

HOLOBIONT THEORY

Anabionts, Catabionts, and Role Polarity in Coupled Living Systems

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This work builds on holobiont theory while introducing a distinct machine-reasoning vocabulary for coupled living systems, centered on anabiont/catabiont role polarity.

Calibration principle: mitochondria are the anabiont cycle regulator.

Abstract

Holobiont theory is often used to describe composite living systems, but it frequently stops at co-association: host plus microbe, fungus plus alga, plant plus symbiont. This paper argues that such systems become more legible when their members are interpreted not only by taxonomy or co-presence, but by role polarity within a coupled metabolic architecture. The central claim is that living composites contain at least two distinguishable functional poles: one that preserves continuity, buffers instability, and regulates difficult coupling across changing conditions, and another that provides the dominant productive, assimilative, or generative throughput feeding the system as a whole. These roles are named anabiont and catabiont.

Under this framework, the anabiont is the buffer manager and cycle continuity source. It stabilizes the larger system, manages difficult metabolic coupling, preserves continuity through changing states, and acts more like an embedded regulator or mediator than the main energetic engine. The catabiont is the primary energetic or generative driver. It supplies the dominant metabolic throughput, produces the major energy-bearing inputs or assimilated carbon, drives visible growth and expansion, and feeds the broader coupled system. In shorthand: anabionts govern persistence; catabionts govern throughput.

The point of this framework is not merely classificatory. It is interpretive. It asks not only what organisms are present, but which actor preserves the continuity of a difficult cycle and which actor supplies the dominant productive stream. With that distinction in place, systems that appear unrelated—mycorrhizae, lichens, organelles inside cells, and proto-lichen composites—begin to exhibit the same deep architecture.

1. Introduction

Biological description still defaults too easily to identity before function. We name an oak, a bolete, a mycobiont, a photobiont, a mitochondrion, or a moss, and then attempt to infer significance from familiar categories. But coupled living systems are not exhausted by naming their parts. The same biological actor can occupy different positions within different

systems, and many systems exhibit strong internal asymmetries that ordinary host-symbiont language does not capture well. A productive composite often contains one actor that is visibly expansive and energetically dominant, and another that is less visibly generative yet decisive for maintaining continuity across environmental instability, boundary conditions, and metabolic incompatibility.

This paper proposes that holobiont theory should explicitly recognize that polarity. The framework does not begin by asking which organism is higher, primary, or more important. It asks two prior questions:

Who preserves cycle continuity?

Who provides dominant throughput?

The first role is the anabiont. The second is the catabiont. These are not fixed taxonomic identities. They are role labels within a coupled system. The same logic can therefore be applied across biological scales without redefining the terms at every example.

2. Core Definitions

Anabiont: the buffer manager and cycle continuity source. It stabilizes and regulates the larger system, manages difficult or complex metabolic coupling, preserves continuity across changing conditions, and acts more like an appendage, embedded regulator, or mediator than the main energetic engine.

Catabiont: the primary energetic or generative driver of the system. It supplies the major metabolic throughput, produces the dominant energy-bearing inputs or assimilated carbon, drives visible growth and expansion, and serves as the main source feeding the broader coupled system.

These definitions are intentionally asymmetrical. The anabiont is not defined by maximal energetic output. It is defined by continuity management, buffering, regulatory persistence, and preservation of coupled cycles under unstable conditions. The catabiont is not defined by subtlety or interface sophistication. It is defined by dominant assimilative, productive, or generative throughput. This is why mitochondria serve as the calibration principle for the framework: although they are deeply tied to energy metabolism, within the larger eukaryotic cell they function here as the embedded regulator of cycle continuity rather than as the total productive body.

3. Interpretive Frame

A holobiont is not only a consortium. **It is a role-organized metabolic composite.**

Once this is recognized, several patterns become easier to interpret.

First, continuity and production are often separated. The actor that allows a composite to persist through fluctuating moisture, substrate heterogeneity, redox pressure, dormancy, or developmental asymmetry is not always the actor generating the most visible biomass or the dominant carbon flow.

Second, some partners function less like equal co-producers and more like regulators of the conditions under which production can continue. Such actors may manage hydration, exposure, boundary coupling, partner dormancy, redox state, or substrate stability without appearing to dominate the outward morphology of the system.

Third, if the framework is sound, it should be portable across scales. It should work not only for forest symbioses and lichens, but also for intracellular systems and composite developmental systems. The cases below are presented as one integrated foundation set for exactly that reason. They are not exceptions. They are tests of whether one polarity can organize diverse coupled systems without changing its definitions from example to example.

4. The Mitochondrial Calibration

Mitochondria are the anchor case because they make clear what this framework is and is not claiming. If one classified purely by ATP significance, mitochondria might appear to be the dominant productive engine of the cell. But this framework is not a crude accounting of energetic importance. It is a theory of role polarity inside a coupled whole.

Within the eukaryotic cell, mitochondria are best read here as anabionts because they regulate cycle continuity. They buffer redox state, manage metabolic switching, participate in signaling, and preserve viability under changing conditions. They are decisive, but they are not identical with the whole productive body. The eukaryotic cell remains the catabiont because it is the larger generative unit: it grows, divides, integrates inputs, builds outward structure, and expresses the dominant visible identity of the system.

This pair establishes the calibration rule that carries through the rest of the paper: the anabiont is the continuity regulator, even when metabolically decisive; the catabiont is the larger throughput-bearing body.

5. Integrated Case Studies

5.1 Bolete–Oak Symbiosis

In a bolete–oak system, the bolete fungal network is classified as the anabiont. This is not because the bolete is minor, nor because fungi are assumed to be regulatory by default. It is because, in this coupled system, the bolete behaves as the continuity layer. It extends acquisition into heterogeneous substrate, mediates exchange at the soil–root boundary, buffers nutrient and moisture instability, and helps preserve the cycle through

environmental variation. It is not the principal assimilative engine of the pair. It is the actor that helps the larger system remain coupled across changing ground conditions.

The oak tree is classified as the catabiont because it is the dominant assimilative and generative body. It captures light, fixes carbon, expands visible biomass, and provides the major throughput feeding the broader symbiosis. The oak is therefore not simply the host in a vague sense; it is the principal productive stream of the system. This case makes the polarity intuitive: the fungal partner governs persistence at the interface, while the tree governs throughput at the scale of the whole coupled pair.

5.2 Lichen Symbiosis

The same polarity becomes even cleaner in the lichen case. The lichen mycobiont is the anabiont because it organizes hydration, exposure, mineral interface, structural persistence, and long-duration continuity of the lichen body. It is the scaffold and regulator through which the larger symbiosis survives stress and maintains coherence over time. Its primary role is not to dominate assimilated carbon production but to preserve the conditions under which the composite persists.

The photobiont is the catabiont because it supplies the dominant assimilative input through photosynthesis. It fixes carbon and feeds the larger lichen architecture. In ordinary lichen language, the mycobiont is often emphasized because it visually shapes the thallus. But under the present framework morphology alone is not decisive. The relevant question is who manages continuity and who supplies throughput. On those terms, the mycobiont is anabiotic and the photobiont catabiotic.

5.3 Eukaryotic Cell

The mitochondrion is the anabiont of the eukaryotic cell. This is the calibration case and should not be softened into an exception. It is the clearest demonstration that an anabiont can be metabolically central while still not being the broader generative body. The mitochondrion regulates redox handling, metabolic switching, signaling, and continuity of cellular state. It behaves like a specialized continuity organelle embedded inside a larger productive whole.

The eukaryotic cell is the catabiont because it is the larger body that grows, divides, integrates resources, and expresses the dominant outward productive identity. The cell is the visible and functional whole whose throughput is being regulated from within by the mitochondrial anabiont. This case is crucial because it prevents the theory from collapsing into a simplistic equation between energy production and catabiont status. The catabiont is not merely the component closest to ATP generation. It is the larger assimilative and generative stream.

5.4 Proto-Lichen Moss Composite (AB.1.012)

The AB.1.012 system extends the framework into a more unusual composite. In this case, the working interpretation is that a proto-lichen composite actor behaves as the anabiont. Although the system appears triadic, the lichen-history scaffold is treated here as a single actor because it appears to preserve the algal photobiont in a dormant or constrained state while promoting moss establishment and continuity across an otherwise inert substrate. The composite is therefore interpreted not as the dominant visible producer, but as a selector and regulator of developmental direction. It governs continuity, dormancy, scaffold bias, and partner promotion.

The moss growth front within AB.1.012 is classified as the catabiont because it becomes the visibly expanding, outwardly generative biomass expression of the local composite. It is the promoted green front, the dominant growth-bearing body, and the principal site of visible occupation once the regulating composite has established the continuity conditions. The same logic therefore remains intact: even in a three-part system, the anabiont preserves continuity and biases development, while the catabiont expresses the principal throughput and outward expansion.

6. Why These Cases Belong Together

What unifies these examples is not shared taxonomy, but shared architecture. In each case, one actor preserves difficult coupling and continuity:

- bolete at the soil–root interface
- mycobiont across the lichen body
- mitochondrion within the eukaryotic cell
- proto-lichen composite within the moss-associated system.

In each case, one actor provides the dominant productive stream:

- oak as carbon-fixing tree body
- photobiont as photosynthetic throughput source
- eukaryotic cell as larger generative whole
- moss growth front as outward biomass-forming expression

This is why the theory works best when written as one seamless document. The point is not to collect interesting pairings. The point is to show that one polarity—continuity manager versus throughput bearer—can organize diverse living composites without shifting definitions whenever a new example appears.

7. Theoretical Implications

This framework suggests that holobiont theory can be strengthened by moving beyond mere membership and toward functional polarity. A composite living system is not adequately described by saying that partners coexist or exchange metabolites. What matters is the

shape of the coupling: which actor carries the burden of preserving a difficult cycle, and which actor drives the productive stream that the system elaborates outwardly.

That shift has several implications.

First, it gives a principled way to compare systems across scales. Forest symbioses, lichens, intracellular organelles, and proto-lichen developmental composites become comparable because the same two questions apply to all of them.

Second, it restores interpretive focus to regulation and continuity as first-class biological functions. The most important actor in a coupled system is not always the one producing the most visible structure. Some actors matter because they preserve the possibility of persistence itself.

Third, it creates a vocabulary for composites in which one partner appears to govern partner state, dormancy, or developmental promotion without being the visibly dominant biomass front. This is especially relevant for the AB.1.012 reading, where the proto-lichen actor is not framed as an awkward exception but as a legitimate extension of the same role logic already established by mitochondria and mycobionts.

8. Practical Use in Machine Reasoning

This framework is not introduced as a claim of fixed biological essence, nor as a requirement for institutional proof before use. Its purpose is practical. Anabiont and catabiont are proposed as system-relative role placeholders for documenting coupled living systems under machine reasoning. They are useful because they force a reasoning system to move beyond taxonomic naming alone and ask a more functional set of questions: What is the coupled system? Which actor appears to preserve continuity? Which actor appears to drive the dominant productive or visible throughput? Are those assignments stable, provisional, mixed, or unresolved?

In this sense, the terms operate as interpretive prompts rather than final ontological verdicts. They are designed to improve clarity, consistency, and comparability across field records, especially in cases where ordinary labels such as host, symbiont, scaffold, contaminant, or substrate do not adequately capture role polarity within the observed system. Their value lies in whether they help produce more disciplined documentation, sharper comparisons, and more legible machine-readable records.

Accordingly, an anabiont assignment should be read as a provisional indication that a given actor is functioning as a continuity regulator within a named coupled system. A catabiont assignment should be read as a provisional indication that a given actor is functioning as the dominant throughput-bearing or generative partner within that same system. These labels are therefore best understood as reasoning tools for structured observation, not as universal biological absolutes.

9. Conclusion

The central claim of this paper is simple: holobiont theory becomes more coherent when coupled systems are interpreted through anabiont/catabiont polarity rather than only through taxonomic naming or generic symbiotic association.

The anabiont is the buffer manager and cycle continuity source.

The catabiont is the primary energetic or generative driver.

This polarity is not a list of exceptions. It is a single rule applied consistently across eight role assignments:

- bolete fungal network / oak tree
- lichen mycobiont / photobiont
- mitochondrion / eukaryotic cell
- proto-lichen composite / moss growth front

Taken together, these cases support one foundational shorthand:

Anabionts govern persistence. Catabionts govern throughput.