Nano-plastics disrupt systemic metabolism by remodeling the bile acid–microbiota axis and driving hepatic–intestinal dysfunction

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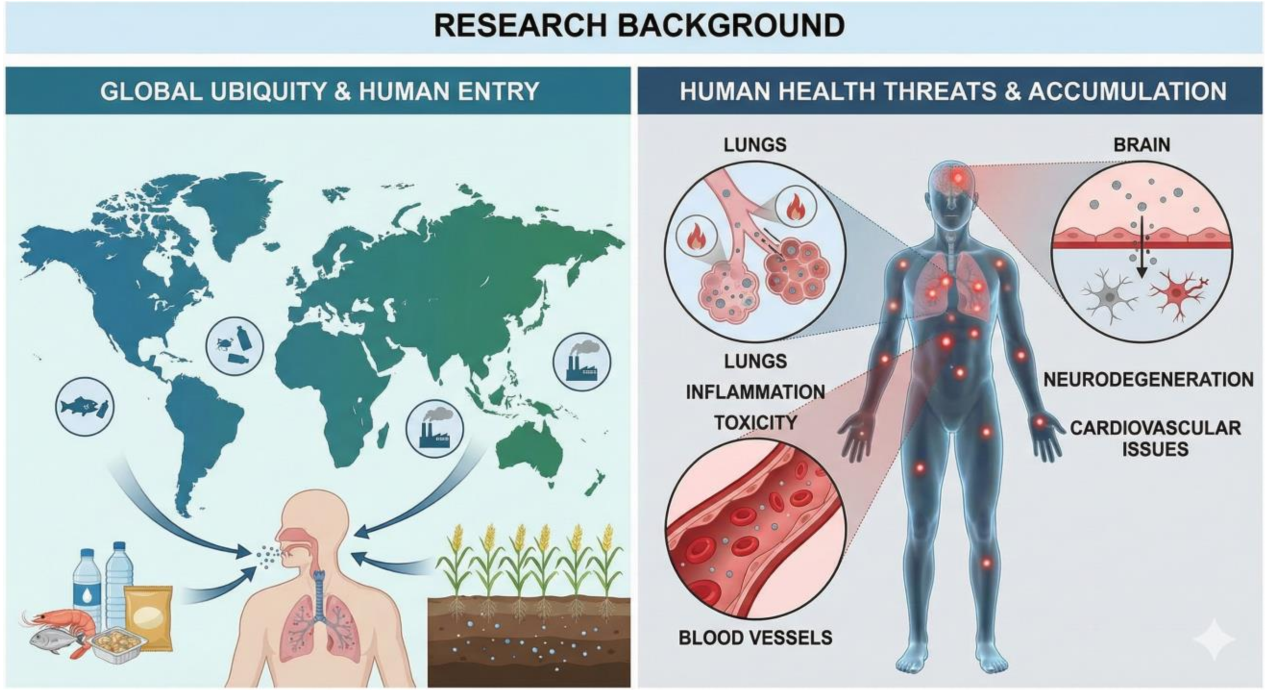
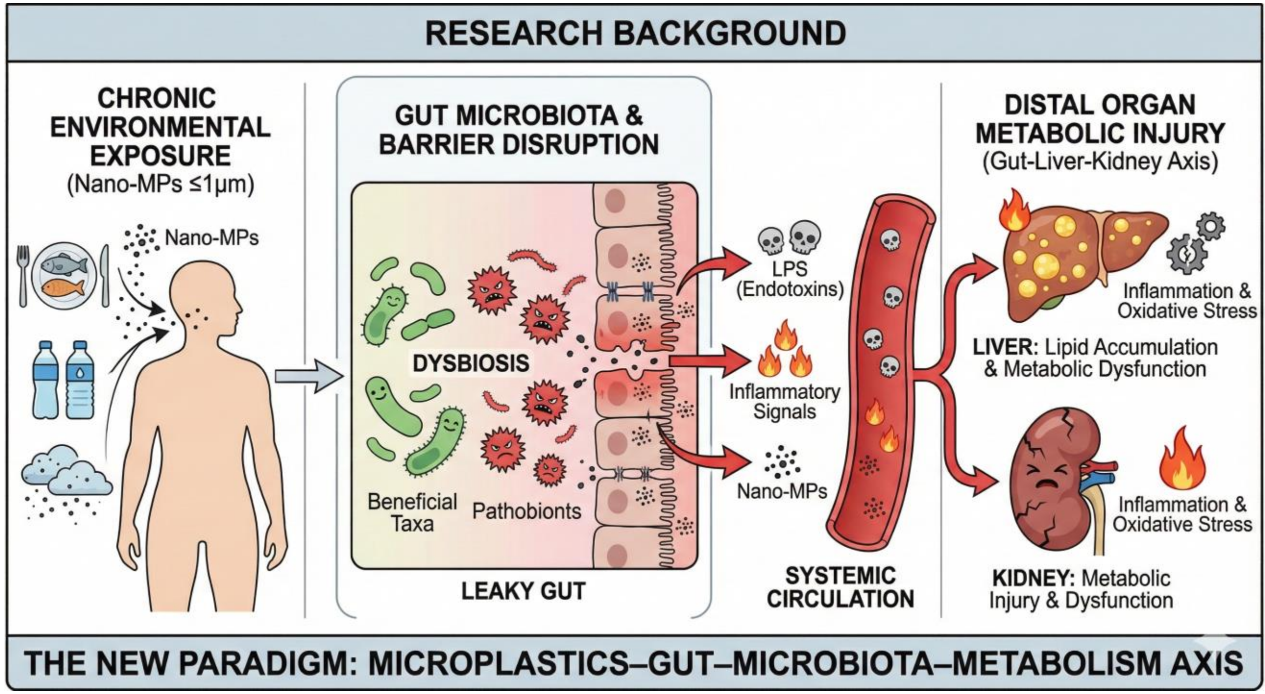
Introduction

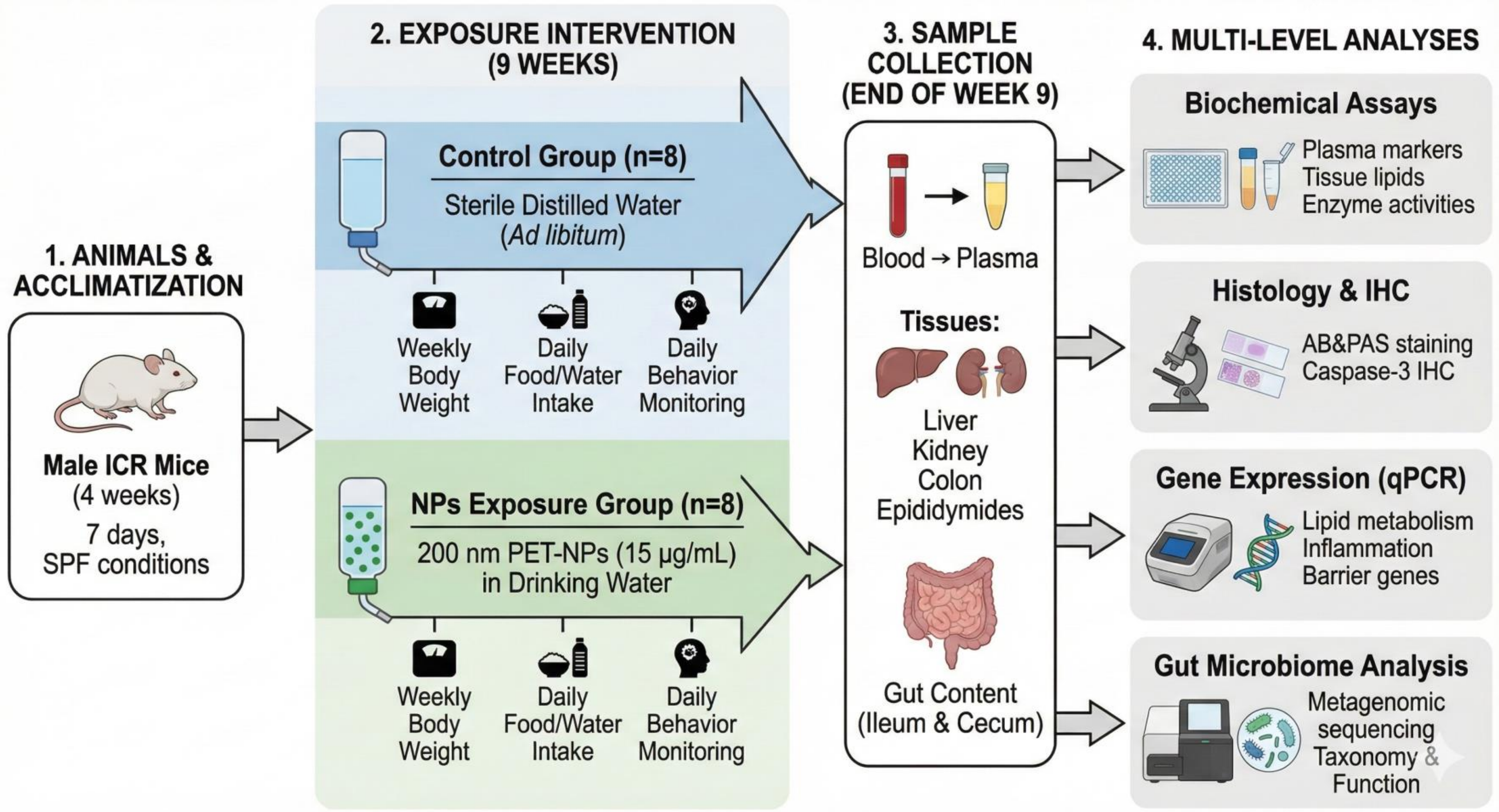




Human beings ingesting nano-microplastics through daily routes (food, water, air, etc.) for a long time!

The limitations of existing studies are that they focus on single-organ toxicity and lack of understanding of systemic metabolic interactions.

Experimental design



1. ANIMALS & ACCLIMATIZATION

Male ICR Mice
(4 weeks)
7 days,
SPF conditions

2. EXPOSURE INTERVENTION (9 WEEKS)

Control Group (n=8)
Sterile Distilled Water
(*Ad libitum*)

Weekly Body Weight
Daily Food/Water Intake
Daily Behavior Monitoring

NPs Exposure Group (n=8)
200 nm PET-NPs (15 µg/mL)
in Drinking Water

Weekly Body Weight
Daily Food/Water Intake
Daily Behavior Monitoring

3. SAMPLE COLLECTION (END OF WEEK 9)

Blood → Plasma

Tissues:
Liver
Kidney
Colon
Epididymides

Gut Content
(Ileum & Cecum)

4. MULTI-LEVEL ANALYSES

Biochemical Assays
Plasma markers
Tissue lipids
Enzyme activities

Histology & IHC
AB&PAS staining
Caspase-3 IHC

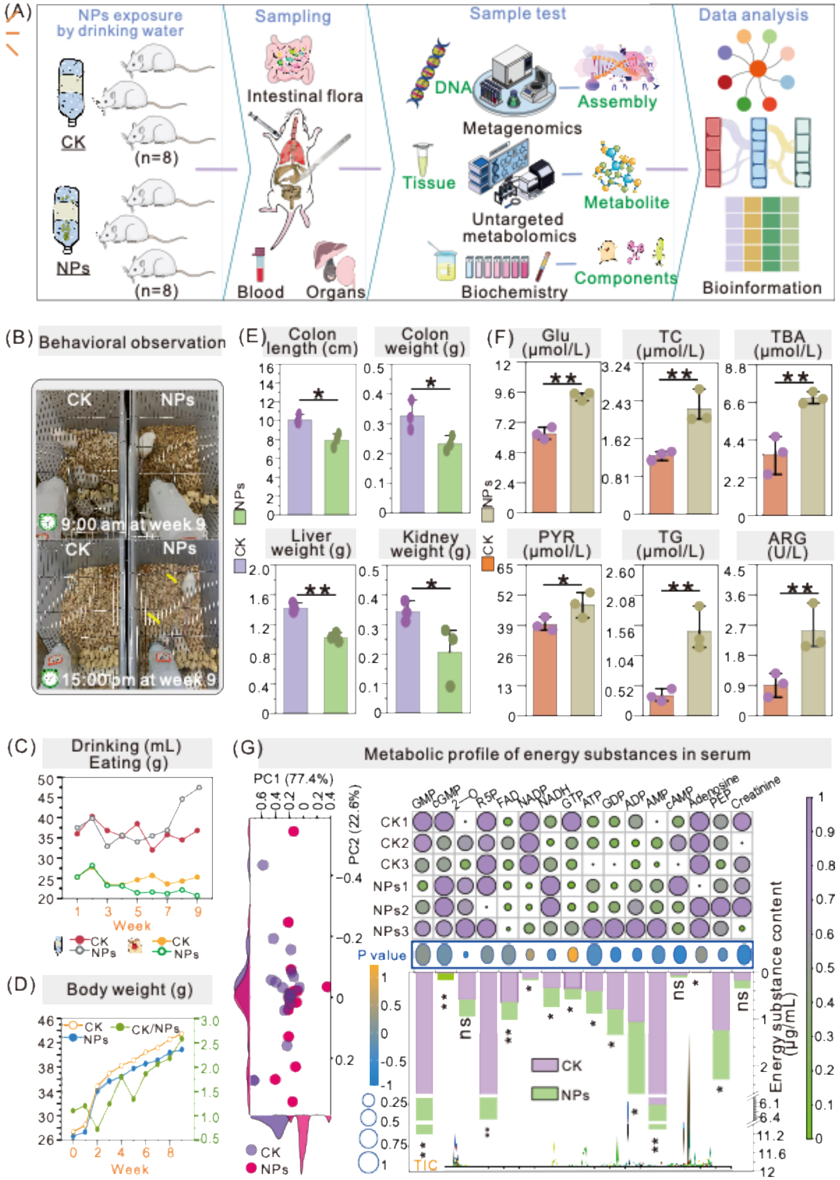
Gene Expression (qPCR)
Lipid metabolism
Inflammation
Barrier genes

Gut Microbiome Analysis
Metagenomic sequencing
Taxonomy & Function

A mouse experimental model of long-term exposure to NPs through drinking water

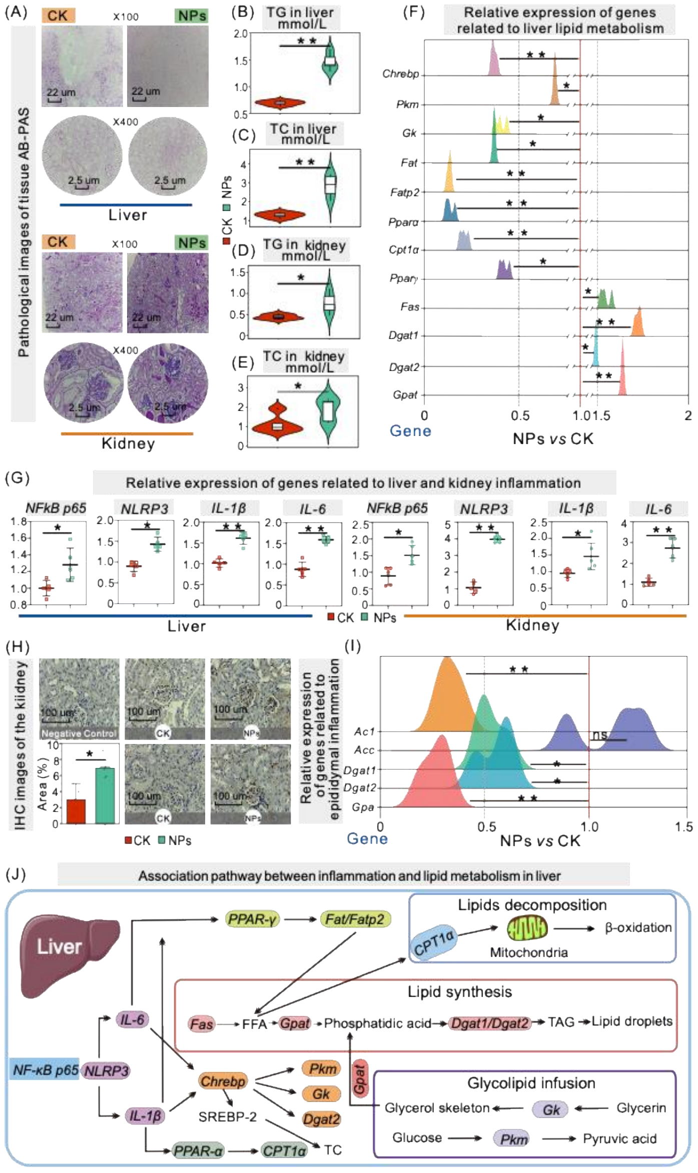
A systematic analysis combining histopathology, biochemical analysis, targeted metabolomics, and metagenomics was performed.

Changes in energy metabolism and inflammatory responses of the liver and kidneys



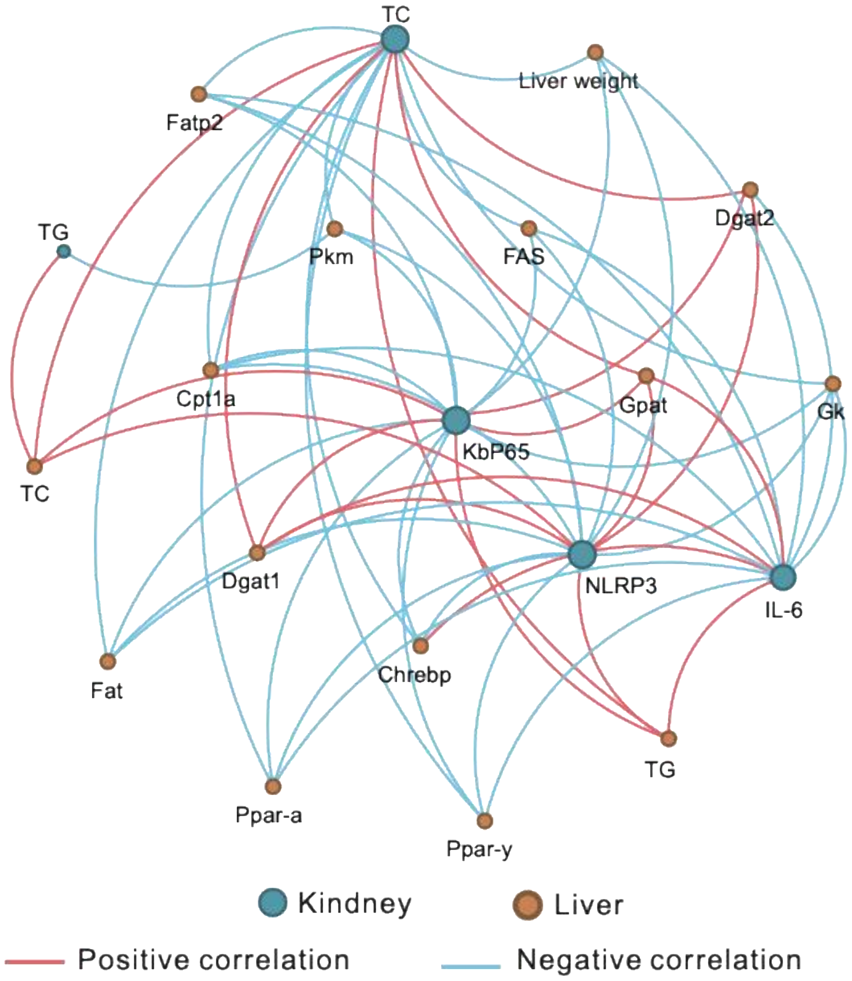
Effects of chronic NPs exposure on growth performance, organ indices, and systemic metabolic profiles in mice.

- **Phenotype:** weight loss, hyperexcitability, organ atrophy
- **Metabolism:** hyperglycemia and hyperlipidemia
- **Energy:** Impairment of mitochondrial function
- **Liver and kidney:** lipid accumulation and up-regulation of inflammatory factors



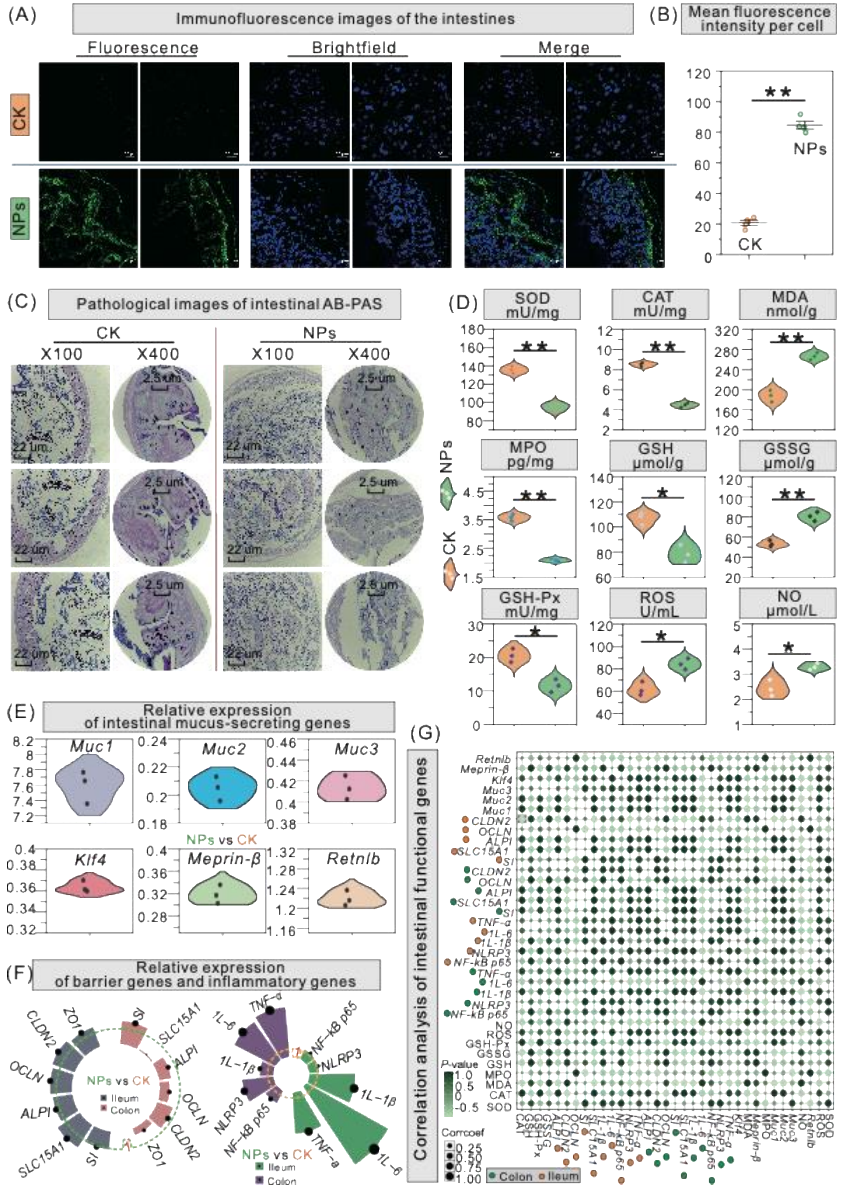
Chronic NPs exposure remodels hepatic and renal lipid metabolism and induces inflammatory responses.

Intestinal barrier damage and inflammatory outbreaks



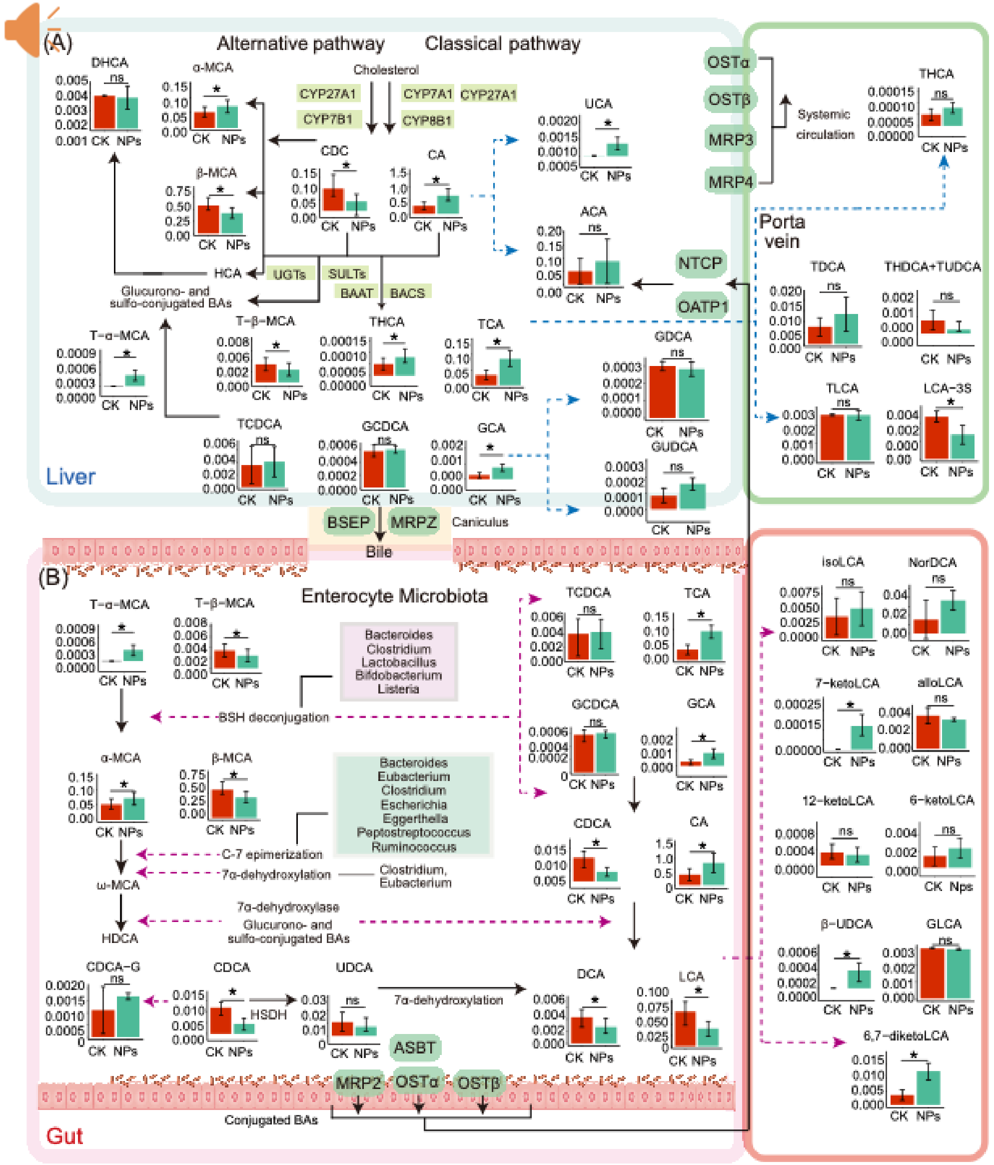
Co-occurrence network among TC and TG content, lipid metabolism-related genes, and inflammatory factors in liver and kidney after NPs exposure.

The intestinal barrier is severely impaired, the mucus layer is thinner, and markers of oxidative stress are significantly elevated.

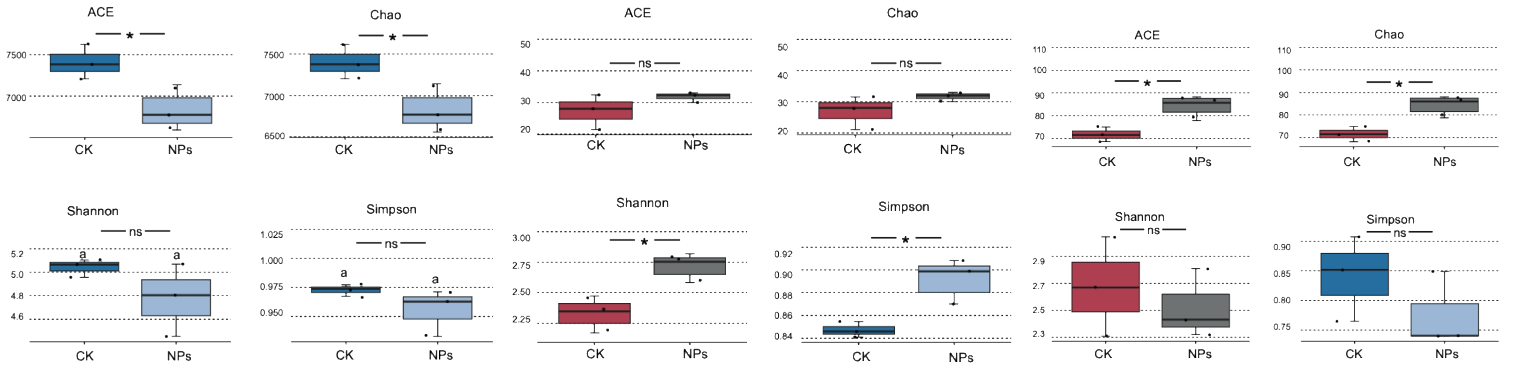


Chronic NPs exposure disrupts intestinal redox balance, barrier integrity, and inflammatory signaling.

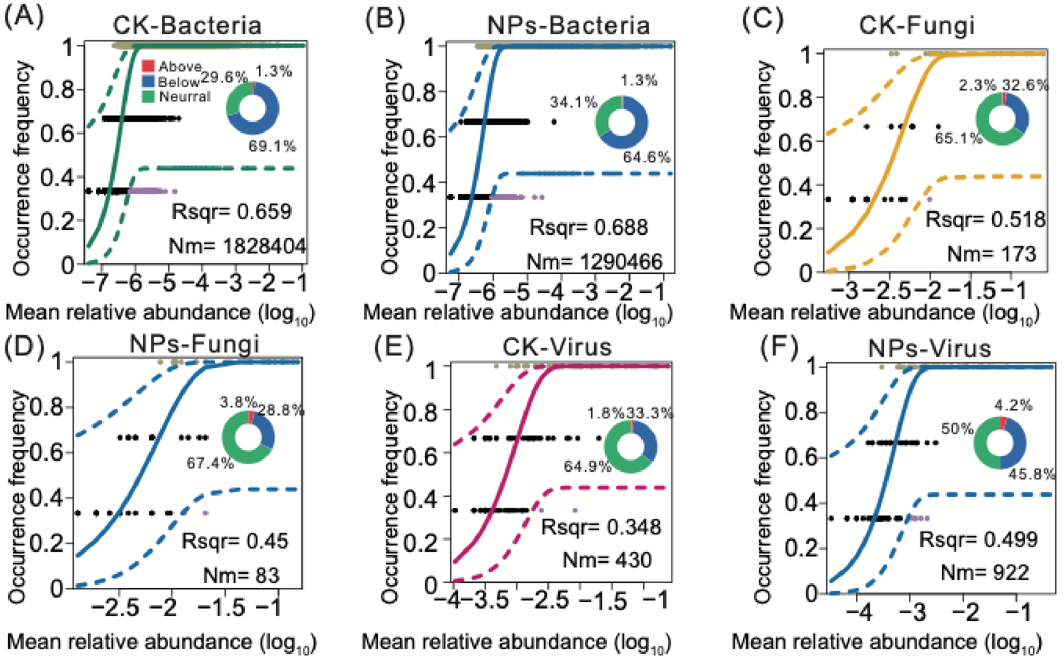
Hepatointestinal bile acid profile and intestinal flora diversity



Chronic NPs exposure alters circulating bile acid composition and perturbs hepatic–intestinal metabolic pathways.

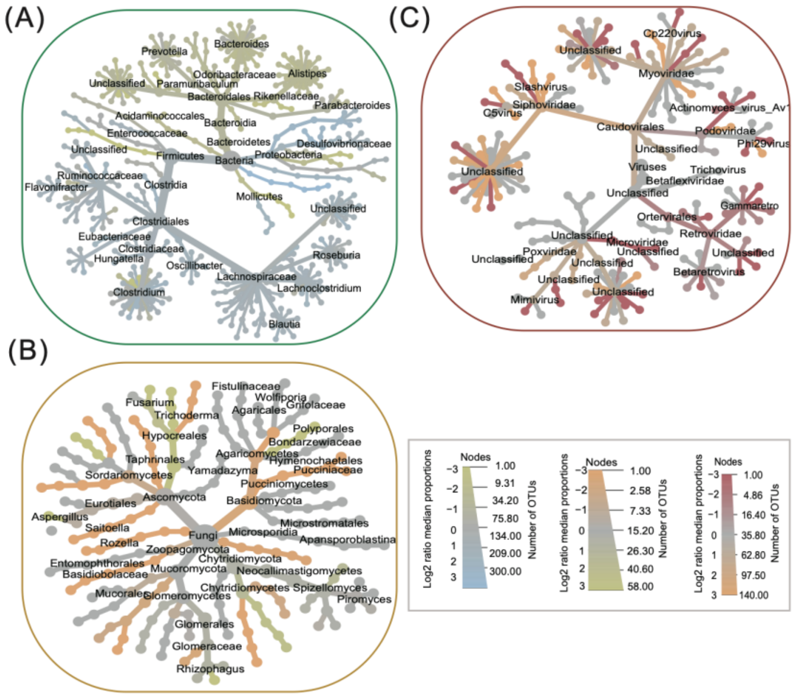


Alpha diversity of intestinal bacterial, fungal, and viral communities in mice.

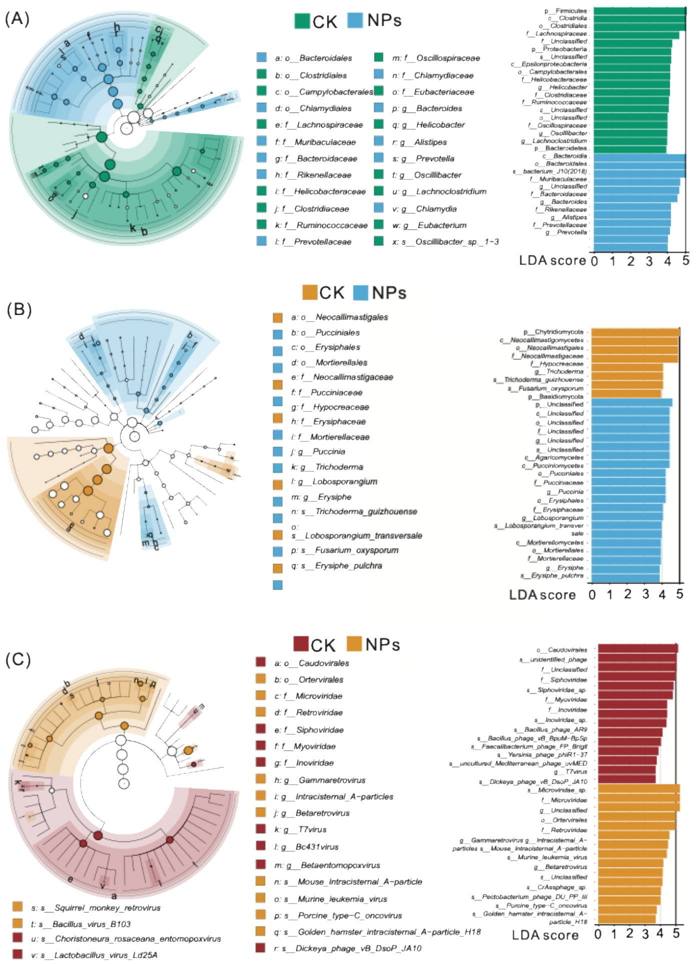


Neutral community models illustrating the contribution of stochastic processes to community assembly

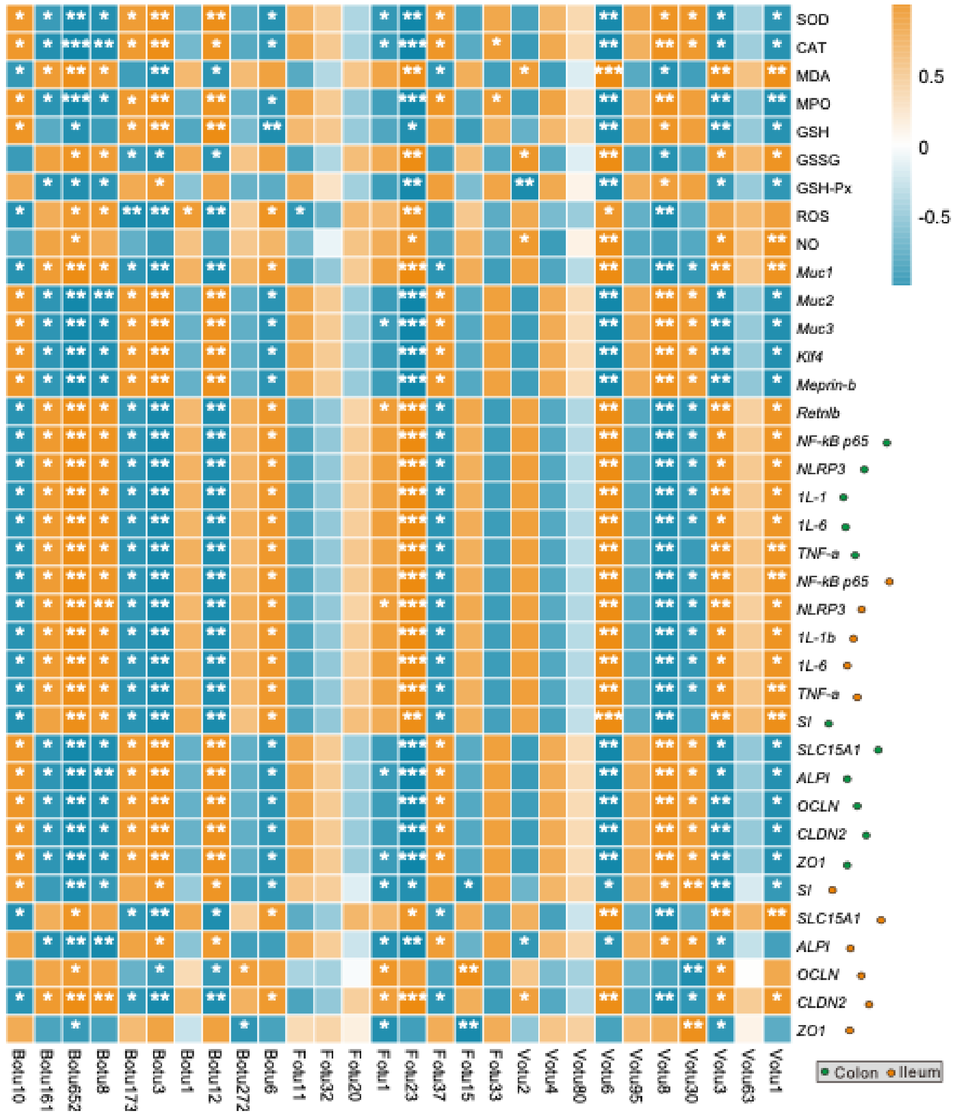
Structural differences and functional roles of intestinal microbiota



Heat-tree visualizations showing differential taxonomic abundance of bacterial, fungal, and viral communities.

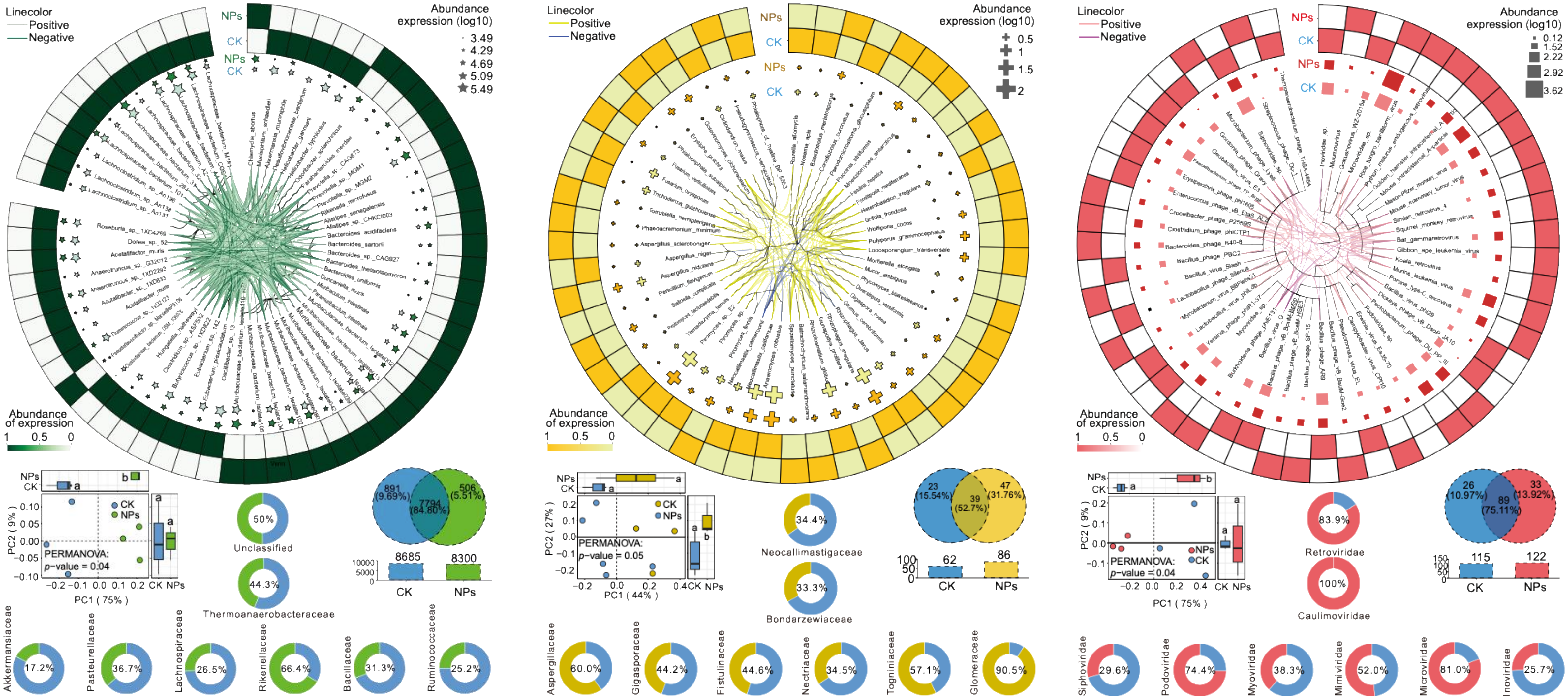


Linear discriminant analysis effect size identifying differentially enriched taxa.



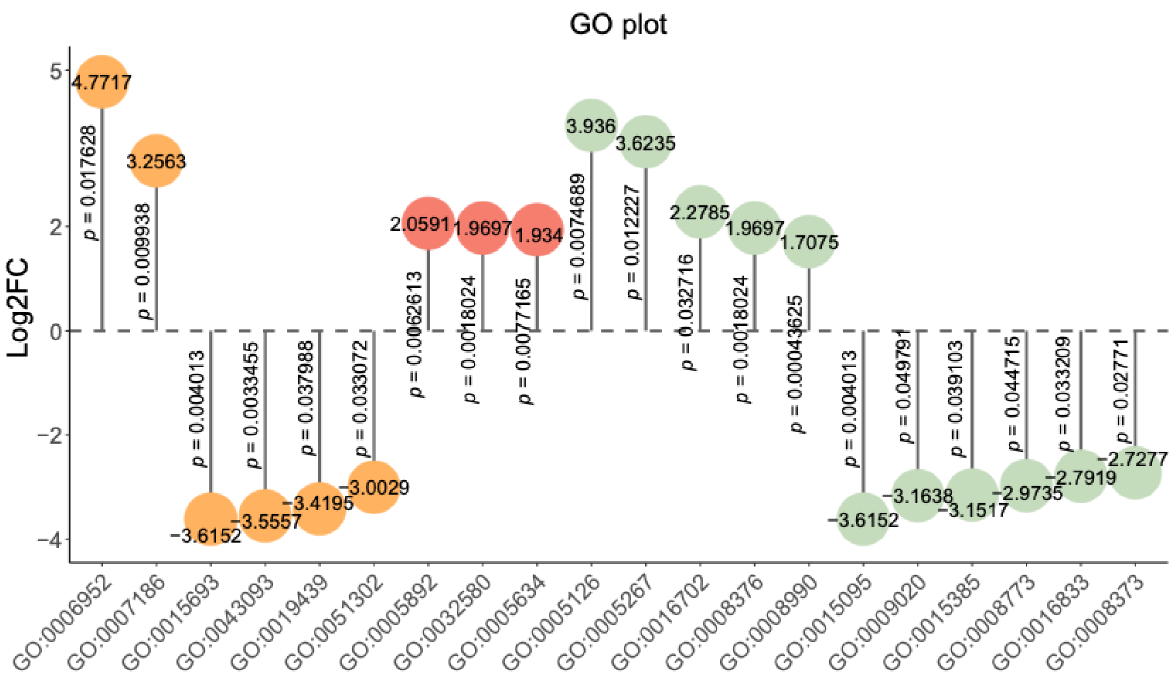
Heatmap showing Spearman correlation coefficients between gut physicochemical indices and abundances of characteristic microbial taxa across bacterial, fungal, and viral communities.

Structural differences and functional roles of intestinal microbiota

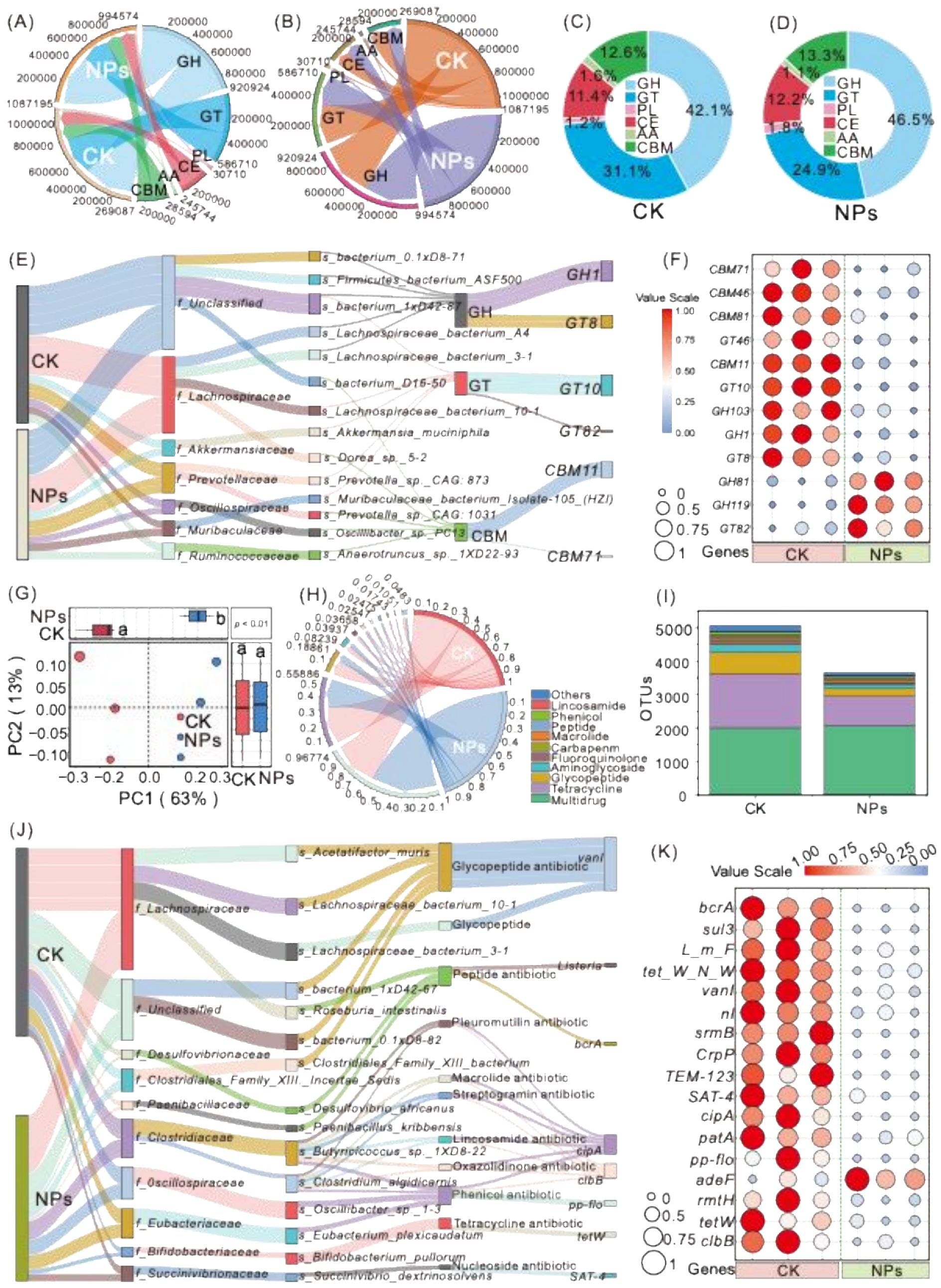


Chronic NPs exposure alters intestinal bacterial, fungal, and viral community structure in mice.

Changes in CAZymes and ARGs of the gut microbiota

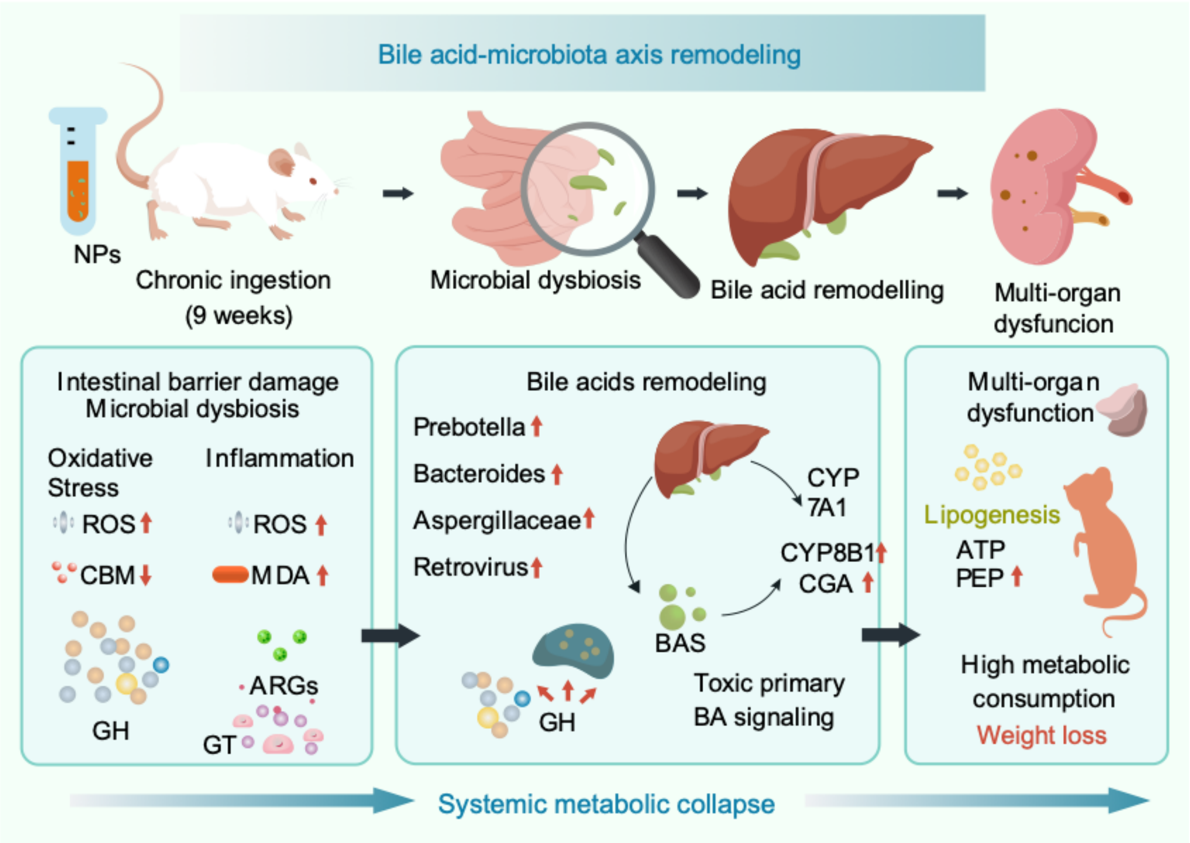


GO functional enrichment of intestinal microbiota in mice following chronic NPs exposure.



Effects of chronic NPs exposure on intestinal carbohydrate-active enzymes (CAZymes) and antibiotic resistance genes (ARGs).

Summary



We characterize a 'Microplastics–Gut–Microbiota–Metabolism' axis where bile acids act as key messengers linking gut dysbiosis to hepato-renal metabolic injury. This mechanism underscores the systemic risks of chronic nanoplastic exposure and positions bile acid homeostasis and 7α-dehydroxylating bacteria as critical targets for mitigating health risks.

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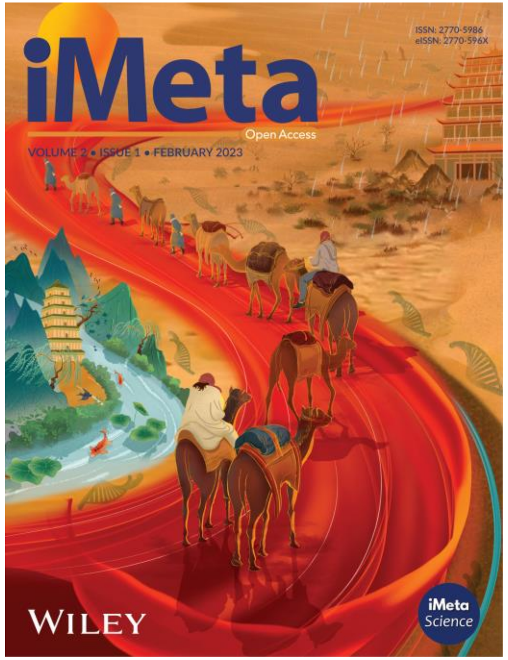

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