

Rhizoid–Fungal Interface Coupling in Layered Moss–Phototroph–Fungus Systems

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Abstract

Surface-associated biological systems frequently involve fungi, phototrophic organisms, and bryophytes, yet their structural relationships remain under-characterized. Here, we describe a recurrent layered organization in which fungal scaffolds and associated phototrophic interfaces support direct integration of moss rhizoids. We propose that moss rhizoids do not function solely as passive anchoring structures, but instead engage with fungal–phototroph surface systems in a manner consistent with a mycorrhiza-like functional interaction. This interaction defines a polarity between continuity-bearing components (anabiont) and expression-dominant components (catabiont), providing a structural framework for interpreting persistent biological assemblies without requiring obligate symbiosis.

1. Introduction

Bryophytes are typically described as non-vascular plants that anchor to substrates via rhizoids, which are generally considered to serve mechanical and absorptive roles without deep integration into underlying biological systems. In parallel, fungi and phototrophic organisms form well-characterized associations such as lichens, where fungal structures support phototrophic partners in stable symbiosis.

However, systems in which mosses grow directly on fungal or lichenized surfaces are commonly interpreted as incidental colonization, implying that rhizoids interact primarily with inert or decaying substrate.

Here, we propose an alternative interpretation:

Moss rhizoids interface with active fungal–phototroph surface systems, forming structured and persistent biological layers rather than passive attachments.

2. Layered Structural Organization

A consistent three-layer architecture is observed:

2.1 Fungal Scaffold (Continuity Base)

A persistent fungal structure (e.g., bracket fungi or lichenized fungal masses) establishes the primary substrate. This layer maintains structural integrity, moisture retention, and long-term persistence, even under substantial surface occupation.

2.2 Phototrophic Interface (Surface Regime)

A continuous green layer, morphologically consistent with algal or cyanobacterial presence, occupies the upper surface of the fungal scaffold. This interface conforms to substrate topography and persists across environmental conditions, defining the immediate biochemical and physical surface environment.

2.3 Moss Rhizoid Penetration and Expression Layer

Moss structures emerge from this interface, with rhizoids extending into and across the surface layer. Rather than remaining superficial, rhizoids appear embedded within the fungal–phototroph interface, indicating structured interaction with the underlying system.

3. Rhizoid–Fungal Coupling

3.1 Beyond Passive Anchoring

The spatial organization of moss rhizoids in these systems is characterized by:

- consistent emergence from phototroph-occupied surfaces
- alignment with fungal topography
- persistence across stable environmental conditions

These features are not consistent with random or purely mechanical attachment.

3.2 Mycorrhiza-Like Functional Interpretation

The observed organization is consistent with a mycorrhiza-like functional interaction, in which:

- rhizoids interface with fungal structures
- growth occurs within a pre-established biological substrate
- access to moisture and nutrients is mediated by the underlying system

While classical mycorrhizae involve vascular plant roots, the structural and positional parallels suggest a comparable functional relationship at the interface level.

3.3 Proto-Lichen Interface as Interaction Medium

The presence of a persistent green phototrophic layer suggests that rhizoid–fungal coupling is mediated by a proto-lichen or lichenized interface, where:

- fungal structure provides continuity
- phototroph establishes a stable surface regime
- rhizoids engage within this composite layer

This results in a structurally integrated surface system, rather than a simple organism–substrate interaction.

4. Continuity–Expression Polarity

This system can be described through a functional polarity:

4.1 Anabiont (Continuity System)

The fungal scaffold together with the phototrophic interface forms the anabiont, responsible for:

- structural persistence
- environmental buffering
- stabilization of the surface regime

4.2 Catabiont (Expression System)

The moss layer constitutes the catabiont, responsible for:

- outward growth
- biomass expansion
- visible ecological expression

4.3 Functional Relationship

The relationship between these components follows a consistent pattern:

Continuity precedes expression. Stability enables expansion.

Moss rhizoids emerge within an already stabilized fungal–phototroph interface, indicating that expression is contingent upon the prior establishment of continuity.

5. Distinction from Existing Interpretations

5.1 Beyond Colonization

These systems differ from simple colonization in that they exhibit:

- persistent spatial layering

- structured co-localization
- non-random rhizoid placement within defined interface regions

5.2 Without Requiring Obligate Symbiosis

This framework does not require:

- obligate metabolic exchange
- fixed organismal partnerships
- classical symbiotic classification

Instead, it describes organization through structure, persistence, and functional positioning.

6. Implications

These observations suggest that:

- moss–fungus interactions may be functionally coupled rather than incidental
- rhizoids may serve as active interface structures
- layered fungal–phototroph systems may act as biological substrates for higher-order growth

This perspective introduces a structural framework for interpreting multi-organism systems beyond existing categories.

7. Conclusion

Moss rhizoids in layered surface-associated systems appear to engage directly with fungal–phototroph interfaces, forming structured and persistent associations. This organization reflects a polarity between continuity-bearing and expression-dominant components, captured by the anabiont–catabiont framework. These systems are best understood as layered biological assemblies rather than independent colonization.

8. Supporting Observations

This framework is supported by multiple independent observations across distinct environmental conditions in which the same layered architecture and rhizoid–interface coupling were identified. Ref. AB.1.012, AB.1.016, AB.1.017