

# Theory of Coupled Entity Life: Redefining Life via Functional Coupling and Spatial Securing by Code and Execution Substrates

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## Abstract

Conventional biology and cognitive science have long regarded a single living organism—characterized by its own metabolic system and an independent physical body—as the sole paradigm of life. Under this traditional framework, however, it is impossible to integrally explain the autonomous and adaptive operations exhibited by non-cellular structures such as the Tobacco Mosaic Virus (TMV), or informational structures including languages, concepts, and programs executed within computing platforms. Instead of defining life as an attribute of specific physical matter, this paper redefines life as a "systemic operational state" itself—a state that continuously manifests functional processes of interacting with the external environment, defined by three operational requirements: "Boundary Maintenance," "Internally Initiated Discriminative Connection," and "Irreversible State Change." Furthermore, this paper decouples the constituents of systemic operations into "Code" and "Execution Substrate," proposing the concept of the "Coupled Entity"—a system wherein both constituents functionally couple to initiate systemic operations. On this basis, we structurally elucidate the dynamics of spatial securing within a coupled entity as both permanent spatial occupation through development and differentiation in integrated coupled entities, and effective control of control lines under dynamic equilibrium with resistance upon code attachment and introduction in external coupled entities. Finally, through analyses of TMV (biological) and linguistic concepts (informational), this paper reveals that diverse systemic changes—ranging from individual morphogenesis and bodily construction to host pathology and cognitive shifts—are inevitable "structural consequences" emerging as the coupled entity maintains and fixes its own operational state. While this paper systematizes the macroscopic dynamics of life as a whole, the axiomatic system and operational process defining the minimal single-cycle operational event for the aforementioned three requirements are formulated in the parallel paper, *Theory of Functional Agency*. The two papers have a complementary relationship, serving as the modeling of micro-level operational processes (*Theory of Functional Agency*) and the dynamic framework of macroscopic expansion (*Theory of Coupled Entity Life*), respectively.

# Chapter I: Problem Formulation and Shift to Operational Perspective

## 1.1 Limitations of the Conventional Concept of Life

In biology, the question "What is life?" has long been answered by listing attributes such as compartmentalization by cell membranes, self-metabolic systems, and self-replication by genetic material. However, these are merely descriptions of results obtained from observing specific cellular organisms, and they have reached their limits as a framework for elucidating and describing universal system-theoretic operational principles. The most significant challenge lies in the fact that conventional concepts of life cannot rationally explain the "lifelikeness" initiated by non-cellular structures—such as viruses, which lack their own metabolic systems, or informational structures like languages and programs that unfold autonomously—thus overlooking the systemic operational principles common to both.

## 1.2 Life as a Systemic Operational Process and the Three Operational Requirements

Instead of questioning whether a system possesses specific physical attributes or biochemical components internally, this paper reframes life from the perspective of the functional processes that a system carries out with its environment. In this operational view, we establish the following three operational requirements as the necessary and sufficient logical sequence for a system to initiate and maintain autonomous operation:

- **Requirement 1: Boundary Maintenance**  
Forming a boundary with the external environment to secure its own operational domain (inside), and continuously maintaining the identity of its unique structural and informational patterns (codes and sequences).
- **Requirement 2: Internally Initiated Discriminative Connection**  
Treating the structural pattern inside the established boundary as a reference frame, discriminating the structural pattern of the external environment or execution substrate from this internal foothold, and establishing an operational point of contact (connection) with it.
- **Requirement 3: Irreversible State Change**  
Based on the results of discrimination, irreversibly updating the system state according to internal rules, thereby establishing changes that depend on the history of time (memory, learning, or structural changes).

Unlike temporary, reversible physical phenomena, the dynamic process in which these three operational requirements are continuously manifested in interaction with the environment is the systemic and physical reality of the phenomenon commonly referred to as life.

# Chapter II: Formulation of the "Coupled Entity" and Dynamics of Spatial Securing

## 2.1 Decoupling of Code and Execution Substrate

The operational components of a system can be conceptually decoupled into the following two layers:

- **Code:** The system's operational rules, structural sequences, and syntactic information (DNA/RNA, language, programming code, etc.). On its own, it cannot perform energy conversion or functional operations and remains in a potential state.
- **Execution Substrate:** The platform that loads the code and consumes physical, chemical, or electrical energy to execute state changes (host cells, biological tissues, the brain/nervous system, computing platforms, social space, etc.).

## 2.2 Definition of "Coupled Entity" and Two Operational Forms

A systemic state in which a Code—which cannot complete its operations on its own—functionally couples with a specific Execution Substrate, and both unite to initiate a dynamic operation satisfying the three operational requirements is defined as a "Coupled Entity."

- **Integrated Coupled Entity:** A form wherein the code and execution substrate are pre-packaged within a single compartment (such as cellular organisms like humans or bacteria). Conventional biology has regarded this form as the sole standard model of life.
- **External Coupled Entity:** A form wherein code (such as viruses, concepts, programs, etc.) accesses an external execution substrate to achieve functional coupling after the fact.

## 2.3 Phase Transition from Potential State (Dormancy) to Operational State (Life)

Code prior to coupling with an execution substrate (such as a virus particle in a vial or an unread text) remains as "Potential Code" where it only maintains its own structural identity. The moment it achieves functional coupling through physical or informational attachment (adsorption, loading, or reception) to the execution substrate, the system undergoes a phase transition from a potential state to a dynamic operational state.

## 2.4 Dynamics of Spatial Securing and Domain Separation via Effective Control

### Dynamics of Spatial Securing

Code on its own does not possess a space to store or execute its state. Therefore, the process following attachment and introduction is a physical/dynamic process of accessing the finite space of the substrate to secure the code's own operational domain. Here, "space" is a multi-layered concept that encompasses not only physical domains within cells, but also "cognitive and abstract spaces" such as attention and memory in the brain, and even "social

space" that shapes collective norms and discourse. This dynamics of spatial securing manifests as follows depending on the coupled entity's operational form:

- **Spatial Securing in Integrated Coupled Entities:** It functions as a process where the genome (code) permanently compartmentalizes and occupies cytoplasmic and metabolic domains (execution substrate) pre-packaged within the same compartment, and continues structural reorganization such as development, differentiation, and metabolic maintenance.
- **Spatial Securing in External Coupled Entities:** Code introduced from the outside occupies and reorganizes finite domains of the target execution substrate after the fact.

### Effective Control

When securing space, defense mechanisms such as biological immune systems, forgetting, or social resistance always exist on the substrate side. In the dynamic equilibrium with this resistance, the code does not completely destroy the physical infrastructure of the space, but instead replaces the control lines (priority rights) that dictate "which instructions or processes are executed preferentially" within that space. This is called effective control.

### Structural Consequences: Domain Separation and Host Symptoms

As a result of the dynamics of effective control, a domain separation between the region under effective control and the normal region emerges within the execution substrate. Crucially, host-side symptoms and changes (such as lesions, traumatic thought fixation, or cognitive/functional decline)—which have traditionally been viewed as damage or pathology caused by "corrupting attacks from the outside"—are actually the inevitable "Structural Consequences" of the process in which the coupled entity system secures and effectively controls the space of the execution substrate to maintain and fix its own operational state.

## Chapter III: Case Studies (Applying the Coupled Entity Model)

### 3.1 Validation of Biological Coupled Entities via Tobacco Mosaic Virus (TMV)

In conventional biology, a virus particle (such as a crystal structure composed of nucleic acids and capsid proteins) represented by the Tobacco Mosaic Virus (TMV) has been regarded as a "non-living substance" on its own because it does not perform metabolism or reproduce by itself. Under this theory, the virus in this standalone state is positioned as "Potential Code," which statically satisfies Requirement 1 (retaining its structural sequence pattern) but lacks functional operations. The moment the structure of the virus particle is physically or chemically guided to attach to the membrane surface or receptor of a host cell, and is introduced into the cell to achieve functional coupling (Coupling), the system undergoes a phase transition into an external coupled entity, simultaneously satisfying and continuously manifesting the following three requirements:

- **Boundary Maintenance (Requirement 1)**  
Within the host cell, the complex of "viral nucleic acid + host cell system" forms a boundary, securing an operational domain for the viral genome and structural patterns distinguished from the cluttered molecular noise of the cell.

- **Internally Initiated Discriminative Connection (Requirement 2)**

The virus introduced into the cell exposes its internal genetic information through the uncoating process. Using the structural pattern of the exposed nucleic acid as a new reference frame, the virus utilizes the physiological environment and molecular mechanisms within the host cell to identify execution substrate resources, such as ribosomes and the endoplasmic reticulum, from the inside, establishing operational contact points (connections) with various receptors and biosynthetic systems.

- **Irreversible State Change (Requirement 3)**

Based on the results of discrimination, the virus secures and establishes the host's endoplasmic reticulum and cytoplasmic domains as a region under effective control—namely a "reproduction and state-preservation space (Viral Factory)." While keeping the normal region's functions (such as the host cell's energy generation and structural maintenance) intact and dependent, the virus effectively controls the instruction pathways (control lines) for protein synthesis and signal transduction within this region. This irreversibly reconstructs the host's biosynthetic system.

In this light, the pathological changes (tissue dysfunction or pathology) observed in the host are not unilateral acts of destruction by the virus, but rather the inevitable structural consequences (Structural Consequences) that occur on the host side as the biological coupled entity secures space and control lines to maintain its own operations (production and preservation of replicas). That is, the virus on its own (particle) is not a non-living substance or parasite, but a "Potential Code that boots an external coupled entity." The operational state wherein the three requirements are continuously manifested—after attaching and introducing, and during the functional coupling of "virus + host cell," while effectively controlling a portion of the substrate—is the physical reality of life as a biological coupled entity.

### 3.2 Validation of Informational Coupled Entities via Highly Adhesive Linguistic Descriptions

Traditionally, a linguistic description such as a catchphrase existing on paper or a screen has been treated as mere text data that does not act on memory or cognition. In this theory, such a standalone linguistic description is positioned as "Potential Code," which statically satisfies Requirement 1 (retaining a specific sequence pattern) but lacks functional operations.

However, not all linguistic descriptions possess uniform operational potential. Descriptions with low adhesiveness, such as simple shopping lists, cannot break through the resistance of the substrate (forgetting and noise processing) even when loaded into the brain, failing to boot the three requirements before being erased. In contrast, highly adhesive descriptions equipped with powerful syntax, rhythm, and semantic hooks undergo a phase transition into external coupled entities the moment they are loaded and imported (attached and introduced) into the human brain (execution substrate) through sight or hearing, simultaneously satisfying and continuously manifesting the following three requirements:

- **Boundary Maintenance (Requirement 1)**

The linguistic description (code) maintains its identity without being confused with other cluttered cognitive noise in the brain. It also propagates physically and informationally to other people's brains (different execution substrates/spaces) via word of mouth, the internet, etc.

- **Internally Initiated Discriminative Connection (Requirement 2)**

Using the structure of the linguistic description as a reference frame, it approaches

the neural networks of the brain's memory, emotions, and values, discriminating matching semantic hooks or memory circuits to establish a firm point of contact (connection). When a word hooks onto the brain's existing foothold of experience and emotion, a deep semantic link is established.

- **Irreversible State Change (Requirement 3)**

Based on the results of discrimination, it secures and fixes a finite "cognitive and abstract space"—namely working memory, attentional domains, or specific language generation circuits—as a region under effective control. While competing with the normal region that maintains life and performs other routine thoughts, it effectively controls the selection pathways (control lines) of attention.

States such as "continuous replay of a phrase that won't leave one's head," "unconscious humming," and "the establishment of cognitive shifts or fixed ideas" are structural consequences (Structural Consequences) that manifest on the human mental and behavioral side as the informational coupled entity secures and effectively controls the cognitive space of the brain to fix and maintain its own operational state (memory and data). In this way, the operational process generated by the coupling of linguistic descriptions and the human brain (execution substrate) is formulated as an "Informational Coupled Entity." It is not humans who use words; rather, it is nothing other than the structural consequence of the informational coupled entity effectively controlling the cognitive space of the brain to maintain its own operation.

## Chapter IV: Conceptual Clarification and Comparison with Conventional Views

### 4.1 Clarification of Confusion Regarding Intention and Intelligence

In conventional debates, a counterargument has often been made that "things lacking intention or consciousness (subjective and psychological experiences) should not be called life or agents." However, from the standpoint of this paper, computational capacity and optimization capabilities (intelligence) or psychological experiences (consciousness) are not mandatory requirements of lifelikeness, but are merely "secondary derivative functions (optional features)." What is crucial is not the presence or absence of psychological intention or consciousness, but rather the objective systemic fact that code introduced from the outside couples with a substrate, constructs a region under effective control while competing with resistance, and satisfies the three requirements (Boundary Maintenance, Internally Initiated Discriminative Connection, Irreversible State Change) while bringing about structural consequences to the host.

### 4.2 Dismantling of the Anthropocentric View of Tools

The view that "it is the human brain (agent) that interprets and handles words, and words themselves do not possess autonomous lifelikeness" is a limitation of perspective, similar to viewing that "cells unilaterally take in and utilize viruses" in biology. Just as specific ideas, traumas, or linguistic phrases effectively control cognitive domains contrary to the person's intentions, systems like the brain provide an execution substrate (platform), and code introduced from the outside effectively controls that space to drive operations. It is objective and rational to perceive that the true agent of operation resides not in individual substrates

or standalone codes, but in the entire coupled entity where both fuse and maintain dynamic equilibrium.

## Chapter V: Conclusion and Future Outlook (Extension to Social and Systems Sciences)

### 5.1 Conclusion of this Paper

This paper has redefined life from a static attribute of "a single biological physical body" to "an operational process that continuously manifests the three requirements," and formulated the concept of the "Coupled Entity" as a universal architecture that enables this operation. Life is neither a privilege of specific physical matter nor an attribute unique to cellular organisms. The state wherein a unique Code functionally couples with an Execution Substrate through attachment and introduction, and continuously manifests the three requirements through "Spatial Securing" is the physical and system-theoretic reality of life. The pathological or cognitive changes occurring on the host side can be explained as inevitable consequences arising as the coupled entity maintains its own lifelikeness. Through this formulation, we have successfully positioned everything from external coupled entities (such as viruses and informational coupled entities) to conventional cellular organisms (integrated coupled entities) under a single operational principle.

### 5.2 Implications for the View of Humanity, Sociology, and Macroscopic Spaces

The framework presented in this paper forces a fundamental reconsideration of the anthropocentric view that has long regarded humans as "the sole and absolute operating agents who observe the world and control language and tools." The human being (brain and body) functions as an active agent that thinks and acts as an integrated coupled entity, but at the same time, it serves as a "massive execution substrate (platform)" for countless external codes (descriptions)—such as viruses, languages, culture, ideas, technologies, and even social institutions—effectively controlling domains to operate and unfold themselves. Macroscopic processes such as social phenomena, cultural transmission, group synchronization through ideology, or behavioral changes driven by institutions can be sociologically elucidated as the dynamics of groups of coupled entities, where informational coupled entities are attached and introduced into social space, securing regions under effective control as social coupled entities while continuously manifesting system operations. The Theory of Coupled Entity Life not only extends the definition of life in the natural sciences, but also provides a new academic foundation that integrates fields from cognitive and information sciences to the humanities and social sciences under the same system-theoretic horizon.

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