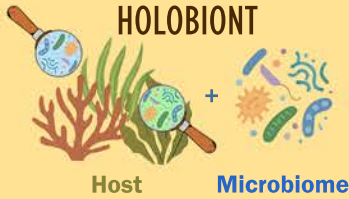




## WHY MICROBES MATTER IN RESTORATION

### HOLOBIONT



Each marine habitat-former (coral, seagrass, seaweed) hosts a characteristic microbial community (the microbiome) that influences its health and resilience. Together they are the holobiont.

### ESSENTIAL FUNCTIONS



Microbes help corals, seagrasses, and seaweeds absorb nutrients, fight off harmful pathogens, and recover from environmental stress.

### MICROBIAL DYSBIOSIS



Stressors like rising temperatures, pollution, and ocean acidification can disrupt the balance of beneficial microbes, allowing harmful pathogens to infect the host.

## WHAT WE KNOW

- **Microbiome Transmission:** Marine hosts acquire microbes both from parents and from the environment.
- **Protection from disease:** Healthy microbiomes can protect their hosts from diseases.
- **Early-Life Importance:** Microbes influence host development and resilience from early life stages, shaping health trajectories.
- **Probiotic Potential:** Beneficial Microorganisms for Corals (BMCs) can be given to the corals to make them more resistant to bleaching and improve stress tolerance; similar approaches are being explored for seaweeds and seagrasses.

## WHAT WE DON'T KNOW

- **How to pick microbes:** We still lack clarity on how most microbes are recruited or rejected by early life stages of corals, seaweeds, and seagrasses.
- **Host-Microbe Signalling:** The chemical “language” (infochemicals) driving microbiome shifts and host responses is poorly understood.
- **Microbiome Stability:** It remains unclear how stable these microbial communities are across generations or under rapid environmental stress.
- **Field Efficacy of Probiotics:** While some microorganisms show promise in lab experiments, their long-term success and scalability in natural ecosystems is largely untested.
- **Microbiome Complexity:** Most research has focused on bacteria, leaving the roles of other microbiome members (fungi, viruses, and archaea) underexplored.

## RESTORATION IN PRACTICE



**Assisted Restoration:** Combining traditional methods with microbiome interventions, such as pre-treating coral larvae or seaweed propagules with probiotics, may improve survival and stress tolerance. Further testing is crucial.



**Robust Risk Assessment:** is essential to ensure the responsible use of microbiome-based interventions by all stakeholders involved.



**Microbiome Stewardship:** Instead of focusing only on fixing damaged ecosystems, we must explore strategies to prevent microbial imbalance and improve holobiont resilience before stress events occur.



**Legal and Ethical Considerations:** What are the limits and long-term ecological and ethical implications of deliberately altering microbial associates of corals, seaweeds and seagrasses?