Synthetic microbial communities: Sandbox and blueprint for soil health enhancement

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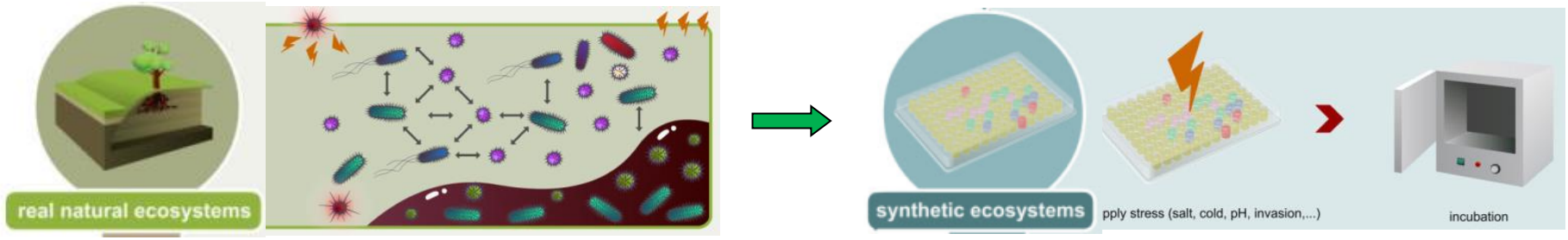
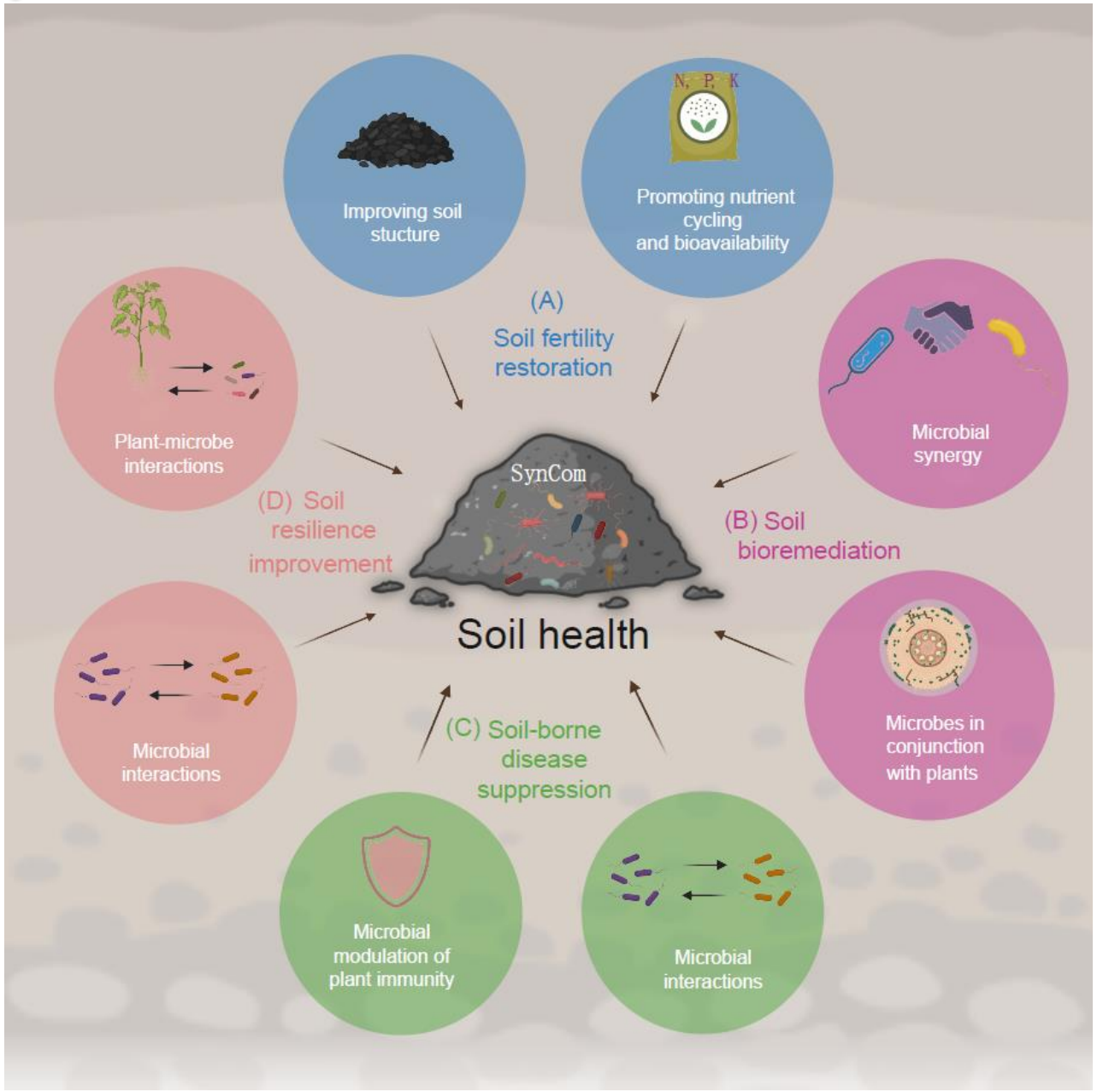
Mei Li, Jie Hu, Zhong Wei, Alexandre Jousset, Thomas Pommier, Xiangyang Yu, Yangchun Xu, Qirong Shen. 2024. Synthetic microbial communities: Sandbox and blueprint for soil health enhancement. iMeta e172.
https://doi.org/10.1002/imt2.172

Introduction



In nature, **diverse microorganisms** do not act as individuals but rather **interact and communicate with one another** in a dynamically changing microbial community, they are **essential for the survival of plants and animals**. However, studying microbial populations directly in their natural environment poses significant challenges due to **their vast population size and complex interaction network**. One emerging strategy to tackle these challenges is to **use simplified, synthetic microbial communities (SynComs)**.

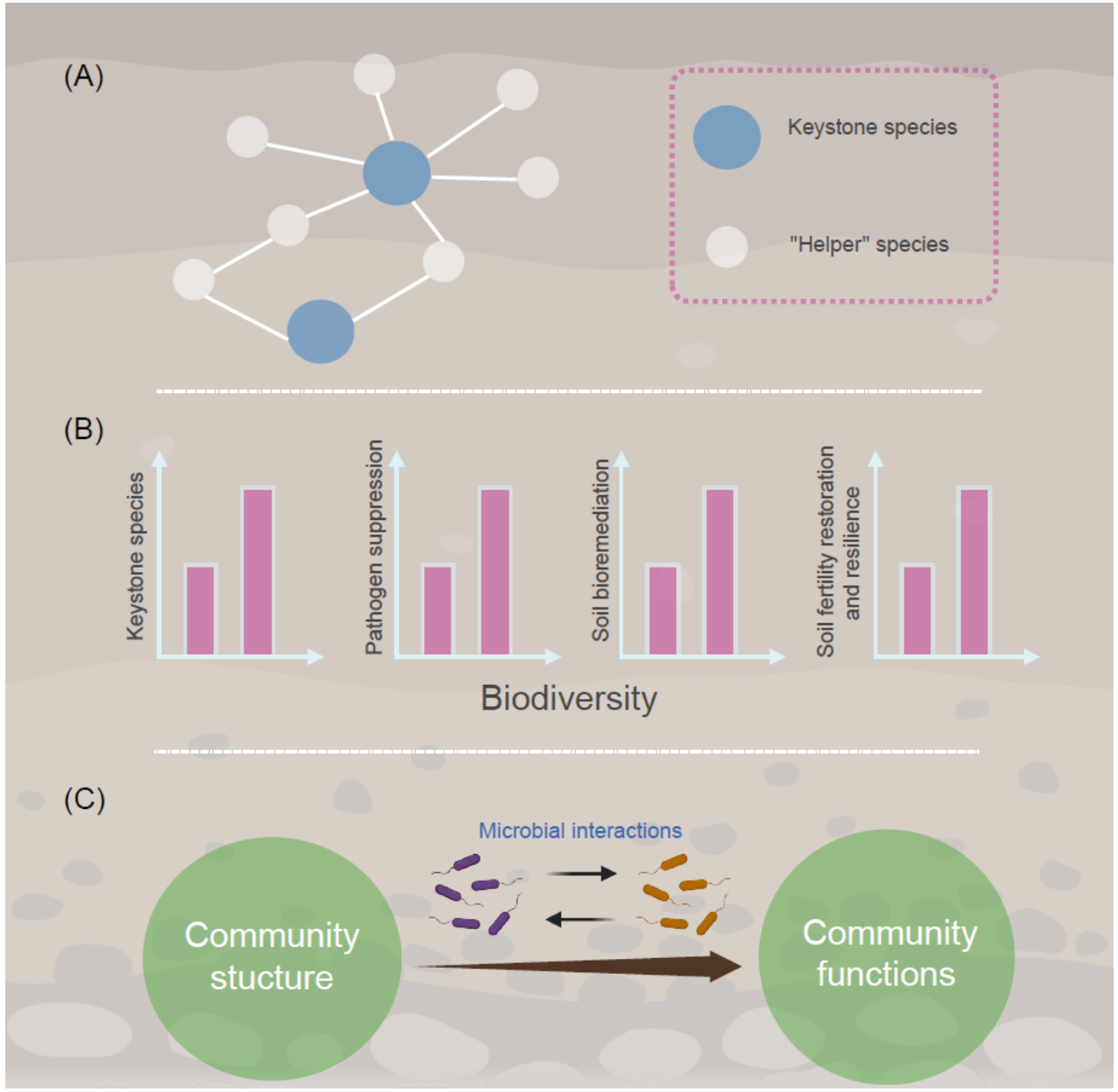
SynComs and its applications in soil health management



SynComs are artificial combinations of two or more distinct cultured microorganisms with well-defined taxonomic status and specific functional characteristics.

SynComs have broad application potentials in the field of soil health improvement, including **soil fertility restoration**, **soil pollutant bioremediation**, **soil-borne disease suppression** and **soil resilience enhancement**.

Principles of designing SynComs to enhance soil health

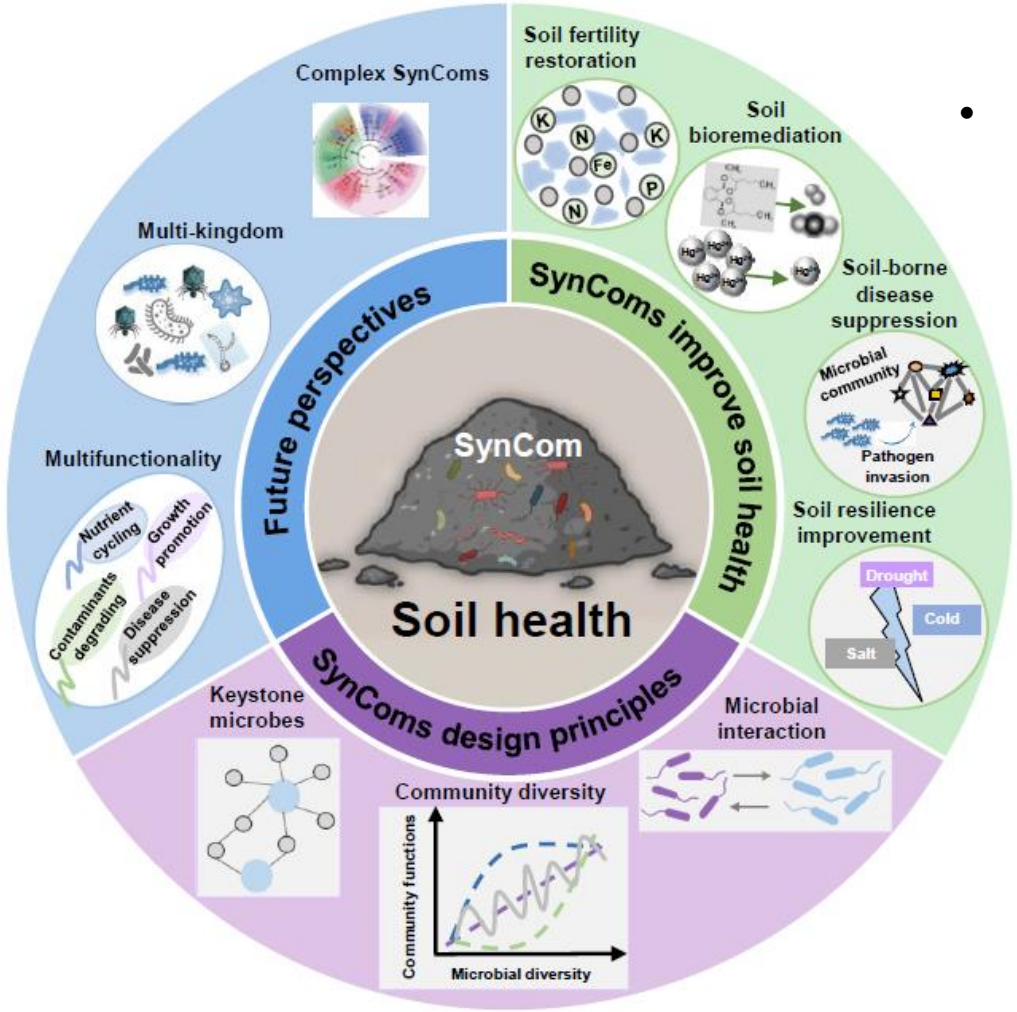


- Including the **keystone species** together with their **“helper” species** when designing a SynCom improves its efficiency.
- SynComs with higher **biodiversity** have more chance to provide more functions linked to soil health enhancement.
- **Interactions** between the members of SynCom play an important role in its functions.

Future perspectives

- Developing SynComs with clear compositions and higher complexity to further investigate more ecological principles.
- Moving toward more realistic conditions, increasing environmental complexity including biotic or abiotic factors in studies on the interaction dynamics within microbial communities.
- Including strains with different specific functions in one SynCom.
- A reliable predictive model linking soil community structure and ecological function should be established, which combined ecological theory, basic experimental data, engineering development strategies and machine learning algorithms to design and apply SynComs.

Summary



Highlights:

- Reviewed the use of SynComs in improving various dimensions of soil health, including fertility restoration, pollutant removal, soil-borne disease suppression and soil resilience.
- Summarized a useful set of guidelines to assess and understand the principles for designing SynComs to enhance soil health.
- Discussed the next stages of SynComs applications, including highly diverse and multi-kingdom SynComs targeting several functions simultaneously.

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