



Spaceflight Redefines Ageing-Associated Microbiota

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Background: The challenges of astronaut health

Physical effects of being in space

Altered gravity

- Lack of gravitational loading
- Lack of hydrostatic pressure
- Lack of convection
- Lack of buoyancy
- Lack of sedimentation

Increased exposure to ultraviolet and ionizing radiation in deep space

- Acute in-flight effects
- Long-term cancer risk



Physical effects of living and working in space

Habitat

- Distance from Earth
- 90 minute day and night cycles
- Acoustic noise (60 dBA)
- Reduced and closed space
- Isolation
- Lack of natural light and surroundings
- Modest increased ambient pCO₂

Conditions of life

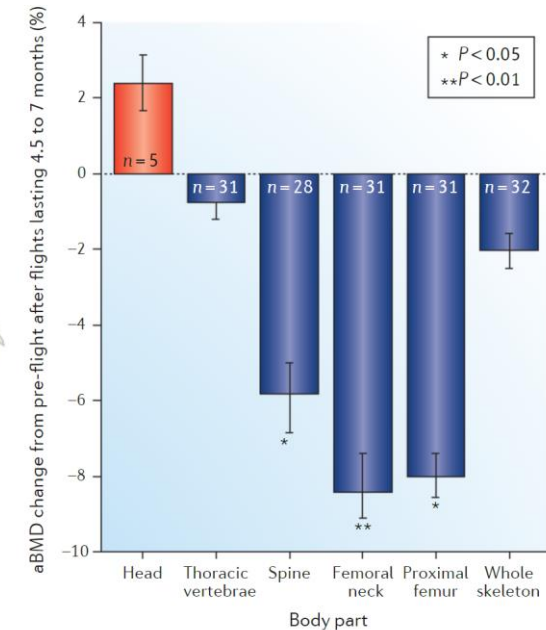
- Limited privacy
- Floating
- Disturbances in sleep
- Hygiene
- Performance pressures

Extravehicular activity

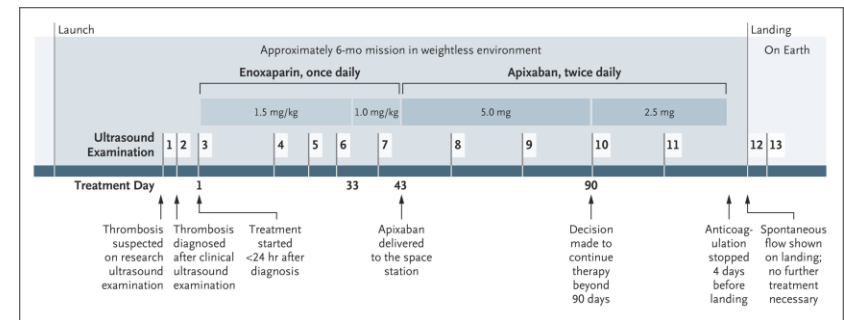
- High vacuum
- Extremes of temperature
- Meteoroids
- Space debris
- Ionospheric plasma
- Hand and shoulder injuries

Combined effects on crewmembers

- Reduced ground reaction force
- Physiological changes
- Behavioural changes
- Psychological changes



■ Gain of bone mineral density ■ Loss of bone mineral density

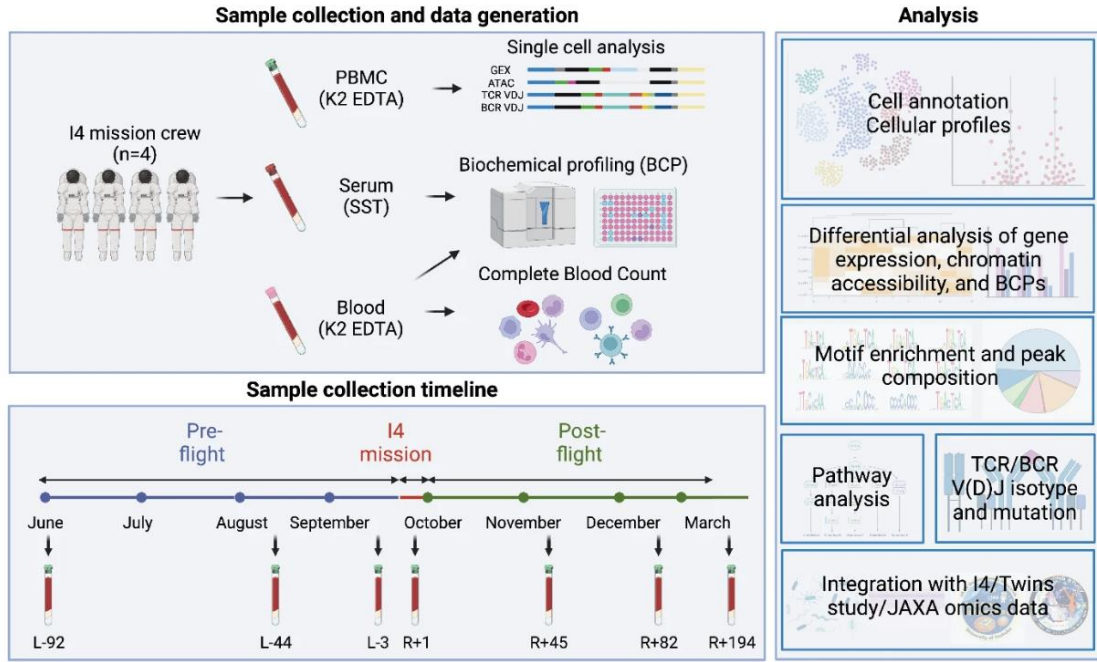


Nat Rev Rheumatol 14: 229-245.

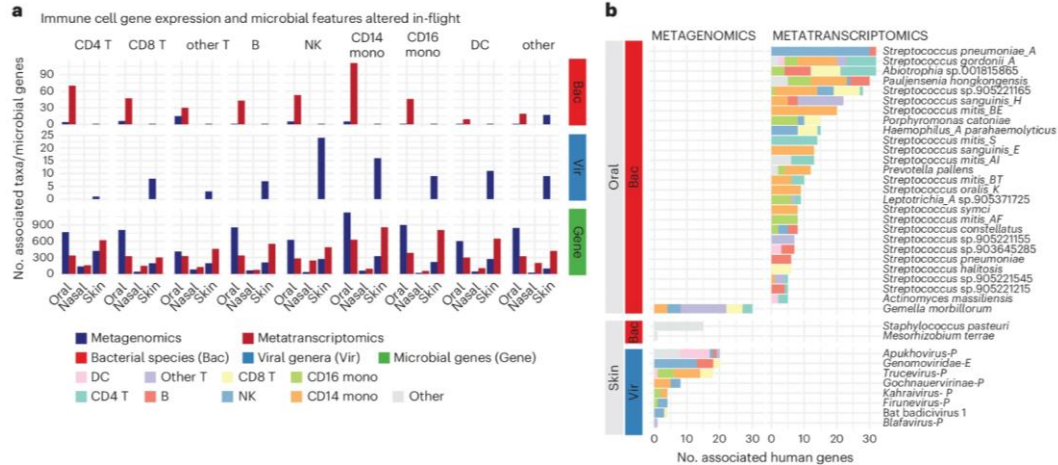
N Engl J Med 382: 89-90.



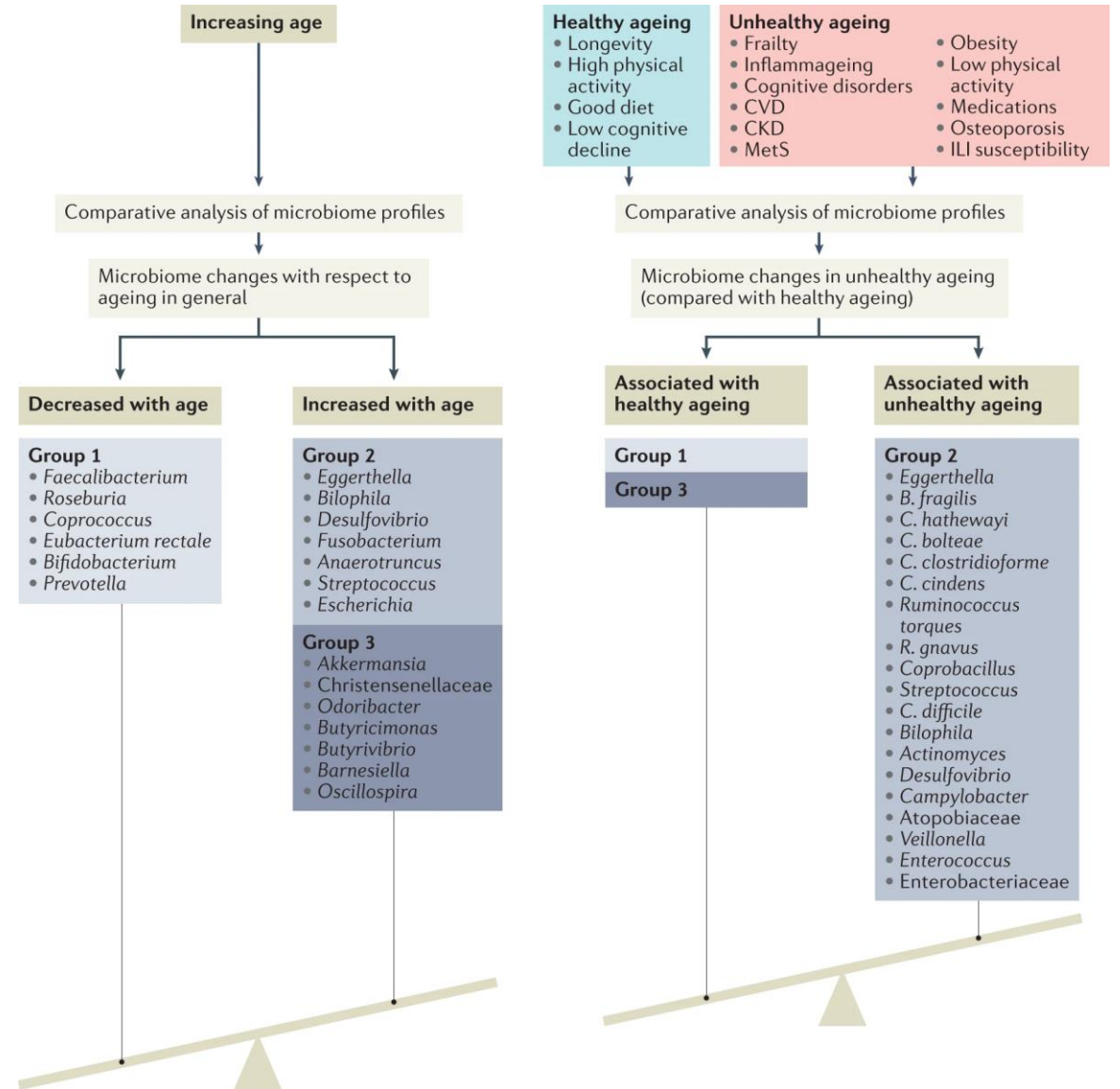
Background: Microbiota influence the ageing process



Nature Communications 15: 4954.



Nat Microbiol 9: 1661-1675.



Nature Reviews Gastroenterology & Hepatology 19: 565-584.

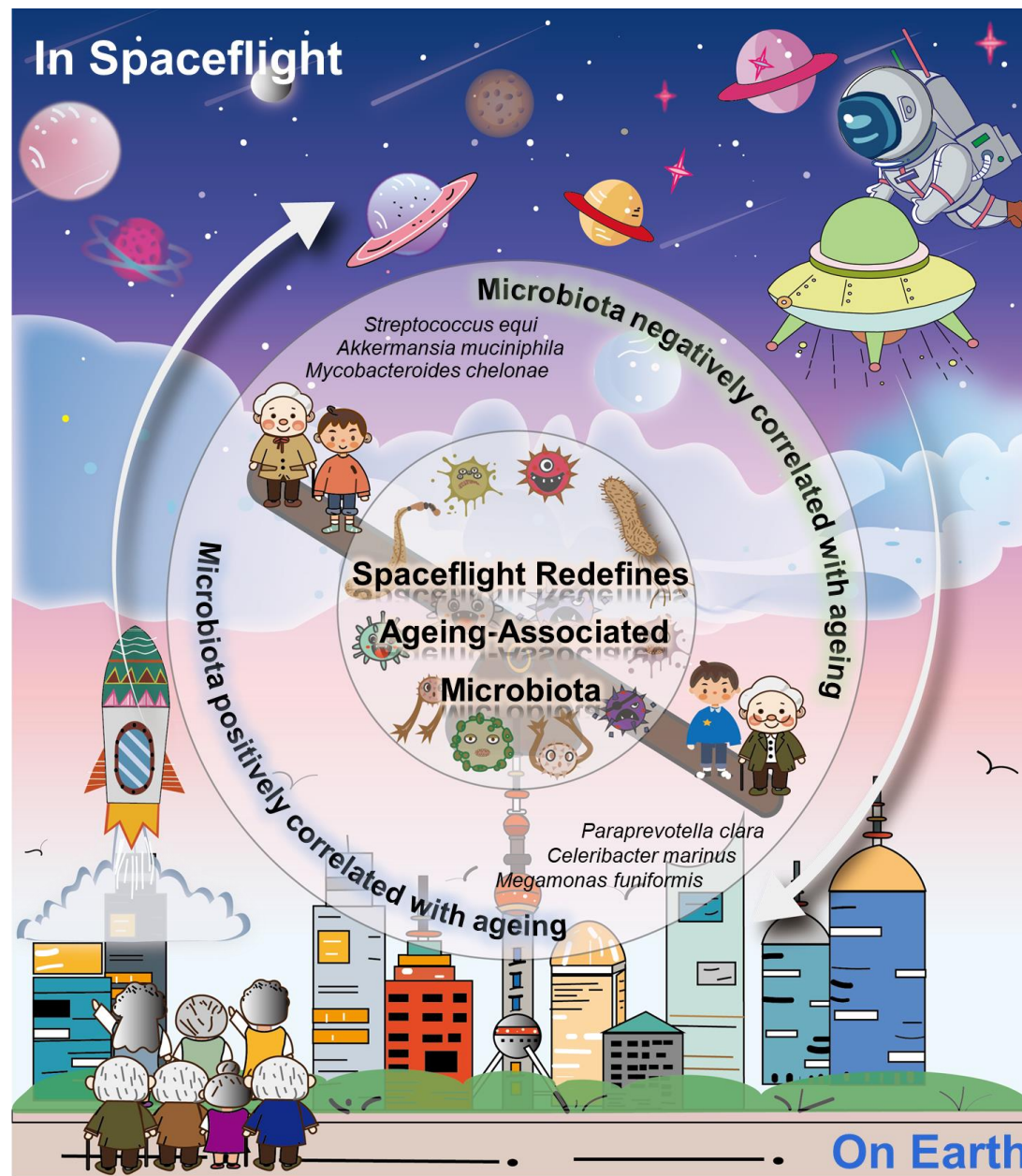


Highlights

- ✓ **The extreme conditions of space present immediate challenges to astronaut health.**
- ✓ **The impact of spaceflight on the human immune system.**
- ✓ **Microbiota play important roles in modulating immune responses and influencing the ageing process.**
- ✓ **Spaceflight-induced changes in microbiota composition potentially influence ageing in astronauts.**

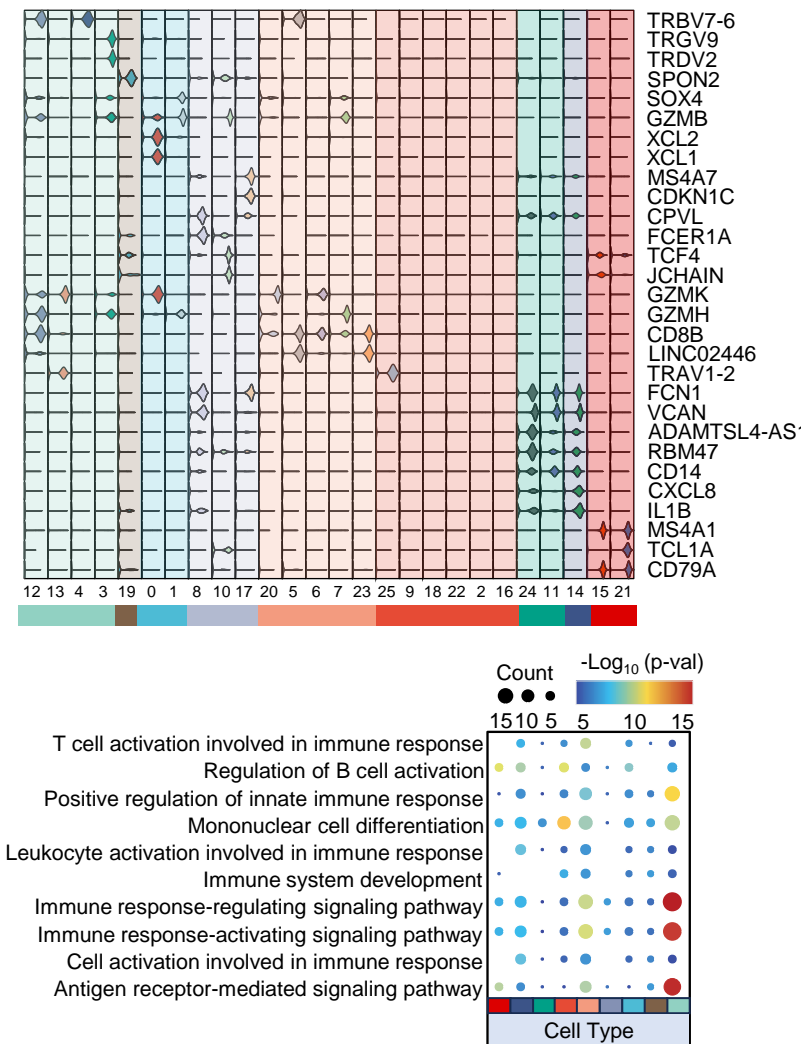
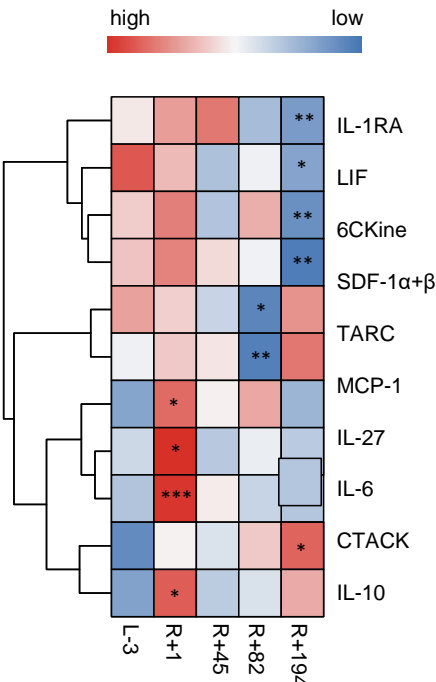
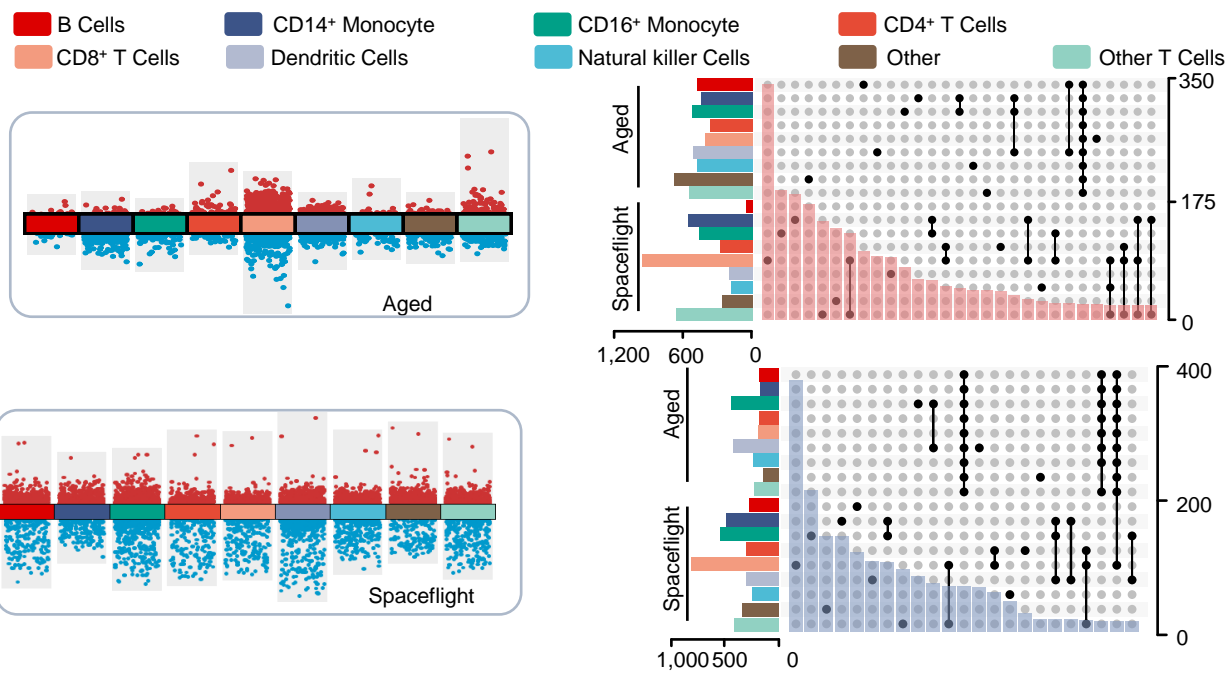
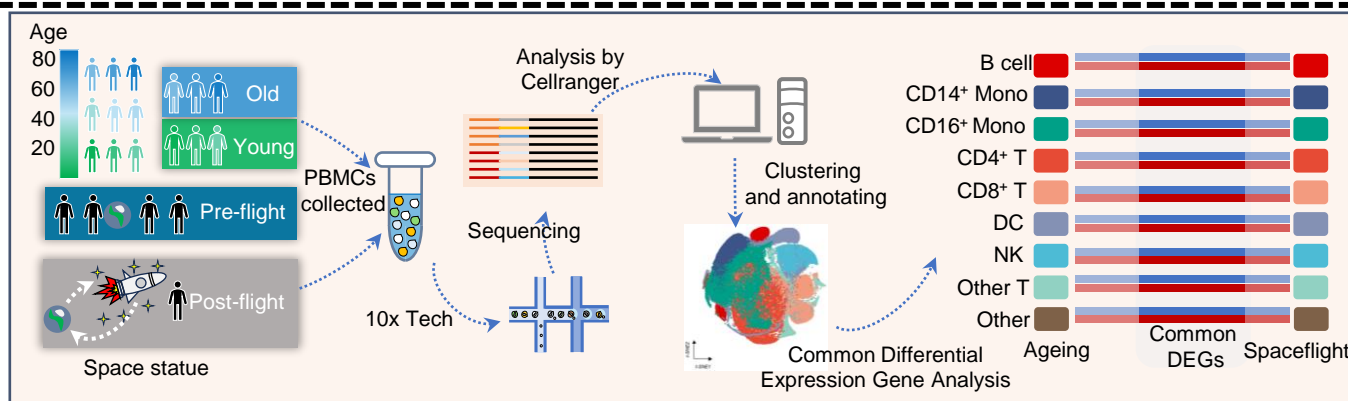


Graphical Abstract





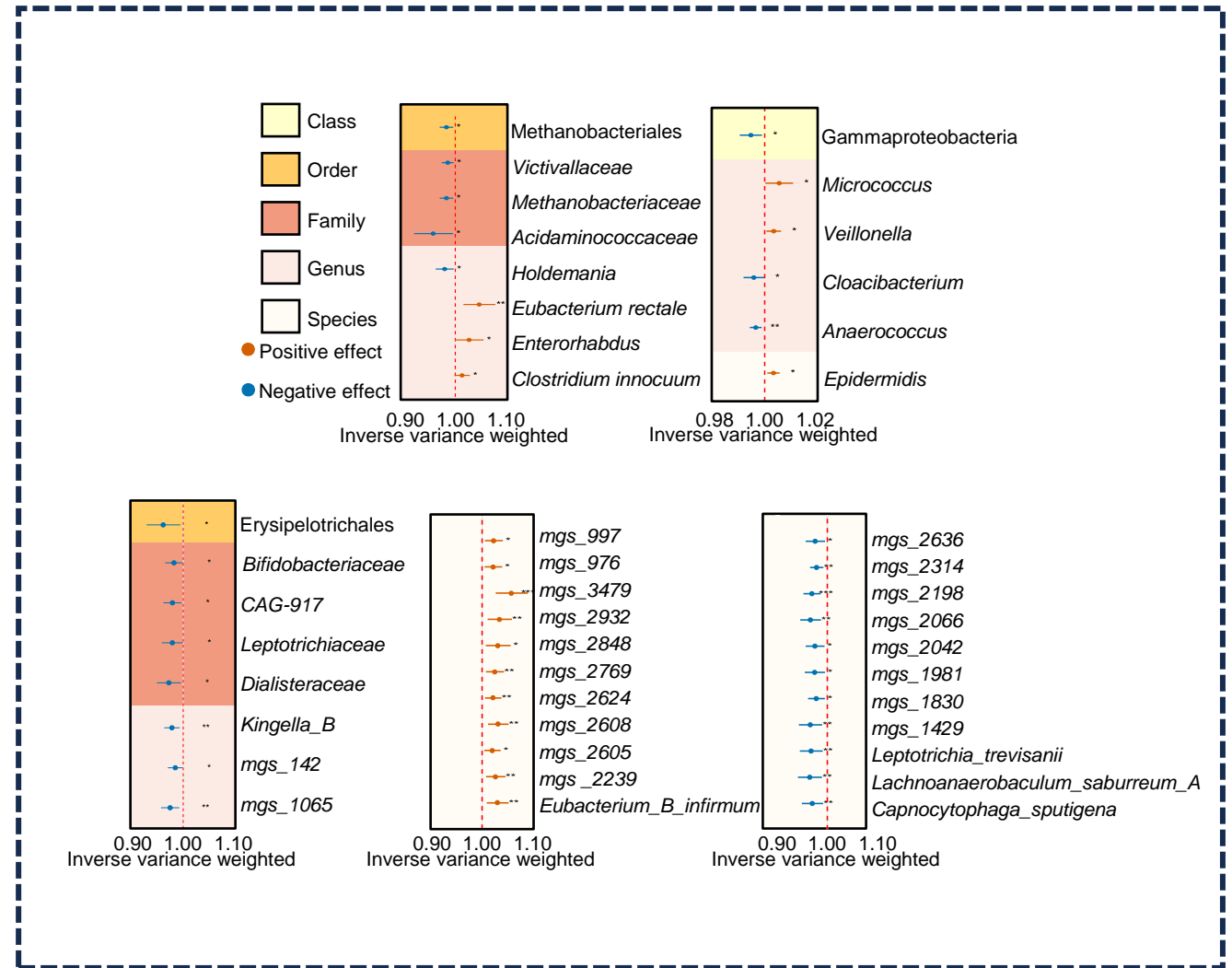
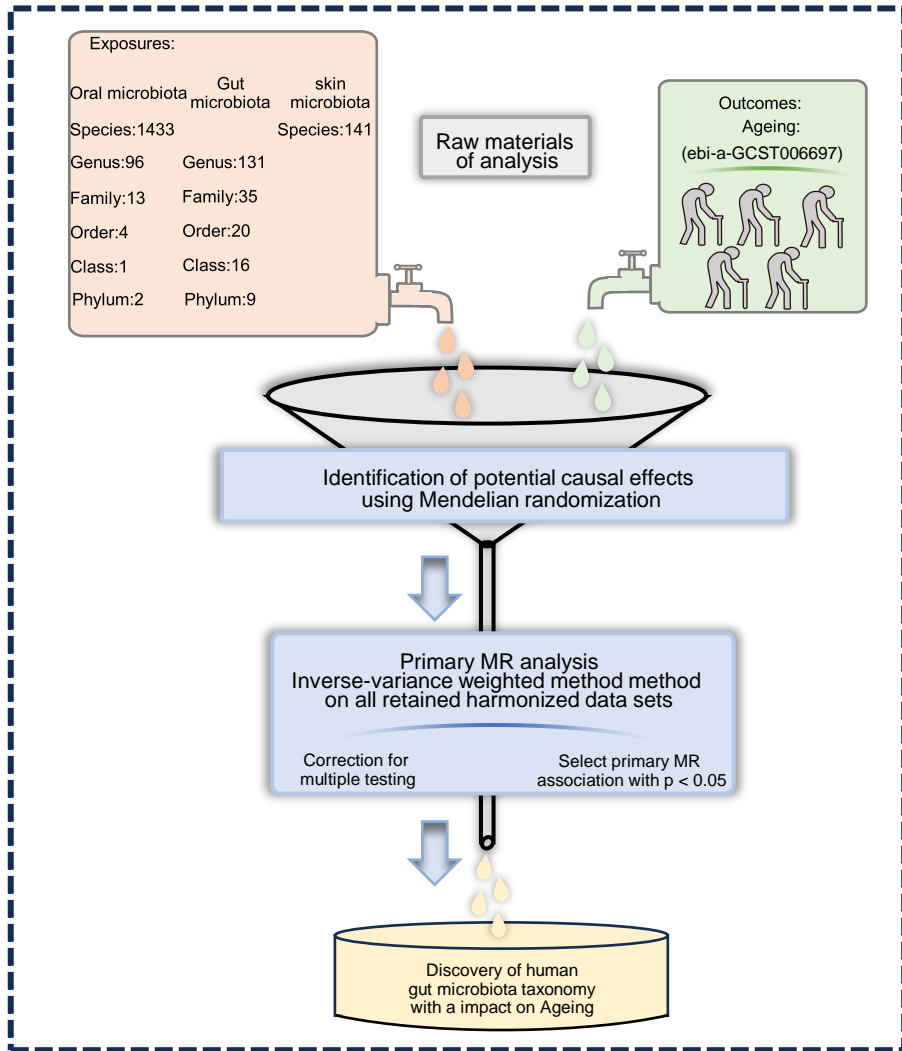
Result: Immune System Alterations in Ageing and Spaceflight



Spaceflight alters the immune function of astronauts in a manner similar to natural ageing.

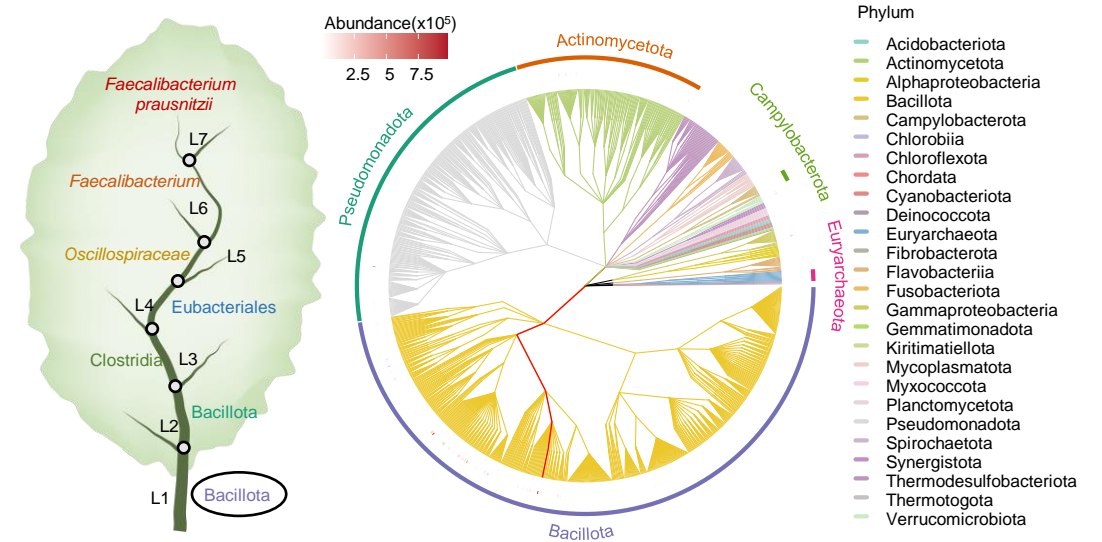
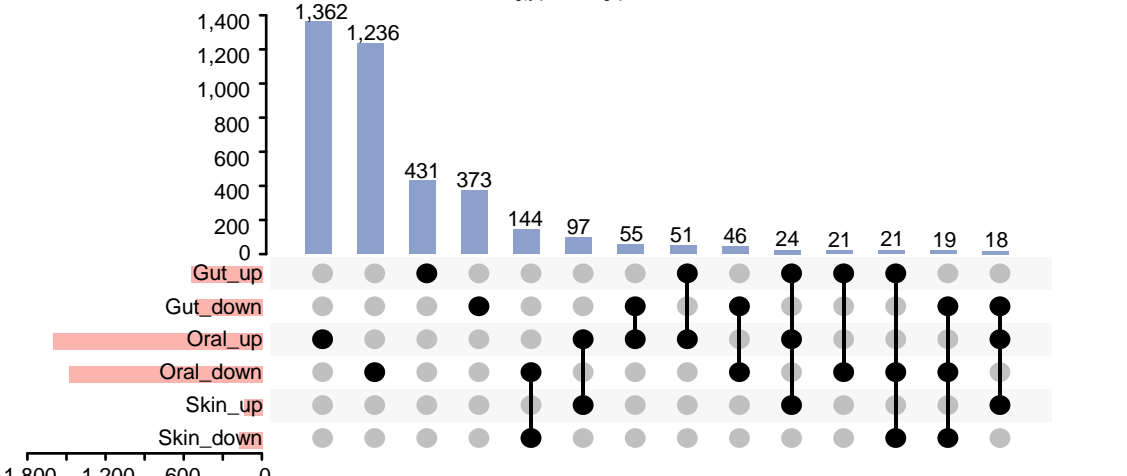
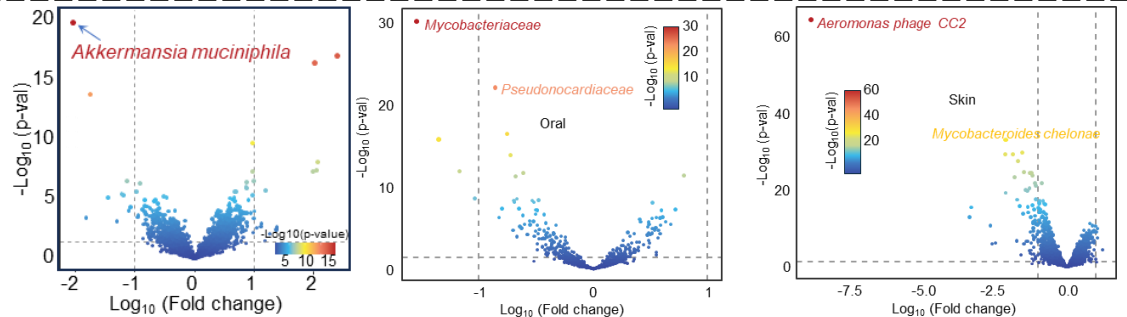
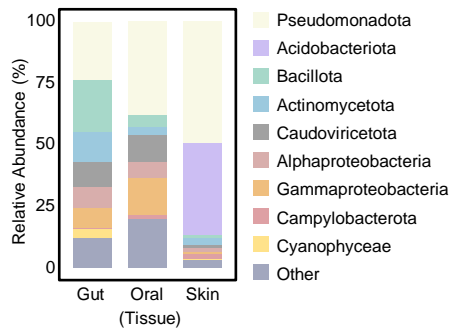
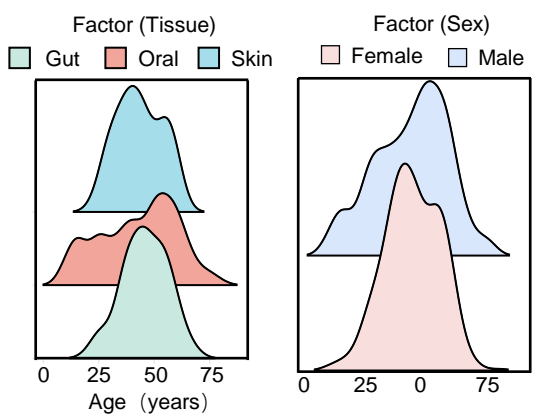
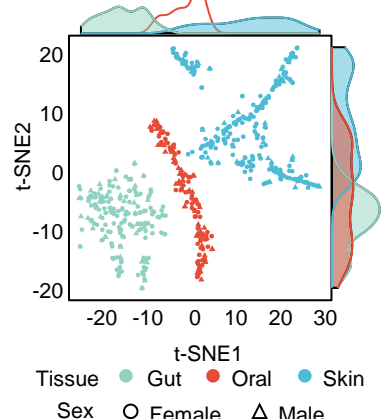
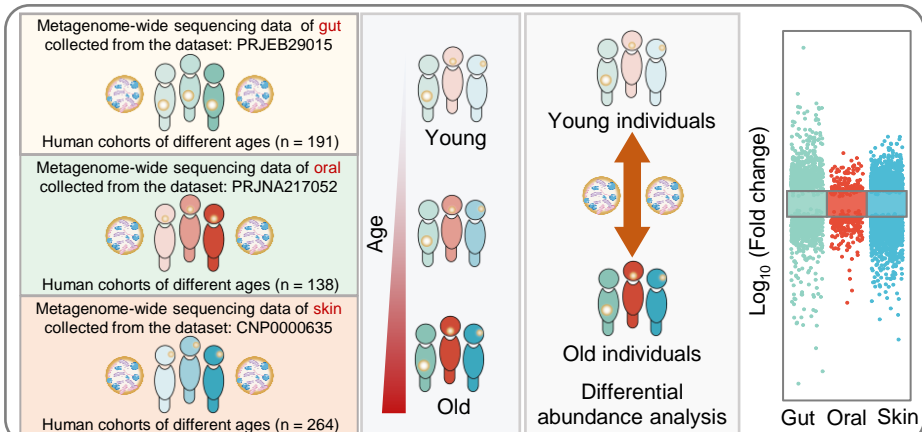


Result: Microbial Associations with Ageing Across Diverse Body Sites



MR analysis shows causality between ageing and specific microbes in the gut, skin, and oral cavity.

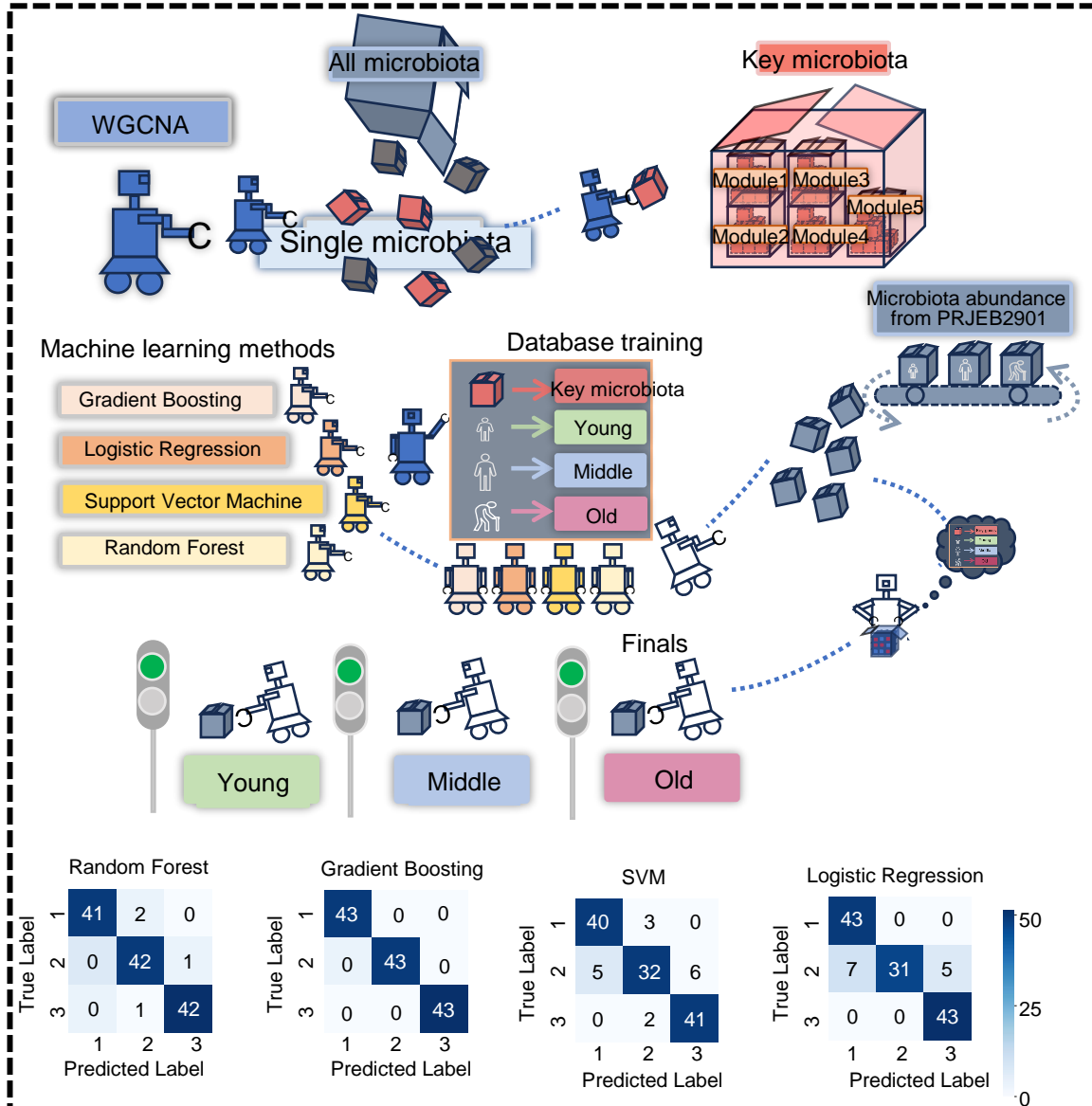
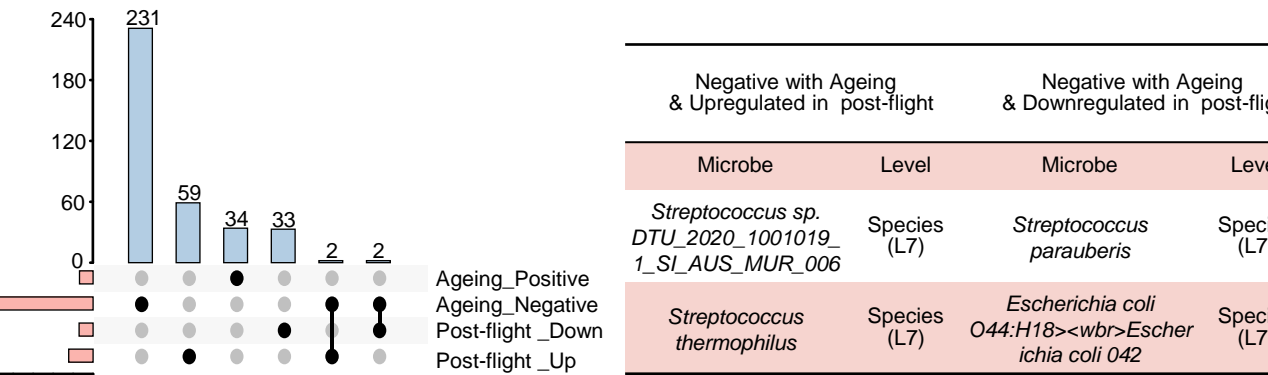
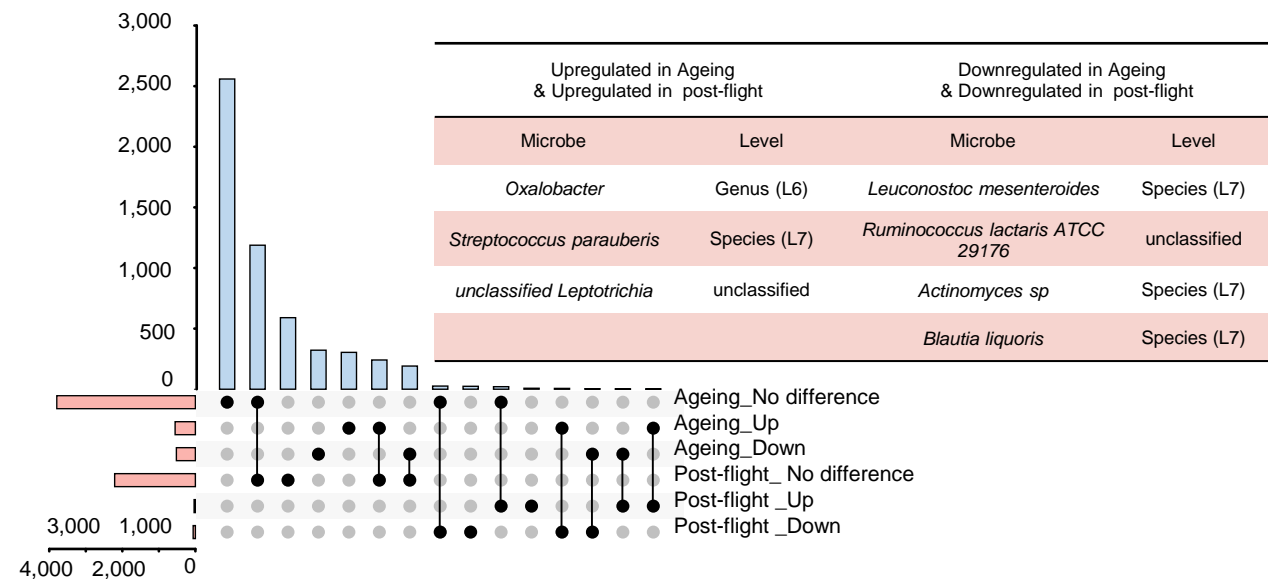
Result: Microbial Shifts in Gut, Oral, and Skin Tissues During Ageing



Metagenomics analysis reveals multiple microbiota that change in ageing.



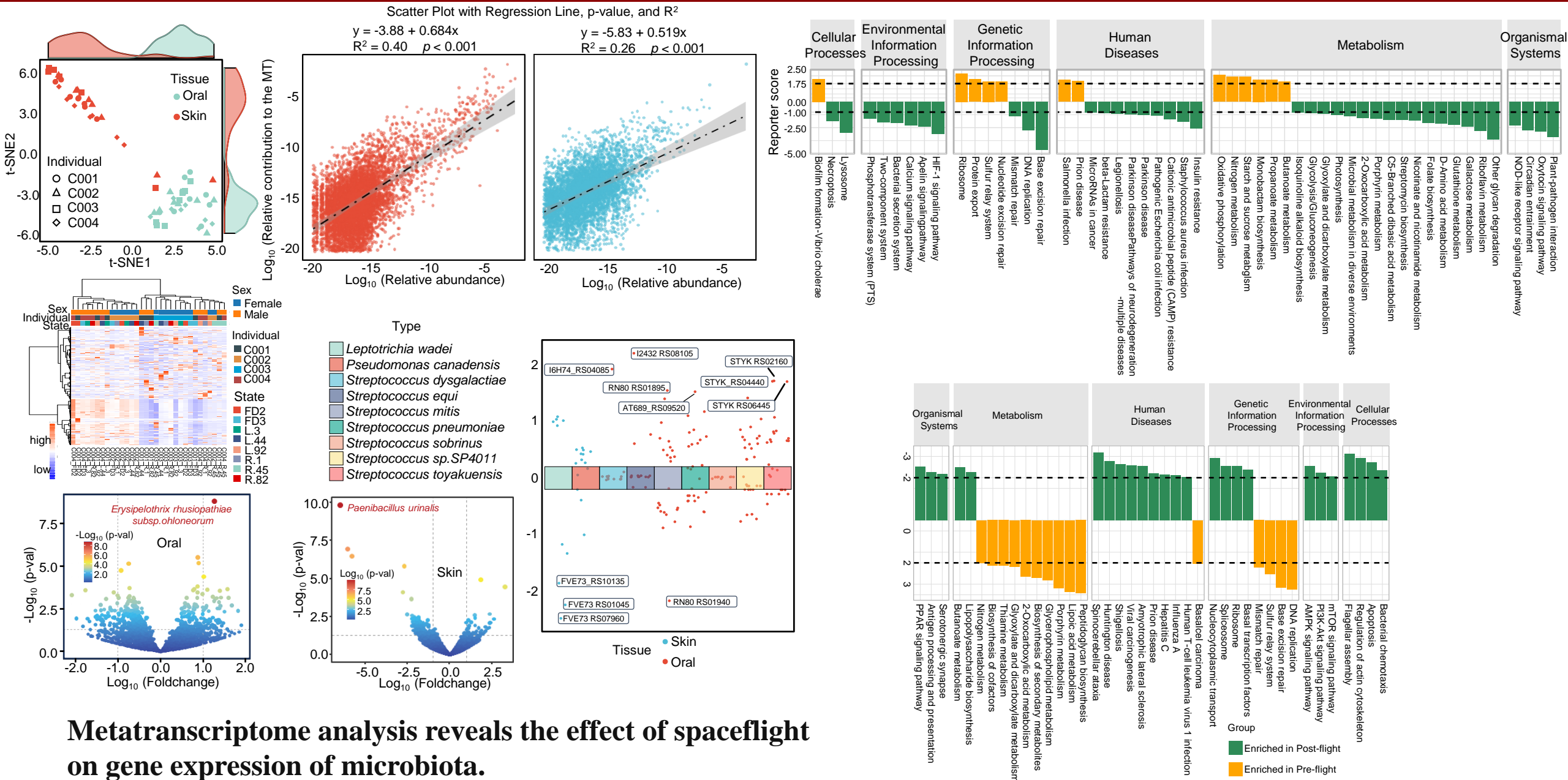
Result: Spaceflight Modifies Age-Related Microbiota



Integrative analysis identifies changes in the microbiota that co-altered during spaceflight and ageing.



Result: Spaceflight Alters Functional Dynamics of Microbiota

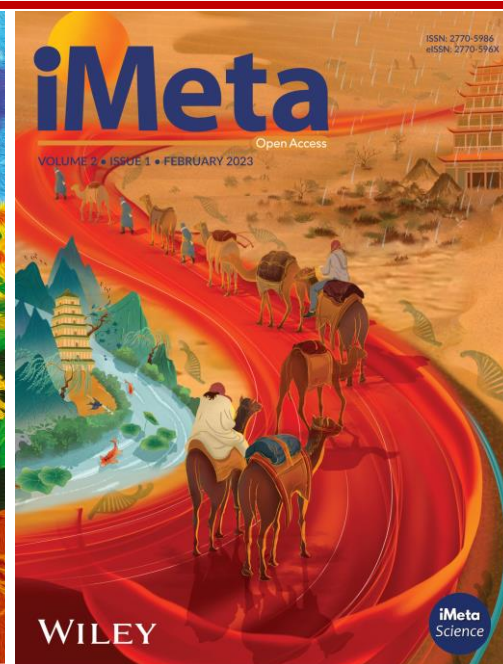




Summary




- ❑ Spaceflight alters the immune function of astronauts in a manner similar to natural ageing.
- ❑ Ageing alters the host microbiota across multiple body sites, leading to changes that may influence the ageing process itself.
- ❑ Ageing-associated microbiota in the oral cavity and skin exhibited significant changes after spaceflight.
- ❑ Spaceflight may potentially impact human health by altering microbiota function.

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