Microbes & Climate Change-Science, People, & Impacts

Colloquium Report from the American Academy of Microbiology

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Microbes and Climate Change- Science, People, & Impacts

This presentation contains the figures from the American Academy of Microbiology's report "*Microbes and Climate Change- Science, People & Impacts*" for educational use, and is a part of the report.

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FIGURE 1

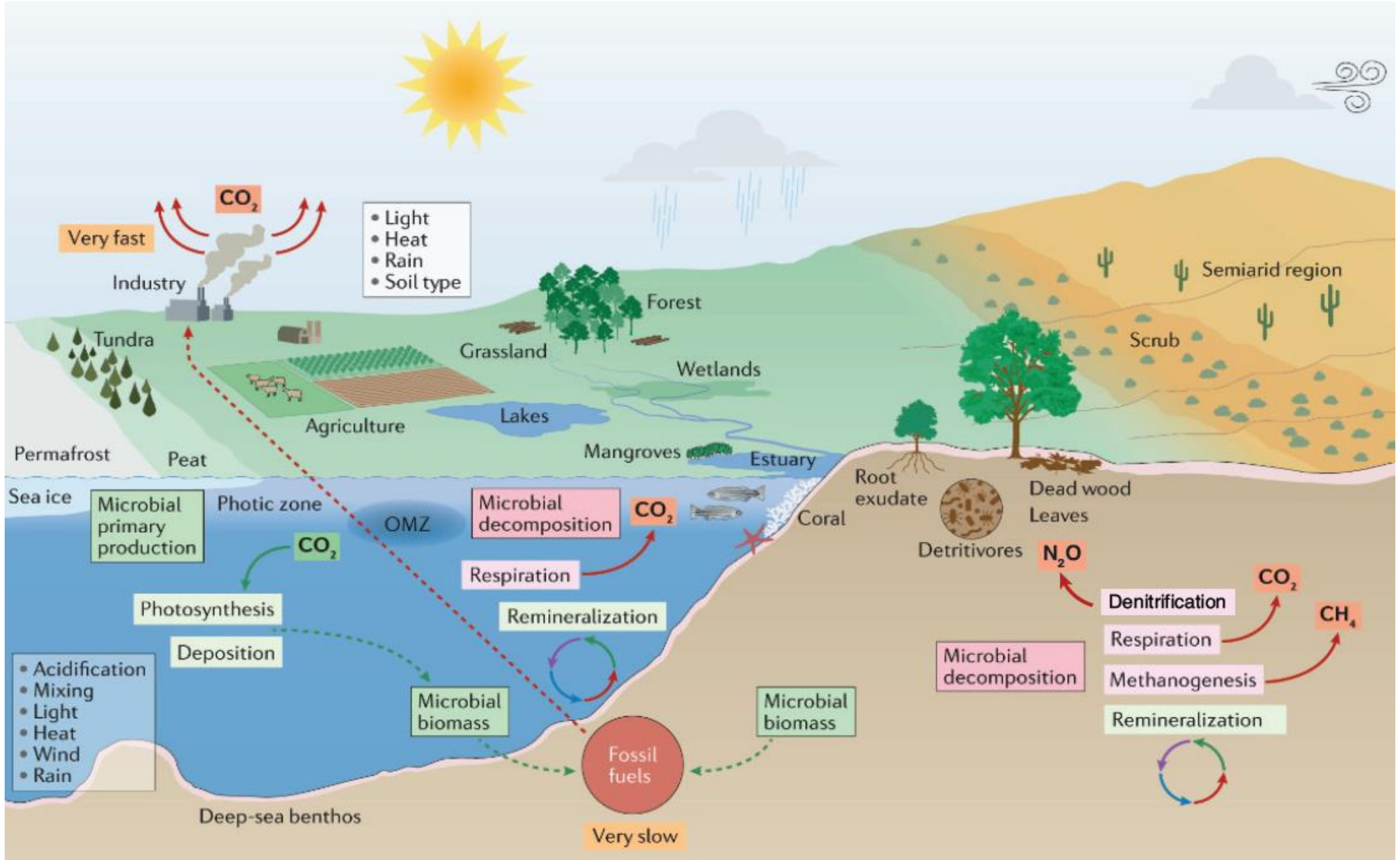


Figure 1. Microorganisms in terrestrial, urban, and aquatic environments consume and generate important greenhouse gases, CO2, CH4, and N2O. Terrestrial microbes decompose organic matter, providing nutrients for plants and producing these three gases. Aquatic microbes use photosynthesis to generate and recycle nutrients for marine life while also helping sequester large amounts of carbon in the deep ocean. Human activities such as burning fossil fuels and agriculture release greenhouse gases at a faster pace than microbial consumption, resulting in imbalances in the carbon cycle, which affect microbial responses and impact on climate change. Figure modified from Cavicchioli, R., et al. 2019.

FIGURE 2

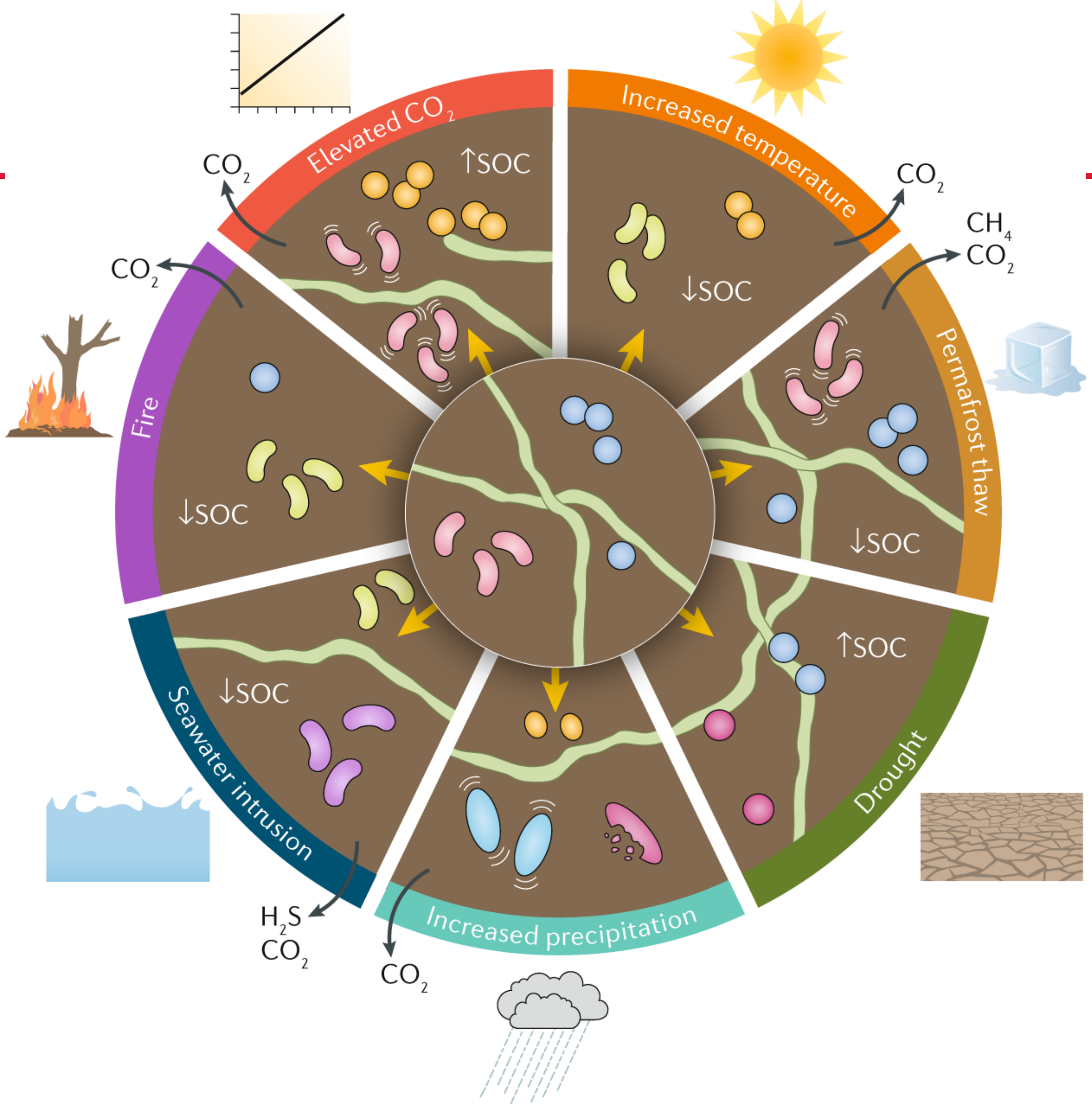


Figure 2*: Climate change induces alterations in soil microbial communities. Bacteria (red), archaea (blue), and fungal hyphae (green) in the center are impacted by changes in temperature, precipitation, storms, soil organic carbon (SOC), and greenhouse gases, leading to changes in community structure as indicated by change to orange, green, or purple microbes. Figure from Jansson & Hofmockel 2019.

FIGURE 3

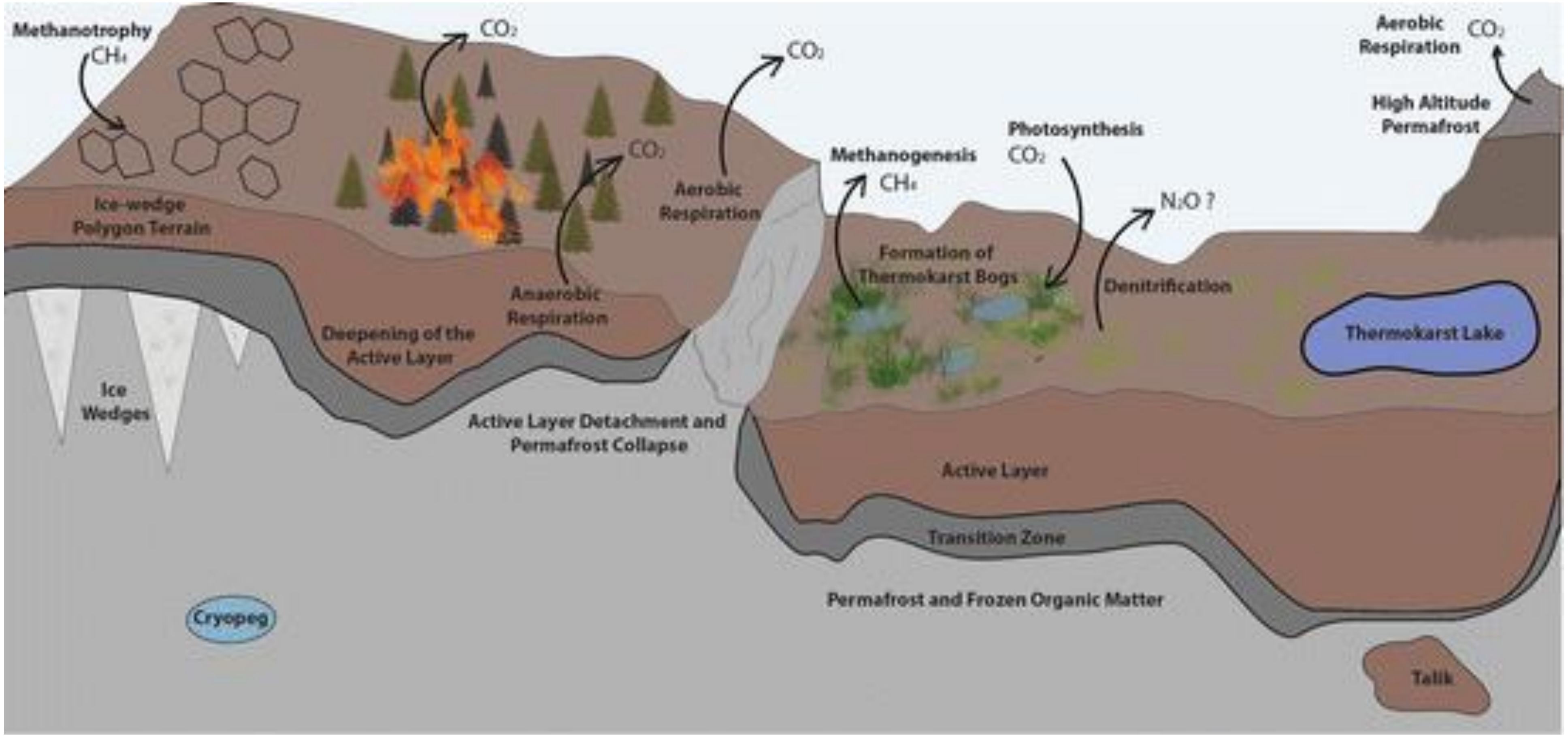


Figure 3. Microbial activity of permafrost consumes (methanotrophy, photosynthesis) and produces (respiration, methanogenesis) greenhouse gases. Figure from Altshuler et al. 2017.

FIGURE 4

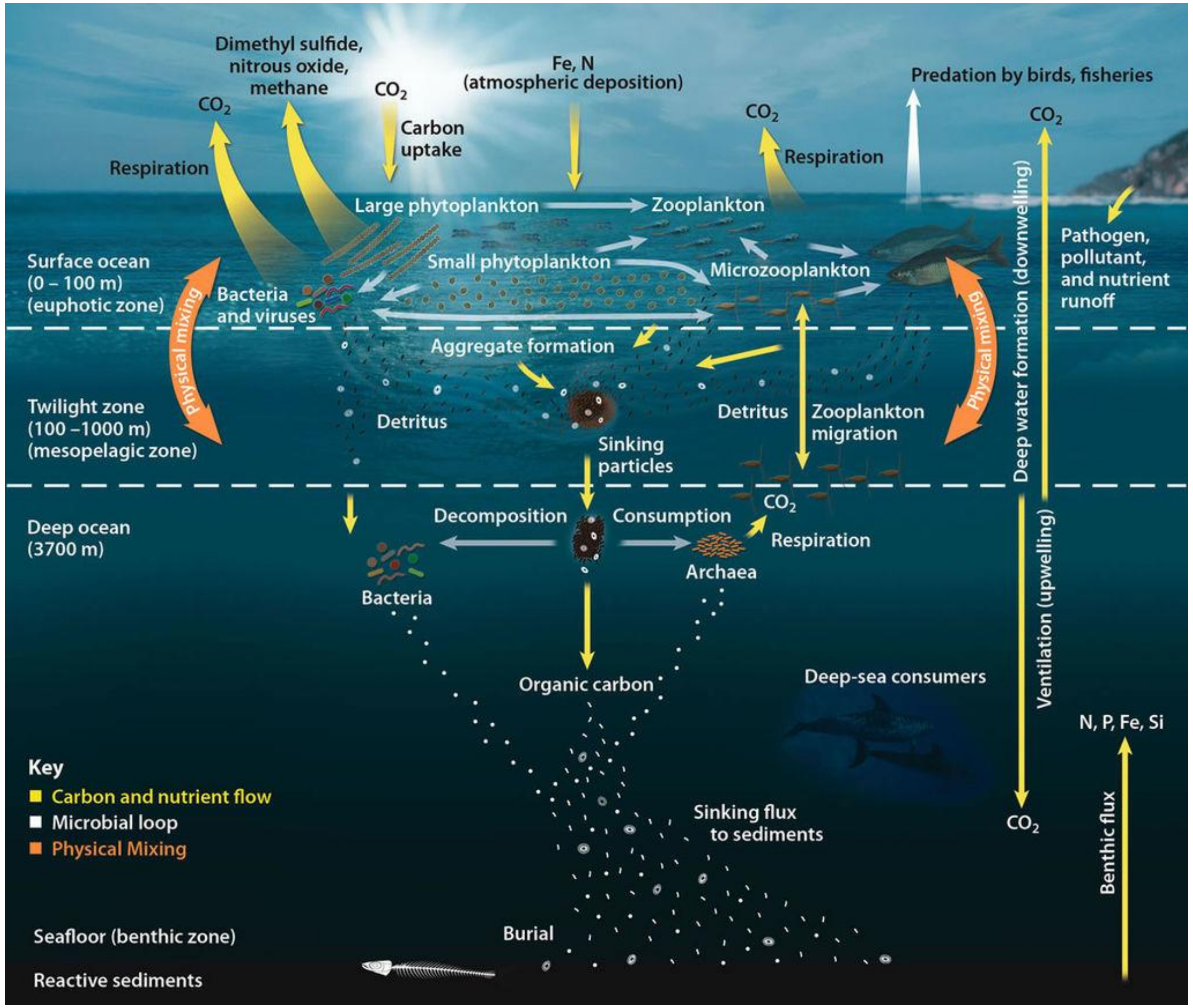


Figure 4. Marine microbes recycle and sequester carbon in the marine carbon pump. Microbial respiration and bacterial lysis provide carbon to marine life, while the viral shunt and photosynthesis lead to carbon sedimentation and storage on the ocean floor. Image is in the public domain.

FIGURE 5

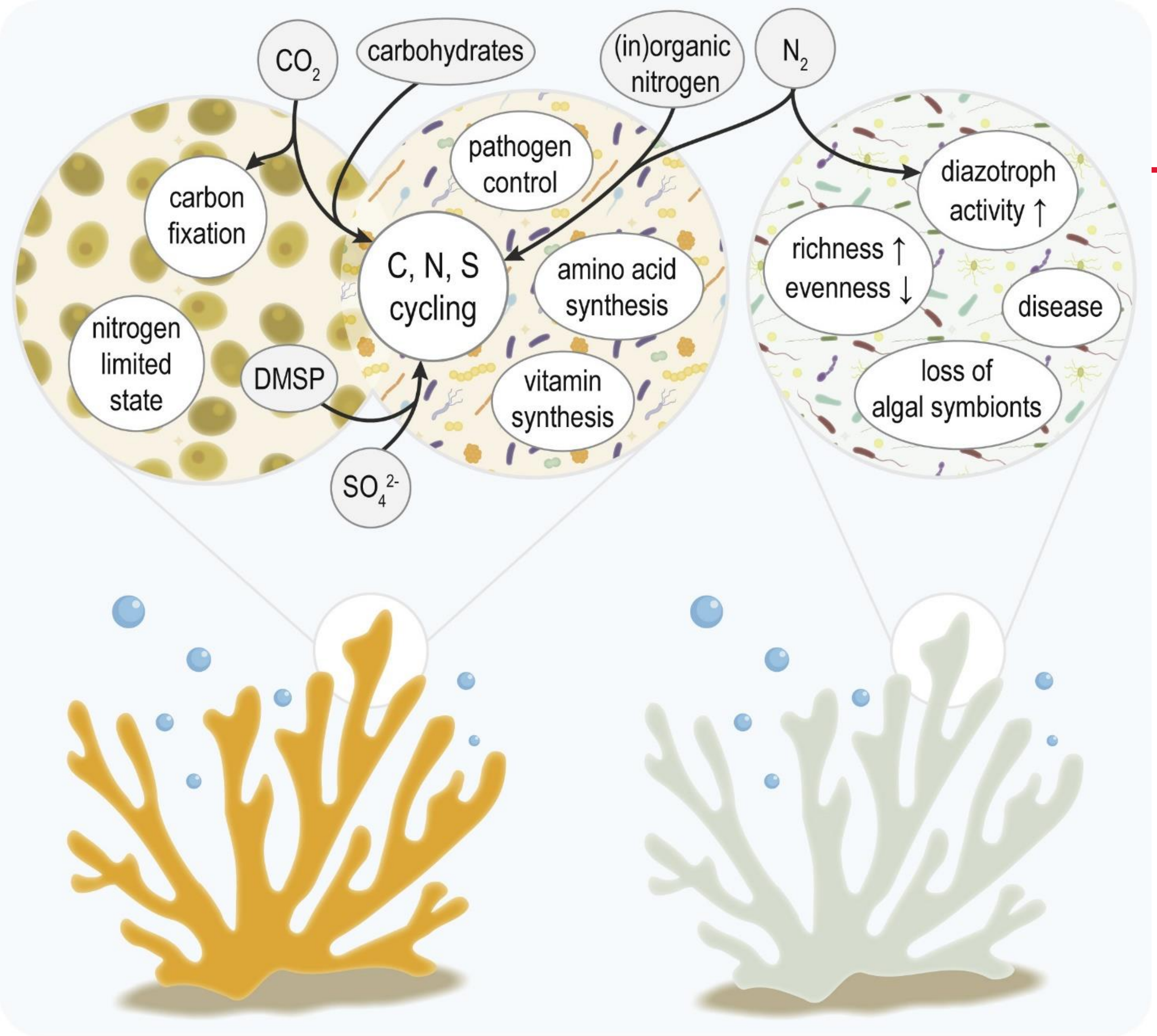
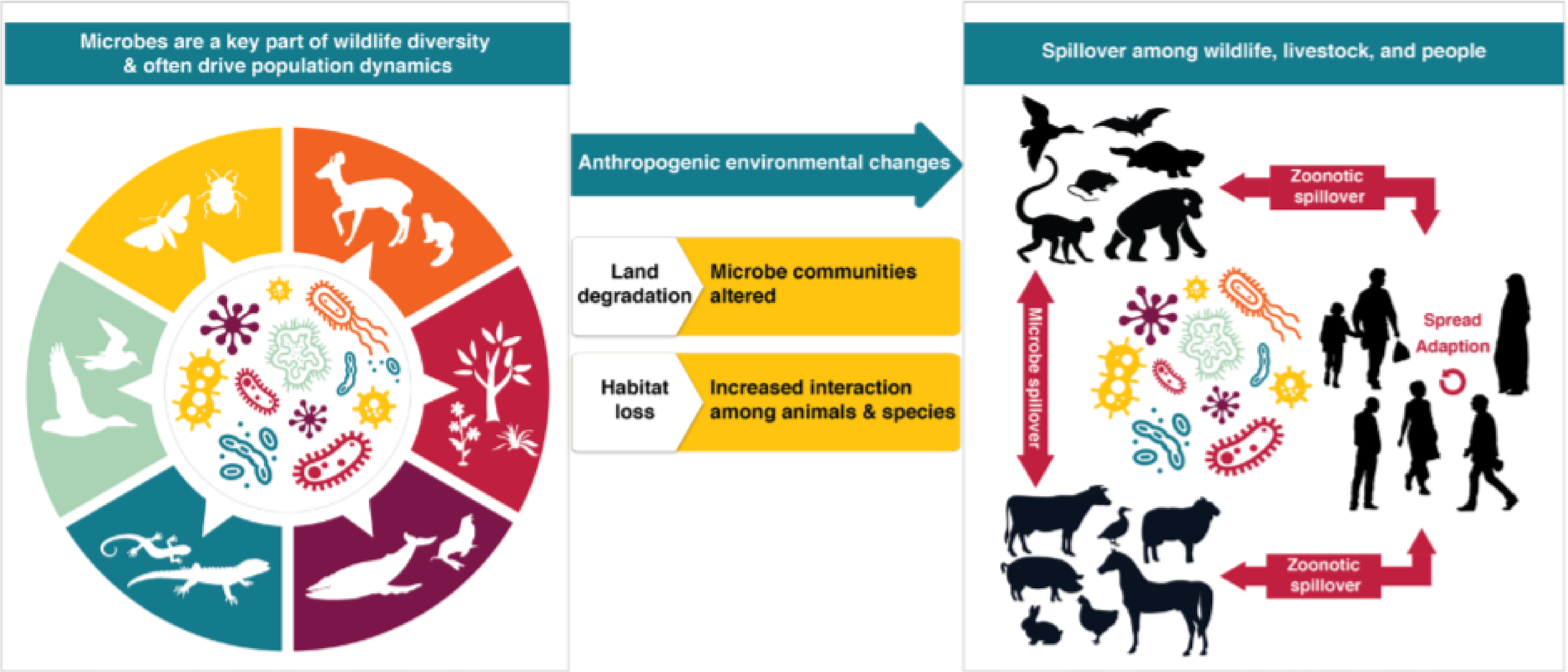


Figure 5. Healthy corals (left) have symbiotic microbial communities to provide them nutrients such as carbohydrates, amino acids, and vitamins as well as defense against pathogens. Warming water and ocean acidification induce coral stress, causing a loss of their algal symbionts and alterations to the coral-associated microbiome, making corals lose their color and thus appear bleached (right). The lack of microbial species richness allows opportunistic pathogens to infect and possibly cause more coral disease. Figure from Vanwonterghem and Webster 2020.

FIGURE 6



Microbes are a key part of wildlife diversity & often drive population dynamics

Anthropogenic environmental changes

Land degradation | Microbe communities altered

Habitat loss | Increased interaction among animals & species

Spillover among wildlife, livestock, and people

Figure 6. Exposures to zoonotic pathogens increase with greater frequency of human and animal interactions. Microorganisms that naturally evolved with wildlife (left) can spill over to humans because of human expansion into natural habits (center) and increased contact with wildlife or livestock (right). Zoonotic pathogens can cause pandemics when they are transmitted easily among humans and can spread quickly because of urbanization and global travel. Figure from [Daszak et al. 2020](#).

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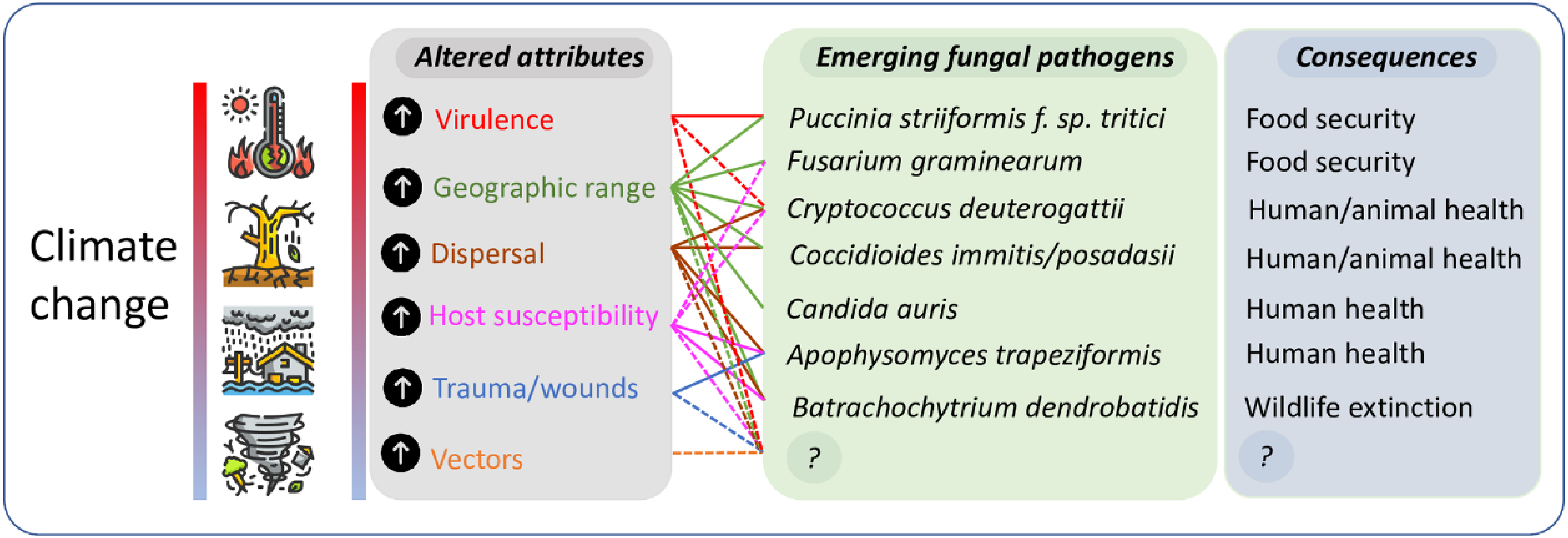
FIGURE 7



Climate change

Altered attributes

↑ Virulence

↑ Geographic range

↑ Dispersal

↑ Host susceptibility

↑ Trauma/wounds

↑ Vectors

Emerging fungal pathogens

Puccinia striiformis f. sp. tritici

Fusarium graminearum

Cryptococcus deuterogattii

Coccidioides immitis/posadasii

Candida auris

Apophysomyces trapeziformis

Batrachochytrium dendrobatidis

?

Consequences

Food security

Food security

Human/animal health

Human/animal health

Human health

Human health

Wildlife extinction

?

Figure 7. Climate change impacts the environment’s temperature, precipitation, and frequency of storms, leading to possible alterations of fungal pathogens’ virulence, temporal and spatial range, and host and vector susceptibility. The emergence of novel features by fungi may have far-reaching consequences on human, animal, and environmental health. Figure from Nnadi and Carter 2021.

FIGURE 8

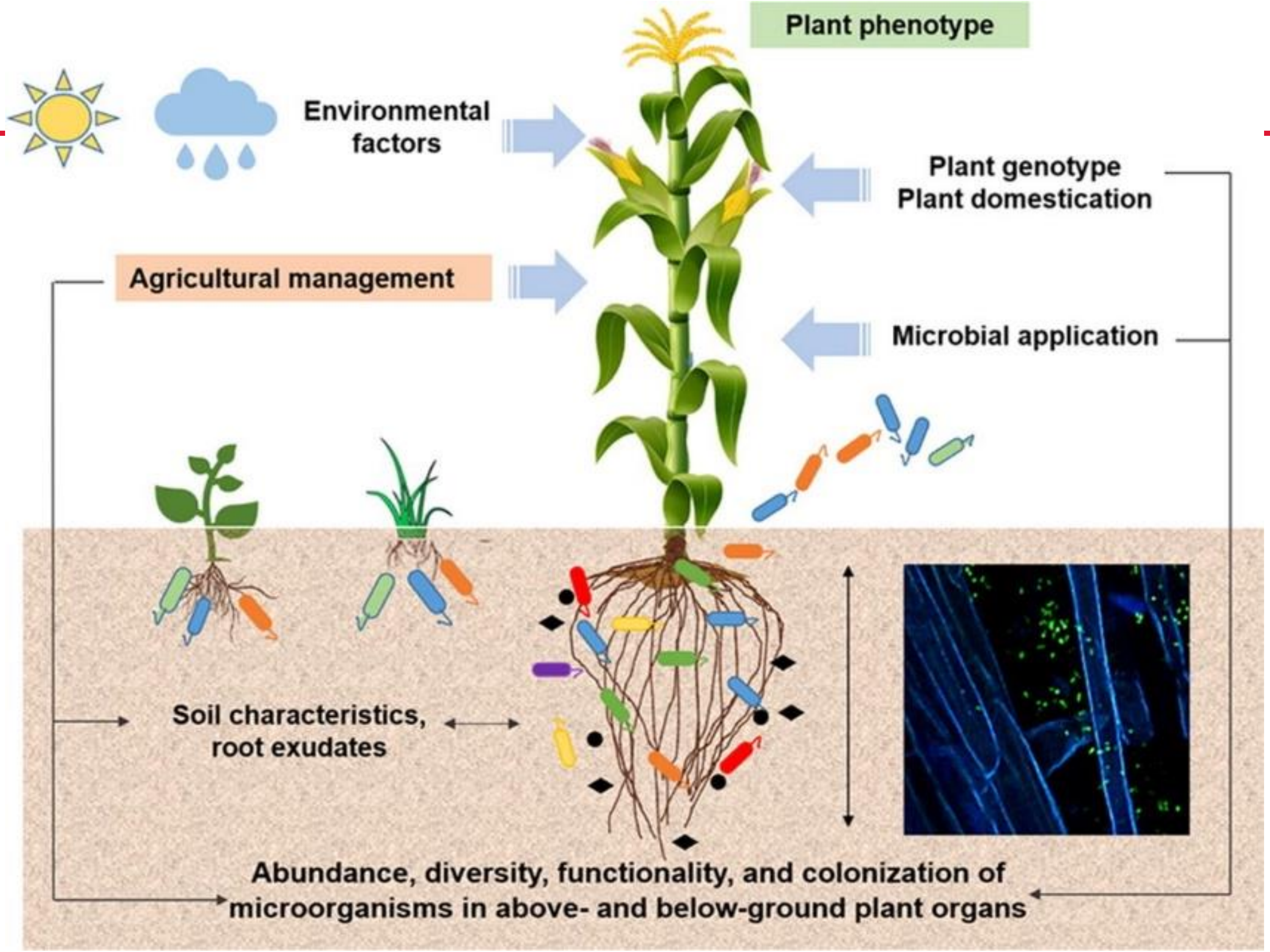
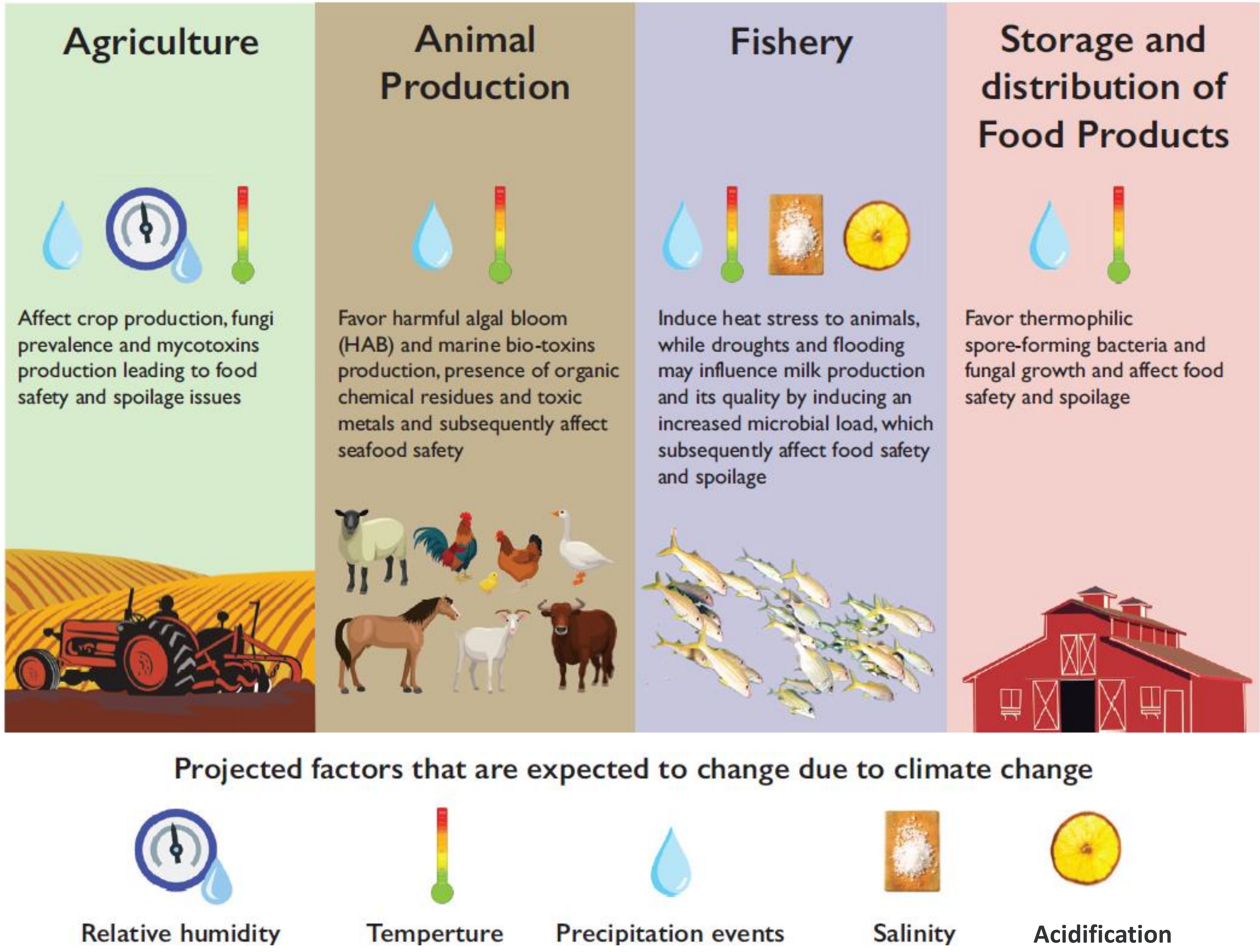


Figure 8. The crop-associated microbiome, which promotes plant health and nutrient availability, is impacted by environmental conditions and agriculture practice. Figure from [Compant et al. 2019](#).

FIGURE 9



Agriculture

Affect crop production, fungi prevalence and mycotoxins production leading to food safety and spoilage issues

Animal Production

Favor harmful algal bloom (HAB) and marine bio-toxins production, presence of organic chemical residues and toxic metals and subsequently affect seafood safety

Fishery

Induce heat stress to animals, while droughts and flooding may influence milk production and its quality by inducing an increased microbial load, which subsequently affect food safety and spoilage

Storage and distribution of Food Products

Favor thermophilic spore-forming bacteria and fungal growth and affect food safety and spoilage

Projected factors that are expected to change due to climate change

- Relative humidity
- Temperture
- Precipitation events
- Salinity
- Acidification

Figure 9. Climate change’s projected changes to the environment (bottom) will impact microbes that affect food safety and security. Altered precipitation and humidity create conditions for more crop diseases and algal blooms that decrease agricultural and livestock production. Warmer temperatures enhance outbreaks of pathogens and fungal toxins that can contaminate human and animal feed stocks postharvest.

FIGURE 10

Figure 10. Example of an algal bloom that covers the water’s surface, polluting drinking water and preventing recreation activities. Image credit NOAA.

FIGURE 11

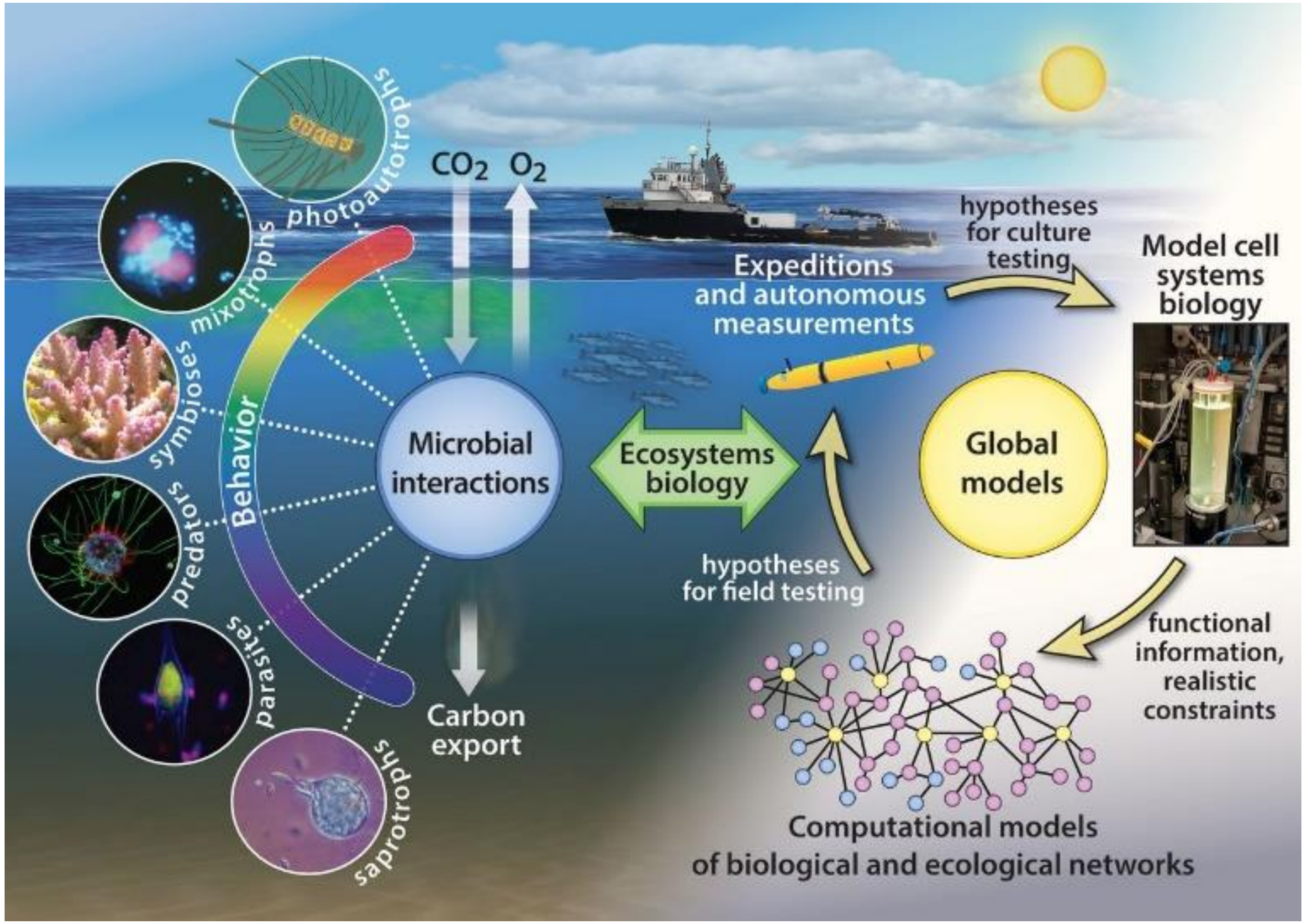


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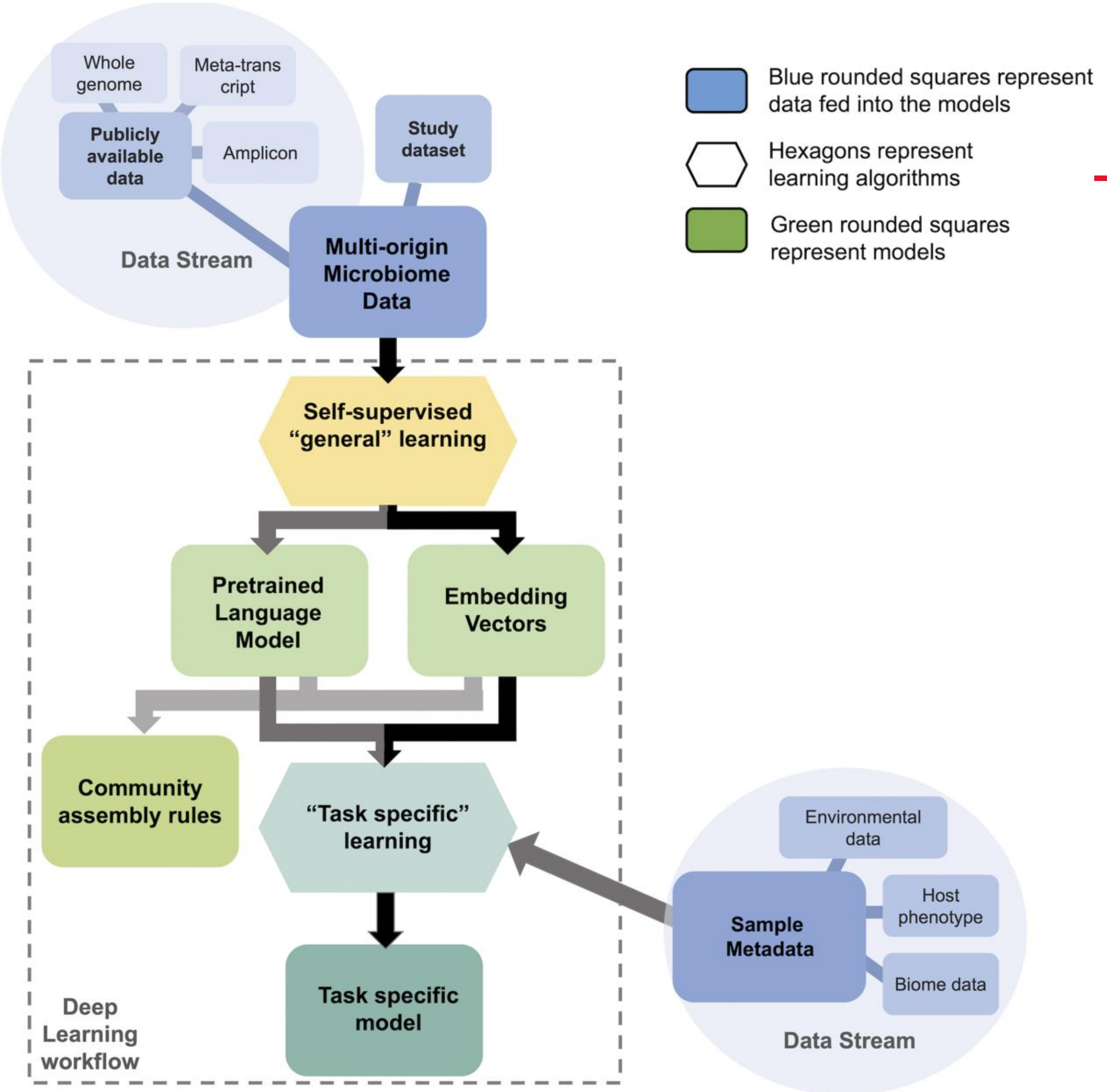
Figure 11. Microbial activities and interactions can be parametrized for computational Earth system models to help understand global carbon cycling. Figure from Worden et al. 2015.

FIGURE 12



Whole genome
Meta-transcript
Publicly available data
Amplicon
Study dataset
Data Stream
Multi-origin Microbiome Data
Self-supervised “general” learning
Pretrained Language Model
Embedding Vectors
Community assembly rules
“Task specific” learning
Task specific model
Deep Learning workflow
Environmental data
Host phenotype
Sample Metadata
Biome data
Data Stream

🟦 Blue rounded squares represent data fed into the models

⬡ Hexagons represent learning algorithms

🟩 Green rounded squares represent models

Figure 12. Models (green squares) and machine learning (hexagons) can process complex data sets (blue squares) to help identify microbial dynamics. Figure from David et al. 2022.

FIGURE 13

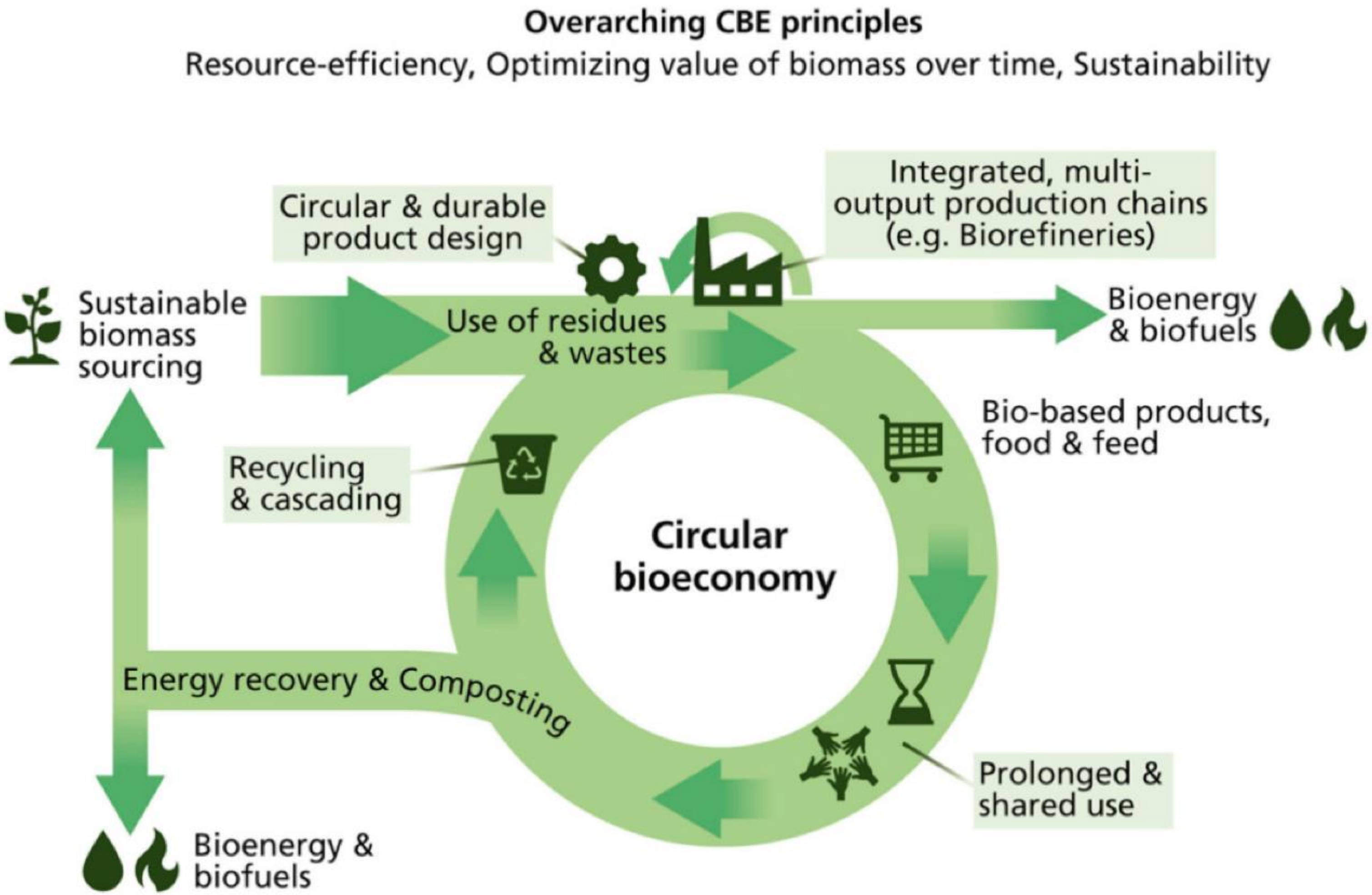


Figure 13. In a circular bioeconomy (CBE), waste products and inputs are recovered, recycled, and reused to produce goods sustainably from biological sources. Figure modified from Stegmann et al. 2020.

FIGURE 14

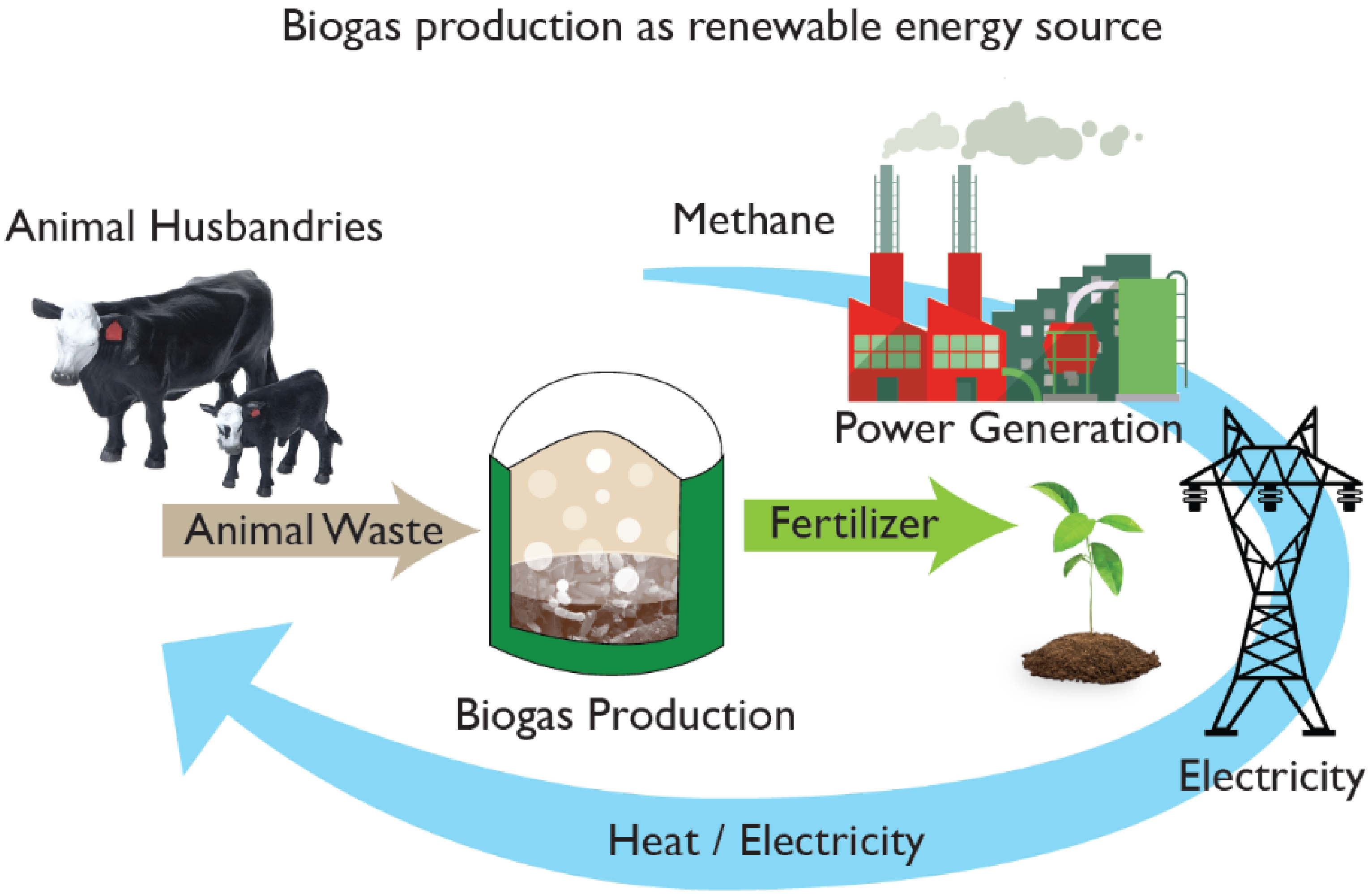


Figure 14. Wastewater treatment microbial communities produce carbon and nitrogen wastes that can be utilized for power generation and agricultural fertilizer to create a circular bioeconomy.

Thank You!

Questions? Contact Us.

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