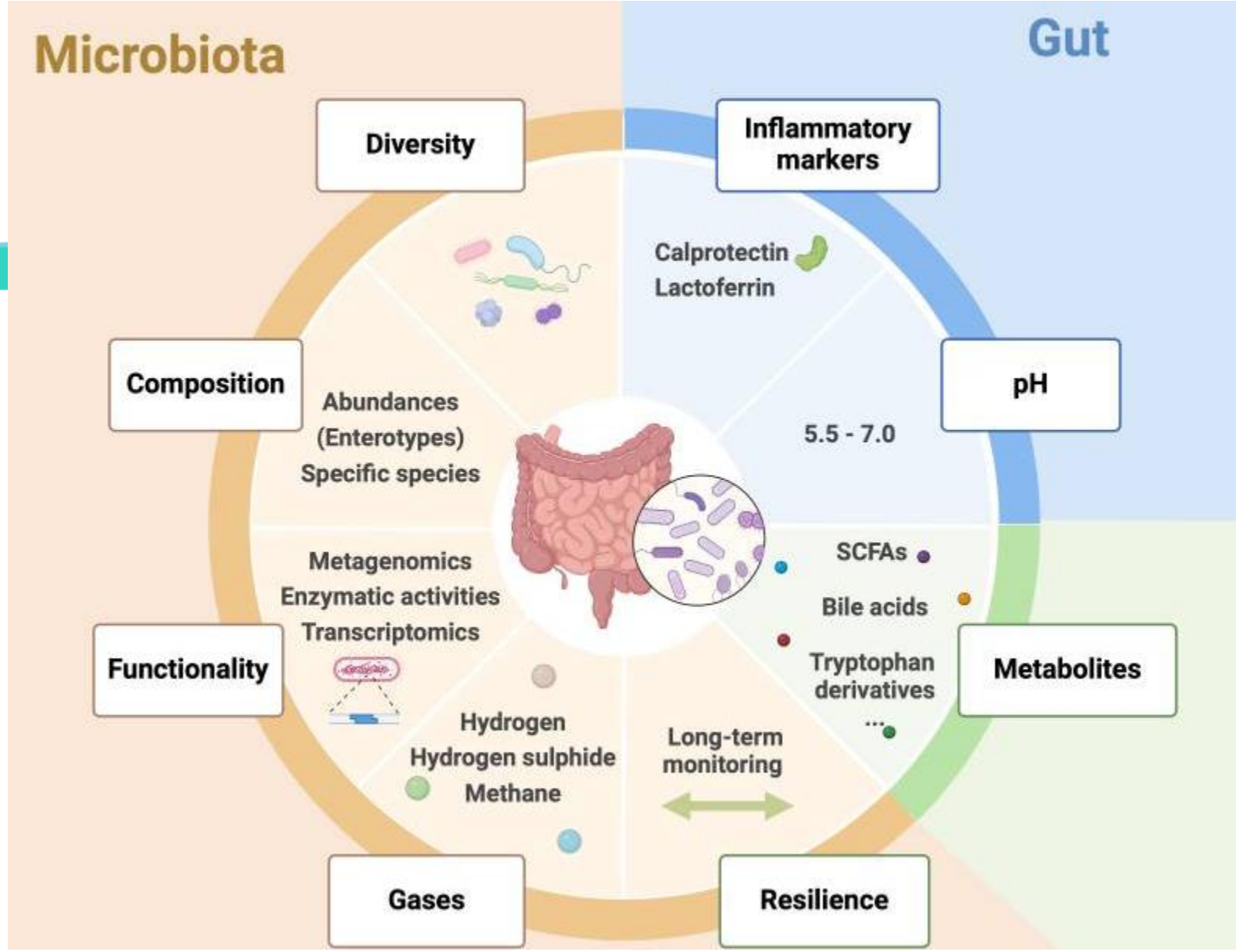
What is a "Healthy" Gut Microbiota?

- The term 'dysbiosis' broadly links microbial imbalances to various chronic illnesses without precision or definition.
- To ascertain what characterizes a healthy microbiome, we need to define 'healthy individuals'.
- The challenge is in distinguishing causation from correlation between the gut microbiome and overall health.
- The resource-heavy nature of comprehensive gut health assessments hinders their practicality and broad application.

Van Hul M, et al. What defines a healthy gut microbiome?. *Gut*. 2024;73(11):1893-1908.

"Healthy" Gut Microbiota

- A healthy gut microbiota is characterized by a diverse and balanced community of microorganisms that perform vital functions for the host.



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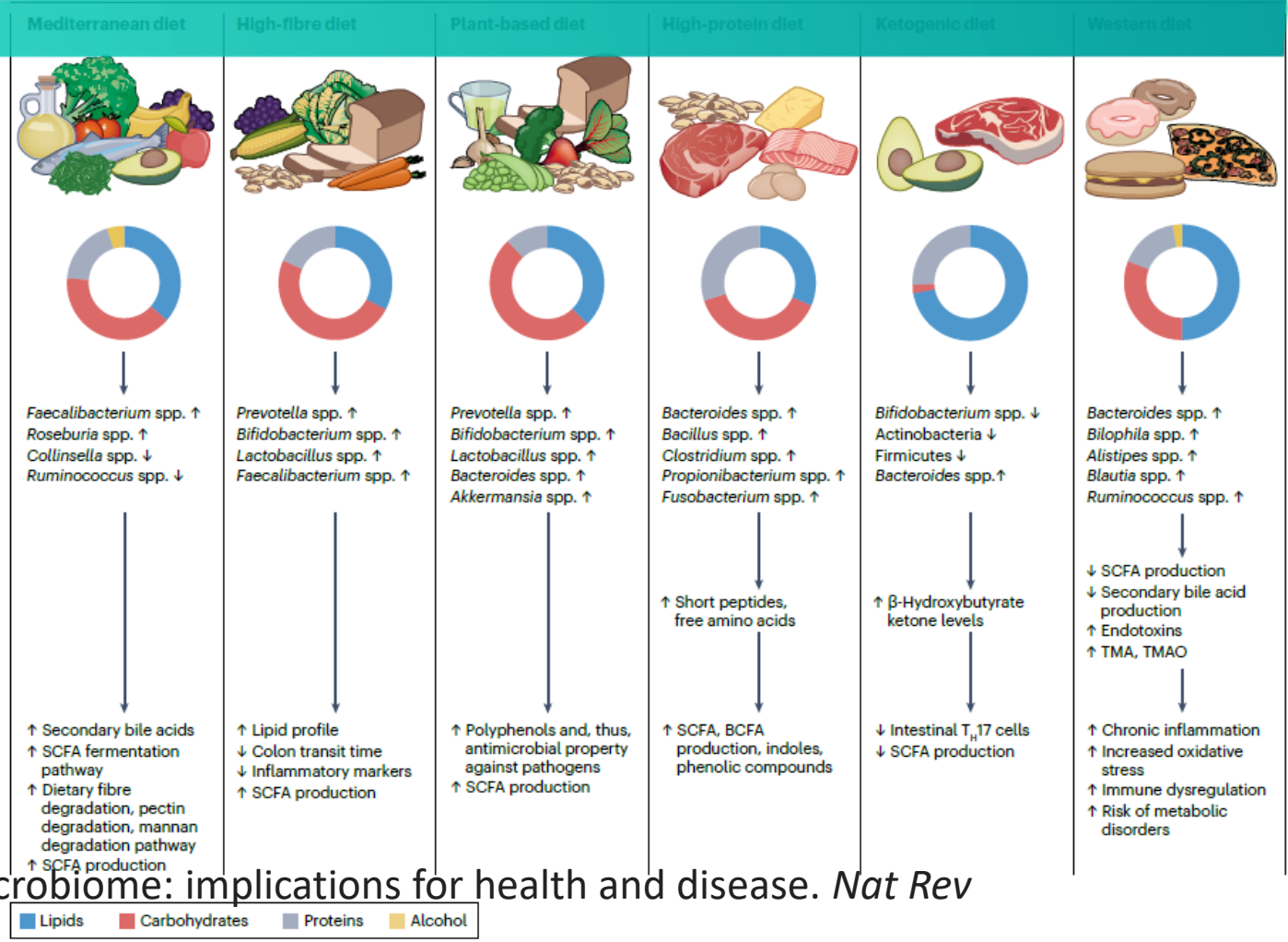
What is a "Healthy" Gut Microbiota?

- Composition: Dominant phyla (Firmicutes, Bacteroidetes) and beneficial genera (e.g., Bifidobacterium, Lactobacillus, Akkermansia muciniphila).
- Function:
  - Fermentation of non-digestible carbohydrates (fiber) into Short-Chain Fatty Acids (SCFAs: butyrate, acetate, propionate).
  - Vitamin synthesis (K, B vitamins).
  - Modulation of the immune system.
  - Maintenance of gut barrier integrity.
  - Metabolism of bile acids and xenobiotics.

Van Hul M, et al. What defines a healthy gut microbiome?. *Gut*. 2024;73(11):1893-1908.

Diet as a Primary Modulator of the Gut Microbiota.

- Diet has a pivotal role in shaping the composition, function, and diversity of the gut microbiome.
- The same diet consumed by two different people can result in differing metabolic health effects and a personalized microbial response.



Ross FC, et al. The interplay between diet and the gut microbiome: implications for health and disease. *Nat Rev Microbiol*. 2024;22(11):671-686.

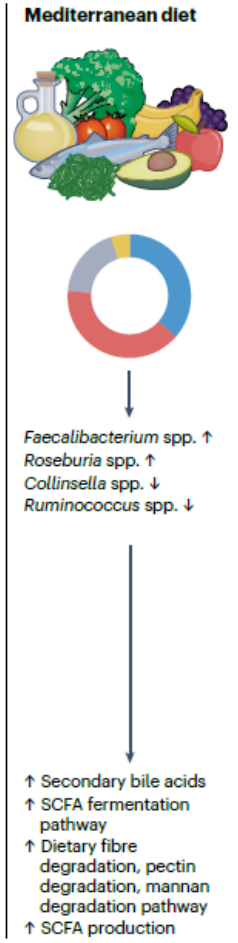
Diet as a Primary Modulator of the Gut Microbiota.

- Fiber/Complex Carbohydrates: The primary fuel for beneficial bacteria, leading to SCFA production.
- Proteins: Plant vs. animal protein effects (e.g., plant protein increases Bifidobacterium, Lactobacillus and SCFAs).
- Fats: Saturated fats are linked to pro-inflammatory microbes; unsaturated fats (e.g., omega-3) are associated with anti-inflammatory profiles.

Zheng, Yijun, et al. "The effects of food nutrients and bioactive compounds on the gut microbiota: a comprehensive review." *Foods* 13.9 (2024): 1345.

The Mediterranean Diet and Gut Microbiota.

- The Mediterranean diet emphasizes a high intake of unprocessed, whole-plant foods, olive oil, dairy products, moderate consumption of poultry and fish, and low amounts of red meat.
- The Mediterranean diet was associated with 36 functional pathways, mostly resembling a plant-based diet, with enriched microbial functions for SCFA fermentation and dietary fibre degradation.
- These changes were linked with positive alterations in body weight and cardiometabolic indicators.



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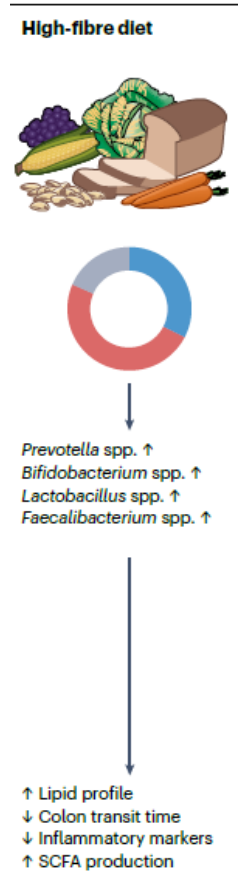
High-fibre Diet and Gut Microbiota.

- Dietary fibre is important for human health as it lowers long-term weight gain, with low fibre intake leading to an increased risk of type 2 diabetes and colon cancer.
- High-fibre diets alter gut microbial composition, including a substantial increase in beneficial Lactobacillus spp. and Bifidobacterium spp. abundance.



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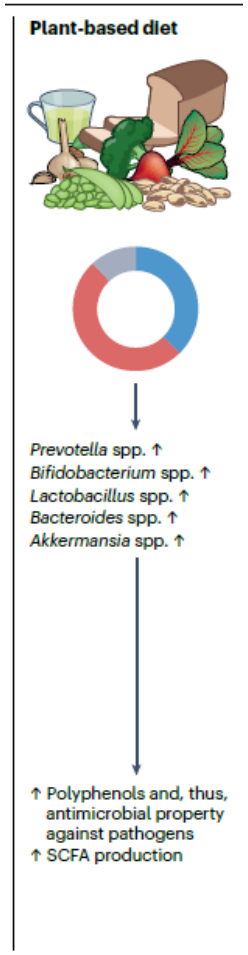
Plant-based Diet and Gut Microbiota.

- Plant-based diets are enriched in polyphenols, host-digestible and indigestible carbohydrates and exert both prebiotic and postbiotic effects.
- Vegetarian diets lead to the formation of a distinct bacterial environment.
- These diets promote the abundance of Bacteroidetes and Prevotella species.
- The majority of polyphenols (90% to 95%) interact with gut microorganisms in the ileum and colon, thereby providing substantial anti-inflammatory and anti-pathogenic properties, as well as cardiovascular protection.



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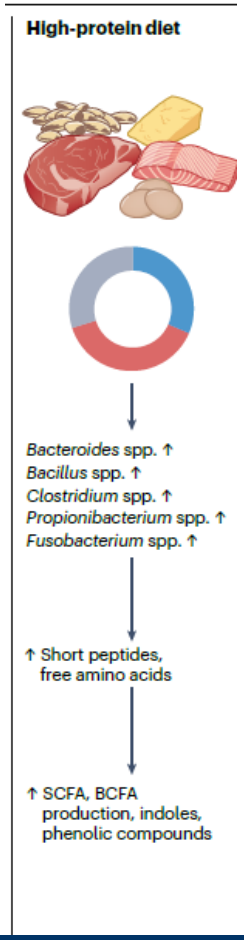
High-protein Diet and Gut Microbiota.

- A diet with protein consumption of more than 1.5 g/kg per day.
- It is typically used for athletes or prescribed for overweight people for weight loss.
- Up to 12–18 g of dietary proteins can reach the large intestine daily and be metabolized by the microbiome.
- Some fermentation products include potentially inflammatory compounds.
- Indoles can be transformed into a toxic metabolite that is deleterious for the kidneys and that is involved in endothelial dysfunction.
- Hydrogen sulfide is potentially mutagenic and may have a role in inflammation, increasing the risk of colon cancer.



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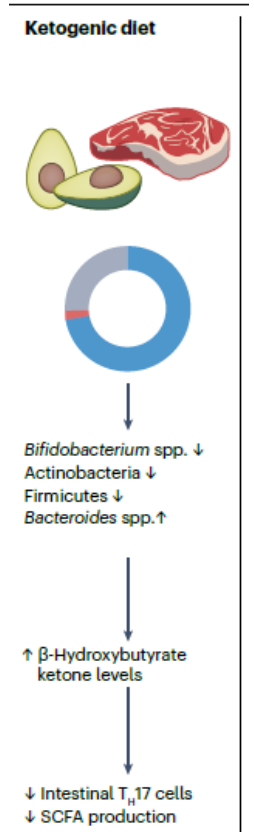
High-protein Diet and Gut Microbiota.

- The ketogenic diet is a very low-carbohydrate, moderate-protein and high-fat dietary pattern replicating the metabolic responses seen during fasting, which elevates circulating ketone bodies.
- A 4-week ketogenic diet has shown substantial reductions in Actinobacteria and Firmicutes phyla within the human gut.
- Specifically, 19 species of beneficial Bifidobacterium were decreased, whereas there was an increase in the abundance of Bacteroidetes species.
- Transplanting faecal microbiota from ketogenic diet-fed human donors into germ-free mice led to variations in intestinal T helper 17 (TH17) cell accumulation.



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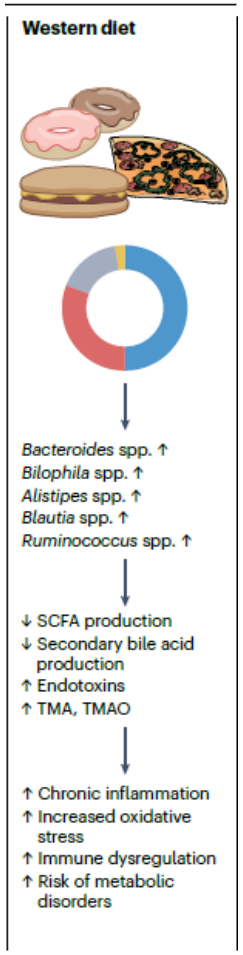
Western Diet and Gut Microbiota.

- The Western diet is characterized by a high calorie content and is enriched in animal protein, saturated fats, simple sugars and ultraprocessed foods, with inadequate amounts of fibre, fruits, and vegetables.
- The Western diet is associated with a marked reduction in gut microbiome diversity.
- Because of the lower fibre input and the different microbial composition, the associated microbiome produces less SCFA.
- Non-nutritive artificial sweeteners such as saccharin, sucralose and aspartame, present in low-calorie or diet food and drink items, have potential long-term effects on microbiome diversity.



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Gut Microbiota in GI Diseases

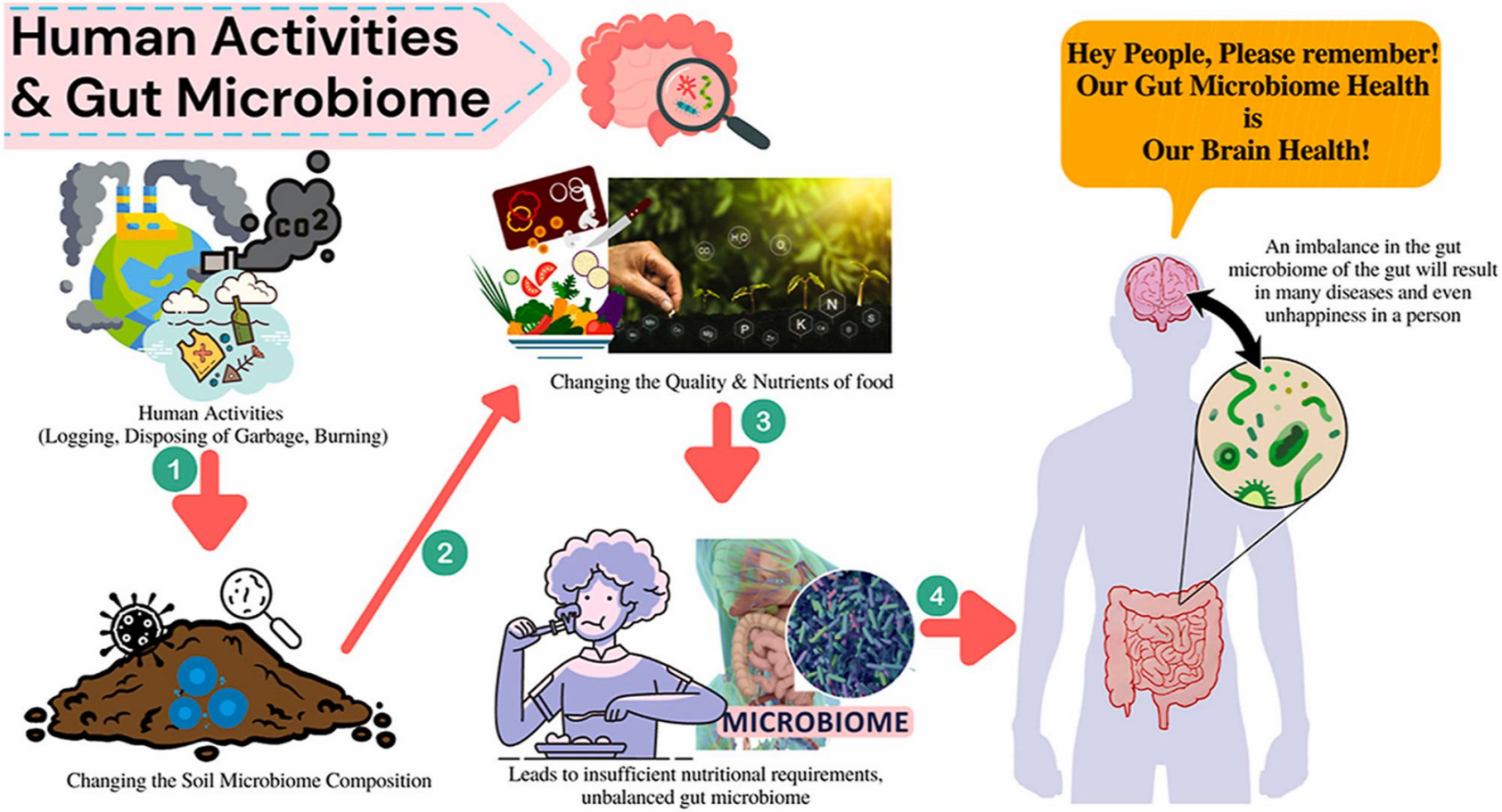
- Inflammatory Bowel Disease (IBD): Reduced diversity, altered SCFA production, increased pro-inflammatory bacteria.
- Irritable Bowel Syndrome (IBS): Variable dysbiosis patterns, potential role of gas production, and altered gut-brain axis.
- Obesity and Metabolic Syndrome: Altered energy harvest, inflammation, and impact on host metabolism.
- Other Conditions: NAFLD, colorectal cancer, C. difficile infection.

Corbin KD, et al. Targeting the Gut Microbiota's Role in Host Energy Absorption With Precision Nutrition Interventions for the Prevention and Treatment of Obesity. *Nutr Rev*. Published online April 15, 2025.

Nutritional Strategies to Modulate Microbiota

- High-Fiber Diet: increased intake of diverse plant fibers (fruits, vegetables, whole grains, legumes, nuts, seeds).
- Prebiotics.
- Probiotics.
- Postbiotics.

Human Activities and Gut Microbime



Future Directions & Takeaway

- Continued research into specific microbial strains and their functions.
- Development of more targeted pre- and probiotics.
- Integration of microbiome analysis into clinical practice.

- Encourage diverse, plant-rich, whole-food diets.
- Consider targeted nutritional interventions (fiber, prebiotics, probiotics) when appropriate.