Article Title: What Lives? A meta-analysis of diverse opinions on the definition of life

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Authors: Reed Bender[1], Karina Kofman[2], Blaise Agüera y Arcas[3], and Michael Levin[4,5]*

Affiliations:
[1] Attune Intelligence, LLC
[2] Faculty of Dentistry, University of Toronto, Toronto, Canada
[3] Paradigms of Intelligence Team, Google
[4] Allen Discovery Center at Tufts University
[5] Wyss Institute for Biologically Inspired Engineering at Harvard University

***Corresponding Author:** Michael Levin
200 Boston Ave., Suite 4600, Medford, MA 02155
michael.levin@tufts.edu

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TITLE

Relational Self-Sustaining Patterns

CONSENSUS

Life is a persistent dynamic pattern that emerges through the coupling of entities with their environment, characterized by recursive processes that maintain and regenerate themselves. It exists fundamentally as a relational phenomenon, unable to exist in isolation but rather manifesting through transformative connections and exchanges between inside and outside. Life sustains itself through self-referential movements that create balanced exchanges of energy and matter, continuously recreating the conditions for its own origination and animation. This self-sustaining pattern expresses forms of consciousness and awareness, functioning not as a static state but as an ongoing process that carries forward its history while remaining open to creative transformation.

ANALYSIS

Definition Theme Analysis: Life

Key Themes List

These definitions share 5 major themes:

1. **Dynamic Patterns & Movement** (5/5 definitions)
   - Described as "permanent movement," "dynamic pattern," "self-sustaining system," "fire that lights itself," and "pattern and process"
   - Important because it distinguishes life from static phenomena
   - Used to emphasize that life is a process rather than a fixed state

2. **Relationality & Connection** (5/5 definitions)
   - Expressed as "cannot exist without an other," "coupling of an observer with environment," "organizes energy," "mutual dance," and "mutually transformative connection"
   - Important because it positions life as inherently relational rather than isolated
   - Used to show that life exists in context, not in isolation

3. **Self-Reference & Recursion** (4/5 definitions)
   - Appears as "movement towards balanced exchange," "intrinsically recursive dynamics," "self awareness and self agency," and "recreates the conditions for its own origination"
   - Important because it captures life's unique self-maintaining quality
   - Used to distinguish life from other physical processes

4. **Emergence & Creation** (4/5 definitions)
   - Expressed as "something we have received," "dynamically emerge," "healing," and "creativity"
   - Important because it addresses life's origin and continuation
   - Used to frame life as both received and continuously recreated

5. **Consciousness & Expression** (3/5 definitions)
   - Appears as "expression(s) of consciousness," "self awareness," and "song of life"
   - Important because it connects life to awareness and meaning
   - Used to suggest life transcends purely mechanical processes

Connection Map

These themes connect in the following ways:

1. **Dynamic Patterns → Self-Reference**
   - Life's movement isn't random but self-organizing
   - The patterns maintain themselves through feedback loops
   - Example: "Self-sustaining system" connects pattern to self-maintenance

2. **Relationality → Emergence**
   - Life emerges from relationships, not in isolation
   - New properties arise from connections between parts
   - Example: "Mutually transformative connection" creates conditions for emergence

3. **Self-Reference → Consciousness**
   - Self-reference enables awareness of self and environment
   - Recursive patterns create conditions for consciousness to emerge
   - Example: "Self awareness and self agency" links these concepts directly

4. **Dynamic Patterns + Relationality → Emergence**
   - The interaction of patterns with environment enables creation
   - Patterns persist through relationship with surroundings
   - Example: "Coupling of an observer with their environment" creates emergent phenomena

Shared Approach

The definitions share these characteristics:

1. **Process-Oriented Framing**
   - All definitions describe life as a process rather than a thing
   - They focus on verbs and actions rather than static properties
   - They emphasize becoming over being

2. **Boundary-Crossing Perspective**
   - Definitions blur lines between inside/outside, self/other
   - They position life at the interface of boundaries
   - They reject purely reductionist approaches

3. **Emergent Properties Focus**
   - Definitions emphasize properties that emerge from relationships
   - They suggest life is more than the sum of its parts
   - They point to qualities that transcend mechanical explanations

4. **Cyclical Time Conception**
   - Definitions frame life in terms of cycles and recursion
   - They emphasize repetition with variation

- They suggest life maintains itself through rhythmic processes

The collective approach reveals a view of life as a dynamic, relational process that maintains itself through recursive patterns, emerges from connections, and expresses forms of consciousness. Rather than defining life by a list of properties, these definitions characterize it through its processes and relationships, suggesting life is better understood as a verb than a noun.

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Perceptual Self-Reference

CONSENSUS

Life is a perception-dependent phenomenon defined through self-reference, where entities are considered alive by systems that themselves claim aliveness, rather than through objective properties. This distinction between living and non-living is not fundamental but emerges from the limitations of our sensory interfaces, which artificially separate what may be a continuous reality of Life.

ANALYSIS

Definition Theme Analysis: What is Life?

Key Themes List

These definitions share 3 major themes:

1. **Perception-Based Definition**
   - Used in both definitions
   - Important because it frames life as dependent on observation rather than intrinsic properties

- Used to challenge objective categorization of living/non-living

2. **Self-Reference and Recursion**
   - Present in first definition ("systems that consider themselves alive")
   - Important because it creates a circular definition that depends on consciousness or self-awareness
   - Used to suggest life is defined within a network of living things

3. **Sensory Limitations**
   - Central to second definition
   - Important because it suggests our categorization is flawed due to perceptual constraints
   - Used to argue that the living/non-living distinction is artificial

Connection Map

These themes connect in the following ways:

1. **Perception → Categorization**
   - Both definitions suggest that what we call "life" depends on perception
   - They relate through questioning objective classification
   - They connect by challenging the idea that "life" has intrinsic properties
   - Pattern: moving from objective to subjective definitions

2. **Sensory Limitations → False Distinctions**
   - The second definition explicitly links our limited senses to artificial categorization
   - They relate through cause and effect
   - This connection suggests our understanding is fundamentally flawed
   - Pattern: epistemological limitations creating ontological misconceptions

Shared Approach

The definitions share these characteristics:

1. **Anti-Essentialist Framework**
   - Both reject the idea that life has essential, objective properties
   - They assume categories are constructed rather than discovered
   - They share boundaries that question traditional scientific definitions
   - They collectively focus on the role of the observer in defining life

2. **Monistic Tendency**
   - The second definition explicitly suggests everything is alive ("We always interact with Life")
   - The first implicitly suggests a network of living systems defining each other

- They assume interconnection rather than separation
- This challenges the dualistic living/non-living distinction

3. **Recursive/Self-Referential Logic**
   - Both use circular reasoning that depends on the observer's perspective
   - They share an approach that embeds the definition within the defined
   - This creates definitions that cannot be easily formalized in traditional terms

These definitions collectively challenge conventional scientific approaches to defining life by emphasizing perception, questioning sensory limitations, and suggesting that the distinction between living and non-living may be an artifact of how we perceive rather than an objective reality.

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Definitional Pragmatism

CONSENSUS

Life is a continuous process rather than a definable category, making formal definitions inherently problematic and arbitrary when attempting to draw boundaries across natural continuums. Instead of seeking universal definitions, a more productive approach examines specific properties and contexts where living processes emerge, focusing on the pragmatic utility of definitions as tools for addressing particular questions or experimental approaches rather than as endpoints in themselves.

ANALYSIS

Definition Theme Analysis: Approaches to Defining Life

Key Themes List

These definitions share 4 major themes:

1. **Definitional Skepticism**
   - Used by: All definitions (4/4)
   - Importance: Fundamental agreement that traditional definitions of life are problematic
   - Usage: Expressed as reluctance to create rigid boundaries, questioning the value of formal definitions, or suggesting alternative approaches

2. **Process vs. Category Thinking**
   - Used by: 3/4 definitions
   - Importance: Shifts focus from "what is life?" to "how does living happen?"
   - Usage: Emphasizes life as continuous processes, time-based phenomena, or contextual activities rather than fixed categories

3. **Contextual/Pragmatic Approach**
   - Used by: 3/4 definitions
   - Importance: Suggests definitions should serve specific purposes rather than be universal
   - Usage: Advocates for focusing on particular properties, enumerating interesting configurations, or defining within specific problem contexts

4. **Emergent Properties Focus**
   - Used by: 2/4 definitions
   - Importance: Considers how complex living phenomena arise from simpler components
   - Usage: References learning, geochemical systems evolving into metabolism, or multiple interesting configurations

Connection Map

These themes connect in the following ways:

1. **Definitional Skepticism → Contextual Approach**
   - Relationship: The rejection of universal definitions naturally leads to purpose-specific approaches

- Example: "A formal definition of life is unhelpful" connects to focusing on specific processes like "geochemical systems"

2. **Process Thinking → Emergent Properties**
   - Relationship: Viewing life as processes enables understanding how complex properties emerge
   - Example: "Living is a process over time" connects to how "growth precedes heredity"

3. **Contextual Approach → Process Thinking**
   - Relationship: Context-specific definitions often focus on observable processes rather than categories
   - Example: "Focus on certain properties, such as learning" reflects both contextual and process-oriented thinking

Shared Approach

The definitions share these characteristics:

1. **Anti-Reductionist Perspective**
   - All definitions resist reducing life to simple checklists or binary categories
   - They acknowledge complexity and continuity in natural phenomena
   - They question whether traditional scientific approaches can adequately capture "life"

2. **Pragmatic Instrumentalism**
   - Definitions are viewed as tools for specific purposes, not absolute truths
   - Value is placed on what definitions enable us to do (experiment, understand, explore)
   - Focus on utility over philosophical completeness

3. **Openness to Multiple Frameworks**
   - Recognition that different approaches might be valid for different questions
   - Willingness to consider unconventional perspectives (learning in inanimate objects, enumerating configurations)
   - Acceptance of ambiguity and partial understanding

These definitions collectively suggest that the concept of "life" might be better approached through specific, contextual investigations of processes and properties rather than through attempts at comprehensive definition. They share a pragmatic orientation that values what definitions enable us to do rather than their philosophical completeness.

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TITLE

Autopoietic Boundary-Maintaining Systems

CONSENSUS

Life is a dynamic, non-equilibrium system characterized by self-organization of molecular components within semi-permeable boundaries that separate it from the environment while enabling controlled exchange. It harnesses energy through metabolic processes to maintain its organized state, repair itself, and reproduce. Living systems process and store information that guides their activities and enables adaptation to changing conditions. Through reproduction and information transfer, populations of living entities exhibit evolutionary change over time. The persistence of life depends on the coordinated interaction between its boundary, metabolism, and information-processing capabilities, forming an autonomous whole that maintains its identity despite continuous material turnover.

ANALYSIS

Definition Theme Analysis: Understanding Life

Key Themes List

These definitions share 7 major themes:

1. **Self-organization and Emergence**
   - Present in 11/13 definitions
   - Central to understanding life as a process rather than a static state
   - Described as "dynamic," "emergent," and arising from networks of interactions

2. **Boundary and Autonomy**
   - Present in 10/13 definitions
   - Emphasizes life's separation from environment while maintaining controlled exchange
   - Expressed as "semi-permeable," "bounded system," "spatial closure," or "encapsulation"

3. **Metabolism and Energy Utilization**
   - Present in 9/13 definitions
   - Focuses on energy conversion as fundamental to maintaining non-equilibrium states
   - Described as "harnessing energy," "exploiting matter and energy," or "using metabolism to persist"

4. **Information Processing**
   - Present in 8/13 definitions
   - Highlights life's ability to store, retrieve, and utilize information
   - Referenced as "control systems," "information-carrying substrates," or "unique mechanisms of information storage"

5. **Reproduction and Self-maintenance**
   - Present in 8/13 definitions
   - Addresses life's ability to create copies and repair itself
   - Noted as "self-reproduction," "self-maintenance," or "ongoing self-assembly"

6. **Evolution and Adaptation**
   - Present in 7/13 definitions
   - Emphasizes change over time in response to environmental pressures
   - Expressed as "indefinite evolvability," "adaptation-acclimation-evolution," or "self-organizing evolution"

7. **Non-equilibrium Thermodynamics**
   - Present in 6/13 definitions
   - Positions life as systems that maintain order against entropy
   - Described as "out of thermodynamic equilibrium," "non-equilibrium systems," or "dynamic process"

Connection Map

These themes connect in the following ways:

1. **Self-organization → Boundary Formation**
   - Self-organizing processes create and maintain boundaries
   - Boundaries enable autonomy and identity preservation
   - This relationship appears in most definitions that mention both concepts

2. **Metabolism ↔ Non-equilibrium States**
   - Metabolism provides energy to maintain non-equilibrium states
   - Non-equilibrium states enable metabolic processes
   - This bidirectional relationship creates a fundamental cycle in living systems

3. **Information Processing → Self-maintenance**
   - Information systems direct repair and maintenance activities
   - This enables persistence despite environmental challenges
   - Several definitions link these explicitly as control mechanisms

4. **Boundary + Metabolism → Autonomy**
   - Controlled material exchange across boundaries
   - Internal metabolic processes maintain the system
   - Together these create what several definitions call "Kantian wholes"

5. **Evolution ← Reproduction + Information**
   - Reproduction provides continuity across generations
   - Information systems enable heredity with variation
   - Together these create evolutionary potential

Shared Approach

The definitions share these characteristics:

1. **Process-Based Rather Than Object-Based**
   - Most definitions describe life as dynamic processes rather than static entities
   - Focus on what life does rather than what life is

- Emphasis on relationships between components rather than the components themselves

2. **Multi-level Perspective**
   - Many definitions acknowledge hierarchical organization
   - Consider both molecular/chemical foundations and emergent properties
   - Recognize individual and population-level phenomena

3. **Boundary-Drawing Challenges**
   - Several definitions acknowledge difficulty in precise demarcation
   - Some explicitly mention continuity with non-living world
   - Others note that technical objects created by life may be considered extensions of life

4. **Constraint-Based Understanding**
   - Many definitions frame life in terms of constraints on physical processes
   - These constraints channel energy and matter in specific ways
   - This approach bridges physical and biological explanations

5. **Temporal Dimension**
   - Most definitions incorporate time as essential
   - Life persists "many orders of magnitude" beyond component lifespans
   - Life has cycles (birth, growth, death) while maintaining identity

These definitions collectively suggest life is best understood as a process-based phenomenon emerging from constrained physical systems that maintain boundaries, process information, utilize energy, and persist through reproduction and adaptation over time.

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TITLE

Cognitive Agency

CONSENSUS

Life is a self-maintaining process that interacts with its environment through purposeful agency, processing information to preserve its complex organization. It perceives and responds to environmental conditions, making adaptive decisions that compensate for variations that would otherwise threaten its continued existence. This autonomous system works against entropy through energy exchange, creating and maintaining internal structure through feedback mechanisms while pursuing intrinsic goals. The system's agency is directed toward self-preservation, enabling it to adapt to changing conditions through cognitive processes that guide its interactions with the surrounding world.

ANALYSIS

Definition Theme Analysis: What is Life?

Key Themes List

These definitions share 7 major themes:

1. **Self-maintenance/Preservation** (17/23 definitions)
   - Core to most definitions as life's fundamental purpose
   - Expressed as "self-maintaining," "self-sustaining," "preservation," or "staying the same"
   - Represents life's resistance to entropy and disorder

2. **Agency/Purposeful Action** (15/23 definitions)
   - Ability to act with intention toward goals
   - Described as "adaptive decisions," "purposeful action," or "autonomous problem-solving"
   - Distinguished from passive physical processes

3. **Environmental Interaction** (14/23 definitions)
   - Life exists in relationship with surroundings
   - Involves perception, response, and adaptation
   - Includes absorbing resources and responding to conditions

4. **Information Processing** (12/23 definitions)
   - Ability to perceive, process, and respond to information
   - Includes cognition, learning, and decision-making
   - Enables appropriate responses to environmental conditions

5. **Complexity/Organization** (11/23 definitions)
   - Life exhibits ordered structure and hierarchical organization
   - Creates and maintains internal complexity
   - Often described as opposing entropy or the Second Law

6. **Reproduction/Replication** (8/23 definitions)
   - Ability to create copies or extend patterns
   - Less universally emphasized than self-maintenance
   - Sometimes framed as information propagation

7. **Process-Based Nature** (8/23 definitions)
   - Life as dynamic process rather than static state
   - Emphasis on continuous becoming and change

- Described as flows, networks, or development

Connection Map

These themes connect in the following ways:

1. **Core Relationship: Self-maintenance ↔ Environmental Interaction**
   - Life maintains itself by interacting with environment
   - Environment provides resources and challenges for maintenance
   - This relationship forms the fundamental tension of living

2. **Enabling Mechanism: Information Processing → Agency**
   - Information processing enables purposeful action
   - Perception and cognition precede appropriate responses
   - Agency depends on ability to process environmental cues

3. **Operational Cycle: Agency → Self-maintenance**
   - Purposeful actions serve self-preservation
   - Agency is directed toward maintaining organization
   - Creates circular causality where actions maintain the actor

4. **Structural Foundation: Complexity ↔ Self-maintenance**
   - Complex organization enables self-maintenance
   - Self-maintenance preserves and builds complexity
   - Each reinforces the other in a positive feedback loop

5. **Temporal Extension: Self-maintenance → Reproduction**
   - Self-maintenance extends to reproduction
   - Reproduction extends preservation beyond individual lifespan
   - Both serve pattern preservation at different timescales

Shared Approach

The definitions share these characteristics:

1. **Process Over Substance**
   - Most definitions focus on what life does rather than what it is
   - Emphasis on dynamic processes rather than static properties
   - Life as verb (living) rather than noun (life)

2. **Relational Perspective**
   - Life defined through relationships rather than isolation
   - Emphasis on system-environment boundaries and interactions

- Recognition that life exists within contexts

3. **Multi-dimensional View**
   - Many definitions acknowledge life as complex and multi-faceted
   - Several explicitly reject simple binary alive/not-alive distinctions
   - Recognition that life may exist on a spectrum or gradient

4. **Functional Over Material**
   - Focus on functions and capabilities rather than specific chemistry
   - Openness to non-carbon or artificial forms of life
   - Emphasis on patterns and processes over specific substrates

5. **Definitional Humility**
   - Several definitions acknowledge limitations of current understanding
   - Recognition that complete definition may not be possible
   - Openness to revising definitions as knowledge expands

The collective approach suggests life is best understood as a complex, multi-dimensional process of self-maintaining organization achieved through purposeful environmental interaction guided by information processing, rather than as a specific material substance or static state.

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TITLE

Self-Replicating Information Systems

CONSENSUS

Life is a self-replicating information system encoded in a physical substrate that maintains organization against entropy. It processes and transfers information essential for reproduction, typically utilizing carbon-based elements that form complex, self-organizing agglomerates. The

information contained within these systems enables them to create copies of themselves while persisting on timescales that significantly exceed the natural decay rate of their constituent materials.

ANALYSIS

Definition Theme Analysis: Life

Key Themes List

These definitions share 4 major themes:

1. **Information Processing and Transfer**
   - Used in all 3 definitions
   - Central to understanding life as a system that maintains and transmits data
   - Appears as "information that can replicate," "share information coded," and "information to reproduce"

2. **Self-Replication/Reproduction**
   - Present in all 3 definitions
   - Fundamental capability that distinguishes life from non-life
   - Expressed as "replicate itself," "reproduction," and "self-replicating properties"

3. **Physical Substrate**
   - Present in all 3 definitions
   - Life requires a material basis for its information and processes
   - Described as "physical substrate," implied in "functional construct," and explicitly as "carbon-based elements"

4. **Organization Against Entropy**
   - Present in 2 definitions
   - Life maintains order despite natural tendency toward disorder
   - Expressed as "keeps its entropy significantly lower" and "self-organizing properties"

Connection Map

These themes connect in the following ways:

1. **Information → Replication**
   - Information serves as the blueprint that enables replication
   - The definitions suggest replication cannot occur without information transfer
   - Example: "information to reproduce the life form that contains it"

2. **Physical Substrate → Information**
   - The physical substrate houses and enables information
   - Information requires a material basis to exist
   - Example: "information coded in a physical substrate"

3. **Organization → Persistence**
   - Organization against entropy allows life to persist beyond expected timeframes
   - Creates stability that enables other life processes
   - Example: "timescales exceeding the 'natural' timescale of the decay"

Shared Approach

The definitions share these characteristics:

1. **Functional Rather Than Experiential**
   - All definitions approach life as a set of processes or properties
   - Explicitly stated in second definition: "life is a functional construct"
   - Focus on what life does rather than what life experiences

2. **Systems Thinking**
   - Life viewed as an interconnected system of processes
   - Emphasis on relationships between components
   - Terms like "ensemble," "complex agglomerate," and "set of sub-processes"

3. **Boundary-Setting**
   - All attempt to distinguish life from non-life
   - Create criteria that separate living from non-living systems
   - Example: "what distinguishes life from other self-organizing systems"

4. **Reductionist Approach**
   - Breaking down life into component processes or properties
   - Second definition explicitly embraces this: "allows for a reductionist definition"
   - Third definition lists specific required components (DNA)

The definitions collectively suggest life is fundamentally about information that can reproduce itself through physical systems that maintain organization against natural entropy, though they differ on whether this is an objective phenomenon or simply a useful conceptual label.

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Self-Organizing Thermodynamic Computation

CONSENSUS

Life is a self-organizing, self-sustaining process that operates far from thermodynamic equilibrium, utilizing energy dissipation to maintain its existence. It establishes and preserves boundaries between self and environment while processing information computationally to respond and adapt. Living systems reproduce with variation, enabling natural selection and evolution, which further enhances their ability to persist as distinct entities through time. This computational, adaptive pattern can maintain itself across multiple scales through the dynamic interplay of internal components that collectively work to preserve the system's integrity despite environmental challenges.

ANALYSIS

Definition Theme Analysis: What is Life?

Key Themes List

These definitions share 6 major themes:

1. **Self-Organization and Maintenance**
   - Present in 12/15 definitions
   - Described as "self-organizing," "self-sustaining," "self-perpetuating," "self-producing," or "self-modifying"
   - Critical because it distinguishes life from random assemblies of matter
   - Used to explain how life maintains boundaries between self and environment

2. **Thermodynamic Non-Equilibrium**
   - Present in 9/15 definitions
   - Described as "far-from-equilibrium," "dissipation of energy," or "metabolic energy"
   - Important because it explains how life persists despite entropy
   - Used to frame life as a special energy-processing phenomenon

3. **Information Processing/Computation**
   - Present in 8/15 definitions
   - Described as "computational," "information patterns," "cognitive systems," or "info-computational networks"
   - Significant because it explains life's ability to respond to environments
   - Used to connect physical structures with functional behaviors

4. **Reproduction/Replication**
   - Present in 7/15 definitions
   - Described as "self-replication," "proliferation," or "reproduction"
   - Essential because it enables continuity and evolution
   - Used to explain how life persists beyond individual entities

5. **Adaptation/Evolution**
   - Present in 7/15 definitions
   - Described as "natural selection," "adaptive change," or "Darwinian evolution"
   - Important because it explains life's diversity and resilience
   - Used to connect present forms with historical processes

6. **Boundary/Identity Maintenance**
   - Present in 6/15 definitions
   - Described as "Markov boundaries," "individuation," or "defines self from non-self"
   - Critical because it explains how life maintains coherence
   - Used to distinguish living systems from their environments

Connection Map

These themes connect in the following ways:

1. **Thermodynamics → Self-Organization**
   - Non-equilibrium conditions enable self-organization
   - Energy flow provides the means for maintaining organization
   - Example: "self-sustained out-of-thermodynamic equilibrium process driven by metabolic energy"

2. **Self-Organization → Boundary Maintenance**
   - Self-organization creates and maintains system boundaries
   - Boundaries define what is "self" versus "environment"
   - Example: "self-organising... which defines self from non-self"

3. **Information Processing → Adaptation**
   - Computational abilities enable adaptive responses
   - Memory and information storage allow learning
   - Example: "memory to respond, maintain and adapt to the environment"

4. **Reproduction → Evolution**
   - Reproduction enables evolutionary processes
   - Variation during reproduction creates adaptation potential
   - Example: "capable of open-ended Darwinian evolution"

5. **Central Hub: Self-Organization**
   - Most other themes connect to or depend on self-organization
   - Acts as the foundational property from which others emerge
   - Example: "self-perpetuating pattern of interlocking dynamical processes"

Shared Approach

The definitions share these characteristics:

1. **Process-Based Rather Than Object-Based**
   - Life defined as dynamic processes rather than static objects
   - Focus on patterns, flows, and relationships rather than substances
   - Example: "Life is a scale-invariant, far-from-equilibrium process"

2. **Multi-Scale Perspective**
   - Definitions span from molecular to systemic levels
   - Recognition that life operates across different scales
   - Example: "capable of self-reproducing through time and space, at various scales"

3. **Interdisciplinary Framework**
   - Combines concepts from physics, chemistry, biology, information theory
   - Integrates thermodynamics, computation, and evolution
   - Example: "emerges from the laws of physics and chemistry operating within the universe"

4. **Functional Over Material**
   - Emphasis on what life does rather than what it's made of
   - Material substrate often considered secondary to patterns
   - Example: "The 'matter' doesn't have to be physical matter in our universe"

5. **Tension Between Continuity and Distinctness**
   - Life seen as both continuous with and distinct from non-life
   - Recognition of both gradients and boundaries
   - Example: "this makes the pattern both independent of and contingent on this substrate"

These definitions collectively suggest life is best understood as a self-organizing process that maintains itself far from thermodynamic equilibrium, processes information to adapt to environments, establishes boundaries between self and non-self, and reproduces with variation that enables evolution. The definitions prioritize dynamic patterns and relationships over specific material substrates.
