



太空飞行重新定义与衰老相关的微生物群

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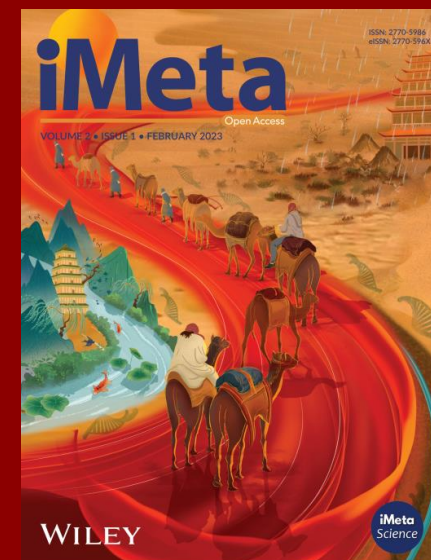
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背景：宇航员健康面临的挑战

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

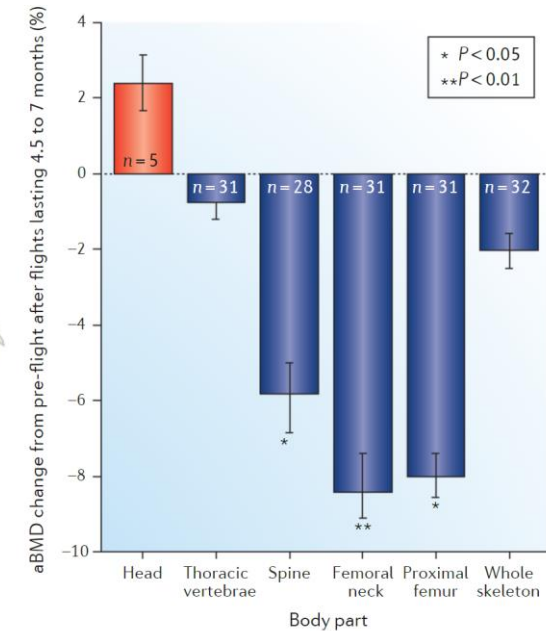
- Limited privacy
- Floating
- Disturbances in sleep
- Hygiene
- Performance pressures

Extravehicular activity

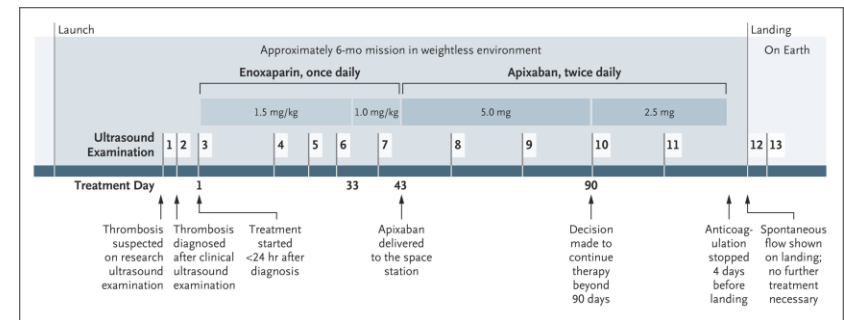
- High vacuum
- Extremes of temperature
- Meteoroids
- Space debris
- Ionospheric plasma
- Hand and shoulder injuries

Combined effects on crewmembers

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



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

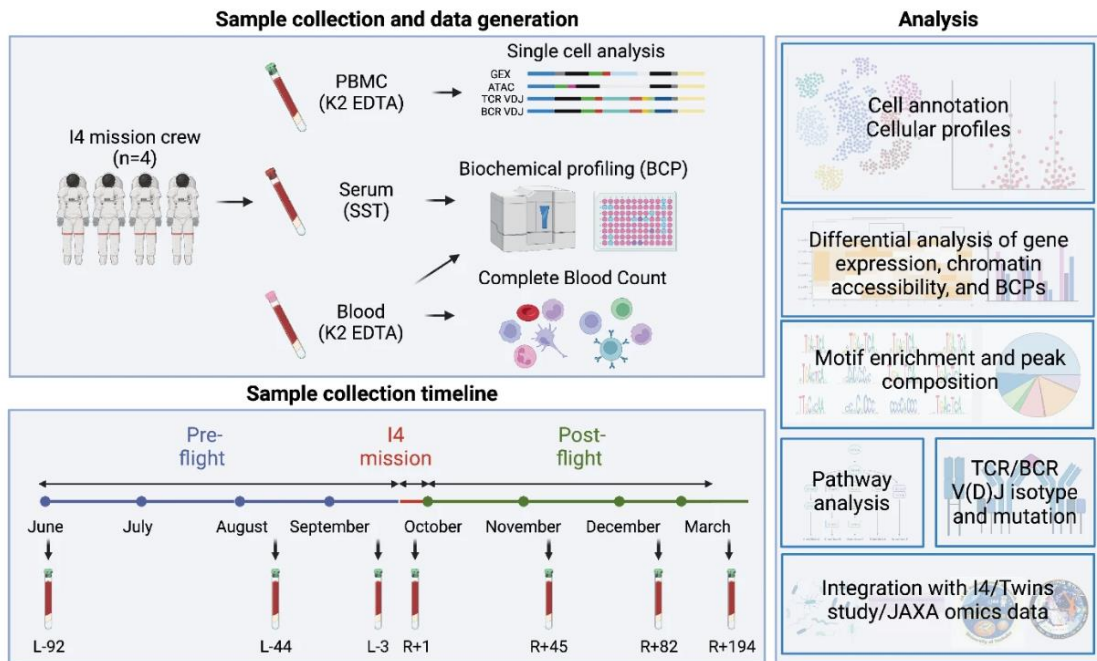


Nat Rev Rheumatol 14: 229-245.

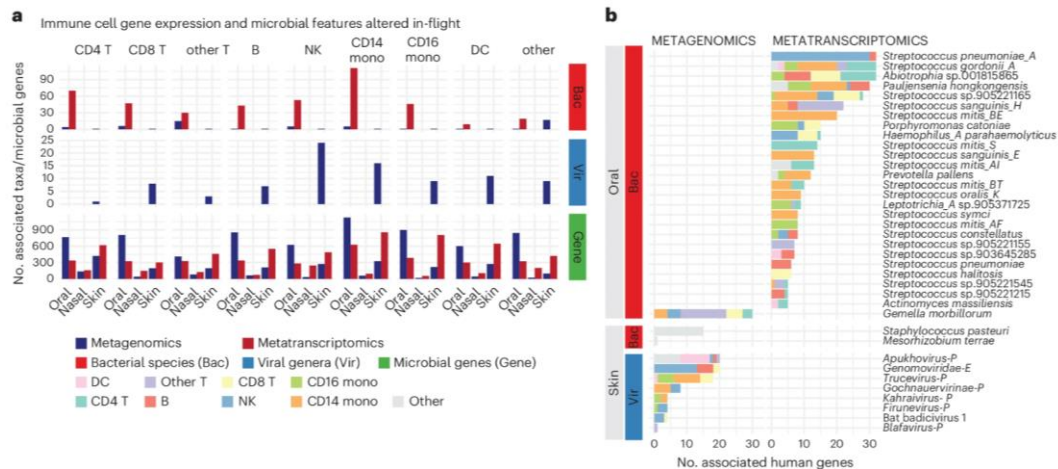
N Engl J Med 382: 89-90.



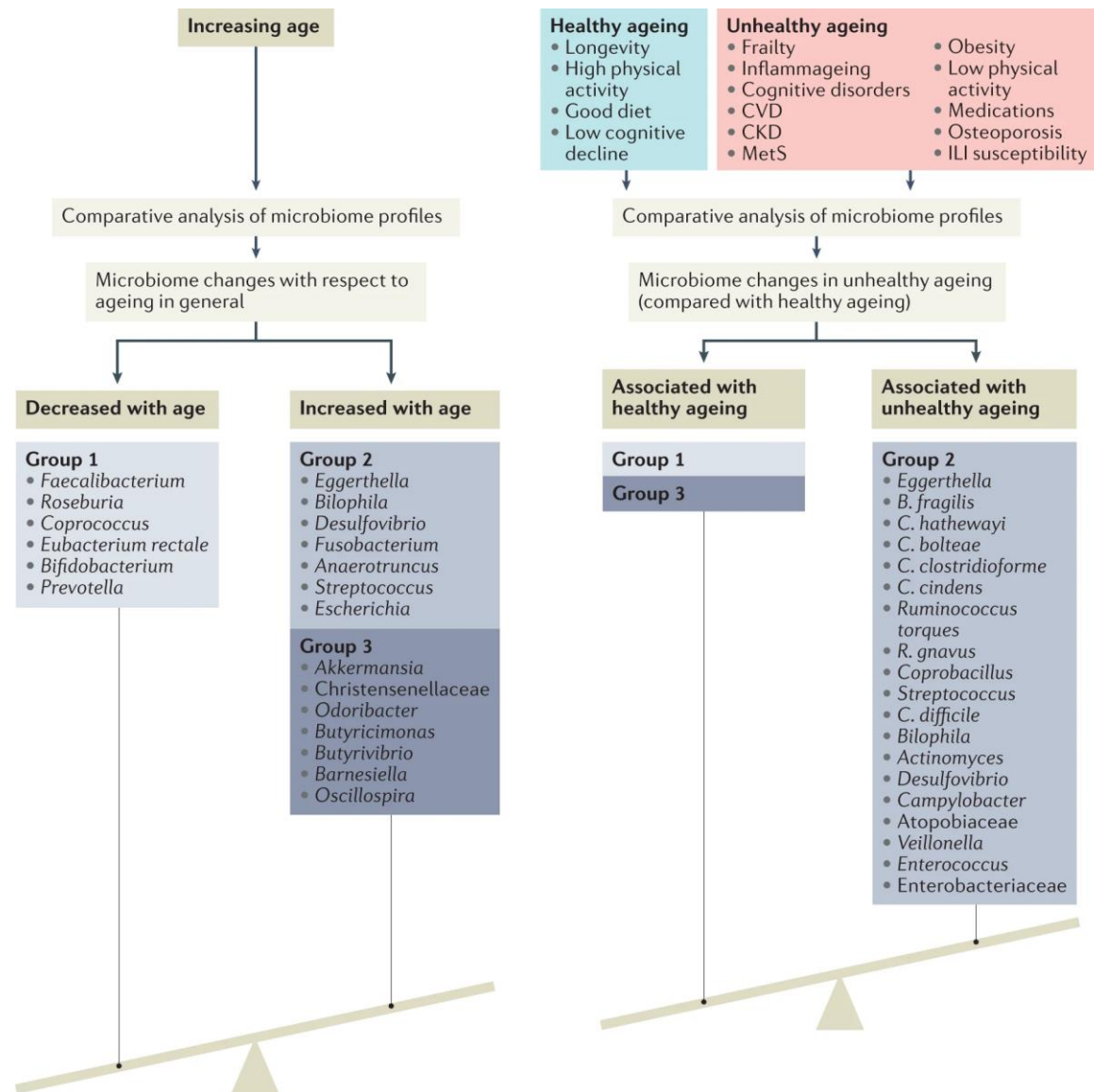
背景：微生物群影响衰老过程



Nature Communications 15: 4954.



Nat Microbiol 9: 1661-1675.



Nature Reviews Gastroenterology & Hepatology 19: 565-584.

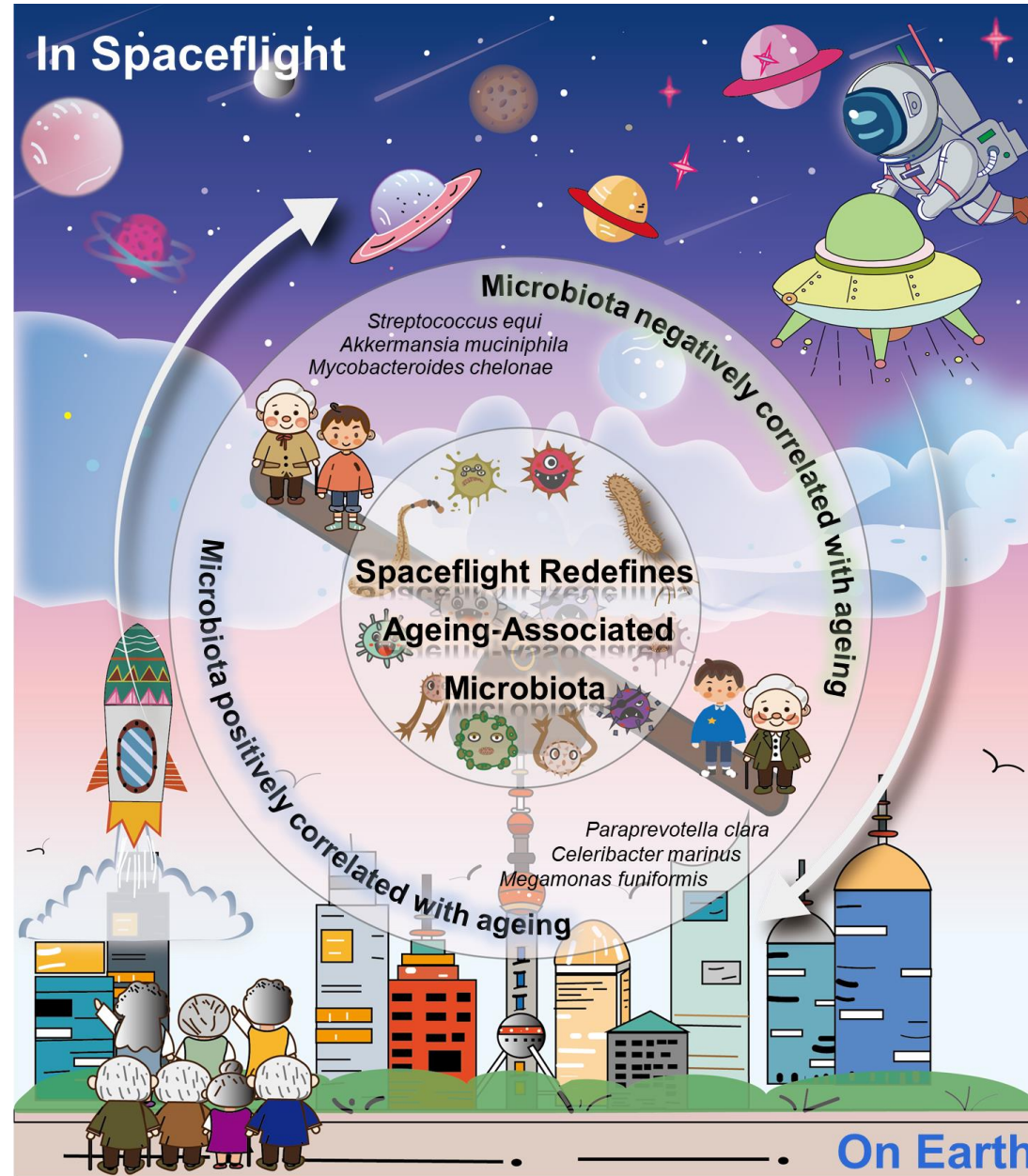


亮点

- ✓ 太空的极端条件对宇航员的健康构成直接挑战，对人类福祉产生长期影响。
- ✓ 太空飞行影响人体免疫系统。
- ✓ 微生物群在调节免疫反应和自然衰老进程中发挥重要作用。
- ✓ 太空飞行引起的微生物群组成及功能的变化可能会影响宇航员的衰老。

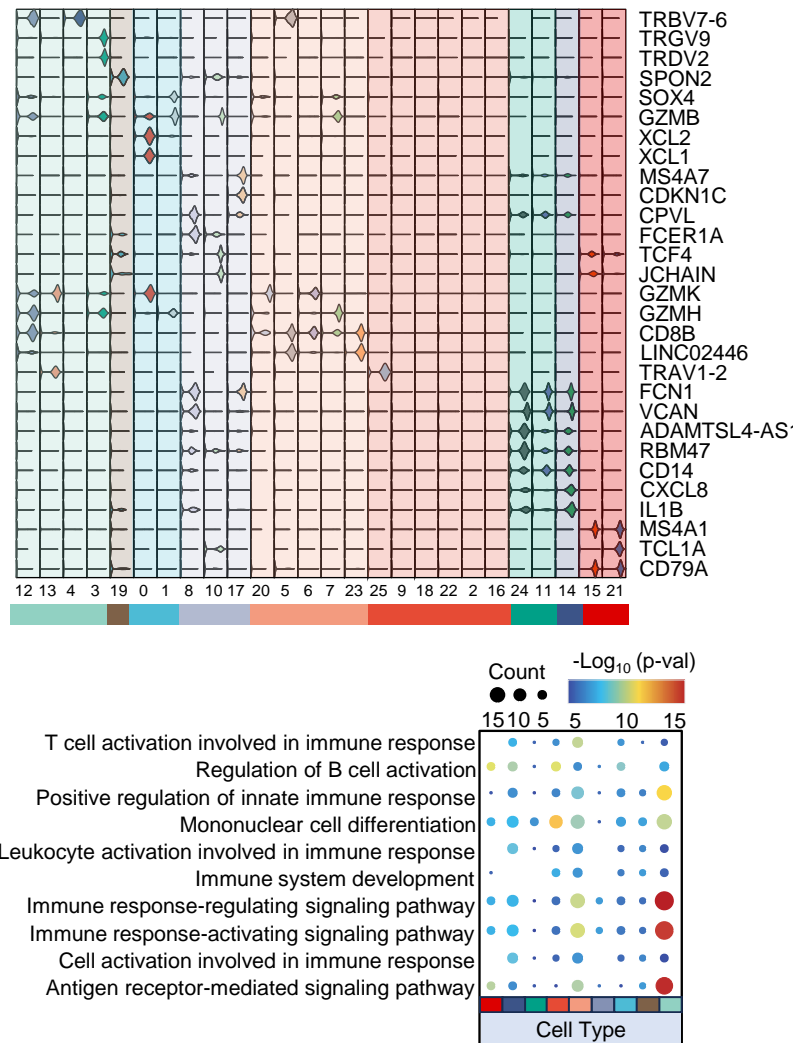
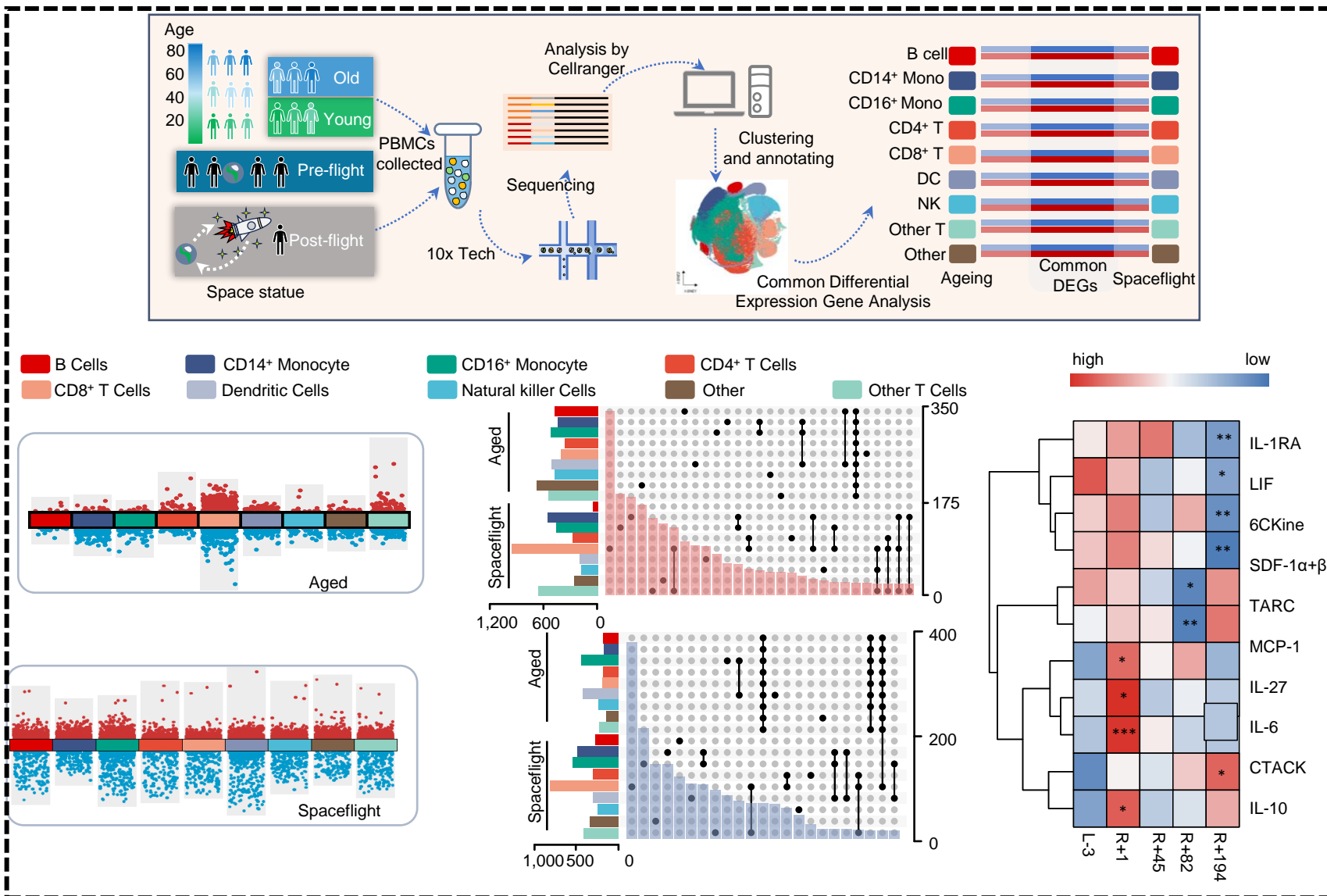


图形摘要





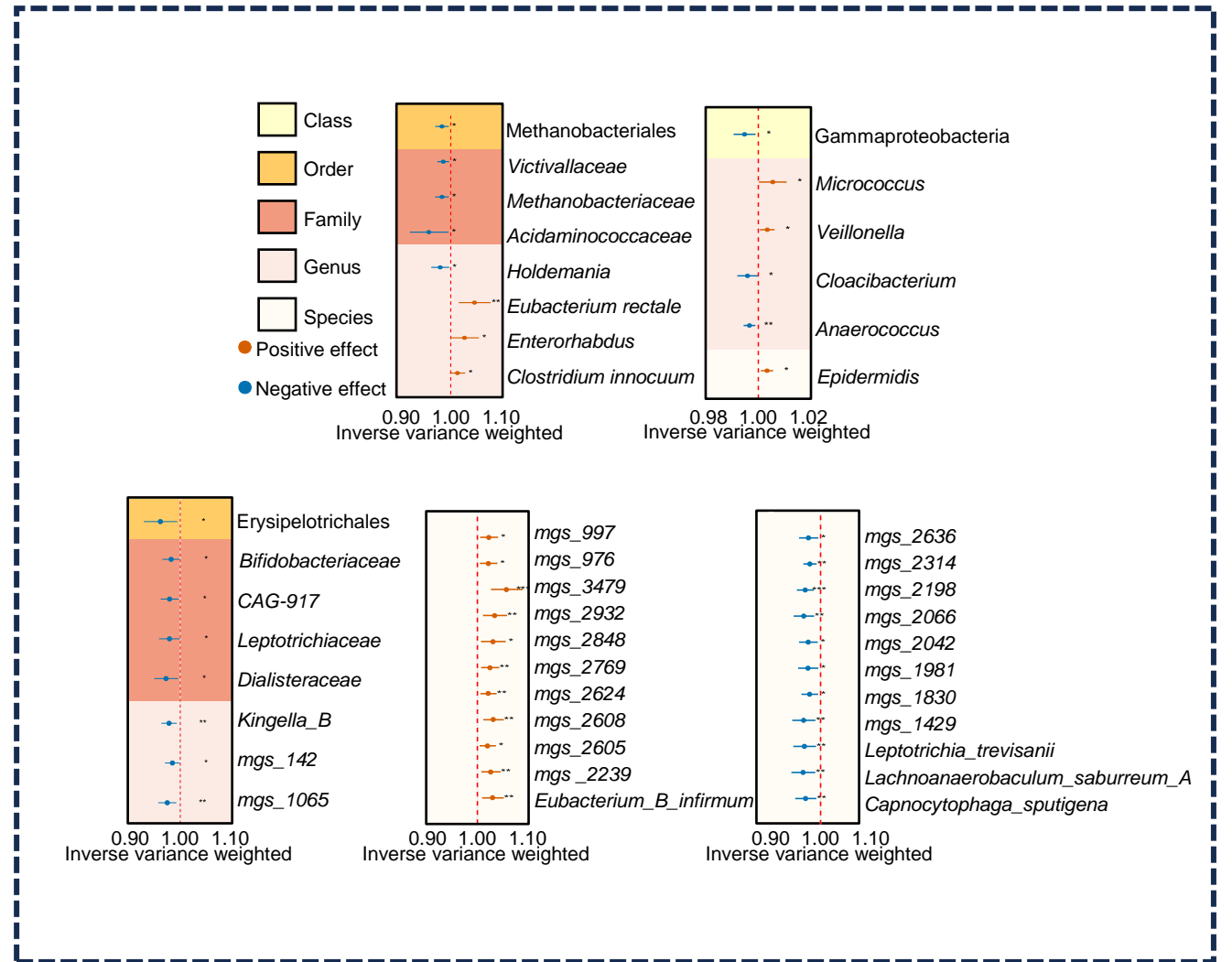
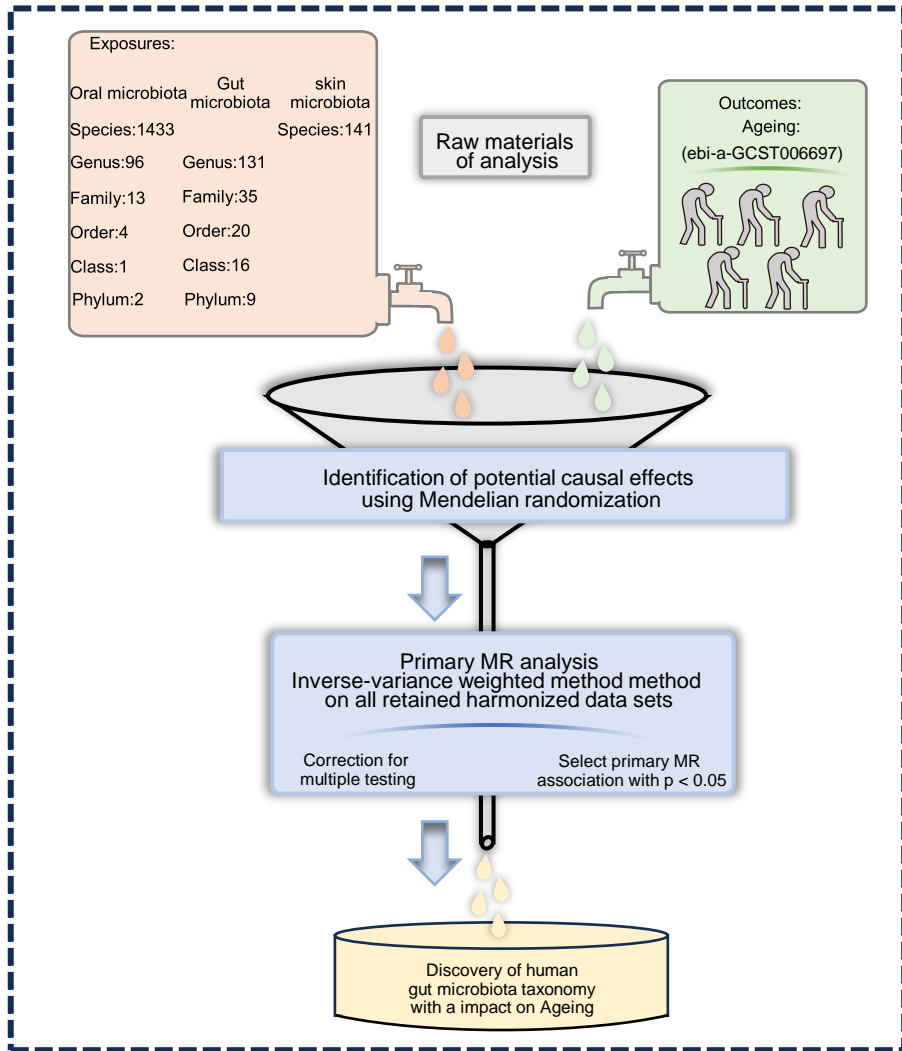
结果：衰老和太空飞行对免疫系统的影响



单细胞测序揭示了太空环境对宇航员免疫功能的影响。



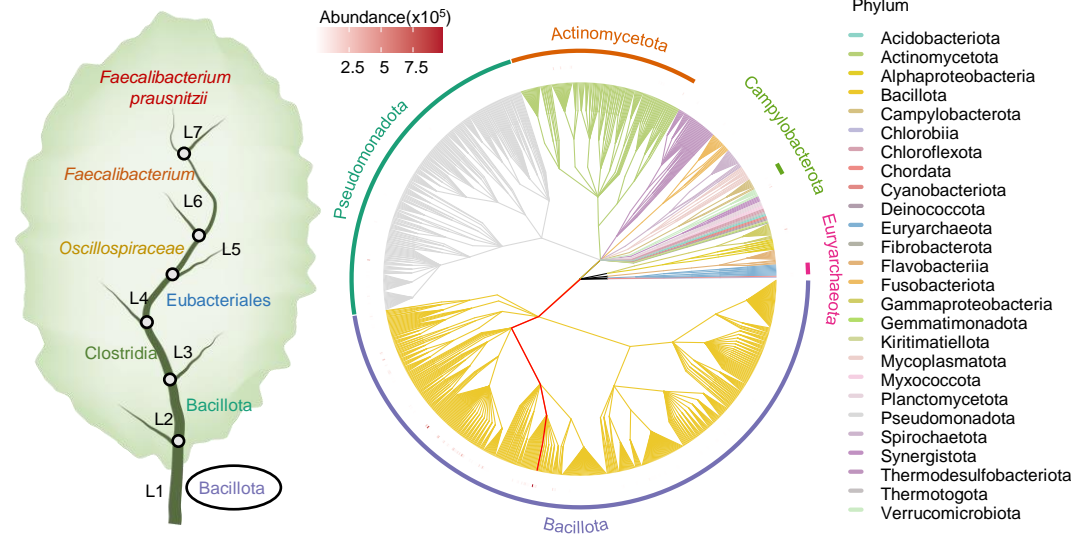
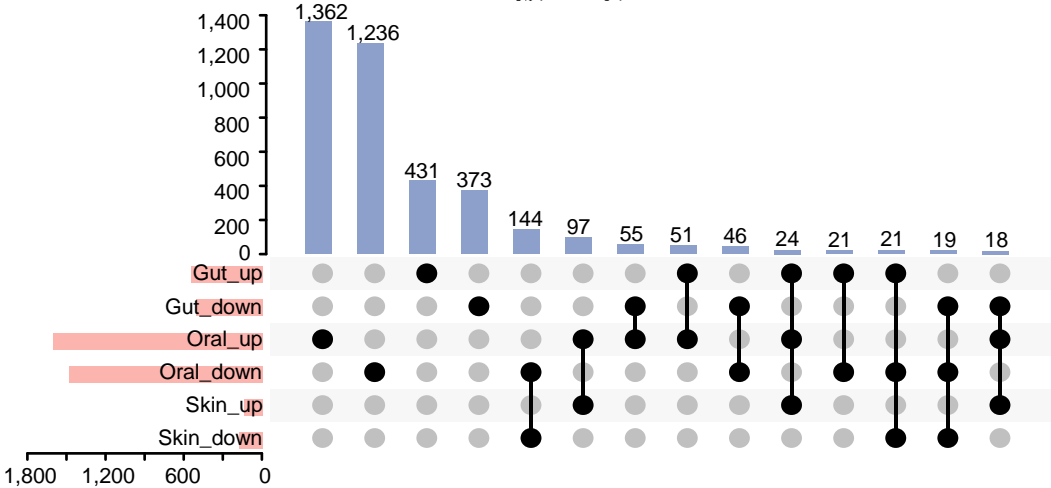
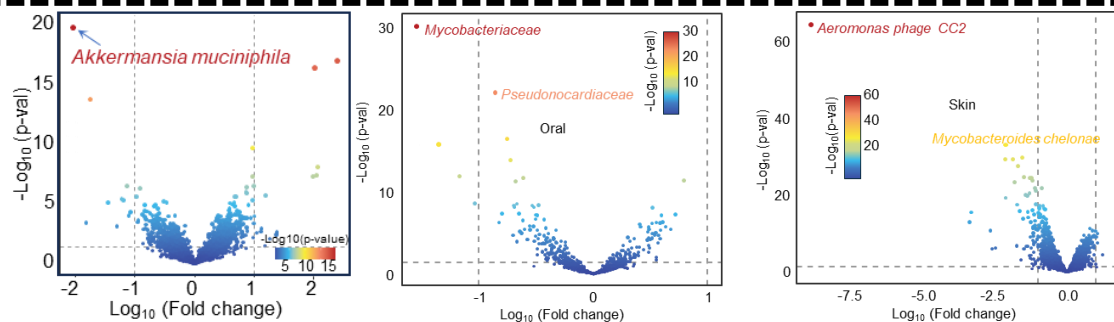
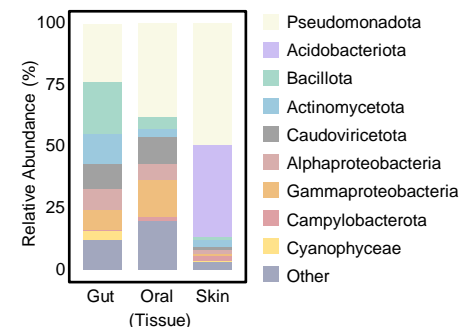
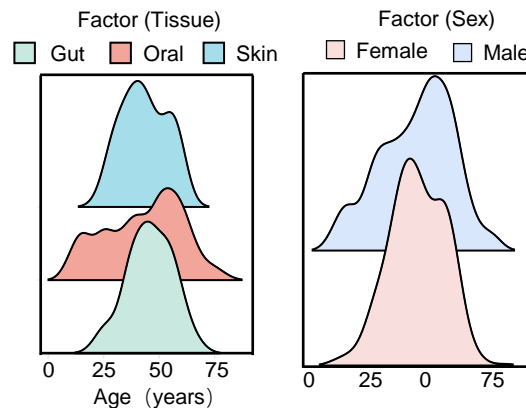
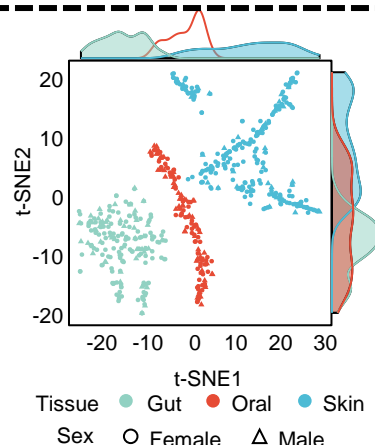
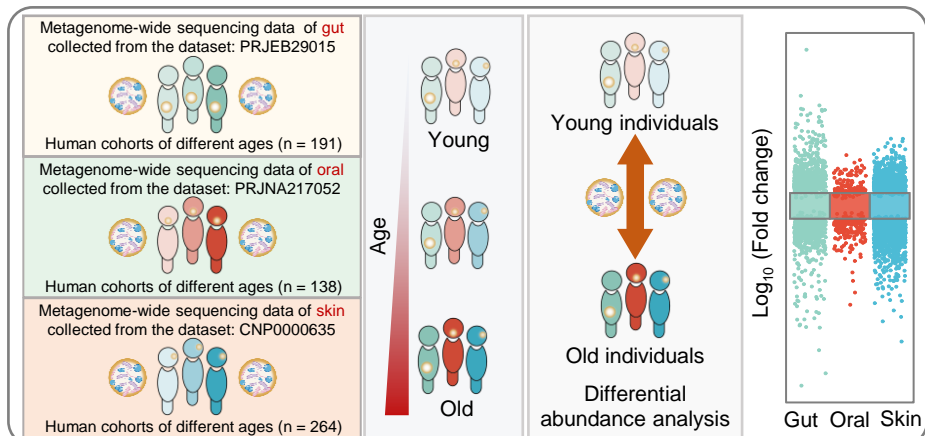
结果：微生物与不同身体部位的衰老有关



孟德尔随机化分析揭示了多个衰老相关的菌群。



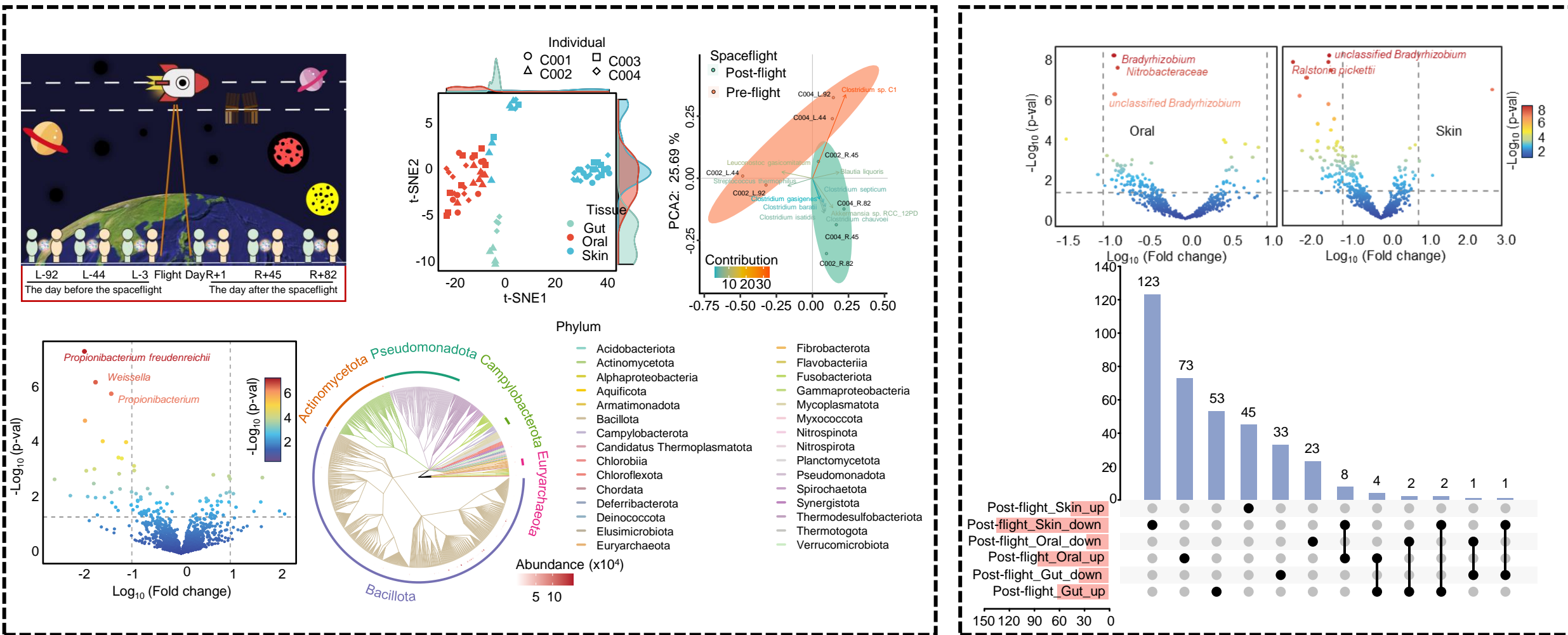
结果：衰老过程中肠道、口腔和皮肤组织的微生物变化



宏基因组分析揭示了多个在衰老进程中变化的菌群。

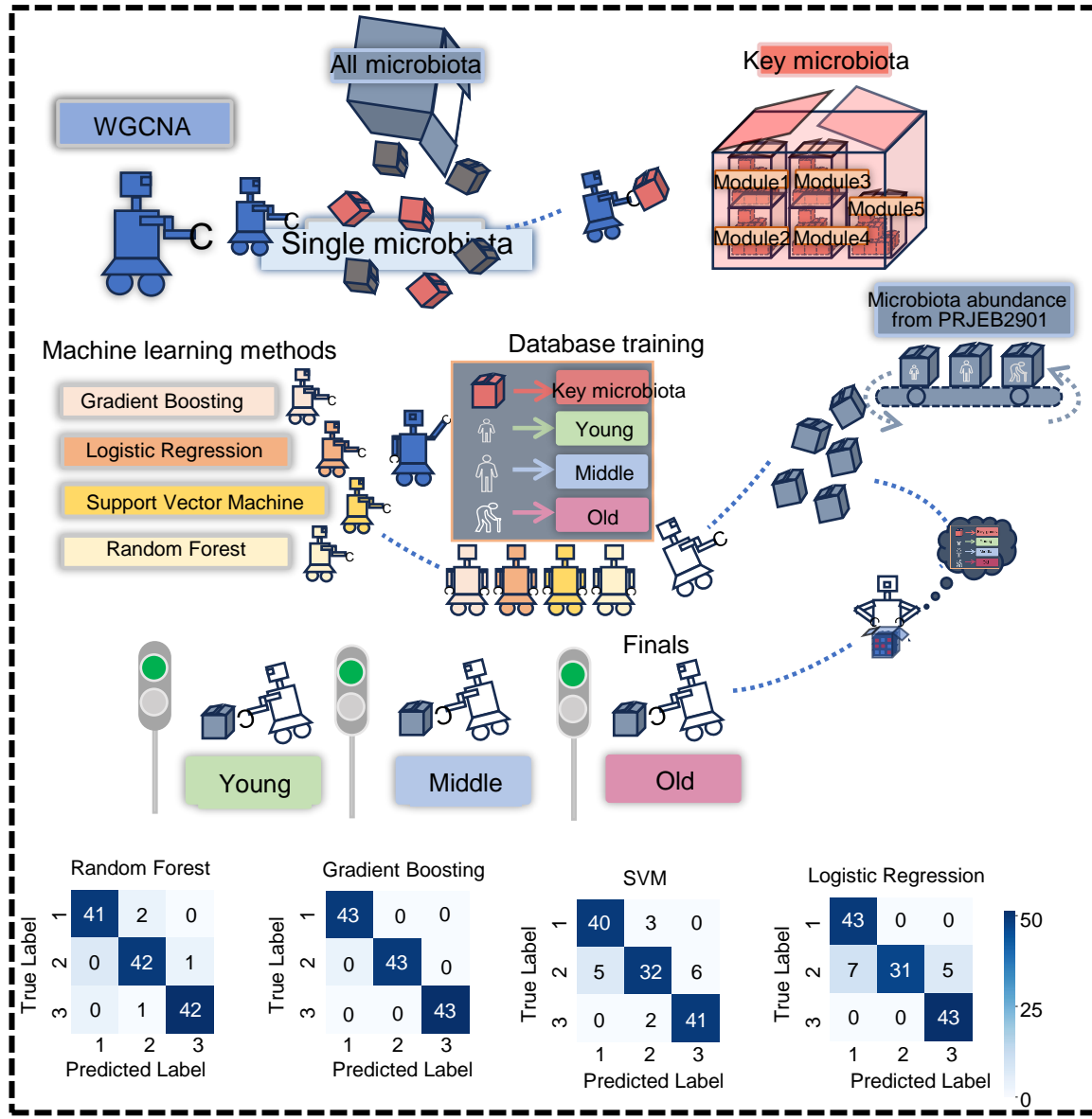
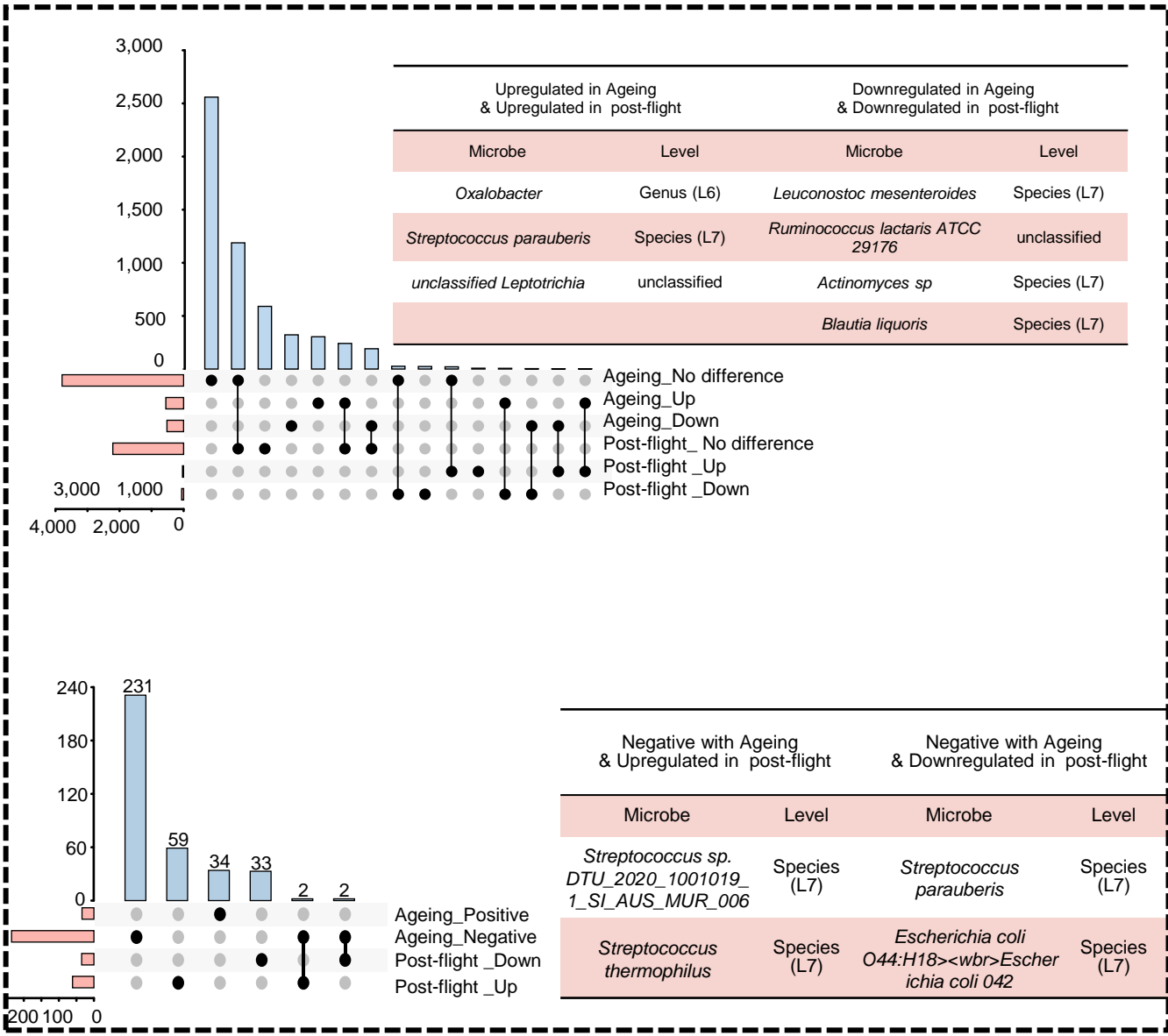


结果：太空飞行改变了宇航员身体多个部位的微生物群



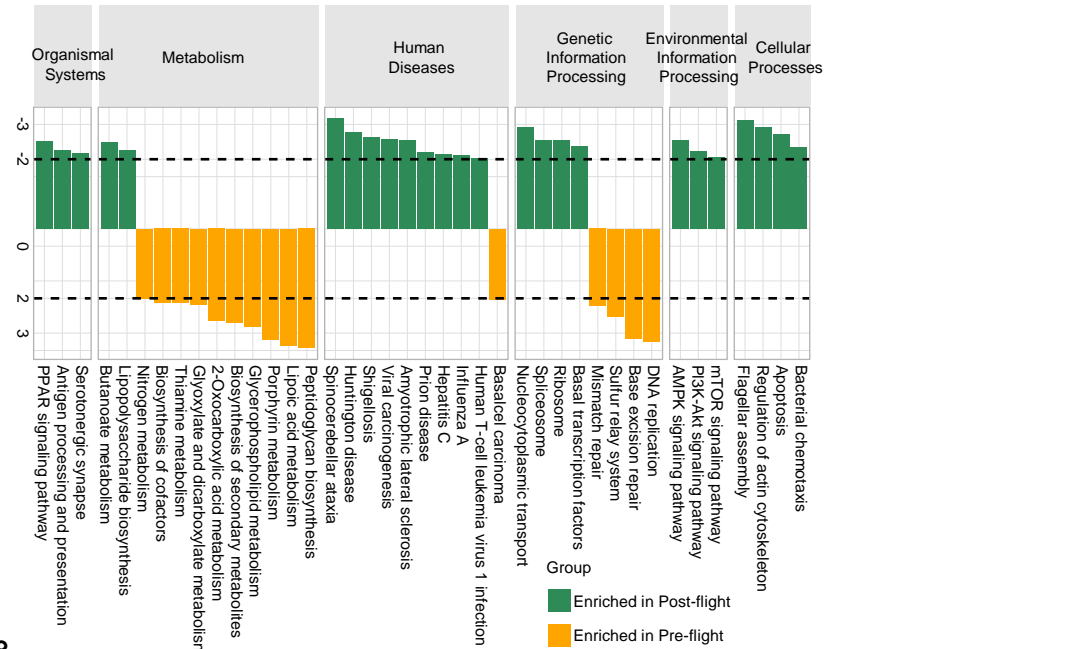
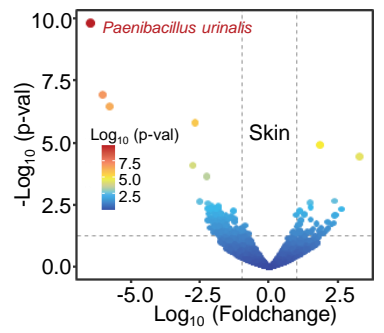
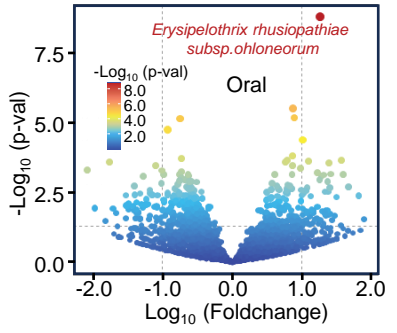
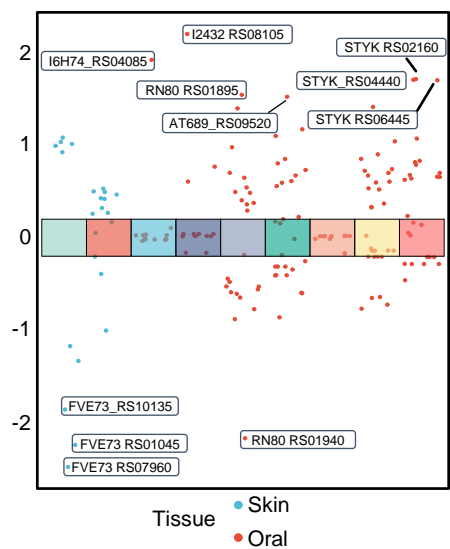
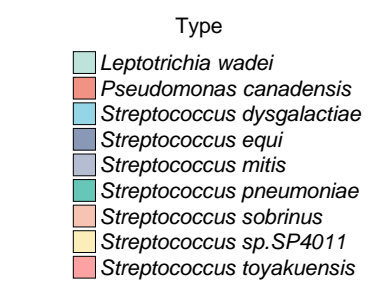
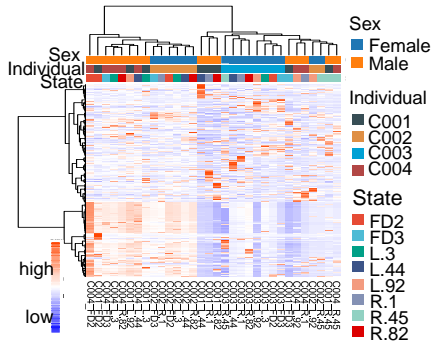
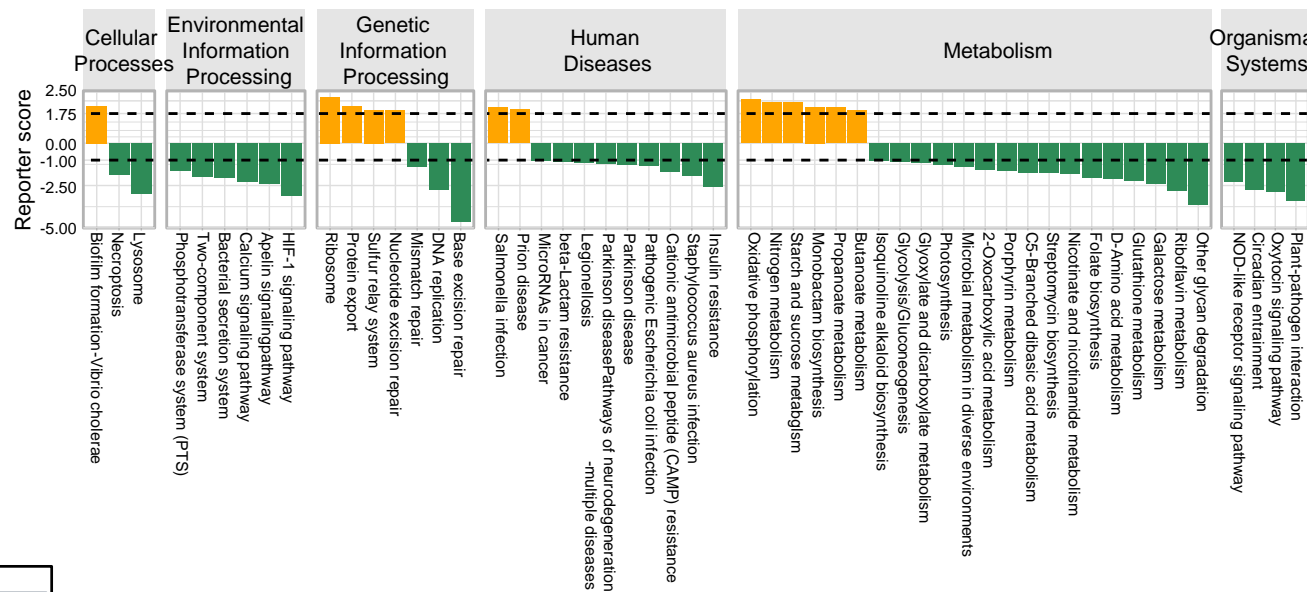
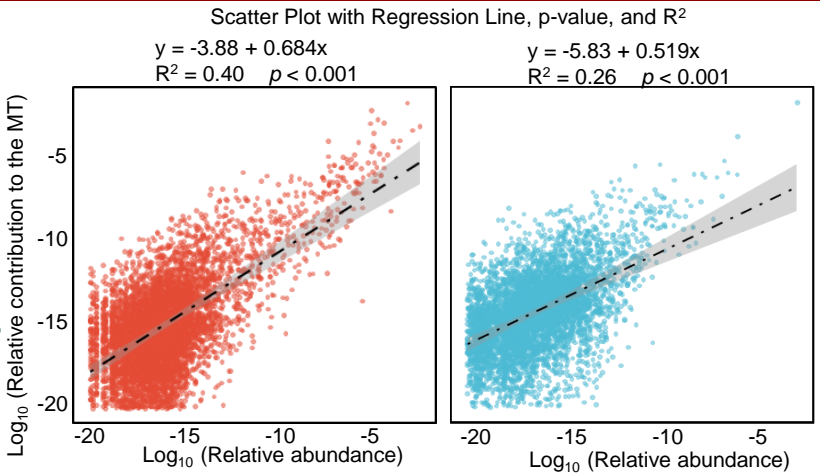
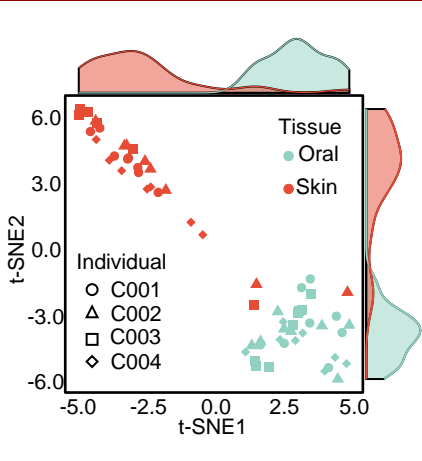
宏基因组分析揭示了多个在太空飞行前后变化的菌群。

结果：太空飞行改变了与年龄相关的微生物群



联合分析揭示了多个太空飞行和衰老中共同变化的菌群。

结果：太空飞行改变了微生物群的功能动力学



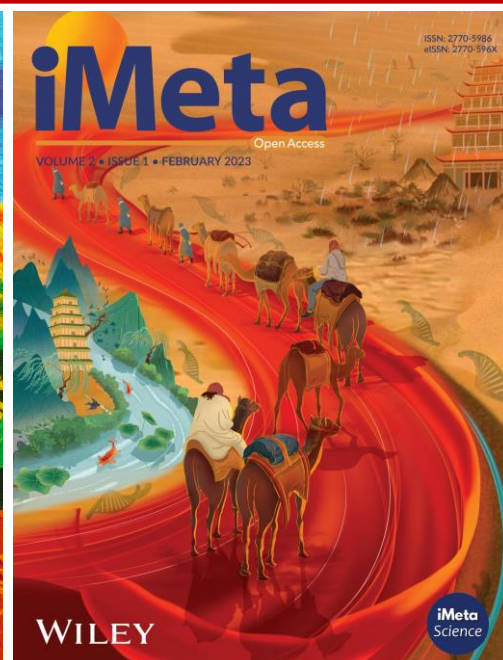
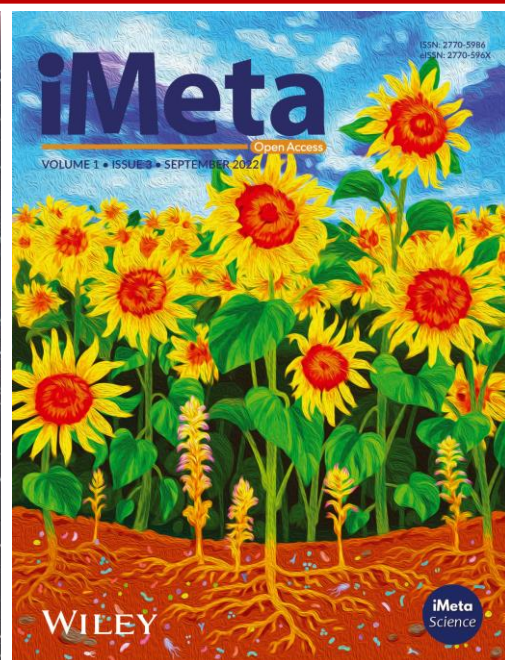
宏转录组分析揭示了太空飞行对菌群基因表达及生物学功能的影响。



总结

- 航天飞行以一种类似于自然衰老的方式改变宇航员的免疫功能。
- 衰老会改变人体多个部位的微生物群，进而影响宿主自身的衰老进程。
- 在太空飞行后，口腔和皮肤中与衰老相关的微生物群表现出显著的变化。
- 太空飞行可能通过改变微生物群的生物学功能而潜在地影响人类健康。

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