Next-Generation Human Resource Development for Harnessing the Forces of Culture and Nature for Peace and Sustainability

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Microbial biotechnology towards sustainable agriculture and carbon neutrality

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About me

Affiliation:

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Position:

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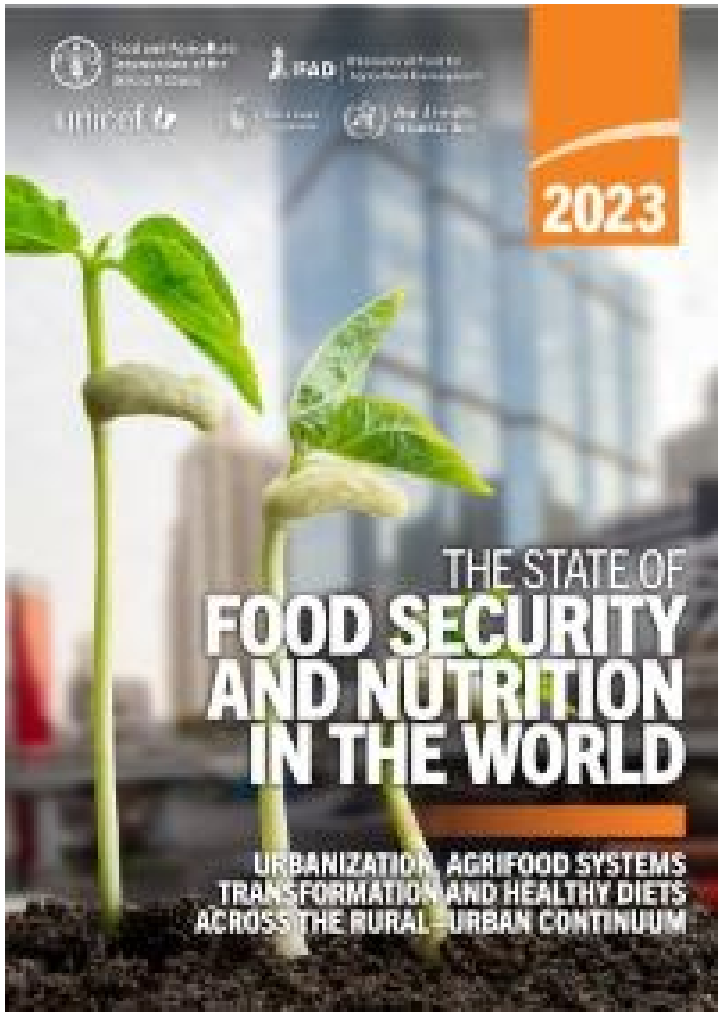
Expertise:

microbiology, cell biology, microbe-plant interaction

Previous work:

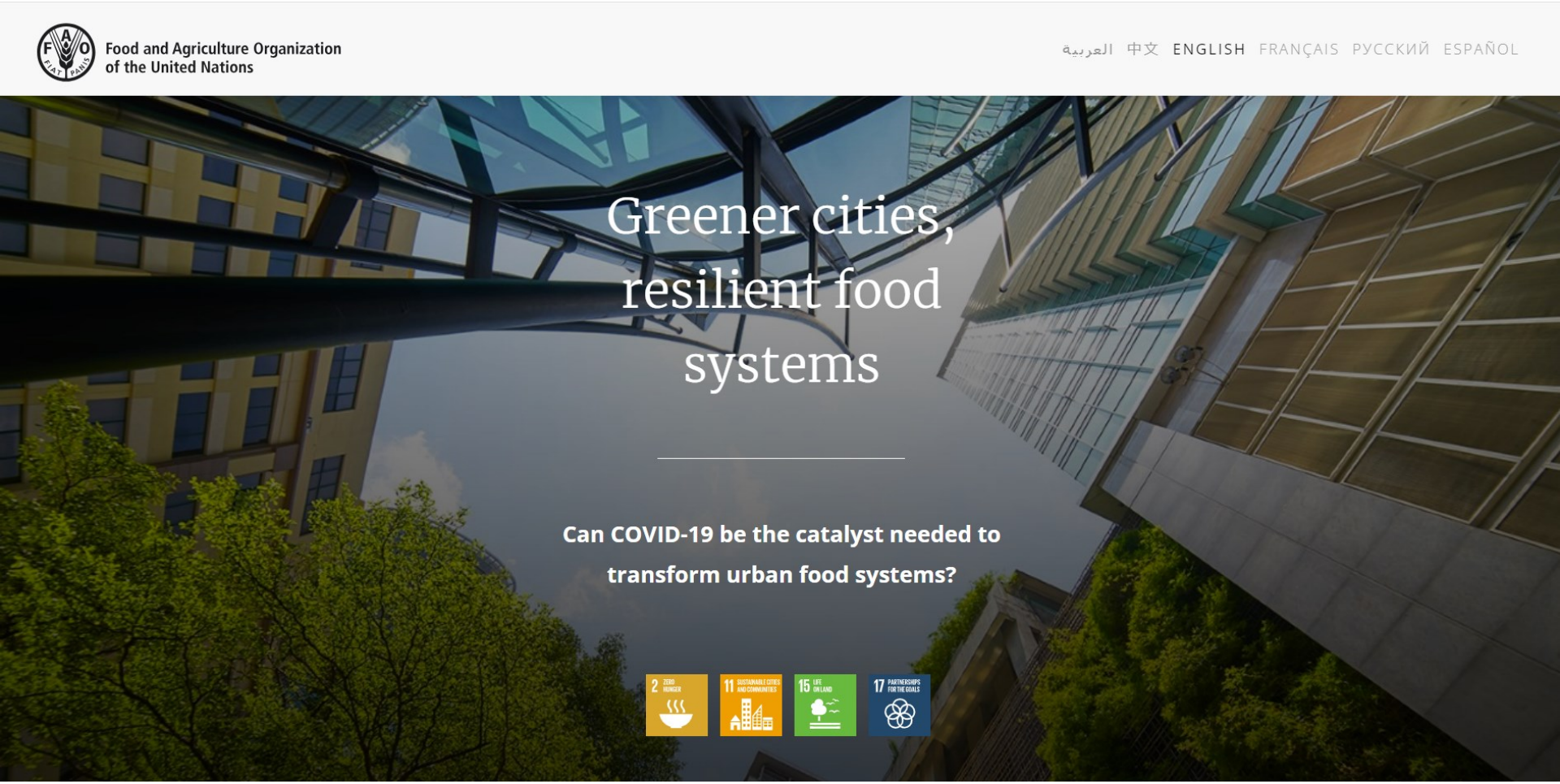
JICA, Ministry of Foreign Affairs, UN-FAO, etc

The State of Food Security and Nutrition



"Between 691 and 783 million people faced hunger in 2022, with a mid-range of 735 million. This represents an increase of 122 million people compared to 2019, before the COVID-19 pandemic." **(FAO, 2023)**

Food systems transformation



Greener, more sustainable and resilient...

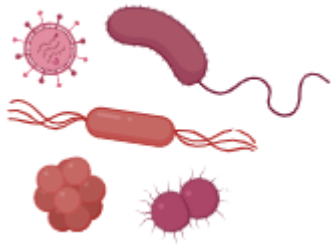
Microbial biotechnology is key

Biotechnology is …

“any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use” (FAO, 2001).

Microbial biotechnology is …

“application of biotechnological principles and techniques to the study and use of **microorganisms** and their products.”



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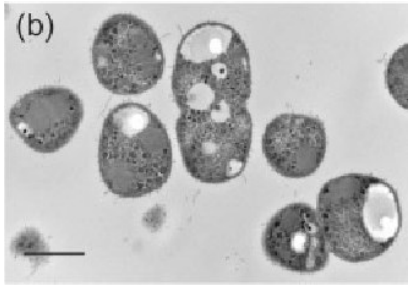
Our research targets: C1 microbes

- C1 microbes are a diverse group of microbes that can use one-carbon compounds, such as methane (CH_4) and methanol (CH_3OH).

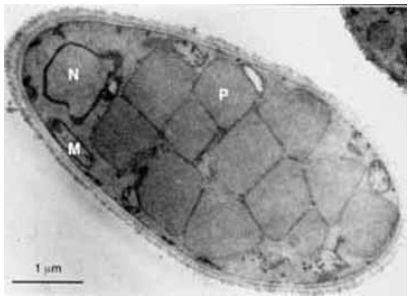
CH_4-using bacterium



Methylovulum miyakonense

Iguchi *et al*. (2011)

CH_3OH-using yeast



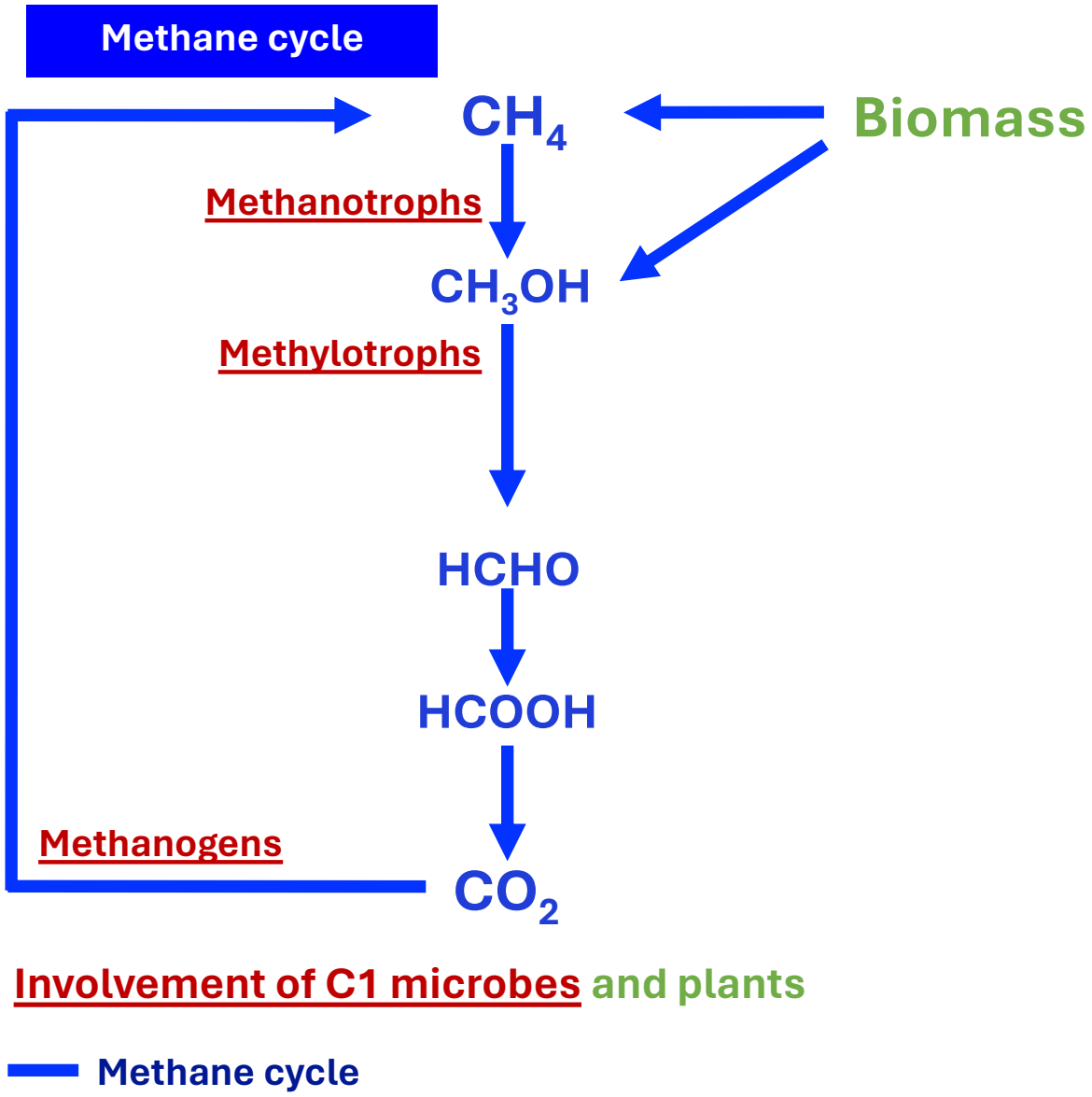
Candida boidinii

Sakai *et al*. (1988)

- They are useful platform for producing useful proteins and have been studied for more than 50 years.

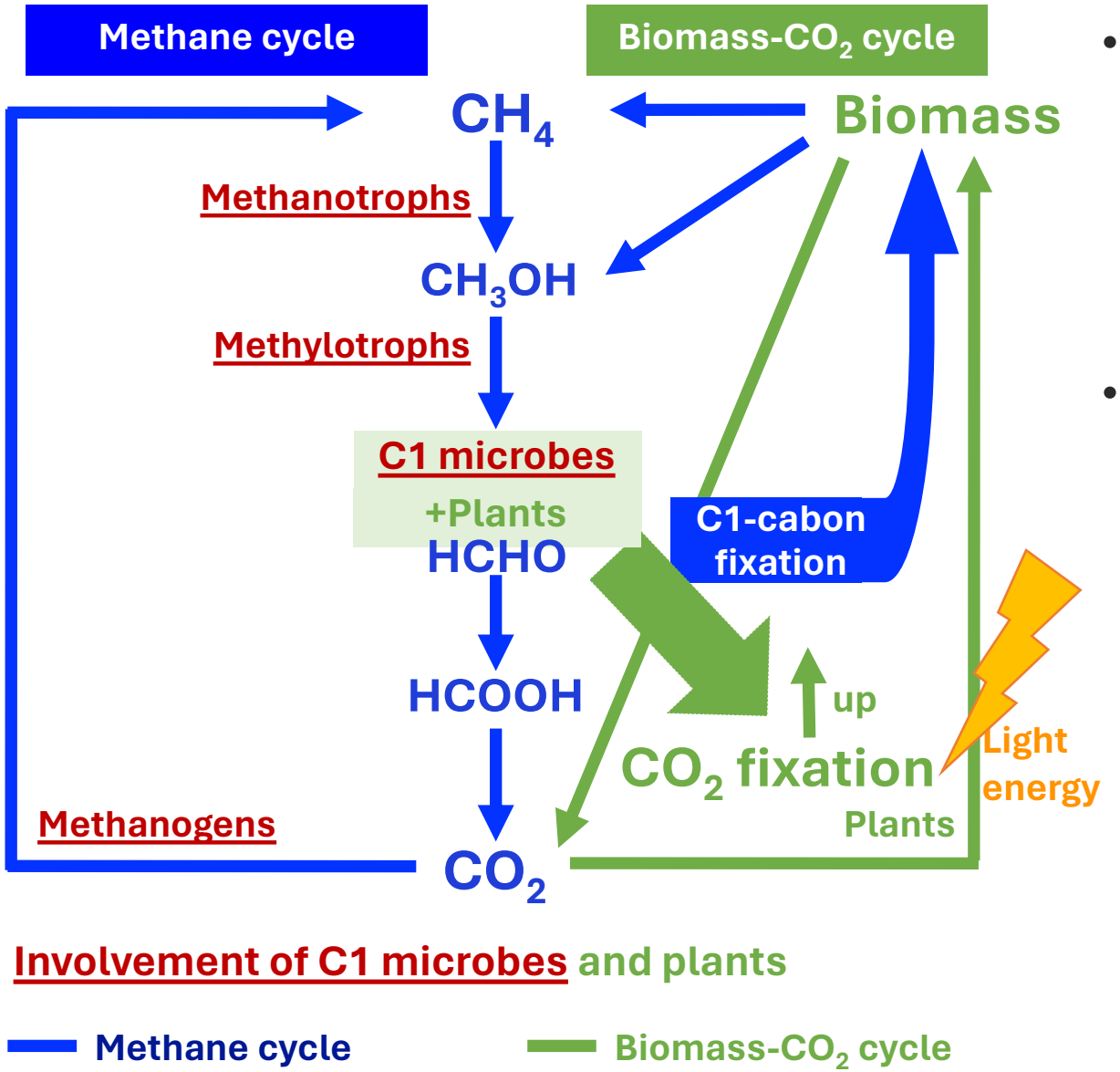
- They have a great potential in contributing to solving the protein crisis that is thought to occur in 2050.

Contribution of C1 microbes to carbon cycle



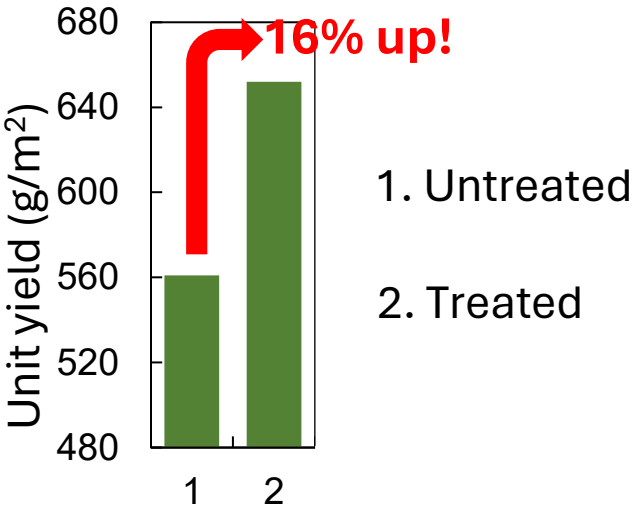
- In nature, C1 microbes play a crucial role in the global carbon circulation.
- Methane is generated from CO_2 by methanogens.
- Methanotrophs and methanol-utilizing methylotrophs oxidize methane and other C1 compounds to CO_2.

Carbon cycle mediated by C1 microbes and plants



- Recently, microbes on the plant leaf surface were found to utilize methane and methanol produced by plants.
- Positive interactions between microbes and plants enhance **CO_2 fixation** and **increase plant biomass** (yield increase).

Growth promotion on sake rice by C1 microbes

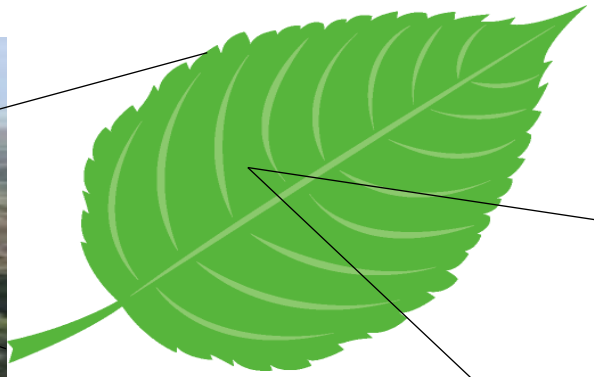


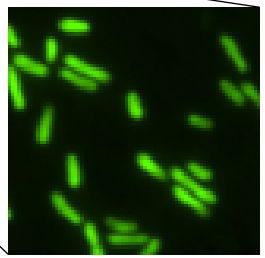
Untreated Treated

Yurimoto et al. *Microb Biotechnol* 2021

Yield increase + greenization

Huge potential of studying C1 microbes on plant leaf





Number of microbes = 10^{6-7} cells/cm^2

X

Total area of the phyllosphere = 10^9 km^2

(Double as that of the earth)

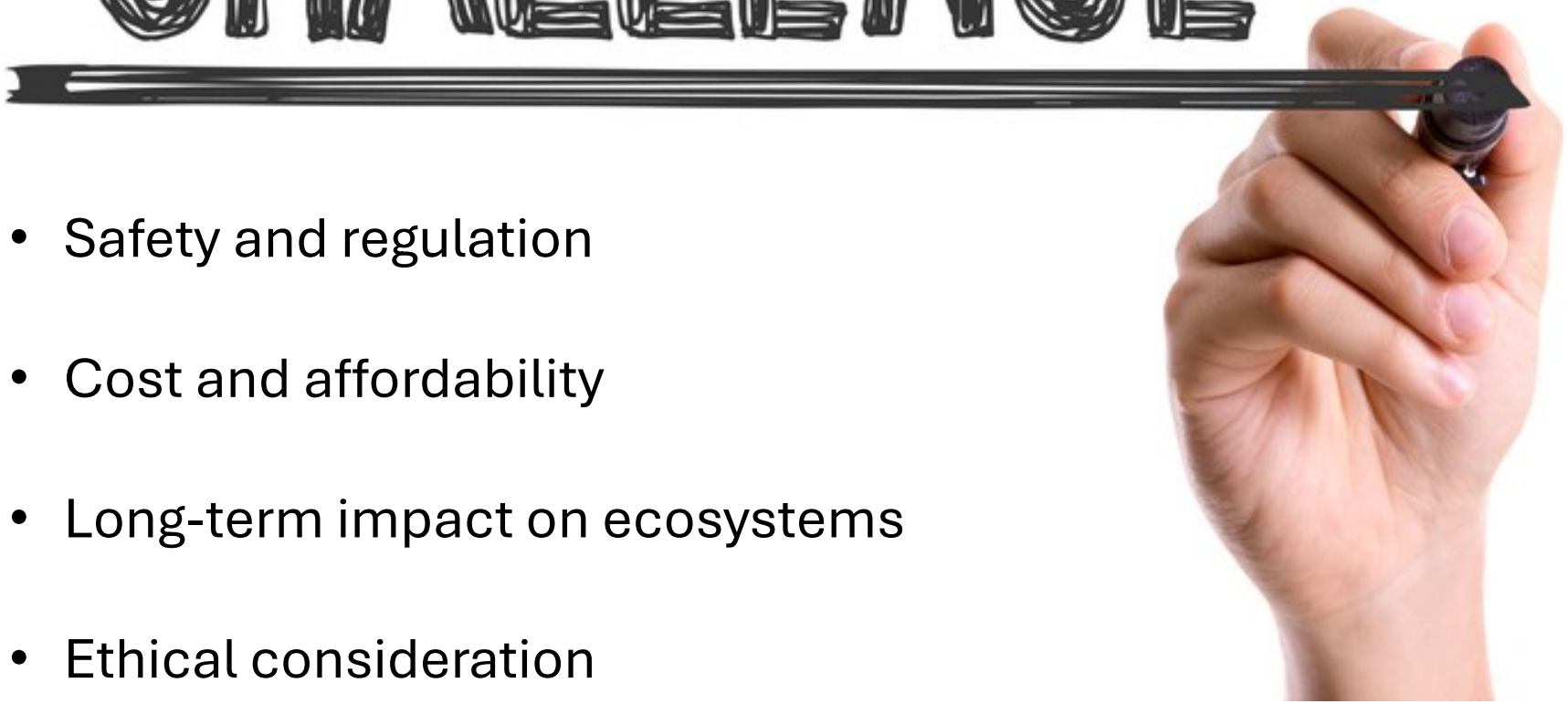
10^{26} cells !!

Lindow et al. *Appl Environ Microbiol* 2003

Microbial biotechnology contributes to preservation of agroecosystems

- Agroecosystems are the ecosystems supporting the food production systems in farms and gardens.
- The FAO recognizes agroecosystems inhabited by communities that live in an intricate relationship with their territory, as Globally Important Agricultural Heritage Systems (GIAHS).
- These sites are resilient systems characterized by remarkable agrobiodiversity, traditional knowledge, **invaluable cultures and landscapes**, and **sustainably managed by farmers**.

CHALLENGE



- Safety and regulation
- Cost and affordability
- Long-term impact on ecosystems
- Ethical consideration
- Cultural conservation
- Public perception and acceptance

Global efforts are underway to overcome challenges

- regulatory frameworks, research and development, education and training, collaboration and partnership, monitoring and evaluation, infrastructure and accessibility, etc…

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"Multidisciplinary approach" is key. But it can be taken only when you have a deep knowledge/expertise of your subject, which eventually allows you to unite several specialists.

"International collaboration" is key. Be ready for exposing yourself to the outside world, which may need to convince your hierarchy.

Thank you for your attention.