



Harnessing microbial metabolism and nutrition to target the gut-mammary axis for better livestock production and health

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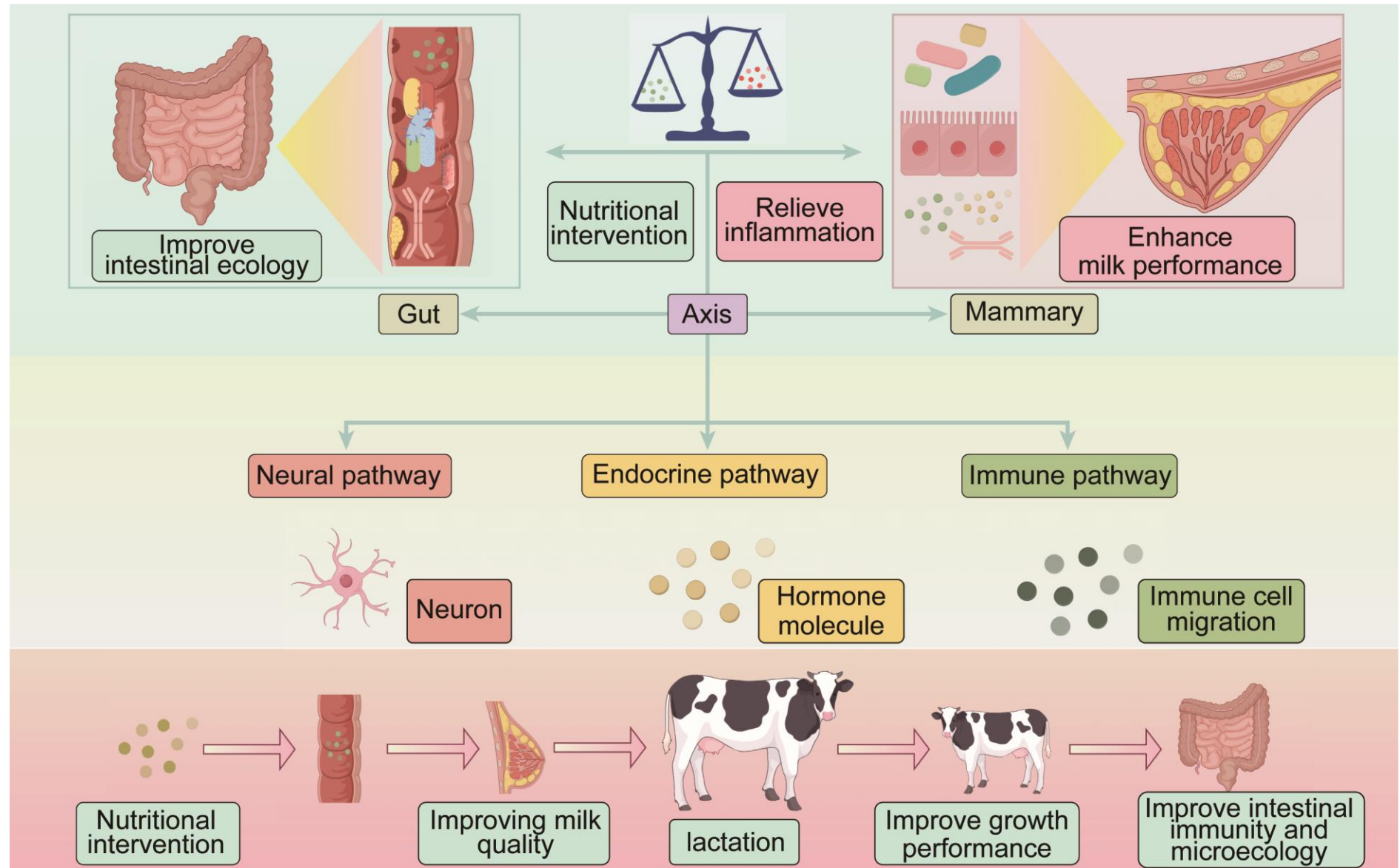
Highlight

- ❑ Highlight 1: The gut-breast axis links gut microbiota and nutritional signals to mammary function through neural, endocrine, and immune pathways;
- ❑ Highlight 2: Nutritional interventions improve milk quality, alleviate inflammation, and enhance lactation performance through microbial metabolite signaling and immune cell trafficking;
- ❑ Highlight 3: Maternal gut microbiota are vertically transmitted via breast milk, enhancing offspring immunity and growth performance.



Introduction

**Three Major
Regulatory
Pathways: Neural
Pathway, Endocrine
Pathway, Immune
Pathway**





Regulatory mechanisms of the gut-breast axis

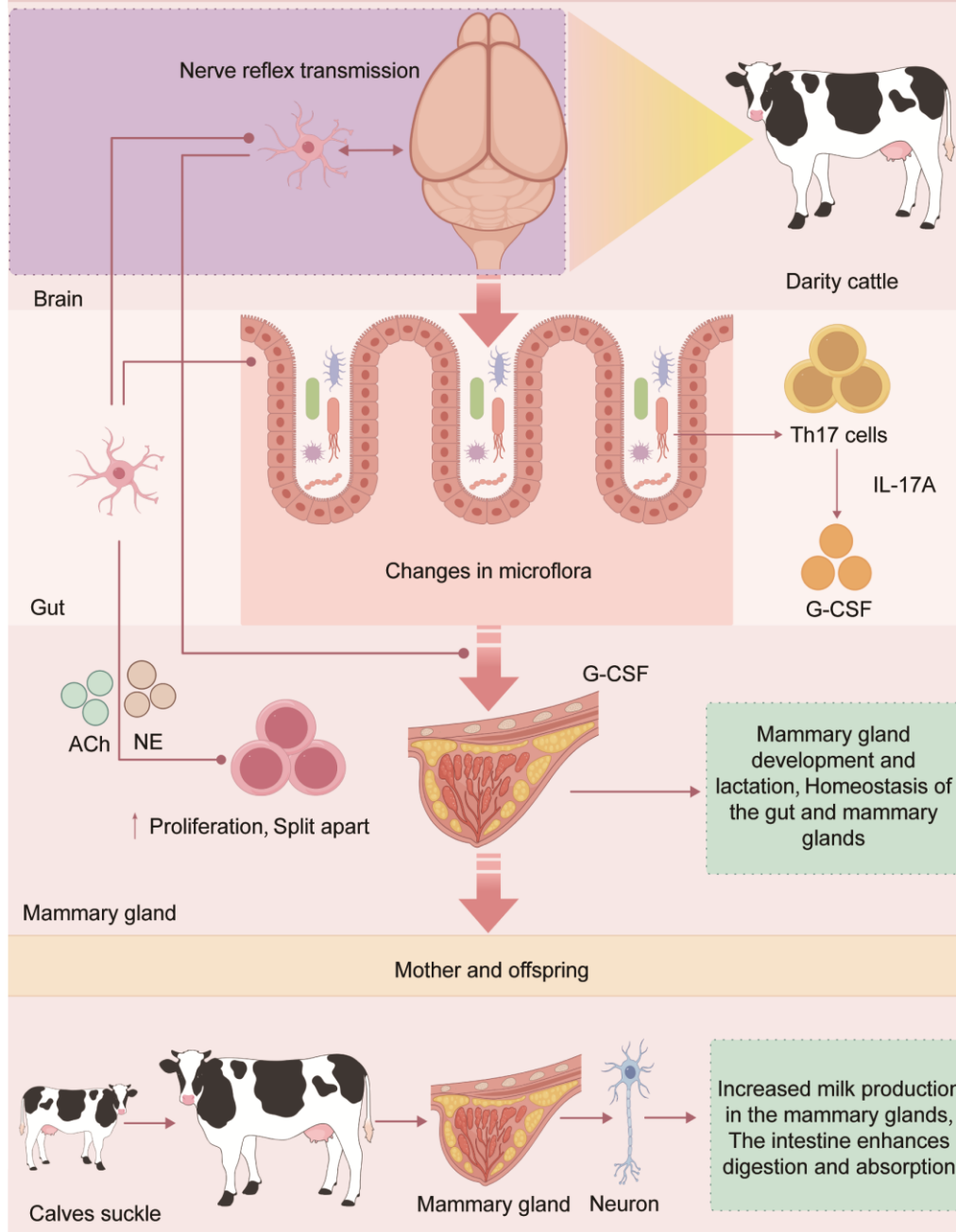


Figure 1. Neuromodulatory mechanisms of the gut-mammary axis.

Regulatory mechanisms of the gut-breast axis

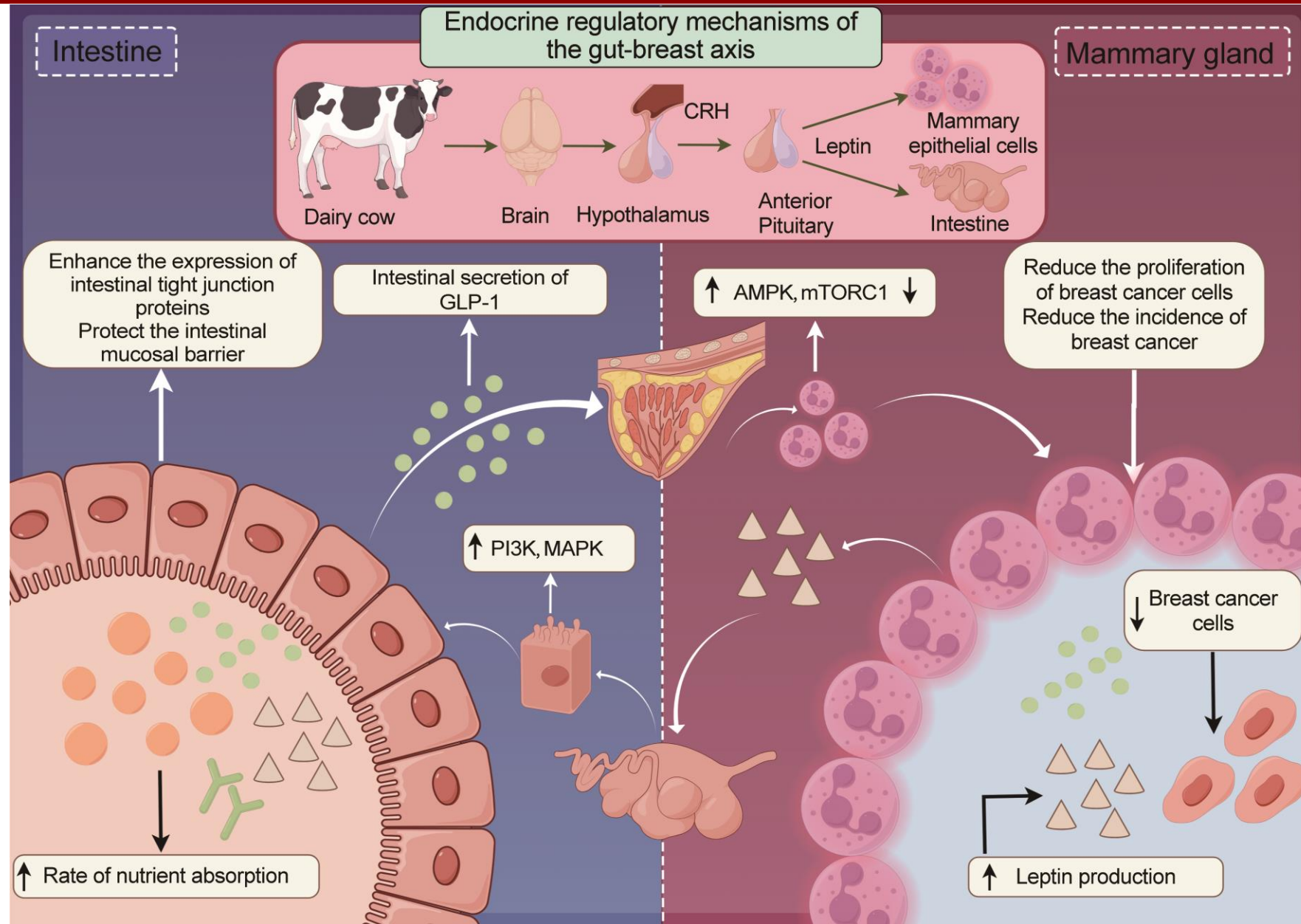


Figure 2. Endocrine regulatory mechanisms of the gut-mammary axis.



Regulatory mechanisms of the gut-breast axis

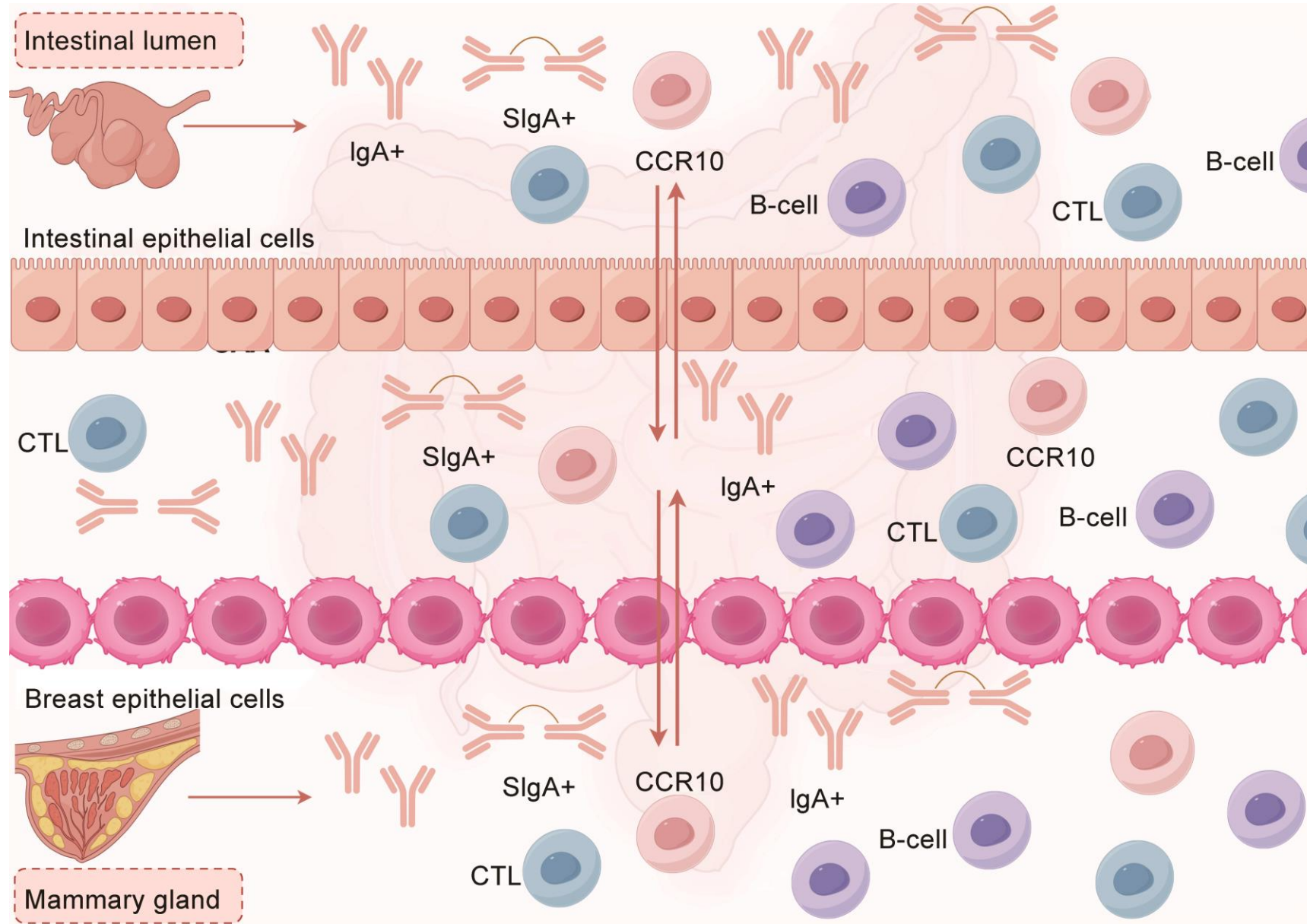


Figure 3. Immune pathways and regulatory mechanisms of the gut-mammary axis.



Vertical transmission along the gut-breast axis

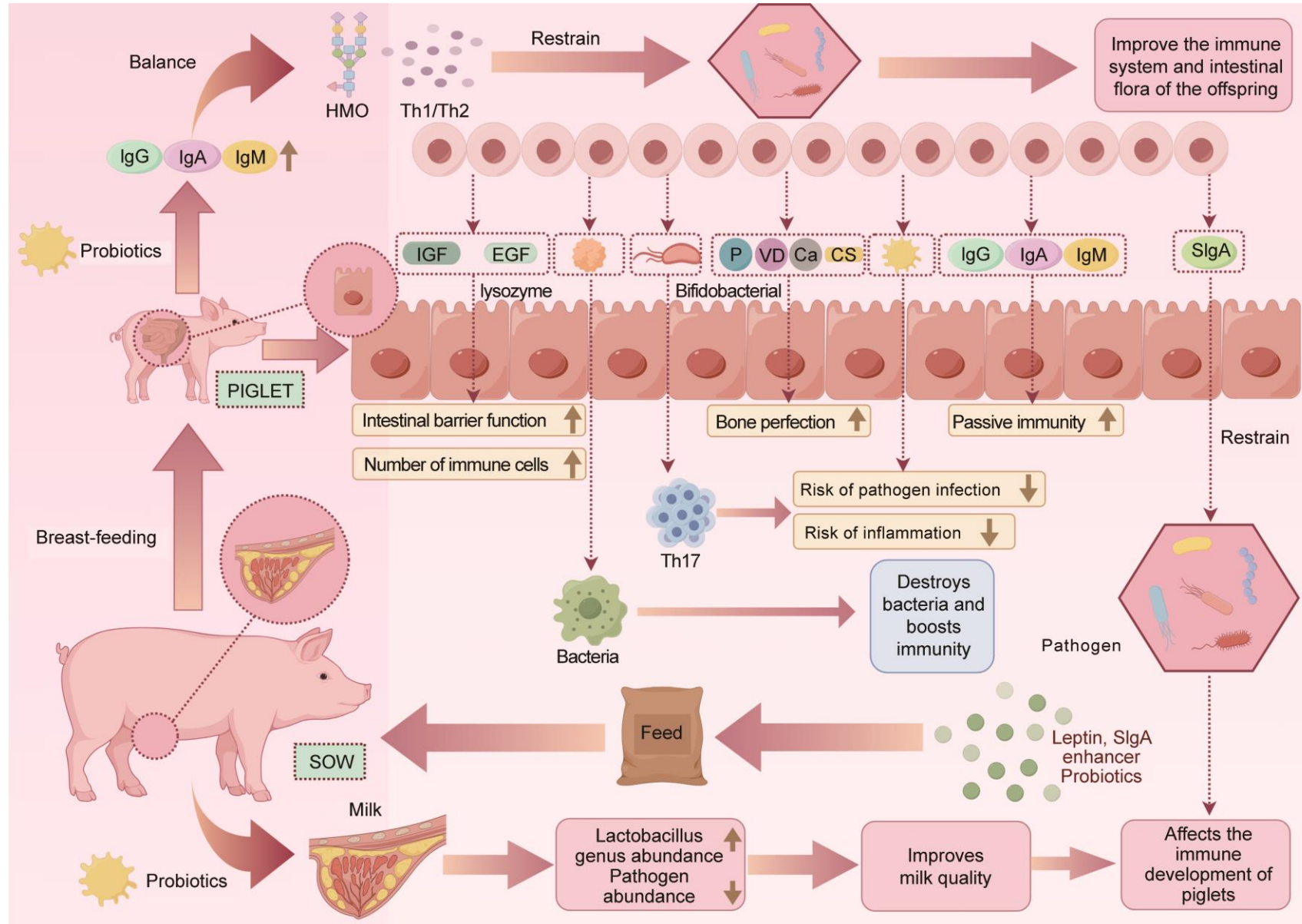


Figure 4. Vertical transmission via the gut-mammary axis improves offspring health and performance.



Species-specific characteristics of the gut-breast axis

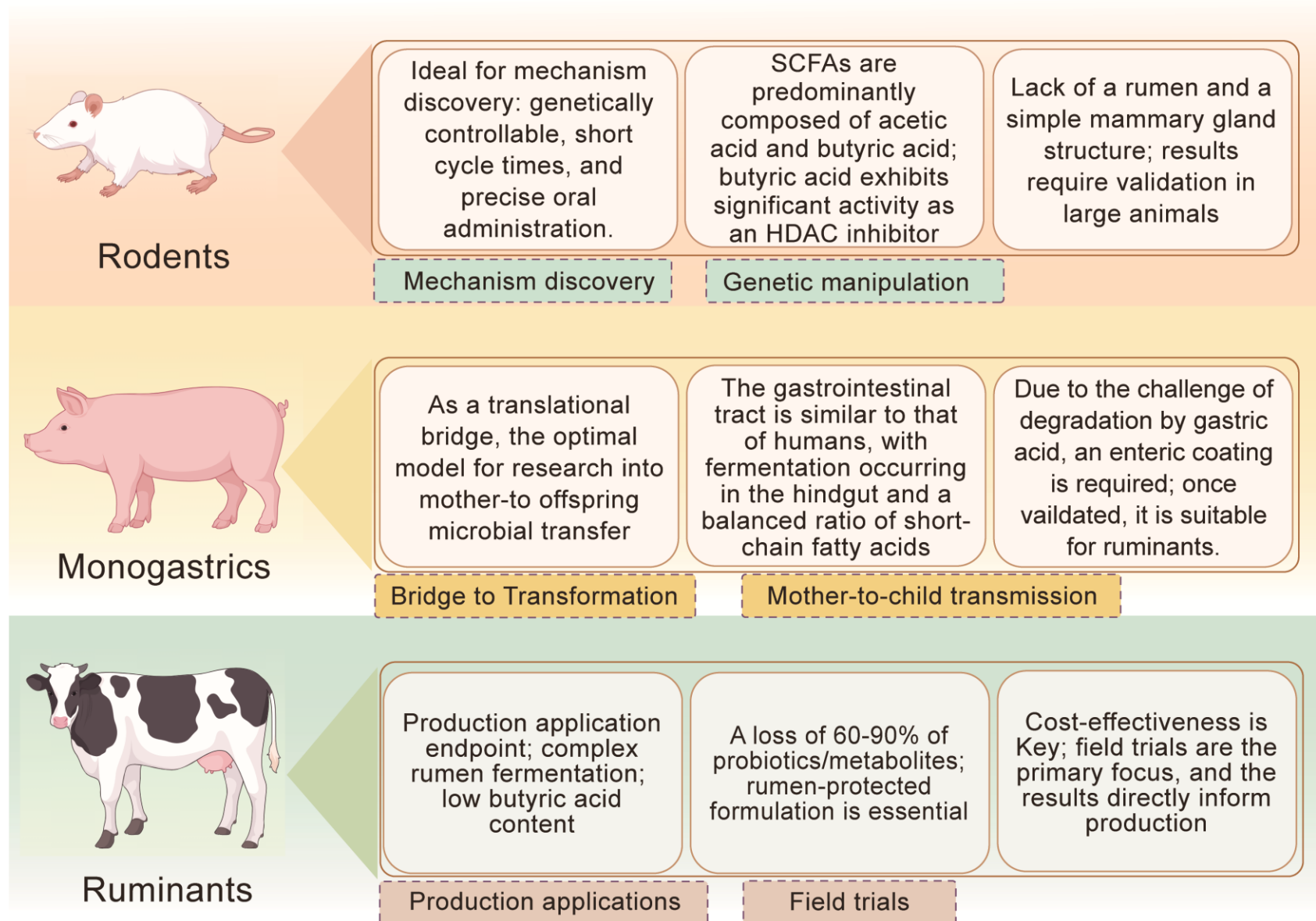


Figure 5. Species-specific characteristics of the gut-mammary axis in rodents, pigs, and ruminants.



Summary

- ❑ This review systematically examines the three major regulatory pathways of the gut-breast axis: microbial metabolites regulate mammary function through HDAC inhibition and GPR receptor activation; the immune cell pathway transmits maternal gut immunity to offspring; and neuroendocrine signaling coordinates nutrient allocation and lactation adaptation;
- ❑ Based on these mechanisms, we propose implementation strategies for precision nutrition, including stage-specific maternal nutrition, microbiome-guided probiotic supplementation, metabolite-targeted interventions, and farm-level decision support systems;
- ❑ Future research should focus on cross-species multi-omics integration, rumen-bypass delivery systems, and real-time biomarker monitoring to advance the practical application of precision nutrition in the livestock industry.

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